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GOING SHORT AND DIGITAL: CONSUMER PERSPECTIVES ON THE DIGITALIZATION OF SHORT FOOD SUPPLY CHAINS

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Abstract: Agricultural digitalization and short food supply chains (SFSCs) are considered to be different avenues for transitioning to more sustainable agrifood systems. Can these avenues be put together, or are they parallel and, hence, not compatible? The answer to that question largely depends on the potential effects of digitalization on SFSCs. Going digital is a transformative process, accompanied by desirable and undesirable economic, social, environmental, and cultural impacts on short supply schemes. In this cross-sectional quantitative study, based on data from 211 individuals who frequently buy from SFSCs, we examined how consumers evaluate these impacts. We also investigated how participants' perceptions of these impacts influence their acceptance of agricul- tural digitalization and their willingness to buy food products from digitalized SFSCs. Our results revealed that consumers view digitalization as a source of positive environmental but adverse social, cultural, and economic impacts on short supply schemes. In addition, we found that acceptance of digitalization and willingness to buy from digitalized SFSCs received moderate-to-low scores. Two regressions showed that buyers' perceptions of the social impacts that follow digitalization shape both acceptance and willingness. These findings uncovered consumers' skepticism toward digitalization, suggesting that their commitment to short supply chains and the values that these schemes represent cultivate the belief that digitalization can negatively transform SFSCs, leading to an unwelcome industrialization.

1. Introduction

The emergence and rapid growth of advanced, digital (or smart) technologies and the first enthusiastic arguments on their potential to revolutionize agrifood production and supply [1–3] spurred high interest in how digitalization can transform agriculture. Combining cross-cutting and geolocation tools, and taking advantage of real-time data collection and processing applications [4,5], digital technologies are viewed as tools that can facilitate the transition to a

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more sustainable future by producing beneficial economic, social, and environmental impacts, while also reshaping farm and market culture in posi- tive ways. However, scholars express some concerns about the potential externalities of digitalization, putting in doubt the economic viability of digitalized farms and exposing several socio-ethical, environmental, and cultural risks associated with the digital transition of agriculture [6–11].

Notably, the scholarly and policy discussion on the pros and cons or the actual and expected impacts of digitalization emphasizes the capacity of digital technologies to change current agriculture without fully elaborating on whether and how digital technologies will transform sub-systems that operate in tandem with prevalent (conventional) farm production and supply paradigms [12–14]. Although they have several complementarities [15], alternative food production/distribution models and digitalized agriculture are often viewed as opposite poles of an agricultural production continuum. In this vein, as Klerkx et al. [16] suggest, there is a need for more research to uncover how alternative niches, more sustainable than the dominant paradigm, can be supported and affected by digitalization.

In the present work, we took a step in this direction, devoting our attention to short food supply chains (SFSCs), which represent alternatives to the mainstream food production and distribution models (operational definitions of SFSCs and digitalization are provided in Table 1 and discussed in the following sections). Selling through short supply conduits is a practice that is gaining momentum, especially in the European Union, where, according to the European Parliamentary Research Service [17], about 15% of farmers choose direct- to-consumer channels to distribute their products. Scholars argue that digitalization can improve food production and marketing in SFSCs [18,19]. However, little research has investigated how producers and buyers view the digitalization of SFSCs and its impacts on these chains. In this study, we aimed to examine how consumers assess the impacts of digitalization on these chains, and to understand whether these perceptions affect consumers' acceptance of agricultural digitalization and their willingness to buy food products from digitalized SFSCs.

1. Short Food Supply Chains: Definition, Properties, and Challenges

Gaining momentum during the first decade of the 2000s, SFSCs initially became a topic of interest for social scientists. This first wave of study gave prominence to the alternativeness of short supply schemes compared to the more "industrialized" mainstream food distribution channels. For Marsden et al. [20], SFSCs are schemes that shorten long supply networks, ensure a better

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connection between farmers and consumers, and allow the exchange of information on food origin and quality. Renting et al. [21] also focused on the relational component of SFSCs, emphasizing that, contrary to their "longer" equivalents, short supply conduits link food producers, processors (if any and if different than the producer of the primary products), and consumers.

