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The Agricultural Innovation System of Azerbaijan: Functions, Linkages, and Constraints

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ABSTRACT

This paper describes the AISA, analyzes linkages between its components, and recommends changes in its functioning. Adopting the systems approach, the paper uses graph-theoretic concepts to characterize the AISA. Three important observations are immediate from the analysis. Firstly, the essential elements of the AISA are at an embryonic stage, and significant accomplishments in policy-making, organizational development, research, education, and credit institutions are yet to come. Secondly, there is ample scope for intermediary organizations to glue the public and the private components of the AISA by facilitating quick and effective flow of knowledge. But, the development of such organizations strongly depends on the presence of an enabling legal environment and the availability of financial and human resources. Under the current conditions Azerbaijan lacks all. Thirdly, especially in public organizations flexible management styles should be practiced to avoid unnecessary deadlocks in their interaction with private organizations.

Keywords: agricultural innovation system; Azerbaijan; systems analysis; graph theory, agricultural research policy.

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INTRODUCTION

A lot has already been said about Azerbaijan's transition from a command to a market economy, and the urgency of building institutions has always been stressed in policy dialogues. Legal changes introduced to support the development of an enabling environment for private initiatives started to take roots in the economic activities. However, public, private, and international organizations still largely operate as stand-alone units, pointing to the need for a framework to facilitate interactions among them. Such framework would require the rehabilitation of the inherited knowledge infrastructure and policies to synergize organizational interactions that directly or indirectly influence the processes of agricultural knowledge generation, diffusion, and application (OECD, 1999; EC, 2000). Agricultural research organizations are, of course, indispensable elements of the agricultural knowledge system but are not enough to promote agricultural production because the production entails more than a mere generation of the knowledge. It requires linkages to be established between market and non-market institutions and channels to be established through which the knowledge freely flow into the areas where it can be used effectively.

Accordingly, the present study describes the components of the agricultural innovation system of Azerbaijan (AISA), analyzes their linkages, and suggests changes in its functioning.¹ The conviction that drives the current study is that innovations take place almost everywhere in society, and therefore, bringing together the diffuse elements of a knowledge system and connecting them around a common goal should promote economic development. Parallel to this conviction, the new growth theory stresses the significance of knowledge accumulation from investment in new technologies and human capital (Romer, 1986, 1990, 1994; Aghion and Howitt, 1998). The evolutionary and industrial economics claims that this accumulation is path-dependent, non-linear, and shaped by the interplay of market and non-market institutions (David, 1975; Nelson and Winter, 1982; Metcalfe, 1995). Last but not least, the institutional economics emphasizes the role of institutional arrangements in enhancing the capability of organizations to deal with issues of competitiveness (North, 1995).

The study adopts the systems approach that takes root in the view that linkages between knowledge generating and using agents are as important as direct investment in R&D, and that science is undeniably necessary but is only part of the whole innovation process. With this approach, policy makers should be able to identify the existing cause-effect structures among the interconnected agents of the AISA, and therefore, design effective science and technology policies to improve the fluidity of the main knowledge channels. An understanding of the innovation system would further help identify leverage points and develop alternative mechanisms to release the constraints on the innovative capacity of the agricultural sector.

Following the Introduction, Section 2 describes the questionnaire used in data collection. The conceptual framework adopted is briefly discussed in Section 3. Section 4 describes the AISA, discussing functions, linkages, and constraints of the organizations in it. Section 5 analyzes the linkages in the AISA, using graph-theoretic concepts. Section 6 suggests ways to improve the effectiveness of the AISA. Finally, Section 7 concludes the study. Appendix introduces graph-theoretic concepts used in the analysis of linkages.

¹ A system is defined as a set of components, each of which consists of a group of organizations organized around a common goal. The term "institutions" is used to mean rules and regulations governing activities of all the organizations in the system.

DATA

Interviews were conducted to gather information by using a questionnaire.² A total of 63 persons were interviewed that include 7 policy makers, 12 directors of agricultural research institutes, 5 professors and graduate students, 1 director from credit institutions, 4 extension and information specialists, 8 directors from private input supply, processing, and marketing enterprises, 10 farmers from large and small farm organizations, 11 directors of private consultancy firms, and 5 project managers from international development agencies.

The questionnaire is organized into 5 Sections. Section 1 concerns organizational profiles including information on the respondent, classification of his/her organization, and internal and external factors that influence organizational performance. Section 2 concerns innovation activities, types and goals of these activities, sources of knowledge about innovations, funding mechanisms, and factors that constrain the activities. Section 3 relates to the type of organizational linkages, strength of the linkages, linkage mechanisms used, and linkage-constraining factors. Section 4 relates to the most recent innovation developed or diffused or used by the respondent's organization. Section 5 covers the Agricultural Science and Technology (S&T) policy issues. In the analysis, national statistics available in the literature were also used.

The questionnaire has two distinct features. Firstly, organizational linkages are scaled as 0 for absent, 1 for weak, 2 for medium, and 3 for strong linkage, in order to show how effectively a linkage mechanism was used during the interaction of two organizations. Secondly, during the interview, channels through which the interviewed organization influenced the others in the system were also discussed. And this information was later used to establish the cause-effect structure of the AISA.

The main difficulty faced during the interviews was that interviewees were not fully able to understand the concept of innovation, and as a result, when asked about organizational linkages related to innovations, they simply reported all the linkages they developed and all the constraints they faced. Furthermore, several questionnaires were not included in the final reporting since the respective respondents were not at liberty to talk, although they were occupying relevant offices. Finally, a mission of 20 days to Baku, Azerbaijan, is not enough to fully characterize the whole system; however, it should be enough to paint an image of the AISA.

A SYSTEMS APPROACH

Definitions of national innovation system are various. While they are quite similar at face value, there are some differences in meaning, emphasis, and use of the concept. Freeman (1987), for example, defines the concept as the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify, and diffuse new technologies; Nelson (1993) defines it as a set of institutions whose interactions determine the innovative performance of firms; Metcalfe (1995) defines it as set of institutions which jointly and individually contribute to the development and diffusion of new technologies; and Smith (1996) underlines the point that the innovative performance of an economy depends not only on how the individual institutions perform in isolation, but on how they interact with each other as elements of a collective system of knowledge creation and use.

² The English and Russian versions of this questionnaire are available upon request. Also available upon request is the list of persons interviewed.

The key difference between the above definitions is that some view the concept as a simple aggregation of institutions, while others point at the synergies that originate from their joint operation. The current study follows the spirit of the latter, viewing that the innovation system is not a simple aggregation of organizations but is a group of agents who operate like an invisible orchestra. The members of the orchestra play pieces of a one-big melody with an invisible harmony among them. This orchestra can be characterized by coherence, harmony, and synergy: Coherence brings different pieces under the same melody; harmony creates a tune that keeps the members around the same spirit; and synergy ties the members more strongly around the common goal. Adapting the definitions above to the sectoral level, the study defines agricultural innovation system as a set of agents that jointly and/or individually contribute to the development, diffusion, and use of agriculture-related new technologies, and that directly and/or indirectly influence the process of technological change in agriculture.

DESCRIPTION OF THE AISA

The structure of organizations in the AISA is shown in Figure 1, where organizations are grouped by their functions including general policy-making (F1), policy formulation, co-ordination, supervision and assessment (F2), financing R&D (F3), R&D performance (F4), technology diffusion (F5), and technology application (F6). This figure further shows organizational links, which are vertical between public organizations and horizontal between private organizations. The figure should be read as follows. The organizations in the 1st layer perform F1 and F3, those in the 2nd layer perform F2 and F3, and those that appear in the 1st and 2nd layers at the same time perform F1, F2, and F3, etc.

