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Cross-Analysis of Agricultural Knowledge and Innovation System of Actors' Interactions in Greece

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Abstract

This study examined Greece's Agricultural Knowledge and Innovation System (AKIS) and assessed the flow of information and linkages among eight stakeholder groups: policy, education, research, consulting, agricultural cooperatives, credit, private enterprises, and farmers. Data were collected using an online survey tool from 61 experts/representatives following an initial phone communication. The Graph Theoretical Technique was utilized to achieve the survey's objectives. The results revealed dominant and subordinated actors in the system and identified a critical

pathway for information flow within AKIS. Policymakers can leverage these findings to strengthen linkages, address information gaps, and promote innovation and equitable development in the agricultural sector.

Introduction

The agri-food sector has been facing a significant challenge in recent times to increase production in response to the growing demands, while also adhering to various restrictions and limitations (Panneto et al., 2020). However, the rising demand for food production has a detrimental impact on the environment, contributing to greenhouse gas emissions, biodiversity loss, and further land degradation. To ensure food security, better nutrition, and sustainable agriculture, it is crucial to include the agricultural sector in sustainable development goals, as emphasized by Stephens, Andrew & Parsons (2018).

Innovation is a critical factor in overcoming the challenges faced by the agricultural system (Oliveira et al., 2019). Adopting innovation practices can accelerate the shift toward sustainable agricultural models (Masi et al., 2022). The Organization for Economic Co-operation and Development (OECD, 2019) recognizes that innovation positively impacts productivity, competitiveness, profitability, and sustainability of the agricultural sector. Innovation is critical for helping farmers and rural communities tackle present and future challenges, and it is closely tied to information flow, learning, and social interaction (EU SCAR AKIS, 2019).

The recent regulation (EE) 02115/2021 regarding rural development highlights the role of AKIS, which is essential in spreading knowledge and diffusion of innovation (Masi et al., 2022). The agricultural knowledge and innovation system (AKIS) concept was established to support sustainability (EU SCAR, 2019). AKIS is a collaborative network of organizations, enterprises, and individuals with a shared goal of introducing new products, processes, and forms of organization into economic use. It also includes the institutions and policies that influence how different actors interact, share, access, exchange, and utilize knowledge. (Zahran et al., 2020; Kassem et al., 2022). According to Renn (2018), the network can also be considered a "real-world laboratory," which implements a transdisciplinary research approach for supporting improved problem-solving and innovation. Actors possess diverse skills, languages, interests, and goals. Therefore, it is necessary to create an environment that fosters the exchange of knowledge, perspectives, and resources to identify and discuss solutions and new ideas (Calliera et al.,2021). According to Zahran et al. (2020), an organization's capacity to collect and share information plays a crucial role in shaping the flow patterns and performance of the innovation system. This approach promotes collaborative learning among researchers, extension workers, farmers, and other actors in the value chain (Akinwale et al., 2023).

Interaction among actors fosters networking, reflecting knowledge flows in AKIS. The more intense interactions within an AKIS, the greater its capacity

for development (EC., 2023). On the theoretical front, linkage measurement facilitates the study of agricultural knowledge generation, diffusion, and application, and hence the dynamism of an AKIS in sustainable agriculture and economic development. (Manzano & Pérez, 2023; European Commission, 2023).

Most research on AKIS in Greece has centered on Farm Advisory services. For the past few decades, numerous papers have been published in journals and international conferences that emphasize the adverse effects of the lack of an extension/advisory mechanism on the farming sector in Greece (Konstantidelli et al., 2018; Charatsari & Lioutas, 2019; Koutsouris & Zarokosta, 2022). Koutsouris et al. (2020) recently studied the AKIS intending to assess advisory services. However, we have limited knowledge about how AKIS actors in Greece communicate with each other and how it affects their ability to receive, share, and learn from information within the system.

The study: i) examined the existing linkages between actors in Greece's AKIS and ii) examined the information flow in Greece's AKIS.

Methodology

The research was conducted in Greece, a country located in southeastern Europe. Greece is situated at the southernmost point of the Balkan Peninsula, between latitudes 35^{o} 00' to 42^{o} 00' B and longitudes 19^{o} 00' to 28^{o} 30' A. Its total area is 131,694 km^{2} and the population is approximately 10,718,565 people (2021).