As research on SFSCs continued to evolve, new elements entered the concept. Among them, proximity is the most pivotal feature of any SFSC. Geographical proximity, which refers to the physical distance between the places of production and consumption, is reduced compared to conventional supply chain schemes. Some efforts have been made to specify the maximum distance between the farm and the point of consumption, but scholars have not yet reached a consensus [22]. Distance is, by default, a relational measure, and it is practically challenging to assess what is "long" or "short," or what "local" means in food production. For example, in the USA, a product is considered local when it travels less than 275 miles from its place of production to the point of consumption [23]. However, for some countries, such a distance is considered long. For example, 275 miles is longer thanthe distance from the westernmost to the easternmost cities of Belgium. Hence, it can be argued that, in SFSCs, the distance is kept to a minimum, as determined by understanding a "region" with no strictly defined borders but definable characteristics.

Apart from geographical features, organizational and social proximity are critical ele- ments of SFSCs. The first type refers to the arrangement between farmers and consumers. Short supply schemes lack intermediaries or involve only a limited number of middle nodes. Interestingly, researchers hold different perceptions of the number of intermediaries that can be engaged in an SFSC. A commonly cited definition describes SFSCs as schemes in which no or only an extra node can intervene between producers and consumers [24]. Galli and Brunori [25] are more elastic in their conceptualization of SFSCs, stating that the number of extra nodes "equals zero or very few (often one, but no more than two)". Others also agree that, to be counted as short, a supply chain should involve a minimal number of middle actors [26,27], without specifying how many nodes can be included in a "short" chain.

Notably, beyond the number of actors involved in SFSCs, it is essential to focus on their characteristics and properties. Since SFSCs are alternatives to conventional food distribution channels, intermediate actors should carry characteristics of this alternativeness and safeguard the locality of the products marketed through these channels. This attribute means that, ideally, they

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should belong to the same area as the farmers and consumers, thus returning a part of the social value produced through the operation of SFSCs to the community by, for instance, offering employment opportunities to other community members and contributing to the sustainability of local food.

In other words, the actors engaged in short supply schemes should promote local cooperation and the economic development of the areas in which they operate [28]. This characteristic refers to the social proximity between the economic actors participating in SFSCs and is often underrepresented in the literature, where the emphasis is put on the socially proximate relations between farmers and consumers and the consequent development of trust, reciprocity [29], and social capital [30].

In summing up the dimensions of SFSCs mentioned above, we can argue that SFSCs are food distribution and marketing schemes that operate within the framework of a specific area or community, facilitate the development of trust and social capital between their nodes, and allow the exchange of food-related information between farmers and consumers. These market arrangements can be direct (i.e., based on the direct selling of local food products from farmers to consumers) or intermediated (when regional actors intervene to facilitate the distribution or processing of products, contributing extra value to the community with their activity).

Such chains produce economic, social, and environmental value, thus contributing to the sustainability of food systems [31] and promoting rural development [32]. Nevertheless, SFSCs face several challenges due to the particular conditions under which they operate. As small-scale farmers, producers selling their products in SFSCs often lack technological capacity [33] and economic resources [34]. In addition, the shortage of workforce [35] and the demanding nature of multicultivation further reduce the operational efficiency of farms and increase the workload for farmers [36].

At the market level, farmers face intra-SFSC (with producers who use similar dis- tribution practices) and inter-supply chain competition (with market actors operating in conventional supply chains). Although the relevant literature often emphasizes the in- teractions between farmers and their customers, SFSCs still encompass a commodified component [37], which is decisive for succeeding in the market. Hence, issues like the continuous availability and variety of products or their quality determine the market per- formance of a farm. However, lacking essential resources, farmers are often not capable of ensuring the quantity and quality of their

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production. On the other hand, the high level of perishability associated with the products usually sold in SFSCs (vegetables, fruits, dairy products) [38] makes programming the production and distribution processes a difficult yet critical endeavor.

2. Digitalization of Agriculture: A Brief Overview

3.1. Agricultural Digitalization Defined

Digitalization is a widely used term that carries different meanings. Relevant defini- tions emphasize varying attributes of digitalization, from the process of the production [39] and use [40] of digital solutions to the transformative capacity of digital technologies [41] and their ability to restructure social life [42], consequently leading to new economic and social realities [43].