Below, functions, linkages, and constraints are described of the 9 key components including the policy (P), the research (R), the education (E), the credit (C), the extension and information (I), the input supply, processing, and marketing (M), the farm organization (F), the consultancy (D), and the external assistance component (X). Each component consists of a set of organizations organized around a common goal. These components are placed on the diagonal cells of Table 1 (henceforth Linkage Matrix) and their linkages on the off-diagonal cells. The first row of this matrix presents the information obtained from the organizations in P, the second row in R, the third row in E, etc. Thick arrows on the matrix show the direction of linkages. Finally, Table 2 lists the key factors constraining the operation of and the linkages between the components.

i. The policy component

Operating under the Cabinet of Ministers, 5 key units characterize this component. Established in 1993, the State Committee for Science and Technology (SCST) coordinates all of the science and technology-related activities of ministries, committees, and state joint-stock companies, supports the Cabinet in the formulation of science and technology policy, sets research priorities, manages the information system, and supervises patent-license activities. It approves all the budgets for these activities. The Ministry of Agriculture (MoA) supports the Cabinet in the formulation of national agricultural policy. The Ministry of Education (MoEd) governs all the educational activities and supports the Cabinet in the formulation of national educational policy. The Ministry of Finance (MoF) supports the Cabinet in the formulation of national budgetary policy, and finally, the Ministry of Economic Development (MoED) supports the Cabinet in the formulation of development policies. There are also several committees responsible for the formulation of agricultural policy in general, and agricultural research policy in particular. For example, the State Land Committee, State Amelioration Committee, the State Commission for Agricultural Reforms, the State Commission for

Figure 1. Organizational structure in the agricultural innovation system of Azerbaijan

Table 1. Linkage matrix

Policy Component (P) (Reorganization)	Formal & weak	Formal & weak	Formal & weak	Mixed & weak				Formal & medium Priority setting Program development & review
Formal & weak	Research Component (R) (Reorganization)	Formal & weak		Mixed & weak	Mixed & medium	Informal & medium	Informal & medium Information sharing Problem diagnosis Technology diffusion Exchange of staff	Formal & weak Workshops/seminars Information sharing Personnel training
Formal & weak	Formal & weak	Education Component (E) (Reorganization)				Informal & weak	Informal & medium	Formal & weak Workshops/seminars Information sharing
Formal & weak			Credit Component (C) (Reorganization)					Formal & weak
Formal & medium Information sharing	Formal & medium Information sharing			Extension and Information Component (I)		Formal & medium Program development Problem diagnosis Priority setting Tech diffusion/demonstration Training	Formal & medium Program development Tech. diffusion Info&finance sharing Workshops Seminars	Formal & weak Tech. diffusion & demonstration Information sharing
Formal & medium	Informal & medium				Private Enterprise Component (M)	Mixed & medium Tech. demonstration Training		Mixed & weak Program development Tech. development Workshops
Informal & medium Information sharing	Informal & medium Information sharing Problem diagnosis Technology diffusion Exchange of staff	Informal & weak Information sharing			Mixed & weak Tech. demonstration Training	Private Farm Component (F)		
Informal & medium Information sharing	Informal & medium Information sharing Problem diagnosis Technology diffusion Exchange of staff	Mixed & medium Information sharing		Formal & weak Program development Sharing of info. & finance Workshops	Informal & weak	Mixed & medium Problem diagnosis Priority setting Technology diffusion & demonstration	Private Consultancy Component (D)	Formal & weak Program development Tech. diffusion Info & finance sharing Workshops
Formal & medium Priority setting Program development Program review	Formal & weak			Formal & strong Priority setting Program development Technology development Technology diffusion and demonstration Information sharing	Mixed & weak	Formal & medium Problem diagnosis Program development Tech. demonstration Information sharing Training	Formal & medium Program development Tech. diffusion Info&finance sharing Workshops	External Assistance Component (X)

Table 2. Factors constraining the operation of and the linkages between the components

Policy	Unclear science and technology policy; heavy reorganizations; excessive organizational fragmentation; overlapping mandates; limited qualified human resources; lack of appropriate sources of finance; limited physical resources; inoperative information dissemination units; limited sharing of facilities
Research	Unclear mandates; absence of agricultural research priorities; excessive fragmentation of the research system; heavy reorganizations; lack of appropriate sources of finance; limited qualified human resources; over employment; poor access to knowledge and information on new technologies; inefficient use of existing resources
Education	Unclear agricultural education policy; limited physical resources; lack of finance; absence of supportive procedures and regulations; poor system linkages; limited qualified human resources; low mobility of experts; inadequate access to information
Credit	Agricultural credit institutions are not yet operating.
Extension & Information	Farmers' lack of interest in extension services; lack of initiatives to utilize the existing agricultural knowledge and information stock; organizational rigidities and long administrative procedures in public offices; weak co-operation between private and international organizations; limited qualified human resources; inadequate access to information on markets; and inadequate sources of finance
Private Enterprises	Limited managerial skills; limited physical resources (e.g., computer-based information sources and storage facilities); information on market developments; high customs duties and cross-border difficulties; long procedures for quality control; farmers' lack of interest in and poor capacity to utilize new seed varieties; lack of mechanisms (e.g., workshops and seminars) to obtain information on international markets; weak legal framework; ineffective monetary transactions
Farm organizations	Lack of land large enough to think about farming for markets (for small farmers); cross-border difficulties; lengthy quality control process for imported inputs; lack of knowledge about the imported new varieties; underdeveloped market infrastructure (roads, transport, communication, etc.); excessive economic risk; poor farm management skills; lack of access to information sources
Private Consultancies	Unclear agricultural priorities; farmers' weak response to the developments in the market; low public awareness on environmental problems; long administrative procedures; inadequate access to market information; inadequate international linkages; weak client linkages; lack of proactive research
External Assistance	Communication difficulties faced in relations with policy makers; insufficient local capacity for project collaboration; limited qualified personnel; inadequate material and financial resources of national collaborating parties; weak legal system

Assistance to Agricultural Private Farm Sector (SCAAPFS), and Agro-Industry Unit all contribute one way or another to the design and implementation of agricultural policy.

Currently, the existing science and technology infrastructure is functioning poorly due to the absence of a clear direction at the national level, the continuing changes in science and technology-related organizations, and excessive fragmentation and reorganization of the policy organizations. One serious obstacle facing this component is that new tasks and new linkages assigned to the ministries lead to overlapping responsibilities due to still unclear territories between the Ministries. Furthermore, the SCST is at a standstill due to the absence of science and technology priorities at the national level and the lack of qualified human resources at the organizational level. In general, public organizations are in serious need of more and qualified personnel, physical resources, and financial resources. Skilled personnel and infrastructural facilities, such as buildings, computers, office appliances, are all lacking.

ii. The research component

This component consists of a total of 26 research institutes: 15 under the Agrarian Science Center of Azerbaijan (ASCA) of the MoA and 11 under the Academy of Sciences and several committees. Of these 11 institutes, 6 belong to the Academy of Sciences, 3 to the Committee for Water Economy, 1 to the State Land Committee, and 1 to the “Azerforest” industrial amalgamation. Established in 1999, the ASCA is responsible for the coordination of agricultural research carried out by institutes under its domain. For research purposes, the MoA has experiment stations, base stations, subsidiary experiment farms, and 20 thousand hectares of land. The other 11 research institutes do not yet have clearly defined relations with the ASCA. Although the SCST is to co-ordinate research programs of all research institutes in the country, no initiative is taken to address the problem of a two-headed agricultural research system.

Established in late 1996, the Agency for Support to the Development of Private Agricultural Sector (ASDPAS) supervises projects initiated by donors and international development agencies. The Agency is directly responsible towards the State Commission for Assistance to Agricultural Private Farm Sector and manages the Farm Privatization Project (FPP). Started in 2000, the Agricultural Development and Credit Project (ADCP) is a second project managed by the ASDPAS. Started in 2001, a third project of the ASDPAS is the Development of Mountainous and Highlands Project. The Agricultural Research Board (ARB) formed in March 2000 coordinates the Competitive Grants System and Knowledge System Reform component of the ADCP. The Board is directly responsible towards the SCAAPFS. In near future, grants would be available for research on a competitive basis, and the ASCA and other research institutes are expected to develop research proposals. The Secretariat of the ARB is to monitor the projects funded.

