Public-Private Partnerships for the Management of a Global Science and Technology Research and Development Network

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Problem Statement: Recent structural and process changes to the financing and generation of knowledge have facilitated the rise in the use of public-private partnerships (P3) for the management of science and technology R&D networks. We examine the global pulse-crop R&D network and its three sub-networks using social network analysis to graphically and statistically highlight the critical role that P3s occupy in the formation and management of a global R&D network.

Background: Pulse crops include peas, beans, lentils, chickpeas and faba beans, which are an important source of protein with twice the protein content of most cereal grains. Pulses provide about 10% of the total dietary protein in the world and are now grown on all continents. Pulse breeding is a R&D intensive process that incorporates the use of biotechnology, genomics and molecular biology. Furthermore, pulse crops are an "orphan crop" as the returns on investment is insufficient to warrant private-sector investment. Therefore, in response to this public goods failure, governments and producer organizations must form partnerships to finance and develop new technologies in order to stay competitive in a globalized marketplace.

Theory: Due to advancements in communications technology and the ability to store and manipulate data the process of knowledge generation is in a state of ongoing transformation. Historically, knowledge was delineated by public and private spheres of dominance, where fundamental knowledge was developed in public institutions in a linear and mono-disciplinary method prior to being transferred directly to the private sector in the form of applied knowledge. The advent of technology has transformed this into a trans-disciplinary process, where heterogeneously organized networks form around P3s that connect universities, government agencies, think tanks and industrial labs together for the pursuit of technological and scientific advancement in an environment where economic growth and competition is more often than not defined in terms of innovation.

Methodology: Social Network Analysis (SNA) is a tool that illuminates the previously invisible relations between individuals and institutions in a networked environment. With SNA it becomes possible to graphically identify and quantify the relative power relations and functions between individuals and organizations within a network or sub-networks. SNA utilizes three unique measures of centrality. First, total degree centrality measures the ability of a single actor to influence communications over a network providing that actor with relative control over the flow of information. Second, betweeness centrality measures how often an actor is positioned between the shortest paths linking other actors. Third, eigenvector measures power by measuring the relative strength of one actor's connections to other well connected actors'. Put simply, a high eigenvector rating implies relative power in a network is derived from the relative importance of an actor's connections, not the quantity of connections.

Data Analysis: 248 unique actors have been identified and coded. There are 42(17%) P3s, 107 (43%) government agencies, 83 (33%) universities and 16 (7%) corporations in the global pulse network. Although P3s represent only 17% of the global actors, they occupy the top rankings as specified by social network analysis. For ease of reference, the global network has been decomposed into 3 sub-networks. The EU system is centred on one P3. The Developing World system is centred on two P3s, while the Export system of Canada, the US and Australia is centred upon two P3s and one government agency.

