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Do Agricultural Knowledge and Innovation Systems Have the Dynamic Capabilities to Guide the Digital Transition of Short Food Supply Chains?

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Abstract: The digitalization of agriculture generates a new environment for the actors involved in agrifood production. In such a context, Agricultural Knowledge and Innovation Systems (AKISs) face the challenge of reconsidering their operational paradigms, redefining priorities, and designing strategies to achieve new aims. To do so, the actors participating in AKISs should develop and exploit a set of competencies known as dynamic capabilities, including the aptitude to sense the change in the external environment, the capacity to seize the opportunities that this change creates, and an ability to transform and adapt themselves to the new conditions that digitalization generates. In this study, using as examples the AKISs operating in Greece and Italy, we aimed to uncover if and how actors participating in these systems attempt and manage to deploy such capabilities. Based on a qualitative approach and drawing on data from two workshops, we discovered that seizing the opportunities sensed is a challenging task for AKIS actors. Our results also indicate that knowledge is a pivotal resource for AKISs, allowing actors to enhance their transformative capacity. However, to create a "collective" knowledge base, AKISs should ensure a functional connection between stakeholders and strengthen the roles of actors not actively engaged with the system, like public advisory organizations, universities, and technology providers.

Keywords: agricultural knowledge and innovation systems; agricultural digitalization; dynamic capabilities; short food supply chains; advisory organizations; smart farming; alternative food networks; digital technologies; advisory work

1. Introduction

Agricultural digitalization, i.e., the production and penetration of novel, data-rich technologies in the field of agriculture for improving farm productivity and efficiency while reducing farm labor, production costs, and the environmental footprint of farming [1], creates great hype and hope for the potential of digital technologies in revolutionizing agriculture and leading to a fairer and more sustainable food system than the one which emerged after the Green Revolution [2,3].

Nevertheless, when viewed through a market and management research lens [4], agricultural digitalization generates a high-velocity environment for several reasons. First, it initiates rapid and discontinuous changes in technology development. Artifacts belonging to the cluster of digital agriculture technologies do not emerge as improvements in traditionally used technologies but are derivatives of enabling technologies like the Internet of Things or artificial intelligence [5]. Second, the attractiveness of the digital farming market led to the entrance of many new actors in the field of agriculture [6]. The digital agriculture industry—a sector that did not exist just a few years ago—grows explosively. Estimations of the global digital agriculture market size predict an increase of more than 220% between 2023 (the time we started the present study) and 2030 [7]. Hundreds of new start-ups have been established to provide sophisticated small- or large-scale digital solutions for farmers, while tech giants not directly involved in agriculture until recently (like IBM and Microsoft) operate now in the field developing digital platforms (e.g., the Watson Decision Platform for Agriculture) or artificial intelligence-based data collection and exploitation applications (e.g., FarmBeats). Bringing a different culture of collaborating, competing, and doing business, the new entrants can heavily alter the social web of farming [8,9]. Third, followed by several risks [10–12] and responsibility gaps [13], digital technologies create different levels of uncertainty [14–16], while they generate the need for new regulatory frameworks [17,18].

Under such conditions, Agricultural Knowledge and Innovation Systems (AKISs) are called to operate in a new scene, where old practices, knowledge, and skills possessed by the actors involved in the agricultural innovation process seem obsolete and inadequate to help them navigate the digital transition [13,19]. To effectively cope with and take advantage of the opportunities offered by digitalization, AKISs cannot rely on basic-level capabilities. Instead, they need to develop and exploit new, higher-order capacities. To what extent and how do the actors participating in such systems attempt and manage to deploy such capabilities? In the present study, building upon management and organizational research and elaborating on the concept of dynamic capabilities [20–22], we attempted to provide some first insights into this topic by investigating the degree to which Greek and Italian AKISs have the dynamic capabilities to sense the opportunities that digitalization opens up, seize them, and transform themselves to exploit the full potential of digitalization.