After 1991, research institutes entered into a period of calamities. The conditions forced them to use experimental stations to generate income. The institutes have developed relations with private seed supply and plant protection companies, and also kept close relations with large private farms. Although uncommon, experts in the experimental stations have now and then developed relations with international organizations via joint projects. The research component needs just about everything. It needs a mandate, qualified personnel, sources of finance, and access to knowledge and information on new technologies. Research has dwindled to nothing due mainly to the absence of agricultural research priorities, limited financial resources, unclear funding mechanisms, and disqualified personnel. Furthermore,

this component is overly divided into separate bodies, making it very difficult to manage and coordinate the institutes. Finally, with the competitive grants, the research institutes have got an opportunity to survive. But, it requires them to downsize their personnel in order to conduct effective research. Even the government has stressed the fact that those institutes in the areas of silkworm breeding, viticulture, fruit and vegetable farming need to be reorganized according to the needs of the country.

iii. The education component

This component includes universities (25 public, 17 private) and colleges (73 public, 4 private). Newly established in 2001, the Agricultural Education Department of the MoEd assumes responsibility for administrative coordination and curriculum preparation of these education institutions, however, as of now only 21 agricultural colleges and one Agricultural Academy are under its domain. The Head Department of Scientific Research, Education, and Personnel Training (HDSREPT) of the MoA is responsible for administrative coordination of research, education, and training programs. In addition to this, the Agricultural Academy independently engages in both teaching and theoretical research. The agricultural colleges, on the other hand, engage in both teaching and applied research. Through the HDSREPT, the MoA supervises post-graduate education of students accepted (a total of 8-10 post-graduate students a year) to the 15 research institutes of the ASCA. Moreover, there are several agriculture-related faculties in the Azerbaijan State University and other engineering and technical universities.

Efforts should focus on potentially problematic issues. Experimental stations, pilot farms, and other applied research facilities are still under the control of the research institutes of the ASCA of the MoA, while the agricultural colleges under the MoEd need these facilities to conduct field studies. It is highly likely that such allocation of resources will jeopardize quality education in the colleges.

Constraints faced by education institutions are abundant. At the ministerial level, linkages are not well defined creating organizational communication problems between the MoEd and the MoA. Unclear roles and tasks at the departmental level slow down daily operations. The lack of qualified personnel, a low degree of expert mobility between related departments, the lack of appropriate sources of finance, and inadequate access to information are among the key problems encountered today. Externally, the education component is adversely influenced by an unclear agricultural education policy and the lack of educational priorities.

iv. The extension and information component

Established in 1998, the Information Dissemination Unit (IDU) of the MoA is responsible for the management of agricultural knowledge flow at the national level. The Unit supports the introduction of new techniques or methods for gathering information on the current status of farming, provides farmers with extension services, and disseminates information on the new techniques farming techniques. Progress has been made regarding its objectives, procedures, client linkages, resources, and program. Private enterprises are also active in the extension and information component. Agro-business firms, agro-consulting centers, and water user associations emerged around the pilot study areas of the ADCP and the FPP.

Established in 2000 within the ADCP, the Information and Consulting Services Center (ICSC) coordinates information and extension services. Through its regional branches, the ICSC provides extension services to people with land but without farming skills, without

knowledge of how to prepare business plans or to apply for credits or loans. The ICSC also disseminates results of projects implemented within the context of the competitive grants program. The ICSC has recorded progress especially in the area of organizational structure, human and physical resources, information flows, program planning and output. Recent changes in the legal system, promoting private consultancy services, are also regarded as forward-looking.

So far, project-based extension services were used to meet current needs, initiated exclusively by international organizations. These services quickly attracted private companies. Private seed and plant protection companies also offer extension services to increase their market share. The IDU of the MoA is the third actor in this component. These diverse and independently initiated efforts point to the need for organizing them around a common ground. The public sector should play a more active role on this ground as, at the moment, such services promise social benefits higher than private benefits.

The existing agricultural knowledge and information is not utilized effectively in analyzing the current and emergent trends in agriculture. There is also the need on the users' side and the demand on the decision makers' side for a systematic approach to structure the existing information inventory but financial support is lacking. Actors involving in the diffusion of agricultural are diverse. Experts in research and education institutions, professional meetings, international networks, computer-based information services, mass communication means are among them. Sources of funding for information and extension services are also diverse. The activities of the IDU are financed from the government budget, those of private companies through client contracts, subcontracts with international organizations, and sometimes by own resources. Project-based activities are funded by international development agencies.

International organizations, private consultancies, farmers, and several research institutes are the major actors in this component. Typically, they use linkage mechanisms such as planning and review, technology diffusion, exchange of personnel, and sharing of information. Unsurprisingly, the IDU of the MoA, private seed-marketing firms, and large farms are also in close contact. Problem diagnosis, programme planning and review and joint resource use are among the most commonly practised linkage mechanisms.

International organizations and private enterprises are the most dynamic units in this component. Obstacles most commonly faced are attributed to organizational rigidities and long administrative procedures. Weak co-operation between private and international organizations and farmers' lack of interest in extension services are also mentioned as constraining. Qualified personnel, adequate access to market information, and adequate sources of finance are demanded highly.

v. *The private input supply, processing, and marketing component*

The private input-supply, processing, and marketing activities are not yet specialized. Typically, a firm engages in all of these activities. Presently, the number of such firms amounting to about 20 is increasing, and they are expected to bring competition and specialization in the near future. Some of these firms have grown out of the pre-independence co-operatives, while others have been newly established.

The processing sector is waiting for the privatization. Of 1759 agricultural processing firms under the Ministry of State Property for Privatization, 1121 are involved in food processing, 540 in weaving, 98 in leather processing, and 42 can food. The cotton sector has experienced

a relatively speedy privatization. At the moment, two international companies control almost 90 percent of the cotton production. They engage in contractual arrangements with farmers, supply all the required inputs for the cotton production, and buy the raw cotton from farmers. In most cases, these companies are also involved in farmers' training on the use of chemicals, watering, etc. After the harvest, the raw cotton is processed in their processing plants and the final product is sold in the world market.

Meat and milk products were and still occupy an important place in people's diet. Forty percent of total household food expenses are for the purchase of milk and dairy products, 26 percent for meat and meat products. For such a vital sector, recent developments are not as significant, although the market for dairy products shows some progress. Joint ventures are the dominant form of business initiated especially by multinational companies. Examples include a joint venture seed marketing firm and two plant protection material supply firms. They all engage in the seed multiplication, processing, import, marketing, and seed protection materials. They also carry out extension services to train customers on how to cultivate crops and use agricultural chemicals.

Five trends emerge in the private input supply and marketing sector. First, private input supply firms gradually make themselves known, specializing largely on the supply of seeds and plant protection materials. Second, large farms operate as producers, processors, and middleman. Third, monopolistic cotton companies engage in the complete chain of production. The chain starts from contractual arrangements with farmers. Inputs are provided to farmers, rarely public irrigation channels rehabilitated, raw cotton harvested and processed and then sold in the world market. Fourth, international companies are transmitters of new seed varieties (grains, vegetables, cotton) and of chemicals, pesticides, and herbicides. Finally, these firms also engage in extension services such as field demonstrations of input use.

The linkages of these private firms with other entities depend on the way the firms have emerged and on the type of product they are interested in. For example, the firms that grew out of the pre-independence co-operatives continue to have relations with research institutes of the MoA. Their only new relation is with international input supply companies. In this connection, these firms have developed "intimate" relations with the Seed Quality Control Unit (QCU) of the MoA. These firms are in close relation with research institutes, the QCU, international seed supply firms, and farmers. They engage in joint problem diagnosis with experts from the research institutes, field demonstrations and training sessions with local customers, and the preparation of TV programs and of information booklets for farmers.

These firms suffer from inadequate access to information on market developments and the lack of up-to-date managerial skills. High customs duties, cross-border difficulties with Russia and Armenia, long procedures for seed quality control, farmers' lack of demand for and poor capacity to utilize new seed varieties, and a weak legal framework for contractual arrangements, land titling, and monetary transactions are also among common complaints. For cotton producers, the situation is somewhat different. The cross-border problems and difficulties in money transactions are more pressing for them owing to the fact that they can only sell their products in the world market. Executives of the firms have direct relations only with top-level bureaucrats, international input supply firms, and with farmers.

vi. *The farm component*

Large farms could play a considerable role in the diffusion of new technologies, as they perform production, processing, and marketing activities simultaneously. They benefit from their structural suitability to the irrigation infrastructure, relatively easy access to other farm inputs, and their close connections with experimental stations of research institutes. Small farms, on the other hand, literally lack everything, but most important of all, they lack land large enough to think about market production. They also lack the knowledge and skills required for market oriented farm production. Small private farmers in the cotton sector are exposed to new imported machines that indirectly benefit them in two ways. First, they are exposed to new technologies, and second, they learn new business procedures (such as leasing).