Figure 1: The Global Pulse System

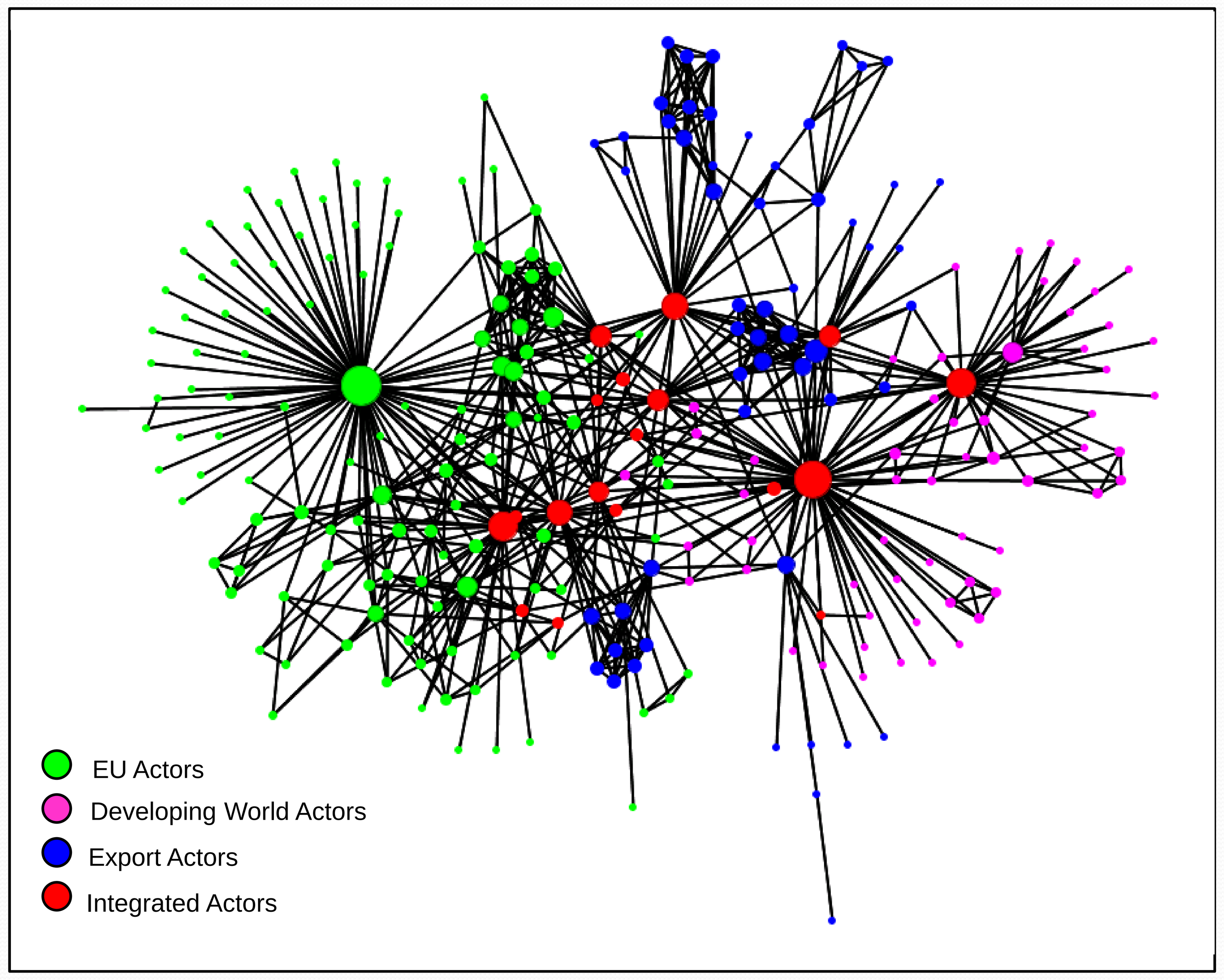


Figure 2: The EU System

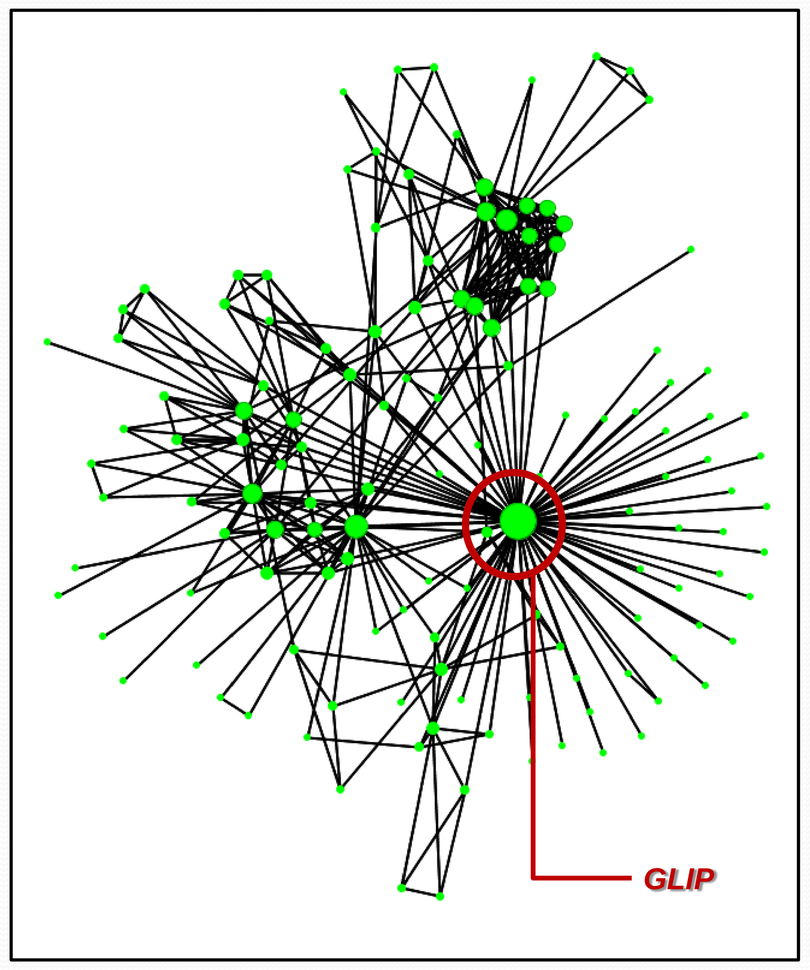