The GTT method combines graph theory in discrete mathematics with systems analysis in engineering. According to Kassem et al. (2022), the method is useful for evaluating questionnaires that pertain to interconnections and necessitates the representation of these interconnections in a square matrix. Specifically, it measures the linkages between the components and identifies dominant and subordinate ones. Additionally, policymakers can benefit from the knowledge of the dominant and subordinate components when designing policies or programs, as it provides helpful information for examining the characteristics necessary for system controllability. The GTT method can help identify the cause-and-effect pathways, detect mismatches, and leverage points. Understanding these linkages is valuable in building game-theoretic models, as equilibria depend on the specific sequence of decisions made by participating actors.

The following actions are taken to implement the method GTT: ı) To evaluate the linkages, a few steps must first be taken. Using the coded linkages matrix developed after creating the optimal system matrix the visual matrix format of the binary links between system components and the density, was obtained. Linkage strength was determined using the refined matrix. After that, the linkage strength (refined matrix) was multiplied using the following scale: strong (1), medium (0.66), weak (0.33), and none (0) to create the adjusted matrix and the cause-effect structure of the matrix (Figure 2) ii) To evaluate information flow, a coded capacity matrix was created using the information

flow matrix values. The adjusted capacity matrix for information flow results from multiplying each cell in the capacity matrix (except diagonal cells) by the corresponding cell in the refined linkage matrix. Finally, the supply-receipt information structure between components was calculated.

Data were collected through a survey of 61 expert representatives (mainly senior managers) from the eight essential stakeholder groups: 1. Public Authority, Chamber, and NGO (P), 2. Research Institutes (I), 3. Educational Institutions (E), 4. Consulting Agencies (C), 5. Private Enterprises (K), 6. Agricultural Cooperatives (F), 7. Credit institutions (V), and 8. Farmers (A). Data was gathered between December 2022 and March 2023 using an online survey tool after an initial phone conversation. The instrument for data collection was divided into two sections. The first section examined the linkages among the components in AKIS. The second section highlighted the interviewers' assessment of the information flow in AKIS. The respondents evaluated the strength of linkages with the rest of the other components within the AKIS with (1) recorded if there is a connection and (0) if there is no connection or a negligible amount. Subsequently, the respondents were asked to clarify the strength of the linkage by identifying (i) the level of linkage: strong (3), moderate (2), weak (1), non-existent (0), and (ii) the type of linkage: formal (3), mixed (2), and informal (1), non-existent (0). Three indicators were used to assess the flow of information: i) its capacity to receive information from other organizations; ii) its capacity to learn, and iii) its capacity to share them. The capacities were evaluated on a five-point scale. (1) weak, (2) little strong, (3) medium, (4) enough strong, and (5) very strong. According to the guidelines of the GTT approach (see Figure 2), the data were assigned, coded, and calculated. The prevailing mode was used to measure the central location. The Excel program was used for the calculations and generating the figures.

Results and Discussion

Linkages within AKIS

The Optimal Matrix

The optimal matrix consists of eight stakeholder groups. The matrix shows all the binary linkages across stakeholder groups. These linkages are placed in off-diagonal cells and follow clockwise rotation. In diagonal cells, the stakeholders exist (Matrix 1).

P	*PI*	*PE*	*PC*	*PK*	*PF*	*PV*	*PA*
IP	***I***	*IE*	*IC*	*IK*	*IF*	*IV*	*IA*
EP	*EI*	***E***	*EC*	*EK*	*EF*	*EV*	*EA*
CP	*CI*	*CE*	***C***	*CK*	*CF*	*CV*	*CA*
KP	*KI*	*KE*	*KC*	***K***	*KF*	*KV*	*KA*
FP	*FI*	*FE*	*FC*	*FK*	***F***	*FV*	*FA*
VP	*VI*	*VE*	*VC*	*VK*	*VF*	***V***	*VA*
AP	*AI*	*AE*	*AC*	*AK*	*AF*	*AV*	***A***

Matrix 1: The optimal matrix of AKIS in Greece

Matrix 1 represents three types of linkages: The first type concerns the links between organizations or individuals to the same group. The second type represents linkages between groups. For example, the terms (PI) in the cell of the first row and the second column of AKIS indicate the interaction of group (P) with group (I), where (P) is the initiator of this interaction. Otherwise, the first column and second row show the interaction of (I) with (P) with (I) as an initiator. Finally, the third type represents the connection between two groups through pathways of binary linkages. (e.g., PIE).

