Nudge research in agricultural economics: two-decade retrospective of empirical evidence

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731

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Abstract

Purpose – Understanding farmer and consumer behavior is essential to the successful implementation of behavior change interventions. The purpose of this study is to summarize existing research, provide a comprehensive overview of nudge interventions, and identify important trends in behavioral agricultural economics. Research on nudge interventions can help policymakers encourage farmers and consumers to change their behavior in desired direction like switching to organic agriculture or eco-labeled products and promote innovation in sustainable agriculture.

Design/methodology/approach – The paper contains a bibliometric analysis of nudge research in general and agricultural economics as well as a literature review of the 53 empirical studies on nudge interventions between 2003 and 2023.

Findings – The frequency of nudge research in all research fields and in agricultural economics has increased over the years. This study summarizes nudge interventions that can be used by farmers and consumers on a variety of agricultural economic issues. Information, social norms, and social comparison as nudge interventions are most prominent in the publications, while green nudges have not been researched to a greater extent.

Originality/value – This study provides a comprehensive overview of nudge research in agricultural economics with potential for theoretical and policy implications. It highlights potential nudge interventions among farmers and consumers that can be applied in practices.

Keywords Nudge, Agricultural economics, Behavioral economics, Literature review, Bibliometric analysis

Paper type Research paper

1. Introduction

Behavioral economics (BE) is about applying insights from laboratory experiments, psychology, and other social sciences to economics in order to understand economic behavior and its consequences (Cartwright, 2011). In BE, homo economicus, which is driven by material gain, is replaced by homo socioeconomicus. In BE, the concept of "nudging" as part of the decision architecture has emerged as a powerful public or private tool to influence decision making, often with interventions that influence individuals to make decisions that are in their best interests. Thaler and Sunstein (2008) defined "nudge" "as a notion that changes people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives" and nudge as an intervention must be easy and cheap to avoid. According to Thaler and Sunstein (2008), taxes, penalties, subsidies, and bans do not qualify as nudges. Nudge interventions (NI) generally include the availability heuristic (the extent to which decisions are influenced by recent experience), the social norm (typical or socially accepted behavior), default options (setting a particular choice as an automatic or preselected option), information, peer pressure, and priming (exposing people to certain cues or stimuli), libertarian paternalism (people's freedom of choice is respected, but they still choose what is best for them), no choice is also referred to as nudging, anchoring (people's choices were influenced by a reference point or "anchor value"), framing (problems are stated or information is presented or "framed" to influence people's choices) (Li *et al.*, 2021; Thaler and Sunstein, 2008).

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While nudge theory has been applied in a variety of fields, its integration into agricultural economics (AE) represents a fascinating intersection of psychological insights and agricultural practices. Various NIs have been explored to encourage farmers to adopt environmentally friendly behavior and support environmental management (Mills *et al.*, 2017), reduce pollution (Schubert, 2017; Carlsson *et al.*, 2018), promote adoption of sustainable practices (Kuhfuss *et al.*, 2015; Chabé-Ferret *et al.*, 2019; Peth *et al.*, 2018; Massfeller *et al.*, 2022b), and design agri-environmental programs (i.e. Kuhfuss *et al.*, 2016a, b, Czap *et al.*, 2019, Chabé-Ferret *et al.*, 2023). In the area of food marketing, nutritional claims (Guthrie *et al.*, 2015), food packaging design, and the promotion of healthier food choices (Lai *et al.*, 2020; McGrath, 2023; Banerjee *et al.*, 2023) are just some of the measures that can influence individuals' food choices.

The objective of this study is to examine the frequency with which articles on nudge theory appear in general and specifically in AE. First, we provide primary data on the applicability of nudge research in AE, including data on nudge research in AE by country, research area and journal. Second, the paper aims to provide a systematic literature review of empirical publications in AE that apply nudge theory. The contribution of this article is to summarize and analyze two decades of empirical findings on the use of NIs in AE as well as research trends. An overview of possible NIs in the field of AE has not yet been published. This study fills this gap by identifying the factors that influence the decision-making behavior of farmers and consumers. The paper's contributions are linked to suggestions for future research directions and offer practical implications for policy makers, agricultural economists, and stakeholders interested in using nudges to address behavioral challenges in agriculture.

The paper is organized as follows. In Section 2 we present the methodology used in this paper. In Section 3, we provide an analysis and dynamics of nudge research in general and in agricultural economics, as well as an overview of nudge interventions. In Section 4, we present the implications, limitations and future directions of the paper.