However, instead of examining how AKISs function and operate in mainstream production sectors, which receive the lion's share of attention from advisory organizations [23], we shifted our focus to a niche of agrifood systems: short food supply chains (SFSCs). In these types of chains, farmers directly sell their products to households (e.g., through farmers' markets, food boxes, on-farm sales), local restaurants, and food retailers without the intervention of other actors [24–26]. So far, despite the realization that SFSCs generate social and environmental value [27] and can help small-scale farmers earn a sufficient income [28], there is little work on how AKISs support the farmers who distribute their products through such alternative networks. On the other hand, the agricultural digitalization literature has not yet explored how digital technologies can boost the efficiency of SFSCs.

The remainder of this article includes sections presenting our theoretical framework, delineating the methods employed, outlining our results, and offering a general discussion, including the study limitations and suggesting directions for future research.

2. Agricultural Knowledge and Innovation Systems in a Digitalized World: The Role of Dynamic Capabilities

The term AKISs describes innovation systems that operate in the agricultural sector and consist of different organizations, their links and interactions, institutional logics, and funding mechanisms [29]. AKISs are social, open, and adaptive systems that support innovation process and knowledge building in agriculture, thus helping farmers cope with the continuous transformation of agrifood systems. Public organizations, private companies (e.g., technology developers and providers, input suppliers, food processors, agrifood supply chain actors), non-governmental organizations, universities, research institutes, training centers, farmers, and other individuals that support or broker innovation and knowledge co-shape the social dimension of an AKIS [30–32]. Nevertheless, as a social system, an AKIS involves not only players but also what Hermans et al. [33] term the "rules of the game": a set of resources (like funds, human assets, knowledge, and relational resources), rules, values and norms, interactions and interactivity patterns, and capabilities. This feature of AKISs means that the actors' ability to produce knowledge and innovation is not unconditioned. Even when holding central positions in the system and possessing capacities required to reach pursued aims, actors cannot fully achieve their purposes when the game rules do not form a favorable environment.

A second characteristic of AKISs refers to their openness. AKISs, at least in most cases, are open to new actors in the sense that the entrance to or exit from the system is not restricted. In the case of agricultural digitalization, openness means that new players, like digital technology developers and sellers, can take positions in the AKIS pursuing their goals, adding to the resource base of the system, and changing its dynamics [34,35]. In such instances, new interactions, cultures of doing business, and ethics emerge as an outcome of the systems' adaptability [9].

The latter construct is a fundamental attribute of any innovation system. Given that innovation is, by nature, an evolving phenomenon, actors participating in AKISs have to follow and adapt to the changes in the surrounding environment. Hence, AKISs are continuously evolving systems [36]: the units participating in them constantly gather information from other actors that operate within or outside the system, process this information, and initiate responses, thus adapting themselves and the whole system to new conditions [37].

Nevertheless, to transform itself, an AKIS and the actors participating in it have to use a set of abilities known as dynamic capabilities. Emerging progressively during the 1990s and 2000s, the term "dynamic capabilities" refers to the capacity of an organization to intentionally create a resource base, extend it, and modify it when needed [38]. These resources can be tangible or immaterial organizational assets and human capital that allow organizations to enact new value-creation strategies [39]. However, not all organizations and systems are inclined to resource creation and expansion for a variety of reasons, like their inability to anticipate how external changes will affect their effectiveness [40], preference to maintain existing routines [41], fear of changing status [42] and losing their ability to reliably produce and offer their products or services [43], and the lack of knowledge or expertise in building a new resource base [44].

Indeed, organizational science postulates that organizations have a natural tendency toward inertia [45–47]. Hence, when little or no change characterizes the external environment, organizations prefer to keep their resource base, routines, and modi operandi stable. The processes of creating, expanding, and modifying resources are usually sparked by the realization that external conditions change radically, thus generating new opportunities and threats and leading to uncertainty. In such instances, organizations (and systems of organizations as well) can initiate either minor adaptations or major transformations to keep up with change and ensure that they will continue achieving their purposes in a potentially radically different environment [48].