The total number of k-edge in the AKIS is calculated using the formula: n!/(n-k-1)! where k and n represent the number of edges in a pathway and the number of stakeholder groups in the system, respectively. In our case, the number of one-edge pathways in the AKIS in Greece is 8! / (8-1-1)! = 56, where n=8 and k=1. So, this study aims to evaluate 56 binary linkages.

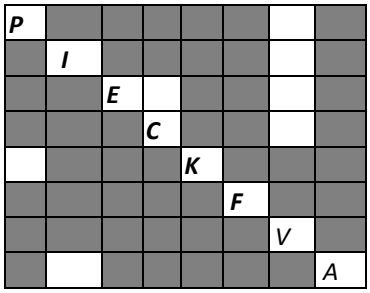
Coding Linkage Matrix

The binary linkages were represented using 0 if the linkage did not exist and 1 if it did. The formatted table based on this coding system is presented in Matrix 2. Additionally, Figure 1 displays the graph of binary linkages between stakeholders within AKIS. The research findings showed that only seven binary linkages were non-existent from 56, so the density of interactions was 0.875, and the system was not fully identified, as only 49 out of the total were identified.

P	*1*	*1*	*1*	*1*	*1*	*0*	*1*
1	***I***	*1*	*1*	*1*	*1*	*0*	*1*
1	*1*	***E***	*0*	*1*	*1*	*0*	*1*
1	*1*	*1*	***C***	*1*	*1*	*0*	*1*
0	*1*	*1*	*1*	***K***	*1*	*1*	*1*
1	*1*	*1*	*1*	*1*	***F***	*1*	*1*
1	*1*	*1*	*1*	*1*	*1*	***V***	*1*
1	*0*	*1*	*1*	*1*	*1*	*1*	***A***

(a)

(b)



Matrix 2: Coded matrix of AKIS in Greece (a) and the visual format (b)

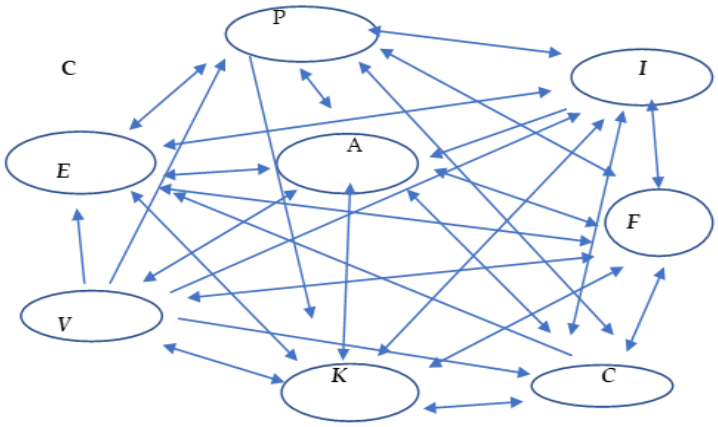


Figure 1: The graph of linkages between actors in AKIS in Greece (c)

The Refined Linkage's Matrix

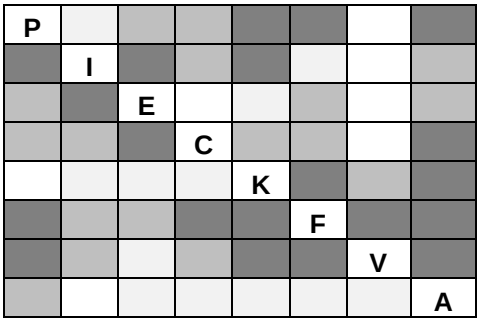
The result of the strength of the connections with the rest of the stakeholder groups within the system is displayed in Matrix 3A. The responses were recorded on a scale of 0,1,2,3 for absent, weak, medium, and strong linkages, respectively. The type of linkages between their organizations and the rest of the actors on the scale: are none (0), informal (1), mixed (2), and formal (3) (Matrix 3C). The visual format of the refined linkage's Matrix represents the strong interaction with dark grey, the moderate with grey, and the weak with light grey colour (Matrix 3B). The findings revealed that the agricultural cooperatives (F) had strong two-directional interactions with private enterprises (K) and credit institutions (V). The same was observed between the research and education. Furthermore, we observed differences in estimating the strength of the linkage. Specifically, differences between (PI), (PA), (EV), (EA), (CA), (KV), (KA), (FA), and (VA) were observed. However, the Public Authorities representatives (P) claimed there were no linkages between credit, while the credit claimed that they have strong. Such linkage could be considered a one-directional linkage. Similarly, (PK), (VP), (VI), (VE), (VC), and (IA) could be defined as one-directional linkages. Furthermore, more than one-half (51.02%) were mixed linkages, less than one-quarter was (22.44%) formal, and the rest (26.54%) were informal. This visual tool (Matrix 3) could be a handy tool for decision-makers in identifying areas with weak or absent linkages and designing and implementing complementary interventions and institutional changes for strengthening the AKIS.