2. Methodology

In the paper, the authors used a bibliometric analysis (Donthu *et al.*, 2021) and a systematic literature review (Moher *et al.*, 2010). The bibliometric analysis was used to evaluate the scientific data. Specifically, for providing data on the number of nudge research, the distribution of nudge research by research area, the trends of nudge research over two decades, the number of papers by country of authors' affiliation, and the journal of publication. The authors used figures for basic presentation. VOSviewer software was used to display the main keywords in the studied area using nodes (VOSviewer Software, 2023). For the systematic literature search, the PRISMA method was used to describe the research steps (identification of articles, screening of articles, and inclusion of articles) (PRISMA, 2024, www.prisma-statement.org). After inclusion, publications were read and displayed in the literature review of publications (Sections 3.3. and 3.4.).

Data were exported from the Web of Science (WOS), the most recognized database for peer-reviewed scientific publications (Birkle *et al.*, 2020). The search terms used in the data search were "nudge", "nudging", "nudges," and "agricultural economics". The time period ranged from 01/01/2003 to 31/12/2023. Filter "or" between nudge, nudging, nudges and AE provide publications outside the scope of agriculture and AE. For this reason, the filter "and" was used to narrow down publications that apply nudge theory specifically in the field of AE. The inclusion and exclusion criteria used in screening papers that explore nudges in AE can be seen in Table 1. The authors have not limited themselves only to AE journals, but to multidisciplinary journals published in WOS.

The total number of papers in the proposed time period (2003–2023) and with the proposed keywords is 100. The authors reviewed and excluded theoretical papers according to specific criteria. The total number of studies included in the statistical presentation (Section 3.2.) and the literature review (Sections 3.3. and 3.4.) finally amounted to 53 (Table 2). The studies are divided into two groups: one focusing on farmers (at the farm level) and one focusing on consumer research questions.

3. Results

3.1 Statistics of nudge research worldwide

A total of 11,307 publications applying nudge theory can be found in the WOS in all research areas. 10,859 publications from the WOS database have examined nudge theory in various fields of research over the last two decades. The increase in nudge research in all research areas is shown in Figure 1. From 2003 to 2023, the number of published papers increased more than two thousand times. In 2023, the number of publications was 17% lower compared to 2022.

The first research area with the highest proportion of publications was business economics, with 1,834 or 16.67% of all publications. In second place was nudge research in science and technology (16.12%), followed by psychology (14.57%) and physics (13.99%). Food science technology accounted for 5.03% of publications and agriculture for 2.71%. Asian Studies (0.02%), Integrative Complementary Medicine (0.02%) and Classics (0.02%) accounted for the lowest percentage of publications. The leading institutions with nudge research were the University of California System (301 publications, 2.77%), the University of London (252, 2.32%), the Centre National de la Recherche Scientifique, France (248 publications, 2.28%). The leading countries were the USA (28.84%), England (11.35%) and Germany (8.03%).

Inclusion criteria
The paper explicitly researches nudge in AE
The paper contributes with empirical data
The paper is published between 2003–2023
The language is English
Exclusion criteria
The paper is a theoretical paper
The paper is not published in a scientific journal
The document is a report, a database, a doctoral dissertation
The full paper is not possible to access

Source(s): Authors adapted from Sandeberg *et al.* (2023)

Table 1. Inclusion and exclusion criteria for screening the papers

Identification	
Records identified from WOS 100	Records removed before screening = 15
Screening	
Records screened 85	Records excluded = 16
Reports assessed for eligibility 69	Reports excluded = 16
Included	
Studies included in the literature review	= 53