Large and small farms paint an opposite picture regarding their linkages and problems. A majority of farms privatised in 1993 were large since they were the first wave to break away from the old kolхозes. The managers of these kolхозes often bought the farms that they were operating for years. Naturally, their pre-existing ties were kept alive with the policy, research and education, input supply, processing, and marketing components. In addition, with independence, they developed links with international organizations. Small farms are, however, a simple expansion of garden plots, and thus, their relations are often with large farm operators. The existing regional farm associations are first not active, and second, they are likely to address the needs of large farms, if they active at all because the associations are usually run by large farm operators who maintain their old relations with policy makers.

Large farms have contacts with researchers at experimental stations, and are engaging in joint problem diagnosis, technology development, and exchange of personnel. On the education side, they have informal contacts with graduate students and professors. They develop relations with input supply firms and input supply enterprises, and rarely through project implementation they develop relations with international organizations that offer new seed varieties and new farming techniques. With them, these farms are involved in joint program development, problem diagnosis, technology demonstration, training, and information sharing. Large farms also developed relations with private input supply firms providing pesticides, agricultural chemicals, and fertilizers.

Large farms complain about the cross-border difficulties faced in seed importing and about lengthy seed quality control. Marketing is also hard due to customers' lack of knowledge about the imported new seed varieties. The conditions become more disadvantageous when one adds underdeveloped market infrastructure and excessive economic risk involved. These farms have also expressed a few weaknesses including inadequate farm management skills and lack of access to information sources. A different picture emerges in the cotton sector. Producers complain that infrastructural conditions are poor for cotton farming, that farmers do not comply with the terms of contracts, and that the banking sector is not efficient in monetary transactions. Farmers, on the other hand, complain that they are trapped into cotton farming, and that the legal system is too weak to protect them against monopolist producers.

vii. *The private consultancy services component*

With the passage in 1998 of the law allowing for private consultancy firms, as many as 35 firms emerged that employ academicians, researchers, and post-graduate students. Their activities are clustered around international development agencies and donors. Most of these firms, which are spin-off entities growing around the ICSC, help farmers find appropriate

sources of credits, help them prepare business plans, and carry out public awareness activities. Simply, they supply knowledge that has until recently been locked in academies and research institutes. Their constantly increasing number implies that the market for knowledge is emerging.

Several trends emerge in this component. First, the majority has already developed project-based relations with international development agencies and donors. Second, the majority has one foot in the private and the other in the public sector. Third, joint activities are not engaged in with public organizations, although for some it is unavoidable to develop such relations, as their unit of investigation is the environment. Fourth, they are all relatively new, and therefore, are in the process of formulating their objectives and activities.

Typically, a consultancy firm develops relations with international organizations and the ASDPAS. The firms hardly consider joint project execution among themselves, although there is a need for it. They have specialized and tacit knowledge. With skilled and energetic staff, they are capable of quickly adapting to changing conditions. But, they are not proactive in business due to the lack of knowledge and expertise in preparing project proposals and to inadequate international and national linkages. Now, they play a pivotal role, facilitating international organizations to effectively operate, and they strongly depend on subcontracts with international organizations.

Their immediate linkage with the ASDPAS is characterized by joint program development, review, and evaluation. With international organizations, they develop joint programs, participate in joint technology diffusion, and share information and financial resources. With agricultural research institutes, they develop joint programs, participate in technology diffusion activities, and rarely use facilities and staff jointly. With farmers, they engage in joint problem diagnosis, priority setting, technology demonstration and diffusion activities. And finally, they further develop linkages with private input suppliers, processors, and marketing agents. These firms obtain innovation-related information from policy makers, research institutes, large processing firms, universities, computer-based information sources, and professional meetings.

The lack of clear agricultural priorities, farmers' weak response to market developments, low public awareness on environmental problems, and long administrative procedures are viewed as the key constraining factors. Among organizational weaknesses they face are inadequate access to market information, inadequate international linkages, weak client linkages, and the lack of proactive research.

viii. The agricultural credit component

Extensive efforts are made to restructure and reorganize the banking system, which by the end of 1999 comprised 70 banks. Four state-owned banks dominated the banking system, basically extending loans to public enterprises but no credit to the agricultural sector (IMF, 2000). At present, it appears that no strategic plan has been put into effect to finance the agricultural sector. Preparations are underway to merge the Agro-Industry and Security banks to create a Universal Bank. But, it is not likely that it will extend credits to private farmers. Most credits and/or loans are expected to flow into the industrial sector. Recently, the government has established an oil fund to help mobilize resources to rural sector in general, and to the agricultural sector in particular. The government further reduced the number of taxes to one (land tax) varying in the range of USD 5-25 for a year.

The cycle of life in the rural sector normally consists of the “effective right” to use land as collateral, land titles, access to credits (if there is any), and a rural insurance scheme. There is a law allowing land to be used as collateral, but land parcels under private farming are too small to use for this purpose. For poor farmers, land seems to be the only asset to secure a small amount of credit. But, credit is not the only thing they need. In fact, before credit they need the skills to prepare business plans to apply for credits. Moreover, a rural insurance system is of great demand to secure investment in farming.

ix. The external assistance component

This component includes a variety of international development agencies, donors, and international NGOs, and has been the key entry point for new or improved knowledge, processes, and practices. Joint project-based activities are the means for exposing national entities to international standards. These activities are usually carried out in collaboration with private consultancy firms, as they have relatively better human and physical resources and have flexible organizational structures. Public entities, however, have been slow in adapting to international standards due to continuing organizational changes and lack of qualified human resources.

These organizations very often engage in project-based capacity-building activities. Together with national counterparts, they carry out such activities as the optimal application of agricultural chemicals, preparation of official documents, provision of advisory services, and (rarely) the testing of new varieties of seeds.

Three types of linkages evolve between international organizations and the rest of the system. First, formal relations are developed with policy units in order to legitimize goals of the projects undertaken by these organizations. Second, direct interactions are developed with beneficiaries of the projects. Close contacts are developed with farmers through training programs for promoting new farming techniques and agri-business practices. Third, formal and informal relations are growing with private market participants. Program outputs are disseminated through newsletters, memos, and TV programs.

International organizations expose the country to new processes. However, the incomplete and weak legal framework hinders their performance. The existing legal framework does not fully address the problems of the country. Around one million internally displaced people are the center of attention for international NGOs and development agencies, and their immediate activities require quick decisions on the government side; however, slow, unclear, and strict procedures in public offices jeopardize the effectiveness of their activities.

Local conditions seem largely unfavourable to international organizations having clear mandates and policies but suffering from the lack of qualified local personnel. They experience serious difficulties in joint program planning. However, in the last couple of years, the situation seems to be improving as to client linkages, qualified human resources, and joint programme planning. But, policy environment is still viewed as constraining. The weak legal system and local organizations' inadequate material and financial resources hamper the development of linkages.

ANALYSIS OF THE AISA

Linkage Matrix presents a structure for the linkages in the AISA. The cross-component linkages are first mapped on the basis of formal (*f*), informal (*i*), or mixed (*m*) relations and then on the basis of weak (*w*), medium (*m*), and strong (*s*) relations. Also indicated in this

matrix are the cross-component linkages established through specific linkage mechanisms. The matrix is presented in two formats: **S** for the linkage types and **S[m]** for the linkage mechanisms actively used. Then, the AISA is characterized by using the graph-theoretic concepts described in Appendix.

Placed on the diagonal cells of **S** are the components of the system and on the off-diagonal cells are cross-component relations. The notation (*fw*) stands for formal-weak relation, (*fm*) for formal-medium, (*fs*) for formal-strong, (*iw*) for informal-weak, (*im*) for informal-medium, (*is*) for informal-strong, (*mw*) for mixed-weak, (*mm*) for mixed-medium, and (*ms*) for mixed-strong. Zeros that appear in some of the off-diagonal cells indicate either a nonexistent or a negligible linkage, or a linkage that the investigator was unable to identify. The format **S** is not fully identified, with a total of 72 relations of which only 45 are identified. Hence, it has a density of 0.63 (= 45/72). Secondly, C is fully detached from the rest of the system. Thirdly, **S** is fairly flexible, reflected by formal, informal, and mixed cross-component linkages. Of 45 identified relations, 25 are formal, 11 informal, 9 mixed. Fourthly, the public (P, R, E) and the private (I, M, F, D) components are at early stages of development, reflected by the dominantly informal relations between them. Equivalently important is the willingness of (M, F, D) to develop contacts with P, which is implied by (*fm*, *im*, *im*) in the first column and (0, 0, 0) in the first row. Fifth, the relationship between the private components is much stronger than that between the public components. The relations among P, R, E, and C are all formal and weak, while those among I, M, F, and D are overwhelmingly at medium strength. Lastly, X has developed relations with all the components in the system. Among these relations, the strongest ones are with I, F, D, and P.