The first step in this direction is understanding that change is on the go and will affect the industry within which the organization operates. Teece [20] labels this capacity "sensing" capability because it reflects the ability of an organization to see changes while (or even before) they arise, recognize discontinuity, and forecast the opportunities and risks that changes encompass. After sensing the opportunities and threats that emerge, organizations can use their "seizing" capacity, which is the ability to address opportunities and avoid threats by maintaining essential resources and generating new ones. The final capability needed to help organizations navigate high-velocity environments is transformational capacity: the capability to transform parts, bundles, or wholes of organizational structures, cultures, and processes [20].

In the case of AKIS actors and the transition to digital agriculture, sensing capacity refers to the capability to foresee the potential of digitalization, identify the opportunities that different technologies offer and evaluate their compatibility with different farming system paradigms (like agroecological production [49] or SFSCs [50]) and demands of farm work [51], understand the difficulties associated with technology adoption (referring to technical issues [52] and lack of skills [53]), estimate the risks that may follow the implementation of digital technologies at the farm level (e.g., economic risks [54], cyber security [55]) and beyond [11,56], and foresee future technology trajectories (Table 1).

Table 1. Digitalization-related dynamic capabilities of AKISs.

Capability	Dimensions
Sensing	Understanding the potential of digitalization Scanning the horizon for technologies that suit the needs of different farmers' segments Forecasting positive and negative impacts of digitalization on farms, environment, and society Foreseeing the future trajectories of technology development
Seizing	Leveraging resources to develop new offerings Creating new resources (knowledge, technical infrastructure) Drawing plans to offer high-quality advisory support to farmers Building alliances with actors occupying key positions in the digitalized innovation ecosystems
Transforming	Altering missions Revamping advisory organizations and the whole AKIS Developing digital applications Redesigning business models

Seizing involves capturing the opportunities identified through sensing and navigating the threats of digitalization. Simply put, seizing is the capacity of AKIS actors to leverage processes and resources to generate new offerings (services but also packages of products and services) for facilitating the smooth and responsible introduction of digital technologies to farms and their effective exploitation. Research reveals that high-quality and reliable advice is essential for efficiently exploiting opportunities associated with digitalization [12]. Nevertheless, conventional competencies occupied by advisors may not be enough to help farmers navigate digitalization. New capabilities, such as monitoring data [57], facilitating data-enabled decision making [19], and helping farmers integrate data-driven technologies into their farms [13], are crucial for operating in a digitalized farming environment. In this vein, investing in knowledge is essential. Another precondition for seizing the opportunities offered by digitalization is creating networks with technology providers to speed up the development of expertise and ensure the flow of knowledge to organizations representing the advisory component of AKISs [58,59].

Finally, transformational capacity is the ability of AKIS actors and the system as a whole to embody the digitalization challenge into their business models. As such, transformational capacity refers to more than just the ability of advisory organizations to develop novel offerings and build alliances with other actors. Transformation entails changing designs, missions, and ways of understanding reality and reacting to it [60]. For instance, shifting from technology transfer to technology co-development and creating new data governance schemes for an AKIS [61] or combining field and data advisors for an advisory organization [62] represent transformations that can enhance the positive potential of digital agricultural technologies.

3. Methods

Our study was conducted in two countries where AKISs are characterized by different structures and organizational features. In Greece, AKIS actors operate without central coordination since the public sector's contribution to the system is limited [63], while cooperation among them is not the norm [64]. In that framework, the ability of the AKIS to support agricultural innovation is limited [65]. The Italian AKIS is more decentralized and pluralistic, involving different categories of actors [64] and adequately supporting facets of innovation [66] but lacking robust mechanisms that support continuous value creation for farmers [67].