Moreover, identifying 12 weak linkages between components, the density decreased to 0.660. The density value denoted that much effort is required for all the components to influence each other positively since 20 strong, 17 moderate, and 12 weak interactions were found. These results agree with Koutsouris et al. (2020) who stated that the Agricultural Knowledge and Innovation System (AKIS) in Greece is fragmented and ineffective. The decentralization of research and training for farmers from the Ministry of Rural Development and Food, along with inadequate coordination mechanisms between stakeholders, have resulted in poor cooperation among the main public components of AKIS.

A

P	*1*	*2*	*2*	*3*	*3*	*0*	*3*
3	***I***	*3*	*2*	*3*	*1*	*0*	*2*
2	*3*	***E***	*0*	*1*	*2*	*0*	*2*
2	*2*	*3*	***C***	*2*	*2*	*0*	*3*
0	*1*	*1*	*1*	***K***	*3*	*2*	*3*
3	*2*	*2*	*3*	*3*	***F***	*3*	*3*
3	*2*	*1*	*2*	*3*	*3*	***V***	*3*
2	*0*	*1*	*1*	*1*	*1*	*1*	***A***

B



C ***P***	*f*	*m*	*f*	*f*	*f*	*0*	*f*
m	***I***	*f*	*m*	*m*	*m*	*0*	*m*
m	*m*	***E***	*0*	*i*	*i*	*0*	*i*
m	*m*	*m*	***C***	*m*	*m*	*0*	*m*
0	*i*	*i*	*m*	***K***	*i*	*i*	*m*
f	*m*	*i*	*m*	*m*	***F***	*i*	*m*
m	*m*	*i*	*m*	*f*	*f*	***V***	*f*
m	*0*	*m*	*i*	*f*	*i*	*i*	***A***

Matrix 3: The refined linkage's matrix (A), visual format (B), and type of linkages (C) Source: Field Survey, 2023.

The Adjusted Matrix of AKIS

It can be helpful to view the relationships between different stakeholder groups as a measure of their influence on each other. According to GTT, the refined matrix (as shown in Matrix 3A) is adjusted by multiplying the strength of the relationship using a scale: strong (3x1), moderate (2x0.66), and weak (1x0.33). This results in an adjusted matrix, where the rows represent the influence values of that group on the others (cause), and the columns indicate the effect values of the others on it (effect) (refer to Matrix 4). A value of 3.00 indicates strong influence, while a value of 0.33 indicates low influence.

P	*0.33*	*1.32*	*1.32*	*3.00*	*3.00*	*0.00*	*3.00*
3.00	***I***	*3.00*	*1.32*	*3.00*	*0.33*	*0.00*	*1.32*
1.32	*3.00*	***E***	*0.00*	*0.33*	*1.32*	*0.00*	*1.32*
1.32	*1.32*	*3.00*	***C***	*1.32*	*1.32*	*0.00*	*3.00*
0.00	*0.33*	*0.33*	*0.33*	***K***	*3.00*	*1.32*	*3.00*
3.00	*1.32*	*1.32*	*3.00*	*3.00*	***F***	*3.00*	*3.00*
3.00	*1.32*	*0.33*	*1.32*	*3.00*	*3.00*	***V***	*3.00*
1.32	*0.00*	*0.33*	*0.33*	*0.33*	*0.33*	*0.33*	***A***

Matrix 4: **Adjusted matrix of AKIS in Greece. Source: Field Survey, 2023**

The Cause-Effect Structure of the Adjusted Matrix

According to the methodological framework of GTT, the sum of each row's values defines each stakeholder group's influence on the AKIS, and the corresponding sum of each column defines the effect of the others on the respective group. The following table is in line with the above (Table 1). The groups are divided into three categories based on causal effect the final values: i) if cause>effect, the stakeholder group is dominant; ii) if cause < effect, the stakeholder group is subordinary; and iii) if cause is equal or relatively equal, the stakeholder group is interactive.

