Review

Three Decades of Behavioural Economics in Agriculture. An Overview of Global Research

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Abstract: Over the last three decades, behavioural economics has been gaining ground in the research on a wide range of agriculture-related themes. This is due to the diversity of the agents involved in the production systems and the agro-food value chains in which opposing interests must be reconciled. The main objective of this study is to examine the dynamics of the research on the application of behavioural economics in agriculture across the world. To do this, a bibliometric analysis has been carried out through a literature review of the period between 1991 and 2020. The results of the study show that the use of behavioural economics has increased in the research on agriculture, particularly over the last five years. The application of behavioural economics in agriculture has focused on analysing consumers, producers, management, marketing, development, environmental issues, climate change, food and health.

Keywords: sustainable development; agricultural economics; behavioural economics; bibliometric analysis

1. Introduction

The beginning of the twenty-first century has been conditioned by a series of threats and challenges that humanity must address. These include the increase in population with its corresponding need for water, food, energy and different products [1]. New consumption patterns have generated a demand for goods and services that make a more intensive use of resources. As well as leading to an increase in the inequalities within and between countries, satisfying these demands also gives rise to an over-exploitation of a planet that is already in a critical state [2]. The consequences of climate change are becoming increasingly evident and more harmful. In addition to these threats, different crises have also affected the planet over the past two decades, particularly the current health crisis derived from COVID-19. All of this highlights the need to adopt measures to guarantee the survival of the current generation, ensuring the same opportunities for future generations based on the principle of sustainability [3,4].

The most pressing needs among the different priorities established by the Sustainable Development Goals of the 2030 Agenda of the United Nations are related to the supply of water and food, the eradication of hunger and poverty and the conservation of a healthy natural environment [5,6]. These challenges are closely connected to each other and are particularly prominent in the most disadvantaged regions. Agriculture is an economic activity that links the above-mentioned challenges together: it is the principal supplier of food, the leading consumer of water resources and one of the most polluting agents on a global level [7–9]. Furthermore, agriculture is one of the most important activities in rural areas, sometimes constituting the only possible livelihood [10,11]. However, from an economic perspective, agriculture is a complex system in which opposing interests prevail regarding the use of vital resources such as land and water. Therefore, finding

consensus solutions is essential for this sector to thrive as it is so closely related to the survival of humankind.

In this respect, Behavioural Economics can be considered as a "school of economic thought and can encompass a number of strands such as 'new institutional/transaction cost economics', economic psychology and psychological economics, consumer behaviour and decision theory" [12]. Although this discipline has become more popular over the last three decades, according to Thaler [13], its origins can be found in Adam Smith. Subsequently, in the 1930s, Fisher and Keynes developed the three most relevant concepts in Behavioural Economics: overconfidence, loss aversion, and self-control [13]. Kahneman and Tversky contributed to this discipline through the incorporation of Psychology in Economics, with a descriptive theory of rational behaviour [14]. The principles and tools of Behavioural Economics have been increasingly applied to the analysis of the adoption of decisions in the field of agriculture, involving different disciplines such as supply-demand [15], farm management [16], or environment [17]. There is growing interest among the scientific community specialised in agriculture to draw from the precepts of Behavioural Economics as it constitutes a tool for policy-makers and stakeholders in designing economic policy programmes and/or more efficient and sustainable practices. However, to date, there are no studies that analyse the state of the research in this field.

Therefore, the objective of this study is to contribute to closing this gap, providing knowledge on the dynamics of the research on the application of behavioural economics in the field of agriculture (hereafter BEA). To do this, a bibliometric analysis has been carried out through a literature review of the period between 1991 and 2020. The output generated in this analysis enables us to identify the principal transforming agents and the different lines of research, allowing this document to constitute a reference for both researchers and policy makers interested in this field of study.

2. Methodology

Given that the volume of research in practically all areas of knowledge has experienced an exponential growth in recent decades, we require methodologies able to manage this vast amount of information. Thanks to the expansion of digital and information technologies, the majority of the scientific research is accessible with a diverse range of repositories. In the mid-twentieth century, Garfield developed bibliometric analysis as a tool designed to cover this need [18]. Originally, this methodology was used to identify, organise and evaluate the principal components of a specific field of knowledge [19]. Today, a wide range of software tools are available for processing, analysing, aggregating and visualising bibliographic information [20,21]. All of this has enabled bibliometric analysis to become a methodology frequently used in disciplines as diverse as economics, agronomics, biology, engineering, medicine or psychology [22,23].

In order to analyse the structure of a body of scientific literature corresponding to a specific field of study, different approaches may be used [24]: co-occurrence, co-citation and bibliographic coupling analysis. On the other hand, different indicators are available to evaluate the different aspects of interest in relation to the bibliographic information [25]: (i) quantity indicators that provide information about the productivity of the different agents involved in publishing the studies analysed; (ii) indicators of relevance that show the repercussion of the publications within the field of study; and (iii) structural indicators that are used to analyse the connections established between the different elements of the same field of research.

A decisive step in conducting a bibliometric study is selecting the sample of studies to analyse. This phase of the research includes the choice of repository from where the information is to be extracted and the criteria that are to be established for including the documents in the sample. These decisions condition the results that will be obtained from the study [26]. The Scopus database has been chosen for this study. The reasons for this are (i) Scopus is considered to be the most complete and most used repository of data referring to abstracts and citations of peer-reviewed literature, (ii) this database is the

most accessible [27,28], and (iii) Scopus offers the broadest range of options including the possibility of fully downloading the information contained, unlike others such as the Web of Science (which only allows the downloading of the information contained in the Core Collection) [29,30]. The parameters used for the search for studies were behavioural economics, nudge, nudging, agriculture, crop, cultivation, agrosystem, agroecosystem and farm. These parameters were used to search for documents in the search fields of title, abstract and keywords, as illustrated in Figure 1. The search was carried out for the period 1991–2020. In order to be able to analyse full annual periods, studies published in 2021 were not included [31]. Given that the different repositories are continuously being updated, it is important to note the moment when the information was accessed. For this study, the data were downloaded in April 2021. The final sample included a total of 176 documents.
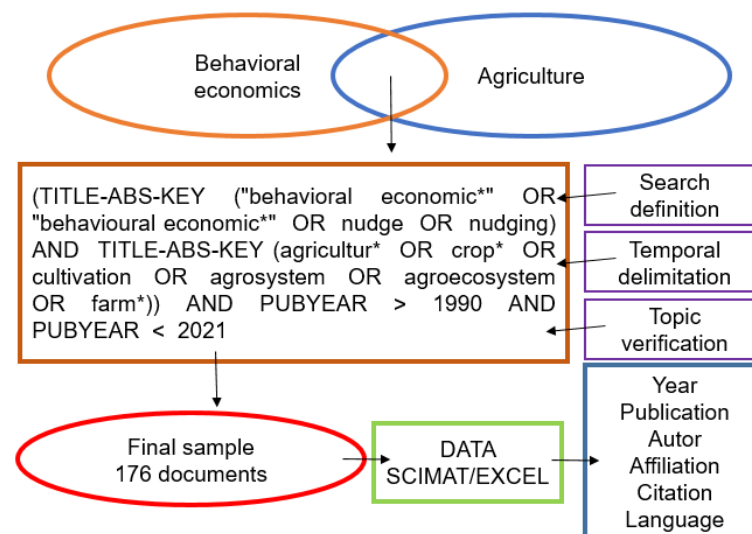

Figure 1. Study procedure.