In each country, we organized a workshop in January 2023. The Greek workshop involved ten farmers who distributed their products through SFSCs and five farm advisors. In Italy, ten farmers and three farm advisors participated. To frame the discussion during the workshops, a discussion guide including questions referring to the performance of AKISs and the actors participating in them, their ability and readiness to guide the digitalization of SFSCs, and the dynamic capabilities of individual actors and of AKISs as a whole was employed. Four researchers served as facilitators in each workshop, motivating participants to express their points of view, putting forward extra questions on topics that emerged during the discussion, and ensuring the involvement of all participants in the process.

To analyze data, we performed two thematic analyses (one for each country) following the steps outlined by Braun and Clarke [68]. After generating initial codes, the members of each research team categorized them into candidate themes, which were then combined to create overarching themes. In the following section, we present the results for each country, splitting them into two subsections referring to the baseline dynamic capability of sensing and the more action-oriented capabilities (seizing and transformational capacity).

4. Results

4.1. The Greek AKIS

4.1.1. Sensing Capacity

The results of the workshop conducted in Greece revealed that the medium-sized and some big private advisory organizations operating in the country are highly capable of sensing opportunities related to digitalization. Having the human resources needed and expertise in technology transfer, these companies can effectively discern opportunities. Moreover, by exploiting their links with technology providers, they can assess the suitability of different digital innovations for farms and draw efficient technology implementation plans. However, traditionally, the clientele of these organizations includes large-scale farmers. Hence, the efforts made in the direction of seeking and noticing opportunities concern "big farming", as the following comment indicates:

> "*Big companies offering advisory services don't even see farmers using short food supply chains to sell their products. They are not their target group. If you ask me whether they can search for opportunities, the answer is: definitely yes. Nevertheless, the right question here is: who can afford the cost of exploiting these opportunities?*" (Antonis, Freelancer advisor).

On the other hand, for smaller private advisory companies and freelancers, finding solutions that suit small-scale farmers participating in SFSCs is a hardly accomplished task. Hence, although freelancer advisors stated that they continuously scan the market for technologies that can increase the efficiency of their clients' farms, they face considerable difficulties in finding "appropriate technologies", as one of them put it. Small private advisory consultancies are in front of a similar situation. Nonetheless, they have a considerable capacity in finding national or European funding schemes for supporting the purchase of digital technologies by farmers. Nevertheless, lacking information on the ways technologies can be exploited and knowledge about how to help producers integrate different digital solutions into their farms, they cannot effectively create opportunities for SFSC farmers.

It is worth noting that workshop participants mentioned that establishing connections between advisors and research institutes can be a potential solution to this problem. However, such institutes are not well, if at all, connected with the other AKIS actors. "*They do research which, I guess, is useful but not in line with the needs of Greek farmers. Even if I'm wrong, keeping such a distance from the field of farming, doesn't help*", commented Nikos, a private advisor.

Finally, even though farmers expect the public sector to offer advice on what technologies are suitable and deserve investment, the state agricultural organizations are not involved in the praxis of digitalization. As a public advisor who participated in the workshop admitted, the job description of an advisor working in public service does not include offering digitalization-related advice to farmers.

4.1.2. Seizing Capacity and Transformational Capability

To help SFSC farmers translate digitalization-related opportunities into benefits, advisors first attempt to build new competencies. Nevertheless, the chances to develop digitalization-related skills are limited. The connection between agricultural universities and field advisors is critical in offering competence development opportunities. "*Agricultural universities could train advisors*", commented Stella (a freelancer advisor), "*but they are completely disconnected from farm production*". To construct knowledge on digitalization, small advisory companies and freelancers rely on their experience or use their social networks (i.e., their counterparts). On the other hand, large-scale advisory companies seem able to invest in their advisors' knowledge by, for instance, organizing seminars or training sessions for their employees.

However, seizing digitalization-related opportunities for SFSCs is a hardly accomplished task. Infrastructural obstacles and particular operational characteristics of the farms that follow this distribution paradigm generate difficulties in the attempt to derive benefits from digital technologies. Moreover, cost constraints, institutionalization, fear of change, and a consequent tendency to inertia seem to shape an unfavorable environment for facilitating digital technology adoption by farmers.