Agricultural digitalization can also be seen through the angle of the development, adoption, and exploitation of technology [44,45], or under the lens of its disruptive and transformative nature [46,47]. Combining these views, we can define it as the process of developing digital agricultural technologies that do not belong to the evolutionary line of farm machinery and integrating them into farming activity to produce new forms of value. This procedure initiates transformative changes in the social fabric of agrifood systems and is accompanied by several risks.

This operational definition summarizes the key points previously presented in the literature. Agricultural digitalization is about developing, adopting, and using technolo- gies with different attributes from analog equivalents, since they collect, process, store, analyze, and transmit digital data. Although legacy technologies (technologies in use that were created under a different design spirit [48] and, in some instances, were considered revolutionary when they emerged) continue to "do the work" for farmers, new tools like sensors, farmbots, unmanned aerial vehicles, and various advancements like the Internet of Things, cloud computing, and artificial intelligence promise to solve problems and address needs that remain pressing.

3.2. What Do We Know About the Impacts of Agricultural Digitalization?

As noted in the previous section, digitalization entails a transformative and disrup- tive nature. As digital technologies supersede their legacy antecedents, they generate new ways of working and managing a farm. Current digital applications like sensing technologies and digital fences allow for the remote execution of farm operations [49,50], while artificial intelligence-supported farm robotic systems can undertake the picking [51], weed control, and spraying of crops [52]. Data provided by smart technologies increase farmers' management capacity [9] and reduce improvisation and experience-based choice in favor of more rational and well-informed decision-

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making [53]. Hence, at the farm level, these technologies can reduce the time needed to perform farm tasks [54] and, therefore, the workload for farmers and farm workers [55], while offering opportunities for more intelligent and insight-based farm management [56].

However, technology-spurred transformations are not always positive [57]. Looking at the social layer of digitalization, the introduction of digital technologies in farming enhances farm productivity [58–60] and improves products' quality [61], with obvious subsequent positive outcomes in the fight against food insecurity and the efforts to supply consumers with highly nutritious food. Nevertheless, some technologies put low-skilled farm workers at risk of exclusion [62], while disconnecting producers from their farm culture [7] and negatively affecting their wellbeing. For instance, a study in Norway indicated that adopters of digital technologies (automated milking systems) express high stress levels [63]. Barrett and Rose [64] also observed that, in Eastern England, farmers associate the adoption of digital technologies with high levels of stress due to information overload and the need to remain continuously connected to technology and the farm. Beyond psychological issues, digitalization can also indirectly affect physical health. For instance, the procedures and materials used in the technology development phase might increase human toxicity, negatively impacting human health [65].

In addition, digitalization can have several positive and negative environmental, economic, and cultural impacts. Concerning environmental impacts, digitalization can help increase resource efficiency [54] and reduce the use of fertilizers and irrigation water [66]. However, negative externalities related to the production of digital technologies have also been uncovered [67], while the shift to a more technology-driven mode of production may lead to the dominance of mono-cultivation, with adverse outcomes for biodiversity [7].

Economic impacts refer to the increase in yields and the simultaneous reduction in production costs [68], which can lead to a growth in income for farmers in the long term [69]. However, the high cost of technologies [70] and possible associated expenses (e.g., for replacing or renovating farm facilities to develop proper infrastructure for digitalizing a farm) can be a heavy burden, especially for small-scale farmers. Notably, a potential cost pass-through practice—frequently used in the markets—will have negative economic effects on food prices and, thus, might reduce poor consumers' access to some food products.

Finally, digitalization can transform farm culture in contrasting ways. By shaping new (digital)

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agricultural innovation systems [71], digitalization connects farmers with new market players, technology developers and providers, and innovation brokers who take various roles (see [72] for a detailed stakeholder analysis). These actors convey new ethics, patterns of interaction, and ways of thinking, thus gradually changing the prevailing cultural norms in the agrifood system [46,73]. Interacting with these new entrants in the agrifood nexus, farmers might develop a new entrepreneurial culture and willingness to follow a more entrepreneurial path [74], while digital technologies are tools that support entrepreneurial decisions [75] and open up new entrepreneurial directions [76]. On the other hand, there are concerns associated with adopters' over-reliance on technology [11,77] and the potential technofication of agriculture [78], which could alienate farmers from a culture that has been developed over generations and reduce their sense of responsibility to their land and customers [7].