Once the sample had been formed, before analysing the information that it contained, we conducted a preparation process in order to eliminate duplications and incomplete information [32]. Subsequently, the information was processed and analysed. The variables analysed were the number of documents published annually, the discipline to which they belonged, the type of document and publication, the language and the centre and country of affiliation of the authors.

The software tools used for processing and analysing the information were Excel (version 2016, Microsoft, Redmond, WA, USA), and SciMaT (v1.1.04, research group of Soft Computing y Sistemas Inteligentes de Información, University of Granada, Granada, Spain).

3. Results and Discussion

3.1. Evolution of the Research on Behavioural Economics in Agriculture (BEA)

Table 1 shows, in figures, the evolution of the most relevant dimensions in the research on behavioural economics in agriculture (BEA) between 1991 and 2020. We can distinguish two clearly differentiated stages in the evolution of the research on behavioural economics in agriculture during the period analysed. In the first half of the period, the publication of studies on this subject matter was highly irregular. In fact, the publication of studies was intermittent. The maximum number of studies published during this period was three, in the year 1997. Similarly, the variables of the number of authors, journals and countries shows the same trend. Given the nature of the variable of the number of citations, it began to be counted in the year 1993, when the first citation of a study in the sample was made. From then, this variable has also exhibited irregular behaviour although with a clear upward trend, reaching a maximum of eight in the year 2005. The average number of

citations per article also grew during the period, reaching a total of 4.7, also in 2005. Before 2005, only 5.7% of the documents making up the sample had been published.

Table 1. Main characteristics of the BEA research.

Year of Publication	Number of Documents	Number of Authors	Number of Journals	Number of Countries	Number of Citations	Number of Citations per Document
1991	1	2	1	2	0	0.0
1992	0	0	0	0	0	0.0
1993	1	1	1	1	1	0.5
1994	0	0	0	0	0	0.5
1995	1	2	1	1	2	1.0
1996	0	0	0	0	0	1.0
1997	3	8	3	2	1	0.7
1998	0	0	0	0	2	1.0
1999	1	5	1	2	5	1.6
2000	1	4	1	2	5	2.0
2001	0	0	0	0	6	2.8
2002	0	0	0	0	6	3.5
2003	1	1	1	1	4	3.6
2004	1	1	1	1	7	3.9
2005	0	0	0	0	8	4.7
2006	1	1	1	1	17	5.8
2007	1	1	1	1	6	5.8
2008	1	1	1	1	10	6.2
2009	2	4	2	2	15	6.3
2010	6	13	5	4	22	5.6
2011	6	14	6	6	30	5.4
2012	7	11	7	3	41	5.5
2013	12	43	10	8	72	5.7
2014	13	23	9	7	109	6.3
2015	19	58	16	10	169	6.9
2016	20	61	18	16	264	8.2
2017	10	35	9	8	323	10.4
2018	21	67	18	13	438	12.1
2019	21	68	16	12	544	14.2
2020	26	81	24	19	705	16.1

The year 2006 constituted a turning point, whereby a growth trend began which stabilised towards the end of the period studied. In this way, the number of documents that had remained stable at one between 1991 and 2005, rose to 26 in 2020. We can observe that the greatest boost in this subject area occurred in the final years of the period studied, given that more than 55% of the articles in the sample were published after 2016. In order to determine whether this trend is due to an overall inertia in research on agriculture, we have conducted a comparison of the percentage of annual variation in the number of publications in both lines of study. The result is shown graphically in Figure 2. In this figure we can observe, on the one hand, how research in agriculture experienced a stable growing trend throughout the whole period, with an average annual variation in the number of publications of 8.7%. With respect to research on BEA, we can observe the aforementioned difference between the two sub-periods. From 2008, the variable experienced an almost exponential growth, with an average annual increase during the whole period of 11.9%. These data allow us to conclude that research on BEA is still in the early stages of its evolution. Furthermore, if the trend remains stable, we would expect that over the next few years, the use of behavioural economics applied to research in agricultural aspects will become a relevant line of study.
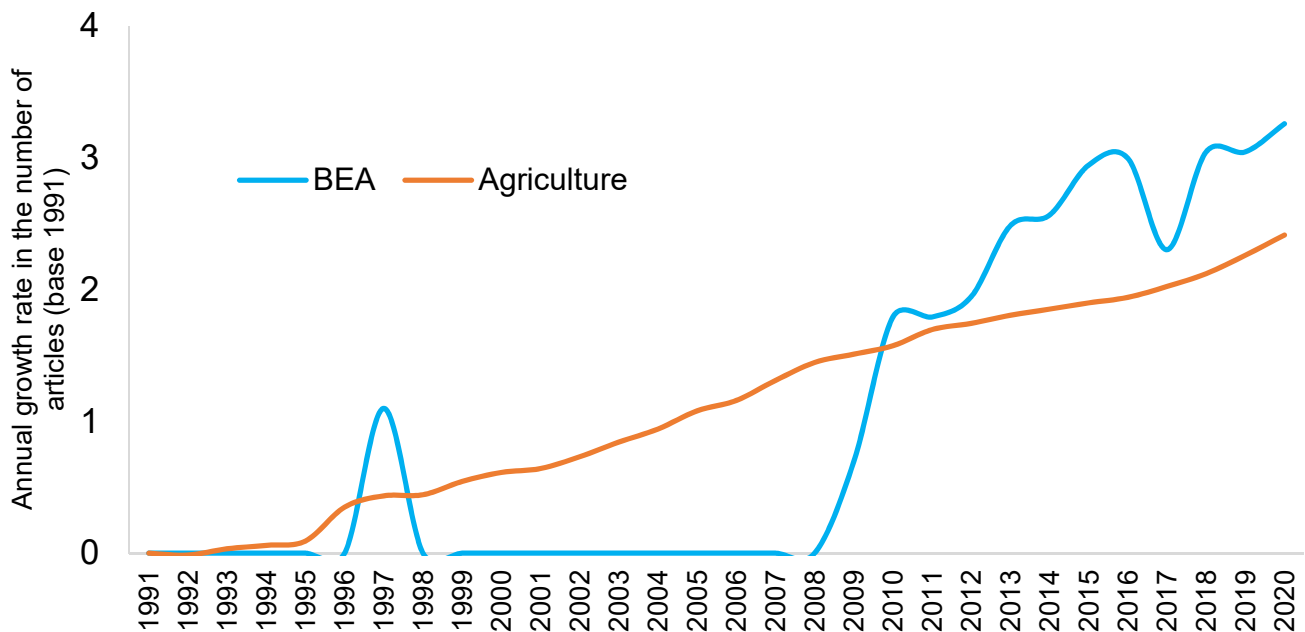
Figure 2. Evolution of BEA and agriculture research.