Assigning 1 to a weak, 2 to a medium, and 3 to a strong relation in **S** yields **S[r]** that allows to establish the cause-effect structure in Figure 2. (Because of the difficulty to assign a value to a formal or informal relation, the analysis does not utilize this information.) According to the structure, D has considerable control over the system; its effect on other components is much greater than others' effect on it. Interestingly, however, R is highly interactive³ with the rest of the system, and it is followed by X, I, E, and M. Furthermore, P is found to be the most subordinate, followed by F, since it is influenced by others more than it influences them. Lastly, C has very low interaction with the rest of the system.

It seems quite reasonable to assume that weak, medium, and strong linkages generate weak, medium, and strong influences, respectively. Incorporating this assumption into **S[r]** would yield an influence-adjusted matrix, denoted by **Adjusted S[r]**⁴, and its underlying cause-effect structure is shown in Figure 3. Comparison of Figures 2 and 3 indicates that the adjustment made creates a polarized structure, one in which P and F are the most subordinate, D and X the most dominant, and I the most interactive components. R has a special place in the system: it is the most interactive component of the public sector and is influenced more than it influences others.

The system **S[m]** represents only those links established through specific linkage mechanisms. This system has a density of 0.35, which is very low compared to the density 0.63 of **S**, and Figure 4 indicates its cause effect structure. According to this structure, the private and public components tend to polarize even more. The private components (D, I, F, X) move towards the northeast corner of the figure, while the public components (P, R, E) move towards the

³ Points on the 45-degree line in the Cause-Effect diagrams represent the case in which cause is equal to effect.

⁴ See Appendix for the construction of this matrix.

southwest corner. D remains to be the dominant component, which is followed by I. The component F is most interactive. On the other hand, P remains to be the most subordinate component, followed by X. Interestingly, the component M shows low interaction with the rest of the system, reflected by the fact that firms under M usually develop informal relations and use linkage mechanisms at a minimal.

Visual format of $S[r]$ below is an alternative representation of the matrix $S[r]$, helping to detect visually the areas where information is lacking. A cell coloured by light (dark) grey implies that linkage information between the relevant components is weak (medium). For example, three white cells in the 1st row imply that P did not declare any significant activity relating to M, F, and D. But, the very same components declared considerable activities relating to P implied by the corresponding dark grey cells in the 1st column. In a similar fashion Visual format $S[m]$, alternative to the matrix $S[m]$, indicates the areas (denoted by black cells) where linkages are constructed only through linkage mechanisms.

$$S^5 = \begin{bmatrix} P & fw & fw & fw & mw & 0 & 0 & 0 & fm^1 \\ fw & R & fw & 0 & mw & mm & im & im^1 & fw^1 \\ fw & fw & E & 0 & 0 & 0 & iw & im & fw^1 \\ fw & 0 & 0 & C & 0 & 0 & 0 & 0 & fw \\ fm^1 & fm^1 & 0 & 0 & I & 0 & fm^1 & fm^1 & fw^1 \\ fm & im & 0 & 0 & 0 & M & mm^1 & 0 & mw^1 \\ im^1 & im^1 & iw^1 & 0 & 0 & mw^1 & F & 0 & 0 \\ im^1 & im^1 & mm^1 & 0 & fm^1 & iw & mm^1 & D & fm^1 \\ fm^1 & fw & 0 & 0 & fs^1 & mw & fm^1 & fm^1 & X \end{bmatrix}$$

$$S[r] = \begin{bmatrix} P & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 2 \\ 1 & R & 1 & 0 & 1 & 2 & 2 & 2 & 1 \\ 1 & 1 & E & 0 & 0 & 0 & 1 & 2 & 1 \\ 1 & 0 & 0 & C & 0 & 0 & 0 & 0 & 1 \\ 2 & 2 & 0 & 0 & I & 0 & 2 & 2 & 1 \\ 2 & 2 & 0 & 0 & 0 & M & 2 & 0 & 1 \\ 2 & 2 & 1 & 0 & 0 & 1 & F & 0 & 0 \\ 2 & 2 & 2 & 0 & 2 & 1 & 2 & D & 2 \\ 2 & 1 & 0 & 0 & 3 & 1 & 2 & 2 & X \end{bmatrix}$$

⁵ The linkages with a superscript 1, which represent those established through specific linkage mechanisms, are used to construct $S[m]$.

$$\text{Adjusted } S[r] = \begin{bmatrix} P & 0.33 & 0.33 & 0.33 & 0.33 & 0 & 0 & 0 & 1.32 \\ 0.33 & R & 0.33 & 0 & 0.33 & 1.32 & 1.32 & 1.32 & 0.33 \\ 0.33 & 0.33 & E & 0 & 0 & 0 & 0.33 & 1.32 & 0.33 \\ 0.33 & 0 & 0 & C & 0 & 0 & 0 & 0 & 0.33 \\ 1.32 & 1.32 & 0 & 0 & I & 0 & 1.32 & 1.32 & 0.33 \\ 1.32 & 1.32 & 0 & 0 & 0 & M & 1.32 & 0 & 0.33 \\ 1.32 & 1.32 & 0.33 & 0 & 0 & 0.33 & F & 0 & 0 \\ 1.32 & 1.32 & 1.32 & 0 & 1.32 & 0.33 & 1.32 & D & 1.32 \\ 1.32 & 0.33 & 0 & 0 & 2.97 & 0.33 & 1.32 & 1.32 & X \end{bmatrix}$$

$$S[m] = \begin{bmatrix} P & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & R & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & E & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & C & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & I & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & M & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 & 0 & 1 & F & 0 & 0 \\ 1 & 1 & 1 & 0 & 1 & 0 & 1 & D & 1 \\ 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & X \end{bmatrix}$$