3. How Do Consumers View Digitalization of Agriculture?

Interestingly, consumers are the least represented group in the literature on the impacts of agricultural digitalization. Hence, little is known about their thoughts on the digitaliza- tion of farms and the food produced by exploiting digital technologies. Some sentiment analyses indicate a rise in the public discussion about digital agricultural technologies [79] and a possibly growing positive stance of social media users toward the digitalization of farm production [80]. However, studies using consumer samples are still scarce.

Among the few exceptions, Spykman et al. [81] found that consumers are generally optimistic about the effects of specific digital technologies (spot spraying) on the environ- ment. Nevertheless, about one-fourth of the participants in their study agreed that digital technologies can alienate farmers from their farms and farm animals. Others [82] concluded that German citizens have a relatively positive attitude towards the impacts of digital agri- cultural technologies on farmers' wellbeing and the environment, while also revealing that the surveyed persons had a moderate belief that digital technologies disconnect farmers from their animals and land. In another German study, Wilmes et al. [83] discovered that consumers' willingness to buy from digitalized farms decreases as digitalization intensifies. In a focus group study [84], Dutch, Finnish, and French consumers expressed mixed perceptions of the aftermath of digitalizing animal farms. Although digital technologies are viewed as tools that enable transparency across supply chains, increase food safety, enhance productivity, and improve farmers' wellbeing, concerns over potential risks related to the "robotization" of farming and the technological waste

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that the overuse of technology generates were also mentioned by the participants. Stampa et al. [85] reached similar conclusions, confirming the existence of mixed consumer perceptions of digitally enabled farm production methods and the products emerging through digital farming.

However, the research conducted to date has focused only to a limited extent on alternative agrifood production and distribution schemes. Wilmes and colleagues [83], ex- amining consumers' attitudes toward digitalized organic farms, found that they were more positive than for larger, conventional farms. Concerning local food consumers, however, Broad et al. [86] concluded that buyers view the food produced through the use of highly advanced technologies as less natural than that produced with the exploitation of more conventional farm machinery. One of our previous studies [33] explains this perception through the lens of symbolic compatibility, indicating that consumers consider digitaliza- tion to be a threat to the distinct and alternative nature of SFSCs. In the present study, we expand on this literature by shedding light on consumers' perceptions of digitalization's impacts on these chains.

4. The Present Study

In this study, we aimed to assess consumers' perceptions of the impacts that digital- ization (e.g., the introduction of technologies like spraying and seeding drones, robotics, or sensor networks) will have on SFSCs, while also examining whether and how these perceptions affect (i) the level to which consumers endorse the digitalization of SFSCs and

(ii) their willingness to buy through digitalized SFSCs. We adapted instruments developed in a previous work to evaluate perceptions of economic, social, environmental, and cultural impacts [33]. Then, we compared the scores obtained for the four categories of impacts to arrive at conclusions regarding their importance for consumers.

Furthermore, to understand how these perceptions affect consumers' acceptance of the digitalization of SFSCs and their willingness to buy from digitalized SFSCs, we built two hierarchical regression models using the constructs mentioned above as response variables. At step 1 of the models, we entered the perceived importance of SFSCs and consumers' general perceptions of digitalization. Perceived importance is a widely used concept in consumer behavior research. Similar to involvement, it refers to the perceived relevance of a product or service for a person, as well as the importance that a consumer ascribes to it [87]. In our case, it describes the importance and personal significance attributed to SFSCs by their customers. The rationale behind using perceived importance as a control variable lies in its potential effects on

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the response variables. Attributing high relevance to SFSCs might reduce the willingness to engage in a different (digitalized) form of these chains. The second variable—general perception of digitalization—reflects individuals' beliefs about risks and trust towards introducing digital technologies in agriculture, which, as research confirms [81,88], might affect their behavior as consumers. Hence, this perception possibly affects both the degree to which consumers endorse the digitalization of SFSCs and their willingness to buy from digitalized SFSCs. In the second step of our regressions, we added the four variables referring to the impacts of digitalization on SFSCs.

5. Methods

6.1. Participants and Procedure

In this study, we followed a cross-sectional quantitative research design. Our data came from 211 Greek consumers (56.9% women; mean age = 41.55, S.D. = 15.18; 56.4% university educated). To recruit potential study participants, we visited farmers' markets and on-farm stores in the Thessaloniki (Greece) region. Data were collected through face- to-face questionnaire completion. In Appendix A, we present the part of the questionnaire that contains the instruments used in our analysis.