As participants noted, the suitable technologies for the case of SFSCs mainly concern small-scale equipment (e.g., humidity or moisture sensors) or combinations of social and technological innovations, like platforms connecting farmers and consumers. Nevertheless, farmers claim that advisory organizations are not sufficiently prepared to exploit even these theoretically simple innovations. Dionisis (an adopter of a sensor network) summarized this perception in the following comment:

> "*I'm not sure at all that they [advisors] can really help. They try to get rid of you by giving instructions that rarely work. Then, you have to contact the company that sells those things, hoping to find a solution*."

In general, the farmers criticize the capacity of (old) AKIS actors to seize opportunities by creating alliances with AgTech companies, hiring specialized personnel, and co-designing action plans for promoting and exploiting digital technologies. However, it is questionable whether digital technology providers are willing to undertake more active roles in AKISs or prefer to keep the role of technology sellers without engaging in the process of innovation facilitation and knowledge creation.

In sum, lacking an operational backbone supporting innovation and adaptation to external changes, the Greek AKIS does not possess a sufficient transformational capacity to navigate digitalization. Public advisory services have a low transformational capacity due to the regulatory framework within which they operate. Advisors who work in the private sector lack relational and human resources, while their digitalization-related expertise is still under construction. Pivotal elements of the agricultural digitalization ecosystem, like research institutes and technology providers, are not or are less connected with the other AKIS actors.

4.2. The Italian AKIS

4.2.1. Sensing Capacity

Data from the Italian workshop indicated that AKIS actors are capable of sensing the opportunities that digitalization opens up for farmers. However, the prevalence of private advisory organizations orients advice provision towards "economically attractive" farm enterprises, like those exporting their products to international markets. Hence, it is not surprising that private organizations scan the horizon for opportunities that can be mainly exploited by large-scale farmers, paying limited attention to SFSCs.

On the other hand, the main activity of public advisory services is supervising some mandatory requirements for farmers, like the certification of exported products. Hence, although advisors stated that public and private organizations jointly attempt to identify digital solutions that suit the needs of different farmers' segments, as in the case of Greece, public service advisors are not linked with farmers. The following comment highlights that public advisory organizations are absent from the field:

> "*I did not even know about the existence of public consultants to support my activity. Is it really true that public advisors can help us?*" (Alessandro, farmer).

Lacking strong connections with farmers, public organizations are not aware of the specificities, problems, and needs of farmers who distribute their products through SFSCs. Hence, albeit conceiving digitalization as an inflection point for the future of farming, their capacity to identify solutions that can pay off is limited. This shortcoming of the Italian AKIS is compensated by the active participation of academic institutes in the agricultural digitalization process. Workshop participants noted that such institutes work with farms and cooperatives to identify together best-fit technological innovations to improve farm competitiveness.

The opportunities sensed mainly concern digital tools that aim to improve farm management and farms' agronomic performance. However, technology providers prioritize solutions that can meet the needs of the most attractive market segments without spending effort to assess the suitability of technologies with farms following alternative production models, as is the case in SFSCs. This one-size-fits-all approach does not allow the consideration of a wide range of opportunities by other AKIS actors. As Giulio (a public advisor) explained:

> "*Farmers need user-friendly digital solutions, which, at the same time, should take into account the heterogeneity of the farming sector. A possibly suitable digital solution for a certain farm may not fit well with other farms.*"

4.2.2. Seizing Capacity and Transformational Capability

In the Italian AKIS, two issues put obstacles to the passing from sensing to seizing opportunities for SFSCs farmers. First, the limited attention paid from the advisory component of AKIS to short supply chains. While AKIS actors do have the ability to detect opportunities related to digitalization, they cannot address the specificities of SFSCs, and they direct their efforts toward the digitalization of mainstream farm production systems. Private advisory organizations mobilize resources to design new services for a much wealthier market: producers who distribute their products through export-oriented supply chains. Interestingly, public organizations also shift their focus on the same cluster of farmers since the dominant perception is that farms distributing their products to international markets heavily contribute to the country's economy. Hence, designing digitalization plans for SFSCs and creating appropriate offerings (like digital facilities and training programs) is not a priority for private advisory firms and public sector organizations.