With respect to the number of authors participating in the research on BEA, we can observe that this variable experienced a more intense variation than the number of documents published. In total, 478 researchers participated in 176 publications. This figure grew from two in 1991 to 81 in 2020. The average number of authors per document has increased slightly over the whole period, increasing from one during the first half of the period of study to three from 2015. However, only 5.8% of the total authors involved in the research on BEA have participated in more than one study. This supports the claim that this line of research is in its infancy. The number of journals in which the studies on BEA have been published experienced an almost identical variation as the number of documents. In this way, the average number of documents per journal remained almost unchanged at one, with a slight increase at the end of the period. This data, again, corroborates the early stage of this line of research, given that the concentration of a high number of articles in a series of journals is more in keeping with a consolidated topic [2]. The total number of journals in which studies on BEA have been published is 116 and the variety has also grown to 24 in 2020.

The variable that has changed the least is that of the number of countries involved in the research on BEA. In 1991, a joint study by researchers affiliated to institutions in Israel and the USA constituted the first contribution of this topic within the sample analysed. Since then, a total of 40 countries have been involved in this field of study. This figure is low if we compare it with other more consolidated topics, which usually exceed one hundred [24]. The number of citations that the scientific studies accumulate in considered to be an indicator of the impact that the research has within the field of study. In this case, although the annual number of citations is not very high, this variable exhibits normal behaviour. The number of citations obtained increases in line with the increase in the number of journals publishing on the topic under study. In this way, the maximum number of citations was reached in the year 2020 at 705. The average number of citations per article can be a clearer indicator. This variable is found to have an increasing trend until 16.1 citations per article in 2020. This figure is very similar to that of other more consolidated topics [27]. This data enables us to determine that this line of research is set to gain relevance within the research on agriculture in the coming years.

3.2. Subject Areas, Type of Document and Language

Scopus classifies the documents based on the subject areas corresponding to the different disciplines. The documents may be included in more than one category if they belong to more than one discipline. The categories expected to be most prominent are those related to economics and agriculture. Even though this expectation is fulfilled, given that Economics, Econometrics and Finance and Agricultural and Biological Sciences are the categories with the highest number of documents, these categories account for less than 40% of the total documents in the sample (Figure 3). This result is explained by the incipient nature of the line of research and the low number of studies which, in the same way as the number of journals does not allow us to clearly differentiate the dominant subject areas. Furthermore, different disciplines are closely related in this subject matter, particularly the social sciences and environmental sciences, as well as all those related to the natural environment and human behaviour. Other prominent categories are Social Sciences with 27.3% and Environmental Sciences with 23.9% of the total documents of the sample.
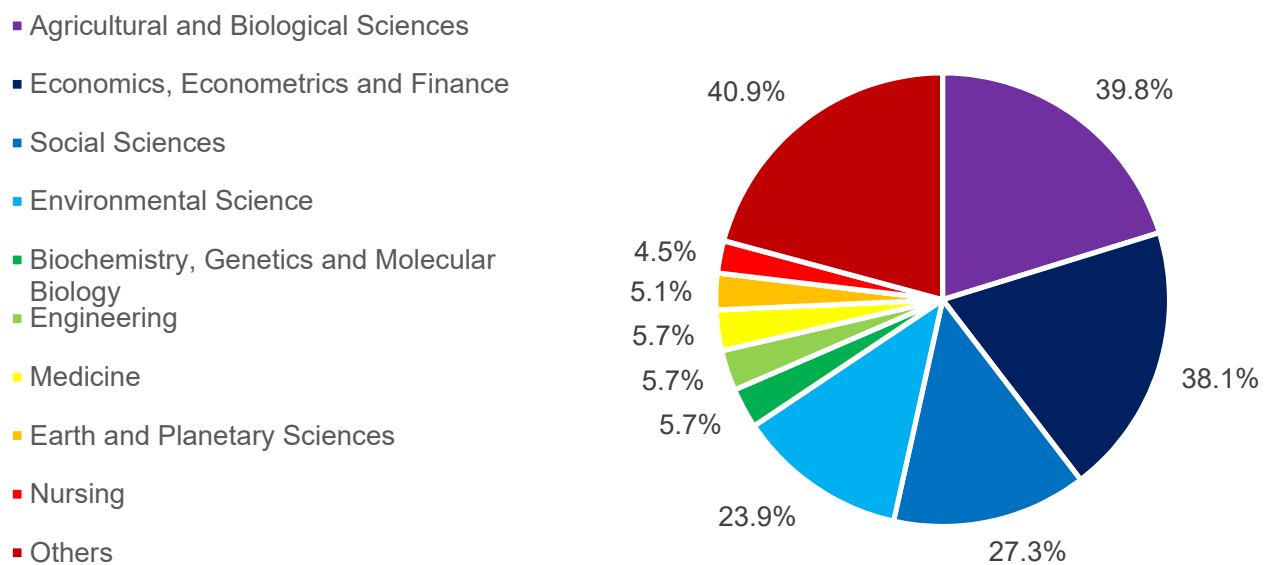
- Agricultural and Biological Sciences
- Economics, Econometrics and Finance
- Social Sciences
- Environmental Science
- Biochemistry, Genetics and Molecular Biology
- Engineering
- Medicine
- Earth and Planetary Sciences
- Nursing
- Others

Figure 3. Subject areas of BEA research.

In Figure 4 we can see the type of document and language in which the studies on BEA were published. This figure shows the diversity in the publication formats of the studies on this subject area. The scientific article is dominant with 73.9% of the total studies in the sample, followed by conference papers with 9.1%, reviews with 6.8% and book chapters with 4.5%. The rest of the formats are conference reviews, editorials, books and notes which account for a little under 1% of the total documents of the sample. As expected, as in practically every discipline, English is the dominant language with 96.6% of the total publications in the sample being published in this language. With percentages fluctuating at around 1%, we can also find documents published in German, Chinese, Dutch, French and Russian.
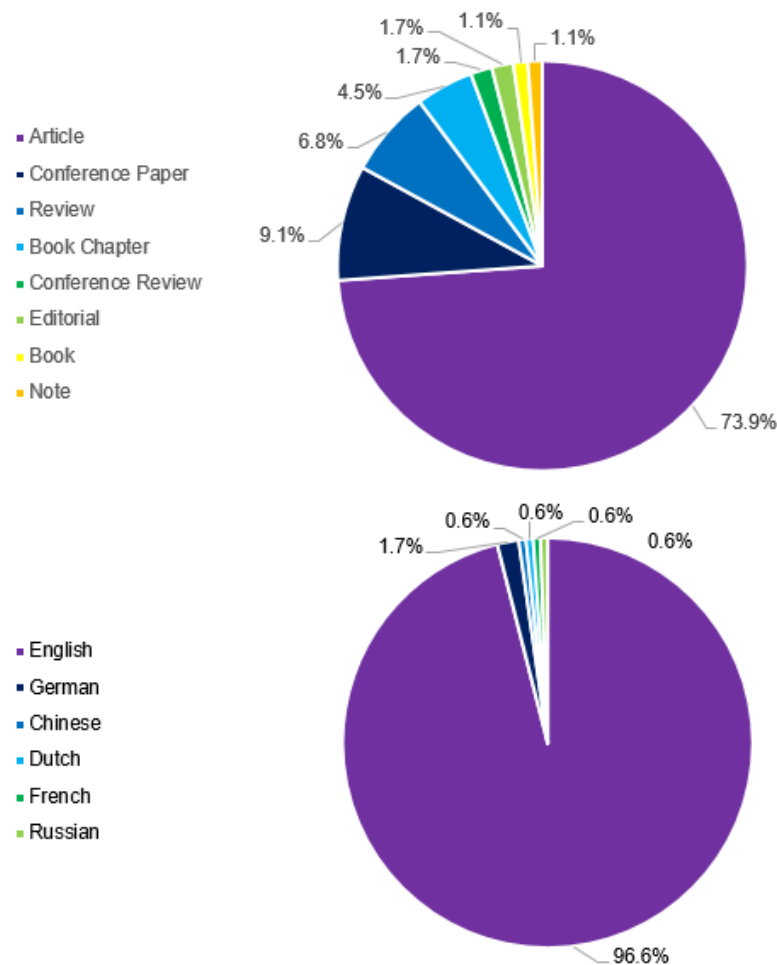
Figure 4. Type of document and language related to BEA research.