Source(s): Authors adapted from PRISMA, 2024, www.prisma-statement.org

Table 2. PRISMA approach research steps

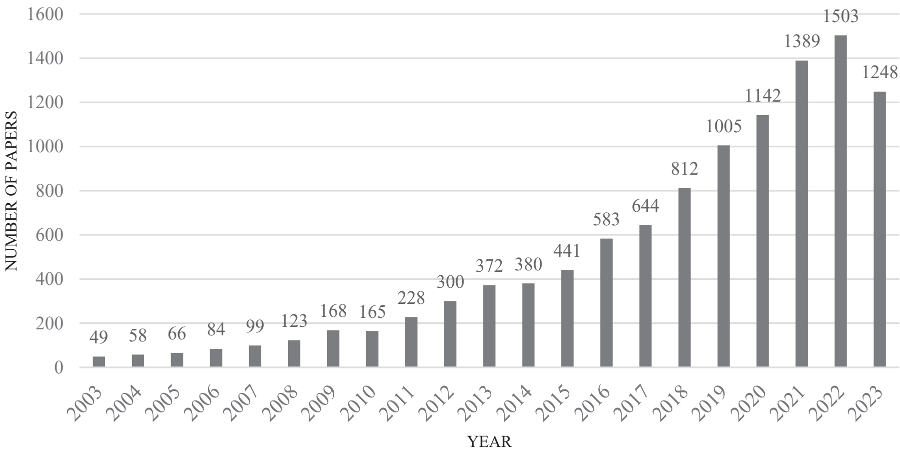


Figure 1.
The number of nudge research worldwide from 2003 to 2023

Source(s): Authors' own compilation based on WOS data

3.2 Statistics of nudge research in agricultural economics

According to the defined keywords and the screening of the papers, 53 publications were recorded in the research period from 2003 to 2023. The statistical data and the literature review can be found below. Precisely, the first two publications appeared in 2013. The largest increase in publications was observed in 2019, where the total number of publications amounted to 9. Most recently, in 2023, there were 10 publications applying the nudge approach to AE (Figure 2).

As we did not limit ourselves to AE journals, but also to multidisciplinary journals in the WOS, the following research areas were represented in the number of publications: business economics (94.34%), agriculture (90.57%), environmental science ecology (62.26%) and food technology (47.17%). Publications can cover several research areas.

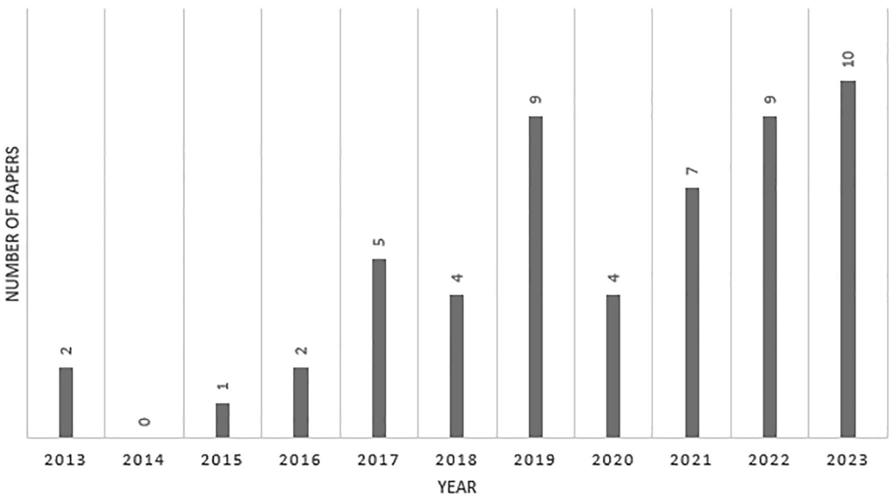


Figure 2.
The number of nudge research in AE from 2013 to 2023

Source(s): Authors' own compilation based on WOS data

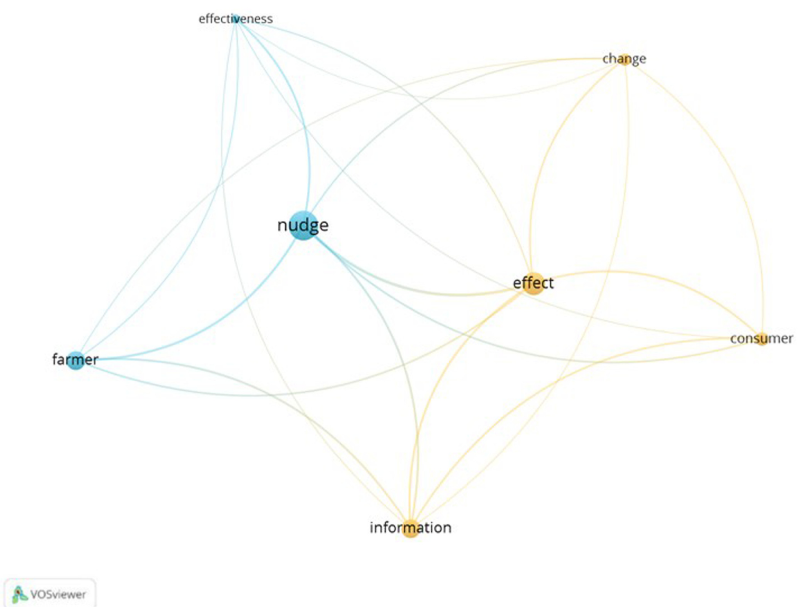
The top 5 journals with the highest number of publications researching nudge in AE (53 papers) were European Review of Agricultural Economics (13%), Ecological Economics (11%), American Journal of Agricultural Economics (9%), Food Policy (9%) and Applied Economic Perspectives and Policy (8%). 20 journals were represented with only one publication (i.e. Agricultural Economics, Agricultural Systems, Land Economics, Sustainability).