The research findings denote that the (F) had the most significant influence on the other actors within the system, with a value of 17.64 and 12.3 for cause and effect, respectively. Also, the (F) ranked first for their cause on the rest of the AKIS, while it ranked third for the total effect of the other groups (Table 1). The agricultural cooperatives are the most dominant stakeholder groups regarding cause- effect which contrasts in line with what was confirmed by Kassen et al. (2022) in Dakahlia Governorate's Agricultural Innovation System in Egypt. Kassen et al (2022) noted that cooperatives are not the dominant actors in AKIS and that they are the ultimate target of all participants. In contrast, Greek literature has demonstrated that agricultural cooperatives in Greece provided material and technical support to farmers, played a significant role in the operation of the agricultural products market, contributed to the economic recovery of local communities, engaged in activities related to the utilization of agricultural production, and in some cases, even competed with private companies (Semou et al., 2022). However, the (A) group was subordinated (Figure 2). It constitutes the most isolated group within AKIS. This result is not surprising as farmers are the final users of knowledge. It is notable that credit institutions significantly influence the system with their financial support. Furthermore, (I) and (C) are in the cause area, but their influences are limited in comparison to (F). (P) with the government policy and regulatory framework is interactive with the others and is followed by (E). According to Zhang & Wu (2018), the Government is one of the important elements of innovation systems as interacts with other factors to meet the needs of rural households and the investments and returns of commercial companies. Additionally, (K) was subordinated in the system and according to Koutsouris et al. (2020), their connection with the public sector was characterised by opportunism.

Table 1: The cause-effect values of the actors in AKIS

Stakeholder Groups	Cause	Effect
Public Authority, Chamber, and NGO (P)	11.97	12.96
Research Organizations (I)	11.97	7.62
Educational Institutions (E)	7.29	9.63
Consulting Agencies (C)	11.28	7.62
Private Enterprises (K)	8.31	13.98
Agricultural Cooperatives(F),	17.64	12.30
Credit institutions (V)	14.97	4.65
Farmers (A)	2.97	17.64

Source: Field Survey, 2023

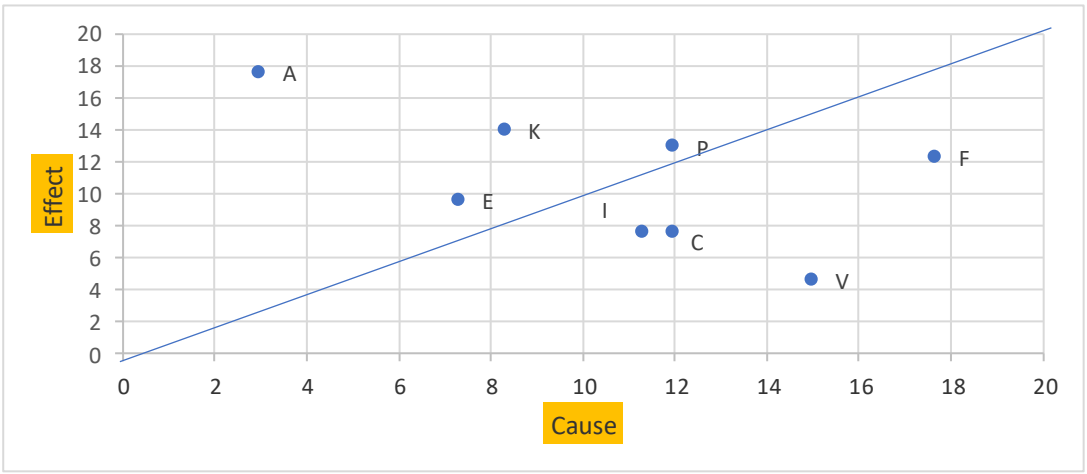


Figure 2: The cause-effect structure of AKIS in Greece. Source: Field Survey, 2023

Evaluation of the Flows of Information within AKIS

The Information Flow Matrix in AKIS

Matrix 5 shows the information flow matrix. This matrix denotes the structure of the components' capacity to share (σ), learn (λ), and receive (θ) information from each other. Their abilities to share and receive are in cells off the main diagonal, while their ability to learn is in cells on the main diagonal. For example, the σ^I denotes the capacity of (I) to share with others, θ^I the capacity of (I) to receive information from others, and λ^I to learn information.

The experts were asked to evaluate the capacities of their organization to share, learn, and receive information within the AKIS. For this purpose, we used a five-point scale: (1) weak, (2) little strong, (3) medium, (4) enough strong, and (5) very strong. Table 2 shows the average capacities to receive (θ), learn (λ), and share (σ) information of the stakeholder groups in AKIS. Our results revealed that (E) and (C) had strong capacities to receive, learn, and share information. In contrast, (P), (I), and (K) had medium capacities in all indicators.