Figure 3: The EU System without GLIP

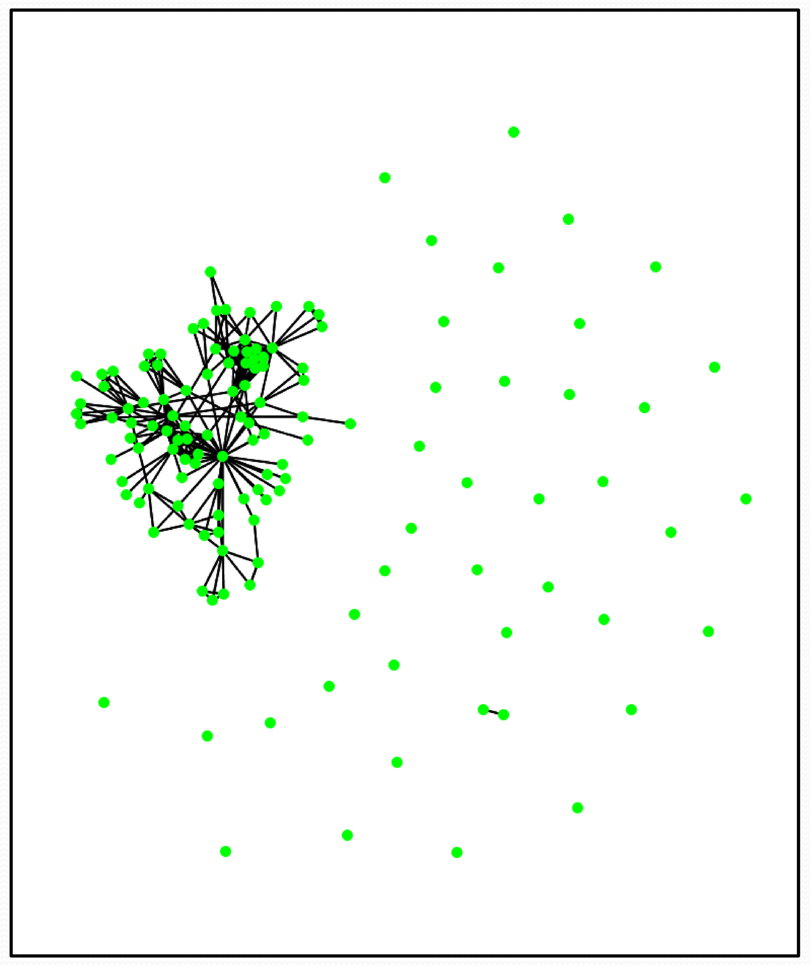


Figure 4: The Developing World System

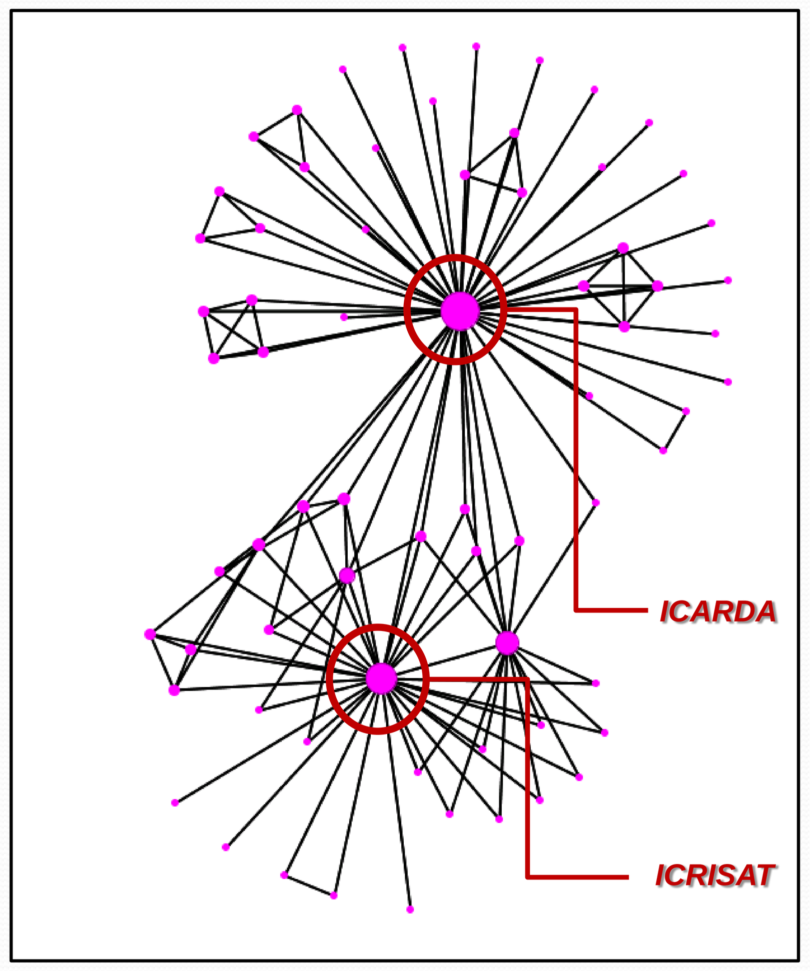