3.3. Journals

　　The documents contained in the sample analysed were published in a total of 116 different journals. Table 2 shows the group of 24 journals in which two or more documents have been published. This group represents 20.7% of total journals and accumulates 40.9% of the total documents and 32.9% of the total citations in the sample. On the whole, these journals are British, with some American, Dutch, Swiss publications and one German and one Indian. As we can observe, the number of documents per journal is very low, as previously mentioned. Only four journals have published at least five documents. The most prolific journal in this subject is the European Review of Agricultural Economics with a total of eight articles published. This is followed by Ecological Economics with seven, Applied Economic Perspectives and Policy with six, Agricultural Economics with five and Agricultural Systems with four. The rest of the journals accumulate between two and three publications. The most veteran journal within the group in the table is Agricultural Systems, given that it has the oldest publication dating to 1997. This is followed in terms of the length of time that they have published on the subject by Behavioural and Experimental Economics (previously called Journal of Socio Economics) and Agricultural and Resource Economics Review, with publications dating to 2004 and 2006 respectively. On the other hand, the journals publishing their first study on BEA most recently are Current Science and Sustainability. The majority of these journals are found within the first quartile in one of the categories of the Scimago Journal Rank (SJR) of 2020. The most relevant journals in terms of the impact factor in the SJR ranking are World Development with 2.386, Global Food Security with 2.350, Food Policy with 2.092, American Journal of Agricultural Economics with 1.949 and Ecological Economics with 1.917. With respect to the number of citations,

the journal that accumulates the highest amount is Applied Economic Perspectives and Policy with a total of 235 citations. This is followed by European Review of Agricultural Economics with 205, Preventive Veterinary Medicine 69, Land Economics 50 and Ecological Economics 49. Similarly, with the highest average number of citations per article is Applied Economic Perspectives and Policy with 39.2. In second place is Preventive Veterinary Medicine with 34.5. These are followed by European Review of Agricultural Economics with 25.6, Land Economics with 25.1 and Journal of Rural Studies with 17.1.

Table 2. Journals related to BEA research.

Journal	Number of Documents	Impact Factor	H Index	Number of Countries	Number of Citations	Number of Citations per Document	1st Publication	Last Publication
European Review of Agricultural Economics	8	1.400(Q1)	7	UK	205	25.6	2010	2019
Ecological Economics	7	1.917(Q1)	5	Netherlands	49	7.0	2014	2019
Applied Economic Perspectives and Policy	6	1.400(Q1)	6	UK	235	39.2	2013	2020
Agricultural Economics	5	1.290(Q1)	4	UK	19	3.8	2016	2020
Agricultural Systems	4	1.694(Q1)	3	UK	12	3.0	1997	2020
Agriculture and Human Values	3	1.065(Q1)	3	Netherlands	36	12.0	2016	2017
American Journal of Agricultural Economics	3	1.949(Q1)	2	UK	25	8.3	2017	2020
Journal of Behavioral and Experimental Economics *	3	0.768(Q1)	3	USA	15	5.0	2004	2018
Journal of Environmental Planning and Management	3	0.806(Q1)	2	UK	34	11.3	2012	2020
Agricultural and Resource Economics Review	2	0.475(Q2)	2	USA	33	16.5	2006	2012
Agricultural Finance Review	2	0.611(Q1)	2	UK	12	6.0	2011	2015
Animals	2	0.584(Q1)	2	Switzerland	6	3.0	2018	2019
Australian Journal of Agricultural and Resource Economics	2	0.683(Q1)	1	UK	2	1.0	2016	2018
Behavioral and Brain Sciences	2	0.812(Q2)	2	UK	30	15.0	2015	2016
Current Science	2	0.281(Q2)	0	India	0	0.0	2019	2020
Food Policy	2	2.092(Q1)	2	UK	18	9.0	2018	2019
German Journal of Agricultural Economics	2	0.146(Q4)	1	Germany	8	4.0	2015	2018
Global Food Security	2	2.350(Q1)	1	USA	11	5.5	2018	2020
Journal of Rural Studies	2	1.497(Q1)	1	UK	34	17.1	2013	2020
Land Economics	2	0.961(Q1)	2	USA	50	25.1	2010	2016
Preventive Veterinary Medicine	2	0.816(Q1)	2	Netherlands	69	34.5	2013	2019
Sustainability	2	0.612(Q1)	2	Switzerland	4	2.0	2019	2020
Water	2	0.718(Q1)	1	Switzerland	1	0.5	2016	2020
World Development	2	2.386(Q1)	2	UK	18	9.0	2017	2020

* including Journal of Socio Economics.

3.4. Countries

USA and Israel are the countries that initiated the use of behavioural economics in the agricultural activity in 1991. Over the years a total number of 40 countries have carried out a research study along these lines. Table 3 presents the ten countries with the highest number of contributions on this topic. Again, the total number of documents per country is very low in comparison with other more consolidated subject areas. Only 10 countries have participated in five or more studies, while just six of them have participated in more than ten. The USA is the country that holds the first position with a total of 72 documents. With much lower figures are the UK with 19, Germany with 17, France with 12 and China and the Netherlands with 11. The maximum number of citations accumulated with the

studies of the sample also corresponds to the USA with a total of 1225 citations. In spite of the great difference in terms of the number of articles, the UK and Germany account for a significant amount with 530 and 459 citations respectively. However, Denmark has the highest average number of citations per article with 46.9, followed by the UK with 27.9 and Germany with 27.1.

Table 3. Countries related to BEA research.