The University of Goettingen (13.46%) and the National Research Institute for Agriculture, Food and Environment (INRAE) (11.54%) were the top institutions with nudge research in AE according to our review. The leading countries with nudge research in AE were the United States (36.54%), Germany (15.39%) and France (15.39%). The leading author was Oliver Musshoff with four publications from the University of Goettingen. The most important words (the largest nodes for nudge, farmer, effect, information) and their connection in nudge research in AE are shown in Figure 3.

3.3 Overview of nudge publications in agricultural economics among farmers

After applying the PRISMA approach, the search revealed that nudge research related to farmers and agricultural management included 31 publications. The publications are summarized in the text by research topic. Summary of NIs is organized by year of publication, in Supplementary material - Nudge interventions among farmers.

3.3.1 Conservation program. Wallander *et al.* (2017) investigated the participation of farmers in voluntary land conservation programs, known in the United States as the Conservation Reserve Program (CRP). In the experiment, the authors sent a letter to a large number of farmers who were eligible to participate in the CRP. The information letter included incentives (social comparison and a social norm message) to increase participation among farmers with expiring CRP contracts. The main results showed that the information



Source(s): Authors using VOSviewer Software

Figure 3. Main words in nudge research in AE publications

letter influences re-participation in the CRP. Czap *et al.* (2015) conducted an experiment with four treatments: no nudging, empathy nudging (sending empathy messages), financial nudging (government payments), and a combination of empathy and financial nudging. The results showed that empathy nudging promoted conservation tillage, and when a greater financial incentive was given, this also led to an increase in conservation tillage. In summary, the data show that a combination of empathy and financial incentives is most effective. Davis and Rausser (2020) investigated the minimum payment required for producers to adopt agroforestry practices under CRP contracts.

3.3.2 Water management. Some research studies relate to water management issues. Barnes *et al.* (2013) have highlighted the nudge options adopted by the House of Lords in 2011. In general, these are the provision of information, changing the physical environment, changing default measures and using social norms and salience. Barnes *et al.* (2013) investigated how the aforementioned nudges affect the voluntary adoption of water quality management techniques between farmers within a Nitrate Vulnerable Zone (NVZ) and those outside the NVZ. Peth *et al.* (2018) investigated water protection regulations in Germany. To improve water quality and prevent water pollution, farmers must maintain a minimum distance from water. Two (green) nudges were defined to improve compliance with the minimum distance to water by German farmers. First, a nudge with information and pictures showing environmental and health damage, and second, a nudge with an additional social comparison meaning that other farmers keep the minimum distance to water. Chabé-Ferret *et al.* (2019) investigated whether nudges can promote water-saving behavior among farmers. Nudges were presented as information on individual and group-specific water consumption. The results of the randomized experiments showed that average water consumption decreased, especially among the largest water users. The most recent work on water management comes from Ouvrard *et al.* (2023), who investigated that farmers in France are reluctant to use smart water meters as devices that store and transmit water consumption data. The informational nudges were defined in the study as "cocktail nudge" and "testimony nudge". The "Cocktail Nudge" included reminders about water restrictions, questions about the importance of water management and descriptions of the benefits of water meters to raise awareness and encourage commitment to better water management. The "Testimonial Nudge" was a nudge with the farmer's picture, name and age and their experience with smart water meters. The testimonials included information about the adoption of smart water meters by other farmers in the region. It was found that both the cocktail and the testimonials increased the likelihood of farmers opting for a smart water meter, especially when combined with a subsidy (a financial incentive).