Second, the lack of expertise in digitalization creates difficulties in the attempt to transform digital tools into workable opportunities for SFSCs, and a high perceived complexity typifies the attitude of AKIS actors toward promoting digital solutions. The workshop revealed that private advisory companies operating within the Italian regional AKIS are eager to re-think their offerings and develop new services for helping farmers seize the opportunities of digitalization. However, they seem to possess only basic digital skills that cannot effectively support the digital transition of farming. As in the Greek case, the lack of competency development opportunities reduces the transformational capacity of the system.

Our data indicated that private advisors recognize their shortcomings in knowledge and skills in digitalization-related fields. However, they hold varying perceptions of the need and feasibility of developing new digitalization-related competencies. For example, Rafaella, a private advisor, stated that training is necessary to keep updated and boost the digital transition in agriculture, but "*it could be too expensive to acquire relevant skills and try to transfer them into an entrepreneurial context*". Adopting a different stance, Luigi, a private advisor working for an advisory society, declared his willingness to attend training activities designed to improve advisors' digitalization-related competencies, even by self-funding his participation.

The lack of skills on the part of farmers and advisory organizations seems to be the main obstacle in their ability to transform themselves and, consequently, facilitate and boost the digital transition of SFSCs. A finding worth mentioning was that universities and research centers—although actively engaged in the AKIS—are not directly involved in the efforts to upskill farmers and advisors. On the other hand, technology providers do have the necessary knowledge assets but are not strongly linked with the AKIS since they (prefer to) keep the role of digital tools suppliers. Hence, the transmission of knowledge from AgTech companies to advisory organizations and farmers is limited. Such conditions raise doubts about the transformative capacity of independent actors and the whole AKIS.

5. Discussion and Conclusions

The present study aimed to provide a view of how dynamic capabilities evolve and affect AKISs' capacity to guide the digital transition of SFSCs. Our work contributes to the growing literature on the new and challenging roles of AKISs [69,70] by focusing on the ways these systems operate in the underinvestigated niche of alternative food networks. Moreover, to the best of our knowledge, this study was the first to apply the dynamic capabilities concept to understand how AKISs can support and guide the digital transition of agriculture, adding to past research on the roles, practices, and competencies of advisors, advisory organizations, and AKISs in a newly created digitalized farming world [13,19,61,71–74]. Going beyond the operational capabilities of AKIS actors (e.g., financial and human resources, knowledge), dynamic capabilities refer to the capacity to upgrade resources and direct them towards achieving new aims [20]. Hence, understanding how AKISs and the actors participating in them manage and deploy dynamic capabilities can contribute to explaining their adaptation to digitalization.

Our analysis indicated that sensing the opportunities that digitalization can create is not a difficult task for AKIS actors. In both countries, our results showed a considerable sensing capacity, which is possibly fueled by the hype that surrounds agricultural digitalization and the generally positive attitude that farmers and society hold toward the potential of digital technologies [75–77]. However, the results reveal that organizations participating in the AKISs have a different ability to discern opportunities.

The expertise and position in networks seem to offer a relative advantage to private advisory companies. This finding can explain why private-sector advisory organizations are more active in supporting digital technology adoption by farmers than other AKIS entities [78]. However, private actors are oriented toward large farms since, in this segment, the possibility of adopting digital technologies is higher [79,80]. Hence, it comes as no surprise that the efforts to support digitalization sometimes overlook the farmers distributing their products through SFSCs, who usually operate small farms.

The Greek case also suggests that sensing can be a function of size since larger organizations perform better in this capacity. Small private advisory companies and freelancers lack information on digital technologies and knowledge of how to integrate them into farms, two critical resources that shape the overall sensing capacity [20].