$\boldsymbol{P(\lambda^P)}$	$\sigma^P\theta^I$	$\sigma^P\theta^E$	$\sigma^P\theta^C$	$\sigma^P\theta^K$	$\sigma^P\theta^F$	0	$\sigma^P\theta^A$
$\sigma^I\theta^P$	$\boldsymbol{I(\lambda^I)}$	$\sigma^I\theta^E$	$\sigma^I\theta^C$	$\sigma^I\theta^K$	$\sigma^I\theta^F$	0	$\sigma^I\theta^A$
$\sigma^E\theta^P$	$\sigma^E\theta^I$	$\boldsymbol{E(\lambda^E)}$	0	$\sigma^E\theta^K$	$\sigma^E\theta^F$	0	$\sigma^E\theta^A$
$\sigma^C\theta^P$	$\sigma^C\theta^I$	$\sigma^C\theta^E$	$\boldsymbol{C(\lambda^C)}$	$\sigma^C\theta^K$	$\sigma^C\theta^F$	0	$\sigma^C\theta^A$
0	$\sigma^K\theta^I$	$\sigma^K\theta^E$	$\sigma^K\theta^C$	$\boldsymbol{K(\lambda^K)}$	$\sigma^K\theta^F$	$\sigma^K\theta^V$	$\sigma^K\theta^A$
$\sigma^K\theta^P$	$\sigma^K\theta^I$	$\sigma^K\theta^E$	$\sigma^K\theta^C$	$\sigma^K\theta^K$	$\boldsymbol{F(\lambda^F)}$	$\sigma^K\theta^V$	$\sigma^K\theta^A$
$\sigma^V\theta^P$	$\sigma^V\theta^I$	$\sigma^V\theta^E$	$\sigma^V\theta^C$	$\sigma^V\theta^K$	$\sigma^V\theta^F$	$\boldsymbol{V(\lambda^V)}$	$\sigma^V\theta^A$
$\sigma^A\theta^P$	0	$\sigma^A\theta^E$	$\sigma^A\theta^C$	$\sigma^A\theta^K$	$\sigma^A\theta^F$	$\sigma^A\theta^V$	$\boldsymbol{A(\lambda^A)}$

Matrix 5: The information flow matrix across stakeholder groups in AKIS

Table 2: **Average capacities to receive(θ), learn (λ), and share (σ) information in AKIS**

Stakeholder groups	Receive	Learn	Share
Public Authority, Chamber, and NGO (P)	m (0.66)	m (0.66)	m (0.66)
Research Organizations (I)	m (0.66)	m (0.66)	m (0.66)
Educational Institutions (E)	s (1.00)	s (1.00)	s (1.00)
Consulting Agencies (C)	s (1.00)	s (1.00)	s (1.00)
Private Enterprises (K)	m (0.66)	m (0.66)	m (0.66)
Agricultural Cooperatives(F),	m (0.66)	s (1.00)	s (1.00)
Credit institutions (V)	s (1.00)	s (1.00)	m (0.66)
Farmers (A)	m (0.66)	s (1.00)	m (0.66)

Average values (1-2.75) were considered weak (w=0.33),
average values (2.76-3.75) were considered medium(m=0.66),
and average values (3.76-5) were considered strong (s=1.00).
Source: **Field Survey, 2023**

P(m)	*mm*	*ms*	*ms*	*mm*	*mm*	*0*	*mm*
mm	***I(m)***	*ms*	*ms*	*mm*	*mm*	*0*	*mm*
sm	*sm*	***E(s)***	*0*	*sm*	*sm*	*0*	*sm*
sm	*sm*	*ss*	***C(s)***	*sm*	*sm*	*0*	*sm*
0	*mm*	*ms*	*ms*	***K(m)***	*mm*	*ms*	*mm*
sm	*sm*	*ss*	*ss*	*sm*	***F(s)***	*ss*	*sm*
mm	*mm*	*ms*	*ms*	*mm*	*mm*	***V(s)***	*mm*
mm	*0*	*ms*	*ms*	*mm*	*mm*	*ms*	***A(s)***

Matrix 6: **The capacity of the flow matrix. Source**: **Field Survey, 2023**

The Adjusted Capacity Matrix of AKIS in Greece

From the capacity of the flow matrix (Matrix 5 & 6) and the average capacities to receive(θ), learn (λ), and share (σ) information (Table 2), the adjusted capacity matrix of information flows between AKIS actors in Greece was obtained (Matrix 7). For example, the function $\sigma^P\theta^I$ = (mm)= (0.66*0.66) =0.4, which indicates the information flow from (P) to (I). The same actions were taken for all linkages in AKIS to confirm the ability to effectively flow information between stakeholders.