Country	Number of Documents	Number of Citations	Number of Citations per Document	H Index	1st Publication	Last Publication
USA	72	1225	17.0	20	1991	2020
UK	19	530	27.9	13	2009	2020
Germany	17	459	27.1	7	2011	2020
France	12	253	21.1	7	2010	2019
China	11	12	1.1	2	2009	2020
Netherlands	11	194	17.6	8	1997	2020
Denmark	9	422	46.9	5	2011	2020
Australia	7	24	3.4	3	2014	2020
India	7	38	5.4	3	2015	2020
Canada	5	14	2.8	3	2016	2020

In order to measure the global nature of the research and the level of international collaboration in the studies on BEA, a study of the collaboration networks established between the most prominent countries in terms of the number of documents has been conducted. The results obtained are shown in Table 4. On average, 41.8% of the studies were carried out through international collaboration. However, this percentage varies greatly depending on the country. While Australia has the highest percentage of studies carried out through international collaboration, with 85.7%, at the other end of the scale, India has only 14.3%. In the majority of cases, the collaboration networks between different countries are very small. There are only three countries with a network of more than 10 members. These are the USA with a total of 13, the UK with 12 and Germany with 11. The USA also stands out as being a collaborator of the majority of the countries in the table. On average, the studies carried out through international collaboration obtained 19.3 citations. This figure falls to 14.6 in the case of studies carried out autonomously. However, again, there are significant differences between the different countries. In conclusion, we can affirm that, due to the incipient nature of this line of study, the collaboration networks are not yet fully developed and the research has not reached the global nature of the traditional subject areas. However, we can observe a trend towards an intensification and a shift in this direction in recent years.

Table 4. International collaboration related to BEA research.

Country	Documents by International Collaboration (%)	Number of Collaborators	Main Collaborators	Number of Citations per Document	
				International Collaboration	Without International Collaboration
USA	27.8	13	Australia, China, Germany, Canada, France	11.3	19.2
UK	47.4	12	France, Spain, Australia, Germany, Netherlands	16.6	38.1
Germany	52.9	11	USA, Denmark, UK, France, India	45.8	5.9
France	41.7	3	UK, USA, Germany	23.4	19.4
China	27.3	1	USA	1.3	1.0
Netherlands	36.4	5	USA, Australia, Colombia, Indonesia, UK	14.3	19.6
Denmark	44.4	5	Germany, Ethiopia, Ireland, Italy, USA	61.5	35.2
Australia	85.7	5	USA, Bangladesh, Canada, Netherlands, UK	4.0	0.0
India	14.3	1	Germany	13.0	4.2
Canada	40.0	2	USA, Australia	2.0	3.3

3.5. Institutions

The first study to apply behavioural economics to agriculture was developed through collaboration between the Hebrew University of Jerusalem and the School of Environmental and Biological Sciences de la Rutgers University–New Brunswick USA, in 1991. In 2020, more than 50 institutions were involved in developing studies along these lines. Table 5 shows the 20 institutions with the highest number of publications on BEA. These institutions belong to nine different countries, all included in Table 3, except for Ireland. There are no institutions representing Canada and China which are among the most prolific countries. This result is due to the fact that some countries participate in this line of research with a higher number of institutions, but with less studies conducted by each of them. Another noteworthy aspect, similar to the case of the countries, is the small number of contributions per institution, with none of them exceeding six studies. Once again, we cannot refer to a group of leading institutions in this subject area, due to its incipient nature.

Table 5. Institutions related to BEA research.

Institution	Country	Number of Documents	Number of Citations	Number of Citations per Document	H Index	Documents by International Collaboration (%)	Number of Citations per Document	
							International Collaboration	Without International Collaboration
Wageningen University & Research	Netherlands	6	120	20.0	6	50.0	19.0	21.0
University of Goettingen	Germany	6	32	5.3	4	33.3	8.5	3.8
Centre d'Economie de l'Environnement	France	5	70	14.0	3	20.0	54.0	4.0
Harvard University	USA	4	450	112.5	4	25.0	3.0	149.0
Martin Luther University	Germany	4	20	5.0	3	0.0	-	5.0
University of Nebraska-Lincoln	USA	4	33	8.3	3	25.0	4.0	9.7
Montpellier SupAgro	France	4	93	23.3	4	75.0	30.3	2.0
Inst. Natl. De La Rech. Agronomique	France	3	79	26.3	3	66.7	37.5	4.0
Australian National University	Australia	3	18	6.0	2	100.0	6.0	-
Trinity College Dublin	Ireland	3	0	0.0	0	33.3	0.0	0.0
University of Reading	UK	3	192	64.2	2	0.0	-	64.0
University of Florida	USA	3	33	11.0	3	33.3	0.0	16.5
National Bureau of Economic Research	USA	3	378	126.1	3	0.0	-	126.0
University of Michigan	USA	3	69	23.0	2	0.0	-	23.0
University of Oxford	UK	3	47	15.7	2	66.7	12.0	23.0
Copenhagen University	Denmark	3	29	9.7	2	66.7	2.0	25.0
Scotland's Rural College	UK	3	106	35.3	3	0.0	-	35.3
University of Montpellier	France	3	34	11.3	3	33.3	23.0	5.5
Nalanda University	India	3	11	3.7	1.0	0.0	-	3.7
The World Bank	USA	3	63	21.0	2.0	66.7	2.5	58.0

The institutions with the highest number of publications on BEA are the Wageningen University & Research from the Netherlands and the University of Goettingen in Germany with six studies each. These are followed by the Centre d'Economie de l'Environnement in France with five; and Harvard University (USA), Martin Luther University (Germany), the University of Nebraska–Lincoln (USA) and the Montpellier SupAgro (France) with four. The rest of the institutions only have three publications. The institutions with the most relevant publications, measured by the number of accumulated citations are Harvard University with a total of 450, the National Bureau of Economic Research with 378, the University of Reading with 192, the Wageningen University & Research with 120 and Scotland's Rural College with 106. However, the institution with the highest average number of citations per article is the National Bureau of Economic Research with 126.1. This is followed by Harvard University with 112.5 and the University of Reading with 64.2.

With regard to the international collaboration of the institutions, the average percentage of studies carried out in collaboration with other institutions is 34.8%, slightly lower than the average per country. However, we cannot observe any regularity in the behaviour of the different institutions. Nevertheless, 100% of the studies conducted by the Australian National University were conducted through collaboration; while others, such as the Martin Luther University or the University of Reading, have not conducted any studies in this way. On average, the studies carried out in collaboration obtained 12.8 citations. Meanwhile, those conducted autonomously obtained an average of 30.4 citations.

3.6. Authors

Table 6 shows the authors who have participated in at least two publications on BEA. This group is formed by a total of 28 researchers who, as already mentioned, account for 5.8% of the total authors included in the sample analysed. These authors are affiliated to a total of twenty different institutions, belonging to eight different countries. In the table, the authors have been grouped based on their co-authorship relationships. The different groups have been differentiated using colours. Within the different colours, we can distinguish different shades based on the amount of studies conducted jointly. The pale shade indicates one document shared, the medium tone indicates that two studies are shared and the dark shade indicates three shared documents. In this way, and by way of example, the first group is represented in violet. Four authors are included in this group. However, two of them appear with a medium shade of violet because they have co-written two studies with other authors, while the other two appear in a dark shade of violet because they share three articles. These co-authorship relationships are relevant given that they help to explain the inclusion of some of the authors in the table.