3.3.3 Agri-environmental and similar schemes. Kuhfuss *et al.* (2016a) investigated the applicability of agri-environmental schemes (AES), which are widely used and of great scientific interest. AES programs are individual contracts that encourage farmers to voluntarily adopt environmentally friendly management practices in exchange for an annual payment (Kuhfuss *et al.*, 2016a). The continuation of AES practices after the contract expired was the main question. The results showed that social norms (information about what others intend to do) were defined as an impetus and encourage farmers to continue AES practices. It was highlighted that farmers' behavior is influenced by the behavior of others. Other research by Kuhfuss *et al.* (2016b) on choice experiments has found that an additional monetary bonus paid on top of existing AES payments can increase farmer participation and land enrollment in AES. Czap *et al.* (2019) investigated the willingness of farmers to sign up for agri-environmental programs in the USA, the Conservation Stewardship Program (CSP), with the aim of improving nature conservation. The empathy nudge, which refers to the handwritten personalized letters (information about the program) sent to farmers, influenced CSP enrollment rates. Photocopied personalized letters as a second empathy nudge did not affect CSP adoption rates like handwritten letters. Massfeller *et al.* (2022a, b) investigated social incentives (participants received information about other farmers' satisfaction with the AES) in the implementation of outcome-based AES. In contrast to previous studies, the authors concluded that social incentives had no influence on the likelihood of participating in AES. Chabé-Ferret *et al.* (2023) tested the impact of non-monetary incentives on the adoption of environmental practices by farmers using payments for environmental services (PES). Nudges included information letters, social comparison nudges, testimonials and pre-printed response forms. Of the treated farmers, some received only the information letter, some received the information letter with the witness statements and some received the information letter with the witness statements and the pre-stamped response form. The information letter mentioned that more than 1,700 farmers had already signed up for the PES program. Four farmers reported their positive experiences with the PES program and the pre-stamped response form could help farmers sign up for the PES program faster. Peth and Mußhoff (2020) conducted a policy experiment among farmers and agricultural students in Germany. A green nudge was used to compare the behavior of students and farmers in complying with agri-environmental measures. One nudge includes information and a picture (dead fish or a crying baby) about the consequences of non-compliant behavior in relation to the minimum distance rule (i.e. the environmental and health impacts that can result from the discharge of fertilizer into water bodies). Another nudge corresponds to the first nudge plus social comparison, i.e. participants receive information about the behavior of other farmers.

3.3.4 Market information. Belay and Ayalew (2020) investigated the role of public price information from commodity exchanges on farmers' production behavior and crop choice. The study confirmed that price information influenced cropping decisions and encouraged farmers to produce a greater quantity of commodities traded on commodity exchanges. In Africa, it is important to improve the availability of market information (i.e. prices) (Solano-Hermosilla *et al.*, 2022). For this reason, the food price crowdsourcing initiative was developed to collect real-time data on food prices from volunteers. Two nudges were social norms and information disclosure, which were used to determine prices for five products: local rice, imported rice, corn, beans, and soybeans. According to Cialdini and Trost (1998), in the work Solano-Hermosilla *et al.* (2022), social norms were "rules and standards understood by members of a group that guide members' behavior without the force of law". Information disclosure was known as the provision of advance information that influences decisions.

3.3.5 Agricultural insurance. It is generally known that the acceptance of agricultural insurance among farmers is low. A study by Davidson and Goodrich (2023) examined how farmer behavior can be changed to increase the acceptance of insurance, specifically the Precipitation Index Insurance Program for Pasture, Rangeland, and Forage (PRF). In the study, a nudge was presented as an informative nudge. The authors distinguished between two informative nudges. The first related to expected forage losses, the second to information on when farmers were most likely to receive compensation.

3.3.6 Pesticides usage. The use of pesticides in agriculture is a hot topic. The EU is trying to minimize the use of pesticides and their impact on climate policy. In addition to the pesticide tax, which is already levied in several countries, a further reduction in pesticide use is needed. Buchholz and Musshoff (2021) investigated how tax incentives and green incentives (traffic light labeling of pesticide toxicity) affect pesticide use. The main conclusion was that taxes and green nudge can reduce the use of pesticides, while tax incentives lead to profit losses. Michels *et al.* (2023) used a virtual apple farm to investigate how two nudges can improve compliance with the 14-day pre-harvest interval rule after pesticide application. The first nudge was defined as a nudge with facts and pictures indicating environmental and health damage that may be caused by a violation of the 14-day pre-harvest interval rule, and the second nudge was a nudge with social comparison, meaning that the majority of fruit growers comply with the rule. In addition, Brown (2018) investigated the influence of behavioral incentives on farmers' practices in managing insect resistance. A nudge was used as a non-monetary tool for pesticide resistance management. Balew *et al.* (2023) investigated the use of incentives (or rewards) among farm managers whose aim was to promote integrated pest management (IPM) as a strategy among farmers. There were two types of incentives: private incentives, which refer to cash rewards for farm managers, and social incentives as public recognition of farm managers' achievements. In addition, farmers in Ethiopia were encouraged to increase their knowledge by receiving information about the losses that can occur if they do not practice integrated pest management.

3.3.7 Organic agriculture and sustainability standards. On the other hand, My *et al.* (2022) investigated farmers' decisions to invest in organic farming and how informational nudges (socially optimal investments), network structures (social interaction) and social comparison influenced investment decisions. Informational nudges, social comparison and interaction influenced farmers' behavior in converting to more environmentally friendly farming and increased farmers' awareness of organic farming. Meemken *et al.* (2017) investigated the certification of sustainability standards (SS) for export among coffee farmers in Uganda using a choice experiment. Farmers preferred the SS that offered higher coffee prices, agricultural training and gender equality measures, while they did not prefer the SS that banned the use of chemicals. Farmers accepted the ban on chemical use only if they received a higher price for the coffee they sold. SS certification can bring profitability in the long run and the introduction of certification was seen as an impetus.