Figure 2. The cause-effect structure of $S[r]$

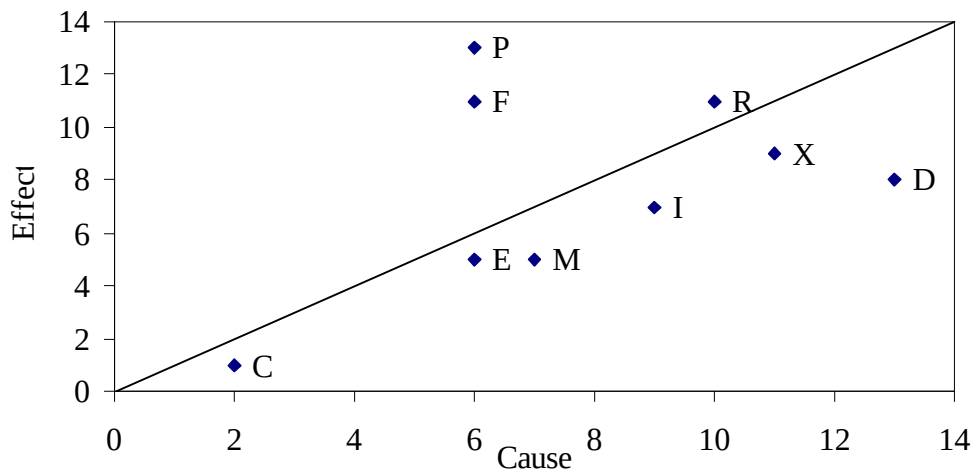


Figure 3. The cause-effect structure of **Adjusted S[r]**

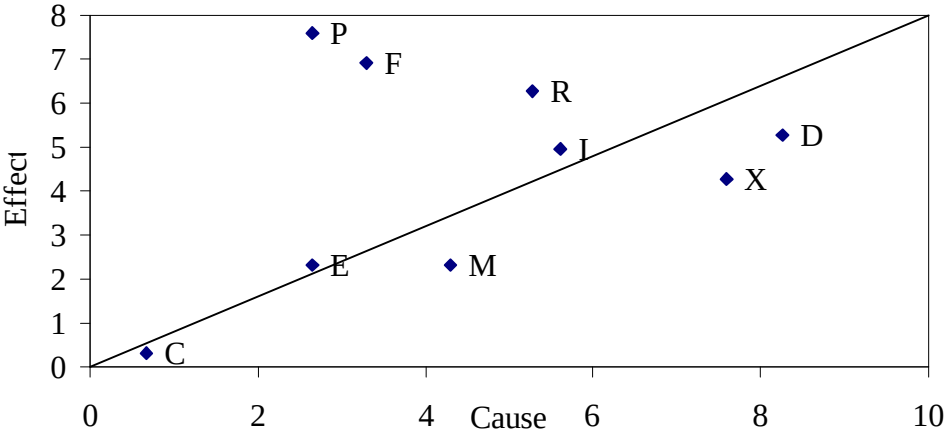
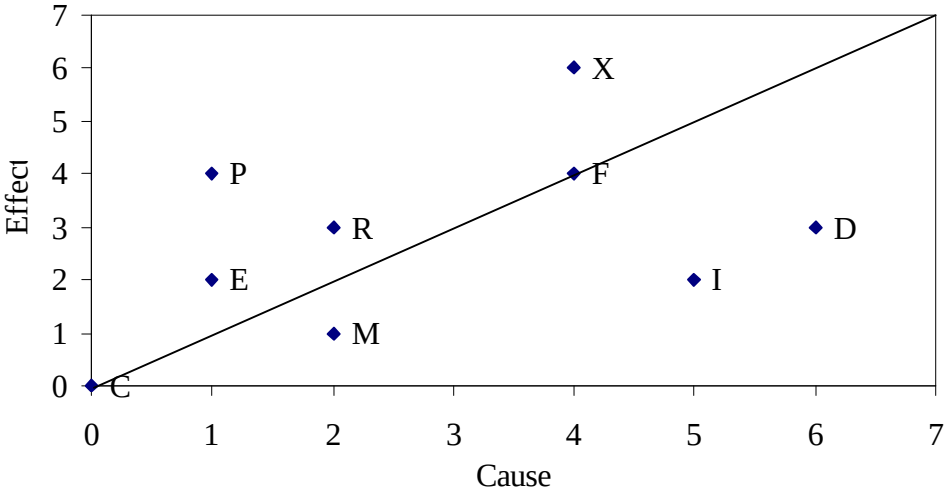


Figure 4. The cause-effect structure of **S[m]**



Visual format of **S[r]**

P								
	R							
		E						
			C					
				I				
					M			
						F		
							D	
								X

Visual format of S[m]

P								
	R							
		E						
			C					
				I				
					M			
						F		
							D	
								X

SUGGESTIONS FOR A BETTER SYSTEM OF INNOVATIONS

Spurring innovation culture should receive most attention at the moment because a system without innovation spirit cannot be successful even if it is fully occupied with all the hardcore infrastructural inputs. To date, public organizations in the system lack this spirit and have been preoccupied with the provision of basic services for obvious reasons. Private organizations, however, have been relatively more active in innovation activities, orbiting around international organizations. Tuning the existing knowledge infrastructure into development goals, if there is any, and supporting it with an effective intellectual property rights system, law enforcement mechanism, innovation-financing scheme, and human resources should usher a new generation of innovation activities. An enabling environment with these qualifications should also pave the way for the growth of interface agents that should glue related but disconnected organizations in the AISA.

A national agricultural policy, a science policy, and a technology policy are the prerequisites for an agricultural innovation system to operate. Setting agricultural research priorities, revitalizing the crucial parts of the research system and tuning them to market developments, and preparing curriculum of agricultural education institutions all require a clear direction at the policy level. In the design of these triple policies, the following considerations should receive special attention. First, labor and natural resource intensive pathways to growth are limited by the availability of natural and human resources and are subject to decreasing returns, while pathways driven by knowledge do not seem to face such constraint. Therefore, information/communication technologies and human capital are far more important than any other technologies. Secondly, consideration should be placed on the observation that the initial distribution of endowments determines the future knowledge accumulation pathway. Therefore, the future implications should be carefully thought of the privatisation of land and state-owned agro-processing enterprises, and remedies should be taken to avoid possible negative effects that are likely to emerge. Thirdly, globalization is expected to speed up regional technology transfers, as agriculture does not recognize administrative borders but is largely determined by the agro-ecological conditions. To this end, a national agricultural innovation system should be able to respond to cross-country externalities.

Information and knowledge should be considered a vital input that drives national innovation system. It brings good governance and financial soundness and improves the quality of human resources, and as a result induces improved interactions between the components of the system. The low degree of the partnership between public and private actors and of the operation of exchange and communication mechanisms characterizes the AISA. The interactions are to be developed to link P and R to M, F, and D. In this endeavour, priority

must be given to the establishment of a strong extension and information component because it is the key component that would facilitate the flow of information from the private sector to the policy and research institutions or vice versa.

Research should not be an isolated phenomenon; it can be integrated into the system at two stages. The first stage requires the abovementioned intermediary organizations and the private consultancy component to help R, M, and F exchange information. In the next stage, R could, through joint research activities with X, expose itself to global processes. With a successful completion of these stages, national research organizations would be able to enhance their research capacity and develop effective research priorities. The ultimate benefit of the success is that the research organizations would be able to take the lead in shaping the national research system according to the needs of the country.

Intermediary institutions, such as marketing associations, farmers' organizations, trade and commerce organizations, and platforms for constructive dialogues should play a more active role in bringing together the components I, M, F and P and R. Specifically, links between these components could be strengthened through policy dialogues where the intermediary institutions could pass information from I, M, F to P and R or vice versa. Such exchange of information should help P and R reassess agricultural policy and agricultural research priorities, respectively.

Stakeholders should be represented in research priorities. Typically, stakeholders exert pressure on the formation of research agenda through two channels. The first is to use funding as a threat, and the second is to influence general policy making through interest group activities. The important point to make is that these pressures are not always unproductive as they could provide information on the true preferences of actors that are directly or indirectly influenced by research results. Furthermore, NGOs, foundations, the private sector and other intermediaries might be important voices for farmer concerns, and might be important partners in the governance of agricultural research systems.

Effective financing mechanisms should be established and coupled with general guidelines of the agricultural, science, and technology policies. The allocation of resources, accumulating in the newly established oil fund, should be based on these guidelines. There is the need to speed up reforms concerning agricultural credit institutions, as the presence of sound financial sources would promote investment in agricultural on the one hand and induce synergy at least between the policy and the credit components of the AISA on the other.

CONCLUSIONS

This paper describes the AISA, analyzes linkages between its components, and recommends changes in its functioning. Adopting the systems approach, the paper uses graph-theoretic concepts to characterize the AISA. Three important observations are immediate from the analysis. Firstly, the essential elements of the AISA are at an embryonic stage, and significant accomplishments in policy-making, organizational development, research, education, and credit institutions are yet to come. Secondly, there is ample scope for intermediary organizations to glue the public and the private components of the AISA by facilitating quick and effective flow of knowledge. But, the development of such organizations strongly depends on the presence of an enabling legal environment and the availability of financial and human resources. Under the current conditions Azerbaijan lacks all. Thirdly, especially in public organizations flexible management styles should be practiced to avoid unnecessary deadlocks in their interaction with private organizations.

Future is full of challenges facing policy makers in Azerbaijan. The first and foremost challenge is to enhance the understanding of agricultural innovation system among policy makers, which is a necessary condition for the design and implementation of the coupled agricultural, science, and technology policies. During this endeavour, as argued by Cooper (1991), theoretical frameworks that have been developed from empirical studies of innovative firms in the industrialized countries could be of great importance since they could provide useful guidelines for policy studies in the region from at least two points of view. First, innovation theories contain insights into how and why technical capabilities are developed in the advanced countries. In effect, they give some new dimensions of meaning to the concept of “accumulation of local technological capabilities”, which has come to play an important part in technology policy in developing countries. Second, innovation studies have much to tell us about the structure of international markets, and this kind of information is important in defining strategies for non-traditional agricultural export development.

The second challenge is to develop methodological guidelines in order to evaluate empirically national institutional set-ups with the view of obtaining comparable results at the international levels. As argued by Capron and Cincera (2000), the present literature does not report any operational guidelines regarding the assessment of organizational linkages underpinning national innovation systems. Such guidelines could also be used as a benchmarking approach in the management of agricultural, science, and technology policies. An equivalently important issue, which has not received enough attention from the literature, is, as argued by (Nelson, 1993), the need for well articulated and verified analytical frameworks linking innovation systems to technological and economic performance.