Table 6. Authors related to BEA research.

Author	Number of Documents	Number of Citations	Number of Citations per Document	H Index	Country	Affiliation	1st Publication	Last Publication
Musshoff, Oliver	5	19	3.8	3	Germany	University of Goettingen	2011	2020
Hirschauer, Norbert	4	20	5.0	3	Germany	Martin Luther University	2011	2018
Peth, Denise	3	11	3.7	2	Germany	University of Goettingen	2018	2020
Funke, Katja	2	9	4.5	1	Germany	Martin Luther University	2018	2018
Banerjee, Simanti	3	17	5.7	3	USA	University of Nebraska–Lincoln	2018	2020
Burbach, Mark E.	2	18	9.0	2	USA	University of Nebraska–Lincoln	2015	2019
Czap, Hans J.	2	18	9.0	2	USA	University of Michigan	2015	2019
Czap, Natalia V.	2	18	9.0	2	USA	University of Michigan	2015	2019
Kecinski, Maik	2	4	2.0	2	USA	University of Delaware	2019	2020

Table 6. *Cont.*

Author	Number of Documents	Number of Citations	Number of Citations per Document	H Index	Country	Affiliation	1st Publication	Last Publication
Napoleone, Claude	2	4	2.0	2	France	Inst. Natl. De La Rech. Agronomique	2018	2019
Subervie, Julie	2	12	6.0	2	France	Centre d'Economie de l'Environnement	2019	2019
Le Coent, Philippe	3	34	11.3	3	France	University of Montpellier	2016	2019
Hanley, Nick	2	77	38.5	2	UK	University of Glasgow	2016	2016
Kuhfuss, Laure	2	77	38.5	2	UK	University of St Andrews	2016	2016
Préget, Raphaële	2	77	38.5	2	France	Centre d'Economie de l'Environnement	2016	2016
Thoyer, Sophie	2	77	38.5	2	France	Centre d'Economie de l'Environnement	2016	2016
Lusk, Jayson L.	3	54	18.0	3	USA	Purdue University	2014	2018
Marette, Stephan	2	31	15.5	2	France	Economie Publique	2011	2014
Gunn, George J.	2	69	34.5	1	UK	Scotland's Rural College	2013	2017
Stott, Alistair W.	2	69	34.5	1	UK	Scotland's Rural College	2013	2017
Toma, Luiza	2	101	50.5	2	UK	Scotland's Rural College	2013	2013
Lunn, Peter D.	2	0	0.0	0	Ireland	Trinity College Dublin	2020	2020
Lyons, Sean	2	0	0.0	0	USA	Economic and Social Research Institute	2020	2020
Carter, Michael R.	2	14	7.0	2	USA	National Bureau of Economic Research	2015	2016
Matthews, Lindsay R.	2	52	26.0	2	New Zealand	University of Auckland	2000	2008
Reisch, Lucia A.	2	240	120.1	1	Denmark	Copenhagen Business School	2012	2013
Seo, S. Niggol	2	11	5.5	1	South Korea	Muaebak Institute of Global Warming Studies	2015	2016
Wossink, Ada	2	53	26.5	2	UK	University of Manchester	1997	1999

The author with the most studies published on BEA is Oliver Musshoff, of the University of Goettingen, with a total of five. He is followed by Norbert Hirschauer with four and Denise Peth, Simanti Banerjee, Philippe Le Coent, and Jayson L. Lusk with three. The rest of the authors have only published three studies. The most citations, both in absolute and average terms are obtained by Lucia A. Reisch from the Copenhagen Business School, with 240 and 120.1 citations respectively. This author has participated in just two studies which were published in 2012 and 2013. She is followed by Luiza Toma, affiliated to Scotland's Rural College, with a total of 101 and an average number of citations per article of 50.5. In third position are Nick Hanley, Laure Kuhfuss, Raphaële Préget and Sophie Thoyer, who accumulate 77 citations in the two articles in which the four share authorship, with an average of 38.5 citations per document. Ada Wossink, from the University of Manchester, is the researcher in the table who has been studying BEA for the longest, with her first article published in 1997. At the other extreme, Peter D. Lunn (Trinity College Dublin) and Sean Lyons (Economic and Social Research Institute) are the most recent newcomers to this line of research with their first article on BEA published in 2020.

With respect to the co-authorship relationships, the group incorporating Musshoff, Hirschauer, Peth and Funke is noteworthy. These German authors are affiliated to the University of Goettingen and the Martin Luther University. The different researchers share the authorship of two or three studies, depending on the case. There is a group of American authors appearing in blue shades who are affiliated to the universities of Nebraska–Lincoln, Michigan and Delaware. Within this group, Burbach, Czap H.J. and Czap N.V share the authorship of the two studies that place them in the table; while only one publication is shared with Banerjee and Kecinski. Le Coent is a unique case. This author has the most extensive collaboration network within the table. He shares a study with Napoleone (represented in yellow), another with Subrevie (orange) and another with the group of authors represented in red (Hanley, Kuhfuss, Préget and Thoyer). Finally, the authors who do not share authorship with any other researchers included in Table 6 are represented in white.

3.7. Main Topics

An analysis of the keywords allows us to identify the most relevant topics within the research on BEA. We will refer to the most salient aspects of each of them.

Behavioural Economics has contributed to the agricultural field in one way by focusing on animal species. In this sense, Gunnarsson et al. [33] study the behaviour of laying hens and the elasticity of demand with respect to certain types of litter (straw and feathers). Huijps et al. [34] explore the sub-optimal economic behaviour in the decision-making of Dutch dairy farmers in order to adopt measures to improve udder health, concluding that the low rate of adoption and of following the advice of the dairy industry is due to a certain level of inertia in the behaviour of the farmers. In order to obtain the desired behaviour, penalties are more effective than bonuses. Kristensen and Jakobsen [35] identify the role of veterinarians as dairy herd health advisers to farmers, as they have the capacity to translate their knowledge within the farming system. The "irrational" actions of the farmers can be explained as their values, behaviours and risk perception are incorporated in the decision-making process. Instead of assuming that farmers seek to maximise profits, other explanatory factors are included in their utility function, such as animal health, animal welfare or other farmer's recognition. Toma et al. [36] focus on the determining factors explaining the biosecurity behaviour of farmers in Great Britain. The results show that the farmer's perceived importance of specific biosecurity strategies is explained through 13 variables including the attitude towards animal well-being and the organic certification of the farm. Brugere et al. [37] study aquaculture. The objective of this article is to argue for farmer-based, syndromic surveillance as a way of overcoming the current limitations of the conventional surveillance systems and demonstrate its usefulness in aquaculture. The authors highlight the complex interconnection of behavioural factors (economic and social) underlying farmer's reporting of disease.