3.3.8 Technology and certified seed adoption. Howley and Ocean (2022) investigated how a nudge or combination of nudges influences farmers' decisions to adopt technology. The nudges in the experiment were a social norm and social signals. The social norm was formulated in the survey as a sentence: " *. . . in a recent survey we ran, over 90% of farmers believed that other farmers should embrace new technology and new approaches to farming,*" implying that information about prior adoption can influence farmers. Another nudge, social signaling, was described in the survey as "*. . . farming network was offering the farmer with an opportunity to participate in a non-monetary award scheme where they would be publicized on a website for using these technologies*". Okello *et al.* (2023) investigated how social incentives (public recognition and goal setting) influenced the diffusion of agricultural knowledge and adoption of certified quality seed among smallholder farmers in Uganda. More specifically, goal setting referred to the process whereby farmers are encouraged to set goals on how to reach other farmers and disseminate agricultural knowledge; and public recognition means rewarding selected farmers who support other farmers to learn about improved agricultural varieties and certified seeds in their communities. Empirical research found that public recognition combined with goal setting had no significant impact on knowledge dissemination or experimentation with agricultural innovations.

3.3.9 Environmental issues. Environmental issues have been studied by various researchers. Li *et al.* (2021) examined the effects of two types of nudge anchoring and framing on residents' willingness to purchase five technologies to manage nutrient runoff. Mills *et al.* (2017) conducted a qualitative study among UK farmers to investigate environmental behavior. The main conclusions are that farmers' environmental behavior was influenced by the importance of understanding values and personal and social norms as well as pragmatic and economic factors. Harun *et al.* (2021) investigated the production of biogas in agriculture and the promotion of a circular economy to encourage environmentally friendly behavior. Nudge was defined as information about opportunities and potential economic benefits. Lopes *et al.* (2022) investigated the effects of nudges and cash payments on the reduction of crop residue burning. The information treatment (positively and negatively worded) included social norms and environmentally conscious suggestions.

3.3.10 Land management. Vetter (2022) used the term "nudge" to refer to the partnership (higher education, government agencies, industry organizations, and third sector organizations) that seeks to nudge farmers toward better land management practices by reshaping their identities, institutions, representations, and discourses. Nudging can be an effective way to achieve environmental, economic and social goals through multi-stakeholder collaboration. Fleming *et al.* (2021) investigated the effects of information about erosion on the willingness to invest in river restoration initiatives.

3.4 Overview of nudge publications in agricultural economics among consumers

Nudge research in AE which focuses on the consumer, comprised 22 publications. The publications are summarized in the text by research topic. The summary of NIs is organized by year of publication, in Supplementary material - Nudge interventions with consumers.

3.4.1 Farmer market and local products. To increase participation in the new farmers' market, the use of information incentives was tested. To increase consumer participation, a printed \$10 voucher was mailed to 6,000 households in Colorado. Half of the voucher contained \$10 and an informational incentive (information about the variety of products available at the farmers' market), while the other half contained only \$10 with no informational incentive. The results showed that the \$10 coupon was effective, but an incentive (list of products) was not enough to motivate consumers to visit the market (Didero *et al.*, 2021). Menapace and Raffaelli (2017) investigated the impact of information about locally grown products (two main features: quality as a function of terroir and reduced carbon emissions due to shorter transportation distances). The results of the study showed that social influence affects consumer behavior and the decision to buy local food.