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APPENDIX

A graph-theoretic method

Concept 1. A linkage matrix **S** is defined as a matrix that maps cross-component linkages relating to a specific goal. Consider the AISA. The goal of this system is to develop, diffuse, and apply new or improved technologies. For illustrative purposes, suppose that the AISA consists of 5 components: Policy (P), Research (R), Information (I), Farm organization (F), and External assistance (X). The components are placed in the diagonal cells, and following clock-wise convention, their linkages are placed in the off-diagonal cells of **S**.

$$\mathbf{S} = \begin{bmatrix} P & PR & PI & PF & PX \\ RP & R & RI & RF & RX \\ IP & IR & I & IF & IX \\ FP & FR & FI & F & FX \\ XP & XR & XI & XF & X \end{bmatrix}.$$

The term PR in the 1st row – 2nd column of **S** represents the linkage that representatives of organizations under Component P commonly claim to have had with those organizations under Component R. Likewise, the term RP in the 2nd row – 1st column of **S** represents the linkage that representatives of organizations under Component R commonly claim to have had with those organizations under Component P. The terms placed in the off-diagonal cells of **S** represent binary (or one-edge or one-to-one) linkages, meaning that the two components are linked with no intermediary linkages, like P→R. A linkage between P and R can also be established through a pathway, like P→I→F→R, which is called a three-edge pathway of linkages. The maximum number of edges is equal to $(n-1)=4$, where n denotes the number of components in **S**.

Concept 2. A coded linkage matrix **S[c]** is defined as a matrix with binary codes: 0 for absent and 1 for existing linkages. For illustrative purposes, we construct an arbitrary matrix **S[c]**,

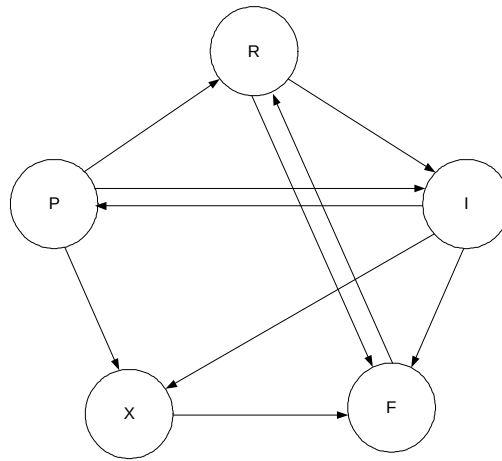
$$\mathbf{S[c]} = \begin{bmatrix} P & 1 & 1 & 0 & 1 \\ 0 & R & 1 & 1 & 0 \\ 1 & 0 & I & 1 & 1 \\ 0 & 1 & 0 & F & 0 \\ 0 & 0 & 0 & 1 & X \end{bmatrix}$$

where the component P has a linkage with R, I, and X, and the component R expresses a linkage with I and F but not with P etc. It should be noted that PR exists but RP does not, which is manifested by 1 in the 1st row – 2nd column and 0 in the 2nd row – 1st column of **S[c]**, respectively. This coding offers a way of representing something that is claimed to exist, and therefore, **S[c]** is not necessarily symmetric. Below, **S[c]** is shown in a different format to detect visual patterns, where black (white) cells indicate the existing (nonexistent) links:

Visual format of $S[c]$ =

P				
	R			
		I		
			F	
				X

A third format to represent $S[c]$ is to define it as a *digraph* (i.e., *directed graph*). The digraph consists of five vertices, P, R, I, F, X, and assumes an implicit function that translates the linkages into real values $\{0, 1\}$. Although it is difficult to recognize patterns immediately in the following diagram, this format has its own advantages.



Concept 3. The matrix $S[c]$ can be refined using the questionnaire described earlier. Individuals interviewed by using the questionnaire would provide opinions on the degree of linkages their organizations have developed with the rest of the organizations in the system. Since the answers to the questions are all expressed in scales, like none, weak, medium, and strong, we can assign to each scale a value: 0 for a nonexistent, 1 for a weak, 2 for a medium, and 3 for a strong linkage.⁶ This procedure would yield a vector of values representing the degree of linkages between the interviewed organization and the rest of the organizations in the system. Repeating the same procedure for each organization would result in as many vectors as organizations. Next, the components are defined as subsets of the organizations already characterized and the vector of values assigned to the organizations in each subset is reduced to an average vector by averaging over the relevant values. By averaging, we aim to reduce the dimensions of the system at hand from the number of organizations to the number of components. Suppose that repeating this procedure for each component yields the refined system $S[r]$,

⁶ Note that if the scale consists of such categories as “very harmful”, “harmful”, “neutral”, “useful”, and “very useful”, then an appropriate set of values to be assigned to these categories would be -2, -1, 0, 1, and 2, respectively. For more reading on measurement techniques for surveys with scaled questions, the reader is referred to Miller (1956) and Tull and Hwakins (1984).

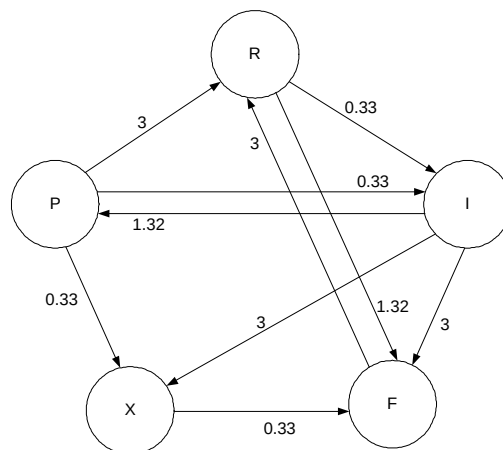
$$S[r] = \begin{bmatrix} P & 3 & 1 & 0 & 1 \\ 0 & R & 1 & 2 & 0 \\ 2 & 0 & I & 3 & 3 \\ 0 & 3 & 0 & F & 0 \\ 0 & 0 & 0 & 1 & X \end{bmatrix}.$$

The values in $S[r]$ represent the degree of binary linkages claimed only and that these linkages, by definition, do not imply direction of influence.

Concept 4. By adjusting $S[r]$, we transform the linkages to the influences between components. During the interview, questions are asked to determine how strongly the interviewed organization believes to influence the others in the system. Depending on the degree of claimed influence, which is scaled as none ($n=0$), weak ($w=0.33$), medium ($m=0.66$), and strong ($s=1$), $S[r]$ is adjusted as:

$$\text{Adjusted } S[r] = \begin{bmatrix} P & 3.s & 1.w & 0.n & 1.w \\ 0.n & R & 1.w & 2.m & 0.n \\ 2.m & 0.n & I & 3.s & 3.s \\ 0.n & 3.s & 0.n & F & 0.n \\ 0.n & 0.n & 0.n & 1.w & X \end{bmatrix} = \begin{bmatrix} P & 3 & 0.33 & 0 & 0.33 \\ 0 & R & 0.33 & 1.32 & 0 \\ 1.32 & 0 & I & 3 & 3 \\ 0 & 3 & 0 & F & 0 \\ 0 & 0 & 0 & 0.33 & X \end{bmatrix}.$$

Concept 5. The cause-effect structure of Adjusted $S[r]$ is established as follows. Cause (C) is defined as the influence of a single component on each of the rest of the components in Adjusted $S[r]$; and Effect (E), as the influence of each of the rest of the components on that single component. These definitions, together with the clock-wise convention that was followed in the construction of the matrix S , imply that rows (columns) in Adjusted $S[r]$ represent cause (effect). For example, the 2nd row indicates R's influence on P, I, F, and X, while the 2nd column indicates others' influence on R. The binary influences in Adjusted $S[r]$ can also be represented as a directed graph:



With a value of 3, the arrow from P to R indicates P's influence on R. Similarly, with a value of 1.32, the arrow from R to F indicates R's influence on F. Hence, the total cause of P on the rest of the system is 3.66, which is the sum of the values in the 1st row of Adjusted $S[r]$, and the total effect of other components on P is 1.32, which is the sum of the values in the 1st column of Adjusted $S[r]$. The C-E coordinates are then (3.66, 1.32) for P, (1.65, 6) for R,

(7.32, 0.66) for I, (3, 4.65) for F, and (0.33, 3.33) for X. The scatter plot of these coordinates in Figure 5 helps identify dominant and subordinate components. The component I is dominant, implied by the observation that it influences the system much more than others' influence on it. On the contrary, the component R is subordinate, implied by the observation that others influence it much more than its influences on others.