Consumers had to answer two introductory questions to be included in the sample. The first one concerned the frequency of purchases from SFSCs. The second question asked whether participants knew what digital technologies are. To ensure that the participants were aware of these technologies, we added an open-ended question in the introductory part of the questionnaire, requesting subjects to mention the digital agricultural technologies that they know. Only persons who buy food products through short supply channels more than once a month, answered positively to the second question, and could offer correct examples of digital technologies were counted as study participants. In their open answer, all participants referred to "hard" digital technologies, like unmanned aerial vehicles for spraying and monitoring crops, or sensor networks.

6.2. Measures

To measure the constructs of interest, we used a series of scales. We developed four instruments to evaluate participants' perceptions of the economic (example item: "digitalization will help farmers increase their income"), social (example item: "digitalization will increase the quantities of produced food products, thus assisting in fighting food insecurity"), environmental, (example

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item: “digitalization will lead to energy waste for the production and operation of digital technologies”—reverse worded), and cultural impacts of digitalization on SFSCs (example item: “digitalization will disconnect farming from its fundamental principles and values”—reverse worded). Each scale consisted of four items answered on a five-point Likert scale. After recoding negatively worded items, we confirmed the unidimensionality of all scales through principal axis factor analyses (eigenvalues ranged from 2.30 to 2.92). Cronbach’s alphas received values that exceeded 0.79. A new variable was calculated for each scale by averaging relevant items.

We also assessed two parameters that can shape consumers’ willingness to buy through digitalized SFSCs: The first was their general perception of agricultural digitalization, which refers to consumers’ trust in digital technologies, their concerns about the future effects of technologies, and their belief that these technologies will revolutionize agriculture and improve farmers’ wellbeing. Items were assessed using a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). An example item was “I fully trust digital agricultural technologies”. The second construct describes the perceived importance of SFSCs for consumers, which reflects the importance that they attribute to short supply schemes. The instrument that we developed included five items measured on a seven- point scale. An example item was: “SFSCs are consistent with my personal values”, with response options anchored by “definitely not” (1) to “definitely yes” (7). The factor analysis procedures revealed that the two scales load on single factors (eigenvalues: 3.51 and 3.91, Cronbach’s alphas: 0.89 and 0.95, respectively). We computed a score for each scale as the mean of its items.

To measure participants’ willingness to buy food products from digitalized SFSCs, we administered a five-point scale from 1 (not at all) to 5 (very much). The question posed to the respondents was “To what extent are you willing to buy food products from short food supply chains in which farmers use digital technologies?” Finally, to evaluate the degree to which consumers agree with the digitalization of the farms from which they buy food products, we used a single item answered on the same five-point scale.

6.3. Data Analysis Techniques

To analyze data, we used descriptive and inferential statistics (paired-samples t- tests, Pearson’s correlations, and Mann–Whitney U tests). We also built two hierarchical regression models (as detailed in Section 5) to test whether consumers’ beliefs about the impacts of digitalization on SFSCs influence their willingness to buy food products through digitalized short

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supply schemes and their acceptance of the digitalization of SFSCs. To calculate the statistical power of our regression, we used Soper's formula [89]. For an effect size of 0.15 and a probability level of 0.05, the power was 0.997.

6. Results

7.1. Primary Analysis

The descriptive statistics of the study variables (Table 2) indicate that consumers are only slightly willing to buy food products from short supply schemes in which producers use digital technologies. Moreover, they express a moderate acceptance of the digitalization of SFSCs. The analysis confirmed that, as expected, acceptance of the digitalization of SFSCs positively correlates with willingness to buy from digitalized short supply schemes.

Table 2. Descriptive statistics and intercorrelations (Pearson's r) for the study variables.

Variable (S.D.)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Economic impacts of digitalization (1)	-							
Social impacts of digitalization (2)	0.62 **	-						
Environmental impacts of digitalization (3)	0.55 **	0.60 **	-					
Cultural impacts of digitalization (4)	0.62 **	0.58 **	0.64 **	-				
General perception of agricultural digitalization (5)	0.60 **	0.67 **	0.62 **	0.59 **	-			
Perceived importance of SFSCs (6)	0.04	0.01	−0.06	0.11	0.01	-		
Acceptance of the digitalization of SFSCs (7)	0.53 **	0.61 **	0.59 **	0.61 **	0.61 **	0.17 *	-	
Willingness to buy from digitalized SFSCs (8)	0.47 **	0.52 **	0.43 **	0.57 **	0.57 **	−0.10	0.66 **	-

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* $p < 0.1$, ** $p < 0.01$.