3.4.2 Health-related issues. There are taxes on fats and sugars to encourage healthier eating (Jumrani and Meenakshi, 2023). Health-related behaviors and reduced sugar consumption have been studied by Hagmann *et al.* (2018). Various policy interventions or nudge options were examined, such as reducing the availability of sugary foods, a sugar tax, banning the advertising of sugary foods, reducing portion sizes of sugary foods, providing information about sugar content on a label on packaging, reducing sugar content in products during production in the food industry, replacing sugar with artificial sweeteners and public health campaigns. Colson and Grebitus (2017) investigated whether health labels on the front of the package (the product studied was yogurt) influenced parents' decisions to choose foods that were healthier for children. Parents were most concerned about their children's nutrition, and parents with overweight or obese children were most concerned by the labels. Cadario and Chandon (2019) investigated how nudges influence healthy eating. Three groups of nudges were defined: cognitive, affective and behavioral nudges. The cognitive nudges defined in the study were - descriptive nutrition labeling, rated nutrition labeling, improved visibility of healthy foods; affective - healthy eating calls where restaurant staff ask customers if they want to eat fruit or vegetables, hedonic improvements where healthy foods are presented as more attractive; behavioral - improvements in the convenience of healthy foods on the menu or in supermarkets to make healthy foods more physically accessible on the shelves, and improvements in the size of healthy foods. Saulais *et al.* (2019) investigated whether "dish of the day" labeling as a strategy encourages consumers to make healthier food choices and influences veggie burger choices. Gittelsohn and Lee (2013) examined interventions that can promote healthier behaviors and address obesity and diet-related chronic diseases. To get children in school to choose white milk (the healthier option) over chocolate milk (with more sugar), verbal prompts or verbal help, health and taste information, and non-monetary incentives were used (Lai *et al.*, 2020). The study showed that prompts are almost as effective as a small non-monetary incentive. Dietary interventions were studied among consumers in Bangladesh (Davidson *et al.*, 2021), using a behavior change communication workshop and a nudge, defined as a printed plate with dietary recommendations. In addition, environmental labeling was investigated by Slapø and Karevold (2019). The study investigated whether eco-labeling influenced consumers' food choices. Eco-labeling was divided into red labeling (meat dishes labeled "High CO2"), green labeling (vegetarian dishes labeled "Low CO2"), and three-color traffic labeling (meat, fish, or vegetarian dishes). Improving diet and buying fruit and vegetables as the basis of the diet was researched by McGrath (2023). In the experiment, nudge messages were placed in shopping carts (posters with the message "More than 9 out of 10 LaManna shoppers buy fruit or vegetables at each shop.") to investigate whether this increases the purchase of fruit and vegetables. The NI showed that the shopping carts with the posters increased the purchase of fruit and vegetables.

3.4.3 Environmentally friendly food and GMO. The growing awareness of environmental issues and the impact of food production on the planet underline the importance of environmentally friendly food. To research environmentally friendly food produced on The experiment was designed to investigate consumers' willingness to pay for more environmentally friendly food (consumer preferences for sustainability - survey one) and for food produced under safer working conditions (survey two) (Campbell *et al.*, 2022). The choice attributes or nudges were the sustainability and safety information, the price and the type of meat produced, which influenced consumer preferences for sustainability and labor safety in meat production. In contrast, GMO were studied by Hashemzadeh *et al.* (2022). The willingness of Iranian consumers to pay more for genetically modified corn oil was investigated. The nudges used in the study were information nudges about the benefits of GMOs and the use of the correct Iranian word for GMO. The effect of the two nudges (two treatment groups) was compared with the control group. In addition, the effectiveness of each nudge was compared with consumer confidence level and perceived risk.

3.4.4 Vegetarian food. Kurz (2018) investigated how meat consumption can be reduced by promoting the consumption of vegetarian food. The two restaurants changed the order on the menu to highlight the vegetarian dishes, which encouraged consumers to switch to a climate-friendly diet. Segovia *et al.* (2023) investigated the purchase of meat and plant-based alternatives in a non-hypothetical online supermarket experiment. The decision to buy meat or plant-based alternatives was influenced by health, environmental and combined information messages.

3.4.5 Food safety and food waste. Britwum and Yiannaka (2019) investigated how different types of information treatments, such as profit and loss-oriented messages, media reports and general information, influence consumers' perceptions of food safety and their willingness to adopt food safety technologies (cattle vaccines against *E. coli* and direct-fed microbial) in the beef sector. Six different information treatments (nudges) were: (1) general information about *E. coli* and two food safety technologies, cattle *E. coli* vaccines, and direct microbial feeding; (2) general information + profit-framed message (benefits of using the technologies to reduce the risk of *E. coli* infection), (3) general information + loss-framed message (emphasized the costs of not using the technologies and the risks of *E. coli* infection); (4) general information + media report (about a foodborne illness outbreak caused by *E. coli*); (5) general information + media report + profit-framed message; and (6) general information + media report + loss-framed message. Overall, the study provided insights into how nudges can be used to promote food safety and improve public health outcomes. Prelez *et al.* (2023) investigated how to reduce fruit and vegetable wastage in consumers' households. The information incentive consisted of a monetary incentive ("how much money you could save"), an environmental incentive ("how you can help the environment by not buying fruit and vegetables that are not eaten") and an additional benefit ("monetary and environmental information"). The results showed that the additional benefit significantly increased consumers' intention to reduce fruit and vegetable waste in the household.