Matrix 7 indicates an information flow structure and specifically presents how fluid the information in the system is.

P(0.7)	*0.4*	*0.7*	*0.7*	*0.4*	*0.4*	*0.0*	*0.4*
0.4	***I(0.7)***	*0.7*	*0.7*	*0.4*	*0.4*	*0.0*	*0.4*
0.7	*0.7*	***E(1.0)***	*0.0*	*0.7*	*0.7*	*0.0*	*0.7*
0.7	*0.7*	*1.0*	***C(1.0)***	*0.7*	*0.7*	*0.0*	*0.7*
0.0	*0.4*	*0.7*	*0.7*	***K(0.7)***	*0.4*	*0.7*	*0.4*
0.7	*0.7*	*1.0*	*1.0*	*0.7*	***F(1.0)***	*1.0*	*0.7*
0.4	*0.4*	*0.7*	*0.7*	*0.4*	*0.4*	***V(1.0)***	*0.4*
0.4	*0.0*	*0.7*	*0.7*	*0.4*	*0.4*	*0.7*	***A(1.0)***

Matrix 7: The effectively adjusted capacity matrix of AKIS in Greece. Field Survey, 2023

The Supply-Receipt Structure of AKIS in Greece

Finally, the effectively adjusted capacity matrix is obtained (Matrix 8) by multiplying the value of each cell in the adjusted capacity matrix (Matrix 7) (except the diagonal cells) with the corresponding cells in the refined linkage matrix (Matrix 3A). This matrix shows how fluid the information in the AKIS. The results showed that high information flow was observed from a) consulting agencies to education, b) agricultural cooperatives to consulting, and c) agricultural cooperatives to credit with a value of 3.0 (see Matrix 8). Also, the findings indicated that an effective pathway for the flow of information within AKIS is agricultural cooperatives - consulting agencies – and education (FCE).

P	*0.4*	*1.4*	*1.4*	*1.2*	*1.2*	*0.0*	*1.2*
1.2	***I***	*2.1*	*1.4*	*1.2*	*0.4*	*0.0*	*0.8*
1.4	*2.1*	***E***	*0.0*	*0.7*	*1.4*	*0.0*	*1.4*
1.4	*1.4*	*3.0*	***C***	*1.4*	*1.4*	*0.0*	*2.1*
0.0	*0.4*	*0.7*	*0.7*	***K***	*1.2*	*1.4*	*1.2*
2.1	*1.4*	*2.0*	*3.0*	*2.1*	***F***	*3.0*	*2.1*
1.2	*0.8*	*0.7*	*1.4*	*1.2*	*1.2*	***V***	*1.2*
0.8	*0.0*	*0.7*	*0.7*	*0.4*	*0.4*	*0.7*	***A***

Matrix 8: **The effectively adjusted capacity matrix of AKIS in Greece. Field Survey, 2023**

According to Kassem (2022), the sum of the values of each row indicates the score of the single stakeholder group as an information supplier. In contrast, the sum of each column indicates the group's score as an information receiver (Table 3). The results revealed that the main supplier is (F), having a value of 15.7, while (A) and (E) are the main receivers with a value of 10.0 and 10.6, respectively. In contrast, Kassem et al. (2022) revealed that extension was the most interactive component in Dakahlia in Egypt. The scatter plot of supply-receipt groups the stakeholders into two categories: i) suppliers (F, C, I, and V) and ii) receivers (P, K, E, and A) (Figure 3).

Table 3: Supply and Receipt values of the stakeholder groups.