The correlations among the four constructs used to assess the participants' percep- tions of the impacts associated with digitalization were, in all cases, high and positive. Nevertheless, it is worth mentioning that the mean score for the environmental impacts of digitalization was the only one that reached a value greater than 3.00, indicating the participants' belief that introducing digital technologies in SFSCs will lead to environmental benefits. Conversely, the mean scores for the remaining three categories of impacts were lower than 3.00.

Paired-samples t-tests revealed that the mean score for the environmental impacts was significantly higher than those for the economic ($t = 15.15$, $p < 0.001$), social ($t = 9.92$, $p < 0.001$), and cultural impacts ($t = 16.44$, $p < 0.001$). In addition, social impacts had a significantly higher mean score than cultural ($t = 4.93$, $p < 0.001$) and economic ($t = 5.83$, $p < 0.001$) effects of digitalization. The difference between the two latter variables was insignificant ($t = 0.853$, $p = 0.394$).

Gender did not affect the variables referring to impacts, as uncovered through the independent-samples t-tests. The absolute values of the mean differences between women and men consumers ranged from 0.04 to 0.18 ($t < 1.76$ in all cases). Age was associated only with the perceptions of social impacts, with a negative r coefficient ($r = -0.16$, $p = 0.018$), revealing that older consumers have a more cautious view of the potential social exter- nalities of digitalization. The level of education was not correlated with any of the four categories of impacts (r values ranged from 0.02 for social impacts to 0.12 for cultural impacts, corresponding to p values higher than 0.05).

Notably, willingness to buy from digitalized SFSCs was correlated with all four vari- ables referring to categories of impacts and the perception of digitalization. Nevertheless, we did not observe significant associations between willingness and participants' age ($r = -0.09$, $p = 0.184$) or gender ($U = 5130.5$, $p = 0.439$). Acceptance of the digitalization of SFSCs exhibited significant correlations with all four categories of impacts, while it was unaffected by gender ($U = 525.5$, $p = 0.335$). Nevertheless, it was significantly and negatively correlated with age ($r = 0.22$, $p = 0.001$), showing that the level of acceptance decreases in older consumers. Consumers' educational level did not correlate with their willingness to buy from digitalized SFSCs ($r = -0.07$, $p = 0.287$) or their acceptance of digitalized SFSCs ($r = -0.02$, $p = 0.742$).

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7.2. Regression Analyses

Our regression analysis for willingness to buy from digitalized SFSCs showed that, among the variables belonging to the first block, only perception of digitalization was significant for the initial and the final model. In the final model (Table 3), the standardized beta coefficient for the variable yielded a value of 0.35 ($p < 0.001$). Regarding the examined impacts, we discovered that only those referring to the social externalities influence con- sumers' willingness to buy food products through digitalized SFSCs ($\beta = 0.20$, $p = 0.016$). The positive sign of the β coefficient reveals that willingness to buy increases when social impacts are considered to be positive.

Table 3. Hierarchical regression analysis for willingness to buy: standardized coefficients of the final model.

	ΔR^2	ΔF	β
Step 1	0.34	52.20	
Perceived importance of SFSCs			0.10
General perception of agricultural digitalization			0.35
Step 2	0.04	3.66	
Economic impacts of digitalization			0.11
Social impacts of digitalization			0.20 *
Environmental impacts of digitalization			0.04
Cultural impacts of digitalization			−0.01

* $0.01 < p \leq 0.05$, ** $p \leq 0.01$.

When we used acceptance of the digitalization of SFSCs as the dependent variable (Table 4), the perceived importance of SFSCs and the general perception of digitalization were significant at the first step, retaining their significance in the final model. Interestingly, the beta value for the importance of SFSCs received a negative beta coefficient, suggesting a negative relation ($\beta = -0.15$, $p = 0.003$). Perceptions of the social ($\beta = 0.26$, $p = 0.001$) and environmental impacts of digitalization ($\beta = 0.20$, $p = 0.006$) contributed significant variance to the model, suggesting that consumers who view digitalization as a way of promoting positive social changes and reducing the environmental footprint of SFSCs endorse the introduction of digital technologies to short supply schemes to a greater extent.