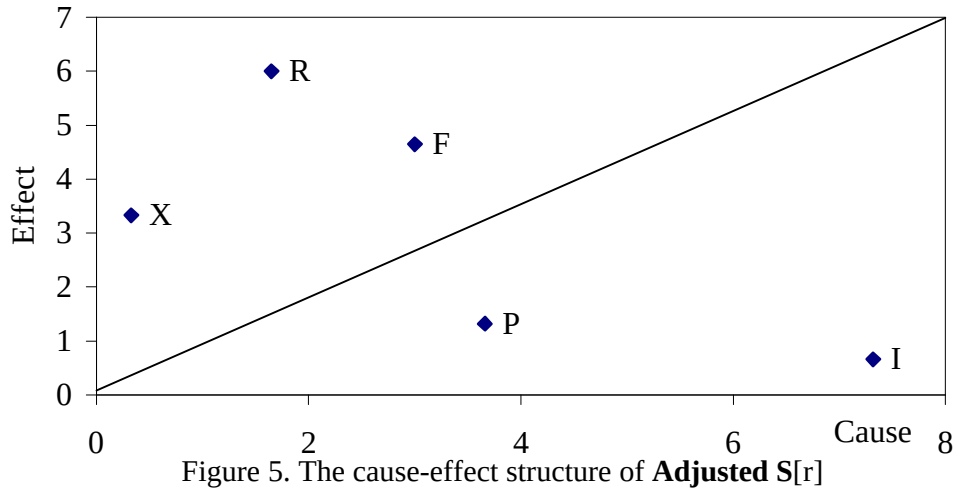


Figure 5. The cause-effect structure of **Adjusted S[r]**

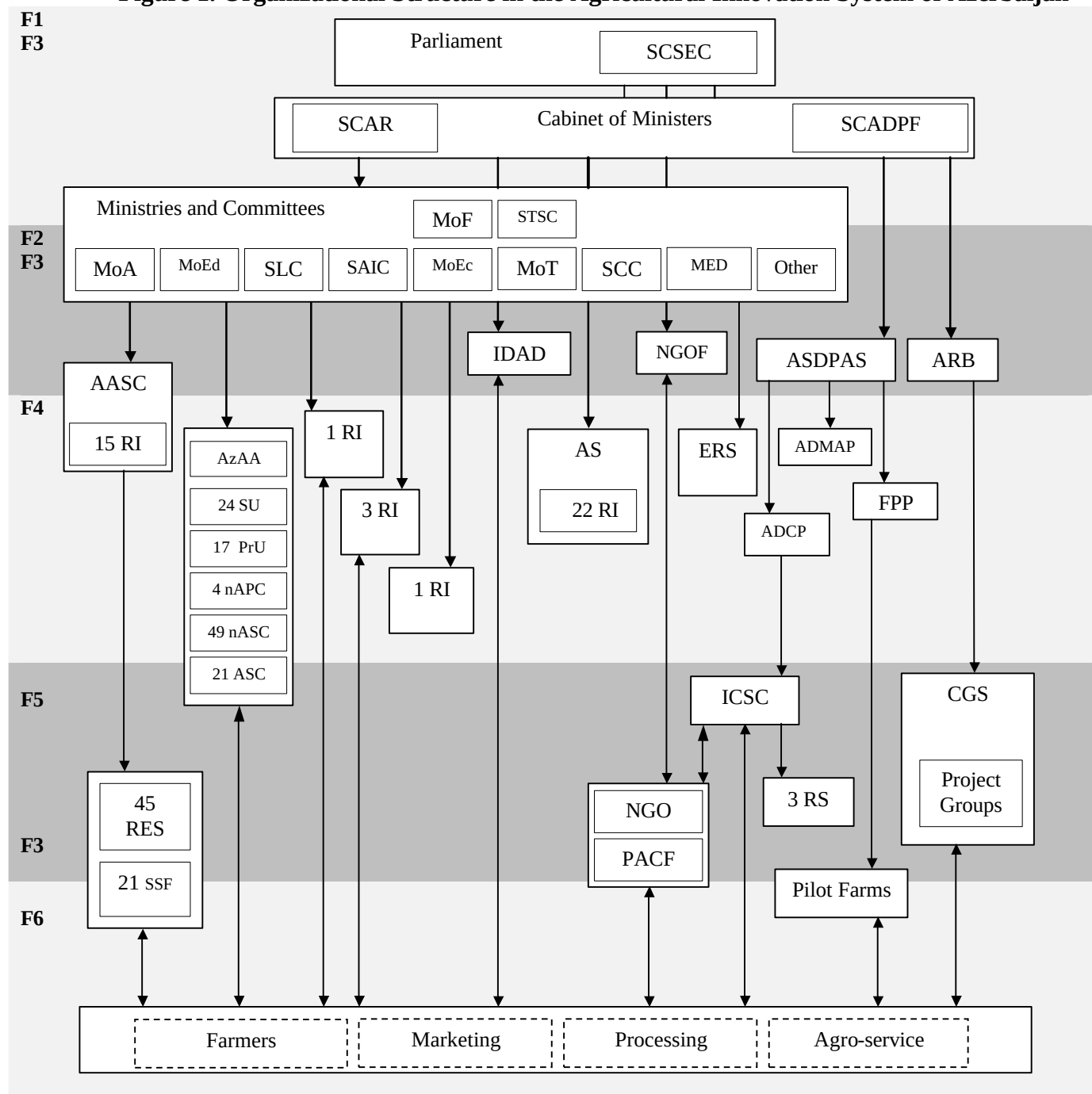
Concept 6. The density of *Adjusted S[r]*, denoted by d , is calculated as $d=b/[n(n-1)]$ with $1 \geq d \geq 0$, where b denotes the total number of existing binary influences, and n is the number of dimensions of *Adjusted S[r]*. Thus, *S[r]* has a density of 0.5, where $b=10$ and $n=5$. A structure is said to be fully identify if $d=1$, which implies that all the components positively influence each other.

Concept 7. A cluster is a subset of components concentrated around a (C, E)-coordinate. The C-E structure is a useful tool for visually detecting clusters in the system. This concept, useful especially in a system with a large number of components, helps identify subsystems and examine their characteristics.

ABBREVIATIONS AND ACRONYMS

ASCA	Agrarian Science Center of Azerbaijan
ADCP	Agricultural Development and Credit Project
ADMAP	Agricultural Development Mountainous Areas Project
ARB	Agricultural Research Board
AS	Academy of Sciences
ASC	Agricultural State Colleges
ASDPAS	Agency for Support to the Development of Private Agricultural Sector
AzAA	Azerbaijan Agricultural Academy
CGS	Competitive Grants System
ERS	Economic Reform Center
FPP	Farm Privatization Project
HDSREPT	Head Dept. Scientific Research, Education, and Personnel Training
IARC	International Agricultural Research Center
ICARDA	International Center for Agricultural Research in Dry Areas
ICSC	Information and Consulting Services Center
IDAD	International Development Agencies and Donors
IFAD	International Fund for Agricultural Development
GTZ	German Technical Support Society
MoA	Ministry of Agriculture
MoEd	Ministry of Education
MoED	Ministry of Economic Development
MoEc	Ministry of Ecology
MoF	Ministry of Finance
MoT	Ministry of Taxes
NGOF	Non-governmental Organizations Forum
nAPC	Non-agricultural Private Colleges
nASC	Non-agricultural State Colleges
NARS	National Agricultural Research System
NGO	Non Governmental Organization
PACF	Private Agro-Consulting Firms
PrU	Private Universities
RC	Regional centers
RES	Regional Experimental Stations
RI	Research Institutes
SCAR	State Committee for Agrarian Reforms
SCADPF	State Committee for Assistance to Development of Private Farms
SCSEC	State Committee on Science, Education, and Culture
SSF	State Seed Farms
SCAI	State Committee for Amelioration & Irrigation
SLC	State Land Committee
SU	State Universities
SCST	State Committee on Science and Technology
SCC	State Customs Committee
TACIS	Technical Assistance Committee for Independence States
USAID	United States Agency for International Development
UNDP	United Nation Development Program
WB	World Bank

Figure 1. Organizational Structure in the Agricultural Innovation System of Azerbaijan



Functions in institutional matrix

F1: General Policy making

F2: Policy formulation, co-ordination, supervision and assessment

F3: Financing R&E

F4: R&E Performance

F5: Technology diffusion

F6: Technology applying