Another important area of study is the field of management. In this respect, Schmid and Robison [38] conduct a series of experiments in order to verify the existence of social capital and explore its impact on the productivity of firms and individuals. The findings show that the identity of the commercial actors is important as it affects the purchase and sales prices, the choice of share or cash leases in agriculture, the acceptance of catastrophic risk or how the banks invest in social capital to retain customers. Barnes et al. [16] compare the voluntary adoption of water quality management techniques within a Nitrate Vulnerable Zone (NVZ) in Scotland. They find that different behavioural groups can be observed depending on the acceptance of the regulation, the responsibility towards issues related to water pollution and the degree of compliance with the established regulation. The authors indicate that these behaviours recorded by the farmers are explained by a range of attitudinal alignments and should include across designations in order to change social norms.

Within the field of management, we can identify a sub-group of literature focusing on the study of perceptions. In this line, in order to promote environmentally friendlier tech-

niques that are innovative, Wossink et al. [39] analyse the degree to which the perceptions of risk and costs of farmers differ from the normative costs and risks and the characteristics that farmers perceive as important for adopting IAFS techniques (Integrated Arable Farming Systems). The results show that farmers consider a minimum level of knowledge, labour requirements and associated risks to be of importance. De Koeijer et al. [40] conduct a review of concepts in agronomy and in farm and behavioural economics in order to determine which input-output combinations are possible while being optimum in practice. Among other factors, the findings show that as well as behaviouristic aspects, the preferences and perceptions of the farmer should also be considered. Duflo et al. [41] assume that farmers have low fixed costs when purchasing fertilizer, introducing a stochastic bias. Therefore there are farmers who postpone the purchase of fertilizers until later while there are others who are more impatient. The authors find that, in accordance with the model, many farmers in Western Kenya do not make efficient use of the investments in fertilizers, but they do respond slightly after the harvest to certain small discounts that are limited in time (such as free delivery). They conclude that these types of policies work better than laissez-faire techniques or strong subsidies. Mills et al. [17] identify the main drivers of farmer's decision-making in relation to environmental management practices that are sustainable over time. They conclude that there is enormous heterogeneity in farmer's beliefs and values in relation to custodianship and productivity.

Another area in which behavioural economics has been significant in agriculture is in the field of development. Banerjee [42] reflects on development economics and examines the conditioning factors involved in people developing their natural talent. He indicates five important issues: contracts theory, coordination failures, political economy, learning and behavioural economics. Drawing from human behavioural ecology and behavioural economics, Tucker [43], studies how people evaluate activities in their portfolios and the possible alternatives considered. The plans to create the Mikea Forest National Park (Madagascar) considered the elimination of slash-and-burn maize agriculture and the promotion of manioc crops (labour intensive). The analysis revealed that manioc is not a suitable replacement for maize as the two crops are cultivated differently (use of labour, delay-to-reward and rainfall); and the planners should offer alternative sources of proteins and cash to conserve small game. Furthermore, few resources should be dedicated to protecting lemurs, as they are rarely eaten and are never sold. Taking some East Asian countries as examples, Wade [44] considers that low-income countries and their aid donors should focus more on industrial policy, as this is does not only mean "picking winners". Industrial policy can be implemented by either leading or following the market. In addition, industrial policy can be adjusted to the available resources and state capacity. Datta and Mullainathan [45] conduct a review of human behaviour and its application to development policy. Through behavioural economics, they indicate the principal pitfalls faced by policymakers in developing countries when seeking to design effective policies for these problems. Specifically, they use as a case study of agricultural policy the intervention made to promote the use of fertilizers among farmers in Sub-Saharan Africa. Nally and Taylor [46] consider that the modernisation projects led by the Rockefeller Foundation were based on principles of behavioural economics, imposing a human capital model on the agricultural transformation that it proposed. In this way, they highlight the fundamental role played by philanthropy in the shaping of a new world order. Brune et al. [47] study the use of policy intervention through savings accounts for the case of developing countries in order to increase the use of agricultural inputs by households. An experiment was carried out in Malawi among cash crop farm households. The results show that offering savings accounts increases the number of bank transactions, but also has a significant and positive effect on measures of household well-being.

Another framework that has received particular interest is economic policy. Bishop et al. [48] study the attitudes towards adopting new technology in dairy farms. They examine the behaviour, motivations and intentions of the potential adopter. An important implication is that it could be beneficial for decision-makers to guide the policies previously

targeting different types of agents. In a study conducted in the Democratic Republic of Timor-Leste, Lover et al. [49] explore the perceived malaria risk, causes of malaria, net usage patterns, barriers to protection and consistent use within families. The results indicate that there is an overall perception that mosquito nets should only be used by pregnant women and young children and there is a need for sufficient sleeping space under a limited number of nets within households. In conclusion, they emphasise that net usage is important for all members of the family, irrespective of age or gender, which highlights the complex behavioural economics. Pedersen et al. [50] question whether the search for profit is the only goal, as assumed by traditional economic theory, or whether there are other factors that explain decision-making as suggested by behavioural economics. They research the effectiveness of incentive-based environmental policies. The results reveal two groups that are differentiated in terms of the use of pesticides: there are farmers who are more interested in maximising profits and others who focus more on land yields and who are less sensitive to the implementation of exclusively economic policy instruments. Clarke and Grenham [51] study micro-insurance markets and their protection against catastrophes. Taking into consideration issues of supply and demand, aspects such as climate change and the associated risks are contemplated, which are typically covered by this type of insurance. In order to increase the demand for acquiring disaster insurance, governments should promote it, maybe using subsidies, with a commitment to limit the subsequent post-disaster financial assistance given to the uninsured. Lusk [52] highlights the importance of the findings generated by BEA, revealing that the behaviour of the subjects is not consistent with the results of classic economic theory. However, he also indicates that Behavioural Economics cannot be used to justify all market failures. This is because consumers suffer from cognitive biases and, therefore, governments must act in a paternalistic way to conduct policy interventions. Miller et al. [53] study agri-environmental schemes (AESs) and the factors that determine farmers' decisions related to maintaining pro-environmental practices that go beyond what is established in contracts. They find that both pecuniary and non-pecuniary factors affect their decisions and that the influence of information regarding social norms is highly significant. Kuhfuss et al. [54], continue studying the AESs. In order to improve the participation of the farmers and increase land enrolment for lower overall budgetary cost, they contemplate the implementation of a conditional collective bonus. This bonus would be paid in addition to the usual AES payment if a given threshold is reached in terms of farmers' participation. The authors show that these bonuses increase expectations of farmers on others' participation, therefore favouring a change towards a pro-environmental social norm and the adoption of less pesticide-intensive farming practices. Bouma [55] study how, despite a commitment made by 195 countries of the United Nations when they signed the Sustainable Development Goals (SDGs) in 2015 and the research existing in this respect, the soil–water–plant–climate system still poses basic problems regarding soil behaviour that have yet to be resolved. It is necessary to share more information in order to be able to link the existing research with stakeholders and policy-makers. This is even more the case with the information revolution which affects the attitudes of increasingly critical stakeholders, making it difficult to discern between irrelevant and relevant information on the internet and social media.