Table 4. Hierarchical regression analysis for acceptance of digitalization: standardized coefficients of the final model.

	ΔR^2	ΔF	β
Step 1	0.39	65.58 **	
Perceived significance of SFSCs			−0.15 **

General perception of agricultural digitalization

0.26 ** Step 2

0.10 10.08 **

Economic impacts of digitalization 0.12

Social impacts of digitalization 0

.26 **

Environmental impacts of digitalization 0

.20 ** Cultural impacts of digitalization –

0.04

** $p \leq 0.01$.

7. Discussion and Conclusions

The relevant literature suggests that both SFSCs and digitalization are paths that can lead to more sustainable agrifood systems [90–93]. SFSCs can directly or indirectly con- tribute to attaining Sustainable Development Goals by generating societal, environmental, and economic benefits [94], as does digitalization by supporting the achievement of goals like ending poverty and hunger, combating climate change, or ensuring the health and wellbeing of farmers, workers, and consumers [95]. However, an unanswered question is whether these two sustainability promises can meet each other. In this work, we aimed to provide some preliminary insights into the topic by examining how consumers evaluate the impacts of digitalization on SFSCs and how their perceptions of these impacts affect acceptance of digitalized SFSCs and their willingness to buy through such distribution channels. In so doing, our study makes two contributions to the agricultural digitalization literature and SFSCs research. First, contrary to most research conducted so far, it examines the impacts of digitalization on a niche operating in parallel with the dominant production and marketing paradigms. Second, although most scholarly efforts in this area analyze the perceptions of farmers or experts, in the present work we shifted our attention to consumers, thus offering some more evidence on a recently developed sub-field of study [33,81–84].

Following a vivid stream of research inquiring into the effects of digitalization on agriculture [7,9,11,14], we divided impacts into four categories: economic, social, environ- mental, and cultural. Our analysis revealed that the environmental impacts of digitalization were assessed as

slightly positive, while the mean scores for the remaining categories received a relatively negative evaluation. In addition, the results showed a moderate consumer agreement with the digitalization of SFSCs. These findings suggest that SFSCs' consumers are somewhat skeptical toward the potential impacts of digitalization on short supply schemes, despite the rhetoric of public policy actors and popular media surrounding the (positive) transformative potential of digital technologies [64,96].

Although our work did not examine the antecedents of this attitude, the differences between our findings and those of studies dealing with dominant food production meth- ods [81,82,84] can be ascribed to the ways in which consumers view SFSCs, the farming model these chains represent, and the popular imagery associated with the production pro- cess behind them. Food shoppers might create an idealized view of SFSCs, thus attributing to them properties that deviate from conventional mainstream food distribution channels. Indeed, research indicates that consumers believe that the products marketed through SFSCs are healthier, fresher, and have a higher quality and lower levels of chemical residues than those distributed through mainstream channels [27,97,98]. Although our aim here was not to confirm the validity of these perceptions, this (possibly romanticized) conception of SFSCs makes most technologies seem incompatible with the critical traits of short food supply schemes [33]. As Bazzani and Canavari [99] argue, SFSCs represent a shift from the "industrialized" to a "domestic" production and marketing scheme. In this sense, digitalizing might equal industrializing short supply chains, an unwelcome evolution for most consumers, as reflected in their limited willingness to buy from digitalized SFSCs.

Another interesting finding was that consumers' perceptions of the possible social impacts of digitalization influence both their acceptance of digitalized SFSCs and their willingness to buy from such chains. Even though the implications of digitalizing the agrifood sector on social sustainability have received only marginal attention in the relevant public debate [100], the social dimension of digitalization had significant associations with the response variables used in our regression models. Simply put, going digital is viewed as a source of potentially negative social impacts for short supply schemes. That perception reduces consumers' acceptance of digitalized SFSCs and their willingness to purchase food products from farmers who use digital technologies. To understand the roots of this relation, one needs to rethink the potent social dimension of SFSCs. Such supply chains are based on a different social structure than their longer, more commercialized equivalents, with strong and trust-laden social ties between

producers and consumers [29,101], who are driven to participate in these schemes by motives such as altruism and willingness to support each other [102–104]. Consumers view digitalization as an evolution that threatens the social structure (and sustainability) of these chains, therefore altering SFSCs' essential and desirable social characteristics.