3.4.6 Other issues. Lange and Coremans (2020) examined the role of consumer knowledge in reducing palm oil demand and its limits. The paper discussed a default nudge as a behavioral technique to encourage consumers to acquire additional information about palm oil. Soregaroli *et al.* (2021) studied how wine consumers can mitigate climate change by considering CO2 emissions. They used carbon footprint information and price adjustments (increasing the product price for a lower carbon footprint) as nudges to influence consumer choices. Savchenko *et al.* (2019) analyzed consumer acceptance of products irrigated with recycled water. Consumers preferred fresh food over processed food irrigated with conventional water. To investigate consumers' willingness to pay for fresh and processed foods, consumers were educated about the benefits of recycled water, the risks, and the combination of benefit and risk information. Malone and Lusk (2019) investigated preferences in beer selection. They introduced cost-reducing nudges (e.g. quality ratings) and uncertainty-reducing nudges (e.g. highlighting special offers) to support consumer decision-making in a market with many options. Banerjee *et al.* (2023) investigated sustainable food choices of consumers in the UK. The study used the term "nudge+", a combination of "nudge" and "think". The "nudge" was a default option that presented consumers with a menu of environmentally sustainable food options, and "think" was a prompt for participants to think about sustainable eating as a long-term dietary choice.

Following the literature review, it can be concluded that the contributions provide a comprehensive overview of the use of NIs in the context of AE, spanning the last two decades. In particular, the authors have conducted a bibliometric analysis to show the evolution of nudge research from 2003 to 2023, with a growing trend in publications using nudge theory.

The focus of the study is on NI applications for farmers and consumers. The analysis highlights a development in research that began in 2013 with a publication examining the impact of NI on farmers' voluntary adoption of water management techniques. For farmers, NI is primarily about the timely provision of information, particularly about market changes and prices. Social norms and social comparisons are also used to influence decisions related to organic farming, the adoption of digital technologies and environmentally friendly practices. The paper identifies several NIs, including empathy, financial nudging, social norms, comparisons, cash rewards, and minimum payments, that are commonly used in agri-environmental programs. The effectiveness of these interventions was examined in the context of issues such as agricultural insurance, pesticide use, conversion to organic farming, sustainability certification and investment decisions.

Consumer-oriented NI applications were also discussed. Publications looked at the factors influencing consumer choices for healthier food and covered aspects such as general food information, locally grown produce, food safety, genetically modified products, plant-based options and recycled water irrigated products. Labeling strategies, including health and organic labels, as well as highlighting sugar content and nutritional recommendations were explored as influential factors in consumer choice. In addition, changes to restaurant menus, particularly the introduction of vegetarian dishes, were cited as an impetus for investigating the increasing consumption of such dishes.

The timeline of NI publications showed that the application of nudge theory is steadily increasing in both farm and consumer contexts. The paper provides a detailed overview of the dynamics of nudge research and its application in addressing AE challenges for farmers and influencing consumer decisions related to food and sustainability.

4. Concluding remarks

The paper aims to fill a gap in the literature by providing a comprehensive overview of two decades of empirical research on nudging in the context of AE. The authors have conducted a bibliometric analysis and summarized relevant publications in WOS, making it a valuable resource for researchers, policy makers and anyone interested in behavioral interventions in the agricultural sector. The main implication of the paper is the identification and categorization of specific NIs. By detailing these strategies, the paper provides practical insights into the ways in which these nudges can influence farmer and consumer behavior, particularly in areas such as organic farming and organic product labeling. The study not only provides a summary of these nudges, but also highlights key trends in AE, including sustainable agriculture, organic farming, reduced pesticide use and agri-environmental schemes. The study is of great practical importance as it provides policy makers and businesses with guidance on how to implement effective nudges to encourage desirable behaviors, such as reducing pesticide use, converting to organic farming or labeling products as organic. In addition, lessons learned can inform academic courses on AE, helping train future professionals in the practical application of BE and nudges. Although the study acknowledges limitations, such as the unavailability of some full papers, the authors believe that the paper provides a broad overview of possible NIs and is not limited to a small number of publications. It is pointed out that in some studies "green nudges" appear that promote environmentally friendly choices for farmers and consumers. Future research opportunities are identified, particularly in exploring green nudges in different countries to influence behaviors related to climate adaptation, mitigation, environmental concerns, organic farming, and reduced pesticide use. The paper suggests that further research is needed to define new NIs for the transition from conventional to organic farming, the adoption of sustainability practices and the transition to a circular economy. It also highlights the importance of exploring innovative incentive measures to encourage farmers to use agricultural insurance and new risk management tools. The study identifies research gaps in the incentives for farmers to adopt digital technologies and in the uptake of plant-based and vegetarian options by consumers and highlights the need for future research in these areas.

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Supplementary material

The supplementary material for this article can be found online.

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