On the other hand, public advisory organizations, although able to sense opportunities (as in Italy), have difficulties initiating strategies to seize these opportunities. Previous work [81] points out that, for public organizations, the seizing capacity determines their ability to change and improve their performance. From the analysis, we can infer that knowledge is a critical resource for enhancing the seizing capacity of AKISs. Seizing requires continuously integrating new knowledge into the existing resource base and focusing on serving clients [82]. When such a routine of mobilizing resources to seize opportunities is absent (like in the Greek case), or public organizations emphasize serving specific segments (like in Italy), there is limited investment in developing new resources and creating services that help farmers exploit digitalization-related opportunities.

Moreover, interlaying with relational resources, knowledge allows the transformation of the system as a whole since it permits actors to develop a mutual understanding of digitalization, both as a promise and as a process, and leverage organizational resources to generate value for themselves, their partners, customers, and the system. The lack of a knowledge-renewal culture, which is evident in the Greek AKIS, obviously reduces the transformational capacity of the system. However, even when a culture that acknowledges the importance of competence development for AKIS actors exists, knowledge-building is not an easy target. From a management perspective, combining different knowledges and levels of expertise is a pivotal step for putting knowledge into social, technical, and economic contexts [83], developing collective knowledge, and sharpening the dynamic capabilities of a system [84]. The same is true for AKISs [85,86]. Enabling knowledge flow within the system can provide opportunities for constructing technical knowledge and designing service offerings that support farmers' transition to digital agriculture. A more active involvement of universities and research institutes is expected to help in this direction since these organizations have the expertise in knowledge generation and transfer mechanisms.

In sum, our work indicated that moving from sensing to seizing and, much more, to producing desirable transformations is an arduous task. Social dynamics and prevailing cultures within AKISs form contexts that may inhibit—as in the two examined cases—or stimulate the dynamic capabilities of a system. Historicity, referring to paths of innovation development in a region or context [65], as well as traditionally adopted roles and relations between actors [87], can also play a negative or positive role in supporting AKISs' capacity to facilitate digital transformation. Since our analysis did not focus on this dimension of AKISs, future research can investigate how previous innovation experiences shape current attempts of AKISs to facilitate digitalization.

Other aspects of AKISs also deserve attention, and we hope that forthcoming work will integrate them into future theoretical frameworks and research designs. For instance, a critical question is what is the role of other resources (e.g., money, human capital) in shaping the dynamic capabilities of the system. Both examined AKISs lack resources, and this attribute can possibly explain their inability to capitalize on their sensing capacity to produce new services in the form of advisory or innovation support for farmers. However, AKISs that have enough resources can also face difficulties in transforming themselves for several reasons, including the lack of alignment between the resources at hand and the emerging opportunities [88] or the tendency of organizations and systems operating in resource-rich contexts to overlook the importance of scanning for new opportunities.

Another issue worthy of investigation is how the involvement of new actors in AKISs (e.g., Ag-Tech, data curation companies) will affect the dynamic capabilities of older actors and the whole system. The entry of new actors that have no previous connection with the AKIS urges those organizations that were already offering advisory services to commit to new roles [89,90], while the heterogeneous expertise of old and new players participating in the AKIS increases the complexity of those systems. Future work can examine how such complexity is reflected in the dynamic capabilities of the system.

As a final note, we are mentioning the limitations of our study. Although research on dynamic capabilities usually focuses on actors representing social units [91] or individuals managing these units [92], here we attempted to shed some light on the AKIS as a whole system. Of course, this is not an easy endeavor. Further work is needed to illustrate how institutions, norms, and other intangible characteristics of an AKIS affect its ability to sense opportunities, seize them, and transform itself to make the most of the identified opportunities and avoid threats. In addition, assessing farmers' dynamic capabilities and understanding how sensing, seizing, and transforming evolve over time can offer more insights into how AKISs react to digitalization and why. Finally, the reliance of our study on two workshops represents a limitation that should be accounted for when considering the findings. More data can expand our knowledge of how dynamic capabilities evolve and affect AKISs. We hope the present study will stimulate future researchers to delve into the topic.

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