On the other hand, consumers' assessment of the potential environmental impacts of digitalization was found to be associated with the degree to which they accept the digitalization of short supply schemes. However, our analysis demonstrated that this is unrelated to their willingness to buy from digitalized SFSCs. This intriguing finding suggests that the difference between accepting digitalization and buying food produced through the exploitation of digital technologies can be vast. Acceptance, a broadly used construct in scholarly work, refers to the endorsement of using digital technologies in farming. The emphasis in scientific [105], policy [13], and public discourses [64,106] on the environmental benefits of agricultural digitalization is possibly what leads consumers to agree with the use of digital artifacts in farming activity.

Nevertheless, when it comes to decisions with more obvious cost/benefit implications (i.e., buying food produced through the use of digital technologies), consumers might attribute limited importance to the environmental impacts of digitalization. The links between acceptance of digitalization and willingness to buy from digitalized farms await further research. Parameters like consumers' ethical or safety concerns, environmental motives, or the symbolic qualities that they attribute to digital technologies potentially intervene in the relationship between acceptance of digitalization and intentions to buy food produced in digitalized farms. Untangling this issue represents a challenge that we leave open for future researchers.

Finally, an observation worthy of comment refers to the significance of the perception of digitalization and the importance that consumers ascribe to short supply schemes for shaping acceptance of digitalized SFSCs. Regarding the former, it seems that the low level of trust in digital technologies and concerns over their possible negative impacts are deci- sive in shaping consumers' stance toward digitalized SFSCs. Beyond personal subjective judgments about the value of digital technologies, the neutral-to-negative perception found in our sample could be due to the poor level of digitalization in Greece [107] and the problematic or even non responsible practices performed by some actors who participate in the digital agriculture ecosystem in the country [47]. However, more work is needed to trace the origins of Greek consumers' negative perceptions of digitalization. With regard to the perceived importance of SFSCs, its significant

and negative association with the acceptance of SFSCs' digitalization reveals a solid personal commitment of customers to these food production and distribution channels, which is translated into an unwillingness to approve a different, more technology-driven form of SFSC.

A couple of potential limitations for this study deserve mention. First, this work offers insights into consumers' views of SFSCs operating in only one Greek region. Across coun- tries, SFSCs are characterized by different levels of maturity [108] and relations between participating actors [109], while consumers' views of these chains also vary [26]. In addition, the pace and width of digitalization are dissimilar between countries or regions, possibly affecting public perceptions of digital technologies. Hence, more research is needed to assess the generalizability of our results in different social and cultural contexts. Moreover, upcoming work could examine how different groups of consumers (e.g., rural versus urban residents, or people with special dietary habits) perceive digitalization with larger samples and/or exploiting different analytical methods (e.g., cluster analyses, quantile regressions). Second, beyond perceptions of the impacts that digitalization may have on SFSCs, there are several factors—external (like the degree to which social and policy actors promote or oppose digital technologies) or internal (such as consumers' ethical concerns or their beliefs about the personal benefits and risks associated with the consumption of food produced with the use of digital technologies at the farm level)—that may affect consumers' acceptance of and willingness to buy from digitalized SFSCs. Future research might examine which—if any—of these factors contribute to forming positive or negative consumer attitudes toward digitalized SFSCs.

Furthermore, we should note that digitalization may take different shapes, ranging from its softest (e.g., exploiting tools like digital platforms and simple monitoring tools) to its hardest forms (exploiting, for instance, hi-tech digital artifacts, farmbots, artificial intelligence-supported decision-making tools, etc.). Investigating how consumers perceive these soft and hard manifestations of digitalization can provide fruitful insights in the field. Finally, although our research focuses on short food supply systems, one can hardly claim that SFSCs' customers are different from those purchasing food products through other mainstream or "alternative" food distribution conduits, since consumers use several parallel channels to buy their food. How do consumers view the digitalization of conventional agrifood production and supply schemes? Are there any differences in how consumers consider the digitalization of conventional and alternative food networks? Do they endorse using digital technologies in other niches operating within agrifood systems, such as agroecology or nature farming? This study leaves these questions

unanswered. Therefore, we invite future researchers to build upon our work and design studies to provide a more detailed picture of consumers' attitudes toward digitalizing the various co-existing agricultural models.

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