Stakeholder Groups	Supply	Receive
Public Authority, Chamber, and NGO (P)	6.8	8.1
Research Organizations (I)	7.1	6.5
Educational Institutions (E)	7.0	10.6
Consulting Agencies (C)	10.7	8.6
Private Enterprises (K)	5.6	8.2
Agricultural Cooperatives(F),	15.7	7.2

Credit institutions (V)	7.7	5.1
Farmers (A)	3.7	10.0

Source: Field Survey, 2023

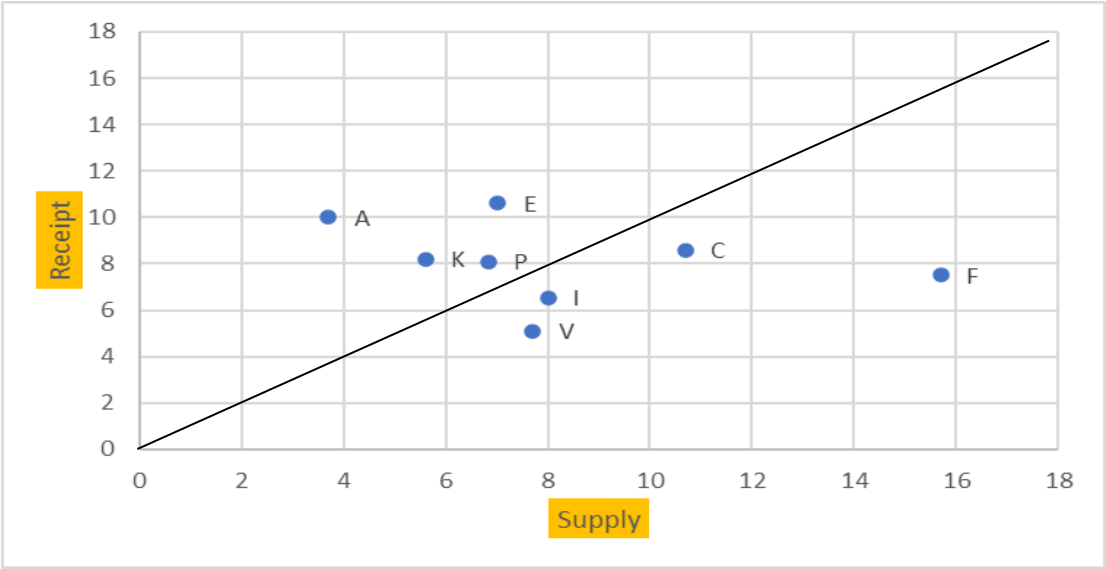


Figure 3: Information flow in the adequate capacity of AKIS. Source: Field Survey, 2023

In conclusion, the results suggest that enhancing connection in Greek AKIS needs building seven linkages and strengthening 12 weak ones. The agricultural cooperatives are the most dominant stakeholder groups regarding linkages and information flow. However, the farmers were subordinated in terms of linkages and information flow. It constitutes the most isolated group within AKIS. This result is not surprising. Farmers are the ultimate users of knowledge. To increase their influence on other actors and share information with others, it's necessary to empower farmers by using consulting agencies as intermediary actors in AKIS. One way to help individuals achieve a particular role in AKIS is by carrying out a capacity-building process. This involves providing more supported training, advice, and awareness activities on issues that concern them and enhancing their business skills. Additionally, mentoring and supporting farmers can help awareness for diversifying their agricultural activities and decision-making.

Compared to agricultural cooperatives, research and extension services have limited impact. To maximize their potential in diffusing innovation, consulting, and research, they need to strengthen their connections. On the other hand, education acts more as a receiver of information than a supplier. This means that it receives more information than it sends out. Educational institutes, both higher and secondary, need to make more efforts to disseminate scientific findings, technologies, and practices to advisors who have a gap in their connection. Education should also strengthen its linkages with other actors to ensure adequate information flow. Private enterprises are currently

subordinated to AKIS and need to strengthen their position in the system, particularly regarding connections and information flow.

Also, this method has the potential to be a valuable tool for decision-makers who want to analyse the interactive structure of AKIS. It allows for the evaluation of various innovation policies and programs by identifying efficient pathways of links between stakeholders, as well as the constraints that hinder these linkages. This information can be used to design and implement complementary interventions and institutional changes to strengthen the AKIS. However, it is important to note that the study has a limitation. The assessment of linkages and information flow relied on self-reports from representatives of stakeholder groups. Therefore, the approach is reliant on what respondents believe, which may not always be entirely accurate (Kassem et al., 2022).

Conclusion and Recommendations

There are linkages and information flow among the eight stakeholder groups of AKIS in Greece. The findings identify areas where coordination and information flow need to be improved between stakeholders. These results can be used by decision-makers to develop governance arrangements that can coordinate service offerings and facilitate the development of new offerings in response to new challenges. Improving coordination can lead to more inclusive policies that address the barriers and opportunities of AKIS. It can also allow for more stakeholders to voice their needs and concerns, resulting in better design and implementation of innovation policies.

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