Another field of study is related to policies referring to food production, food consumption and food security. In this respect, Just [56] seeks to determine whether the food assistance programmes to combat obesity are more effective through traditional economic policies (such as manipulating information or prices) or policies related to behavioural economics and psychology. They find that the behavioural models are effective, but little is known about how eating behaviours interact with prices and other traditional mechanisms. Roosen and Marette [57] analyse how the experiments contribute to the regulatory debate existing about the information referring to food quality and safety. They conduct a brief review of how laboratory and field experiments on food are complemented with theoretical analysis, discussing strengths and weaknesses. Goto et al. [58] study whether environmental interventions can affect the decision-making of elementary school students. They

determine whether students who are motivated to choose white milk due to environmental changes alter their total milk consumption. Their findings demonstrate that school-based practices guided by the theory of behavioural economics can offer useful insights and strategies for improving policies related to food selections. Chandon [59] observes how packaging is important for food manufacturers and retailers as a marketing tool. This author studies how information relating to marketing, health and nutrition creates certain "health halos" leading to the belief that products are healthier than they actually are, with a positive effect in terms of increased consumption and the perception of a lower calorie intake. On the other hand, Reisch et al. [60] examine the challenges faced by humankind in the near future related to the consumption and production system of current foods. In this sense, agricultural production must withstand the impacts generated by climate change, the growing conflicts related to land use and the social and health costs on an individual and societal level. With regard to nutritional aspects, Réquillart and Soler [61] study how government policies related to nutrition have focused on informing consumers about the benefits of balanced diets, which has had a positive but modest effect. Recently, the attention of these policies has been directed towards market environments, with an emphasis on the characteristics of the food supply. Aiking [62] addresses the issue of food security and food sustainability, given that in the next four decades the current food production will have to be doubled. They emphasise that for every kilo of animal protein, six kilos of plant protein are required, leading to concerns related to climate change and sustainability or the loss of biodiversity. Furthermore, intense livestock production is associated with antibiotics resistance and freshwater depletion. Liu et al. [63] explain how the policy carried out in the USA to reduce obesity levels consisting in providing consumers with nutritional information about the products that they consume has had a very modest effect. They indicate that, among other factors, this is because it is necessary to have a certain level of understanding of the nutritional information and due to a conflict between motivation and lack of control. Lagi et al. [15] explain the recent increase in food prices, which is affecting the most vulnerable populations around the world. The authors conclude that the principal causes reside in the investor speculations on ethanol conversion, driven by recent changes in the regulation of the commodity markets and in the policies implemented for ethanol conversion. Richards and Hamilton [64] examine wasting food. They analyse the commercial peer-to-peer mutualisation systems (CPMSs), or sharing-economy firms, as platforms for exchanging food surpluses so that prices generate incentives for all of the actors to manage food surpluses more efficiently. The results show that the secondary markets are an effective way to reduce food waste. Lusk and McCluskey [65] emphasise how public policies affect the decision of food consumers as their choices shape the food and farming system, with the known impacts on health, environment and food security. They discuss the future challenges such as diet-related illnesses and the efficiency of the policies aimed at improving dietary choices, confidence in the food system, farm technologies, environmental impacts of food consumption and food safety.

Since results on the traditional neoclassic economics have highlighted that these could not be supported in the praxis, the behavioural economics offer some explanations to the observed deviations from the theoretical expectations. In this sense, a great part of the scientific production on Behavioural Economics shows influences from Thaler et al. [66], who contribute to the debate on libertarianism and paternalism regarding the State role. So can be the relevance of the term "nudge" be understood as a "gentle push to urge into action", or more specifically "any aspect of the choice architecture that alters people's behaviour in a predictable way without forbidding any option significantly changing their economic incentives". This work establishes strong affirmations by which the responsibility over economic measures is shifted to the policy-maker. According to the measure design, nudges can be articulated so that individuals guide their decisions in a specific planned direction.

As the research corpus has increased, works summarizing the most relevant contributions have been identified through literature review. Particularly, Li and Just [67]

research about the factors explaining why behavioural economics has a great influence on the design of agricultural policies. This study focuses its analysis on two questions. On the one side, consumers' behaviour regarding food and, on the other side, farmers' decision-making in the food production and distribution phases. This work points out how the field of consumer behaviour is still limited, although many advances have been made in other disciplines, as well as in the development of experimental techniques. Moreover, references of previous works show the relevance of the preference inconsistency for sustaining individual habits. In the same way, some governmental practices based on a greater nutritional information of food have had a modest impact on the population and its caloric consumption. The authors also include previous works that highlight that individuals make a moderate cognitive effort when taking a decision regarding the consumption of food; they rather take advantage of the use of heuristic techniques and rules of thumb. Regarding this question, they offer references applied to school lunches. Related to Agricultural Production, the authors emphasize the challenges to apply behavioural economics on this field. Since each farm faces unique production possibilities and constraints, studies related to decisions under risk become special significance. It is observed how farmers wish to maximize benefits and, at the time, minimize risks through the behavioural model from the expected utility theory. In this sense, in order to manage risk and uncertainties, farmers' studies offer examples of production diversification, as well some kinds of insurance coverage and governmental production subsidies. The studies cover the different attitudes toward risks that can be adopted (risk-averse vs. risk-lover), as well as entering into contracts. Further specific examples show how individuals tend to group all decisions without regarding if they provide benefits or losses, whereas in other samples they make a clearer difference. Finally, authors compiled research related to how farmers tend to value more changing in risk rather than changing in outcomes.

A further work that should be taken into account is the one by Streletskaya et al. [68] who completed a literature review on agricultural technology adoption and behavioural economics, in order to better guide economic politics. For this reason, they established definitions, similarities and differences among both of them. Behavioural economics focuses on the study of deviations of decisions from the predictions within traditional economic models. The deviated decisions focus on intrinsic factors like preferences and cognition, among others. They collected these data through controlled economic experiments based on repeated games. This allows a causal analysis of the observed behaviours. The literature on agricultural practice adoption analyses those factors related to technology adoption by farmers and the evolution of uptake within populations. It focuses on extrinsic factors like physical, economic and demographic questions. It studies how populations adopt agricultural technologies through descriptive analyses and regressions. Furthermore, three areas for future research are identified: models of behaviour under risk and deviations from expected utility, behavioural time discounting models, and behavioural models of learning and social preferences.

4. Conclusions

The objective of this study is to analyse the dynamics of the research on applying behavioural economics to the field of agriculture over the last thirty years. To do this, the principal drivers of the line of research have been analysed in depth together with the most relevant research topics. The findings of the study show that use of behavioural economics has increased in the research on agriculture, particularly over the last five years. This progress is evident in the different indicators analysed and is reflected in the greater scientific production and number of actors involved.

Throughout this study we have seen how behavioural economics is a discipline with strong implications that transcends across other fields of study, as it has been proved by the theme classification of the works. Both individual and societal behavioural aspects must be taken into account when designing policies with different objectives, as it can be inferred when we refer to individual decisions and behaviour regarding aggregated dimensions like

offer and demand. The application of behavioural economics in agriculture has focused on analysing consumers, producers, management, marketing, development, environmental issues, climate change, food and health. All of these fields of study have been analysed, incorporating the precepts of psychology on which behavioural economics is based.

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