Figure 5: The Developing World System without ICARDA & ICRISAT

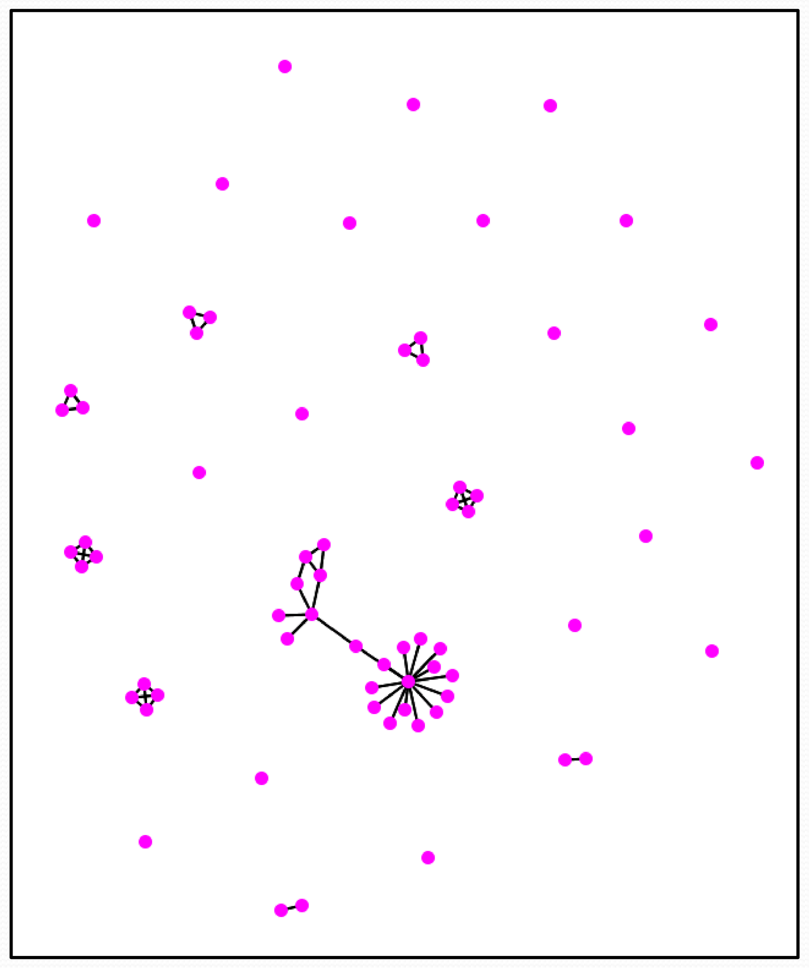


Figure 6: The Export System

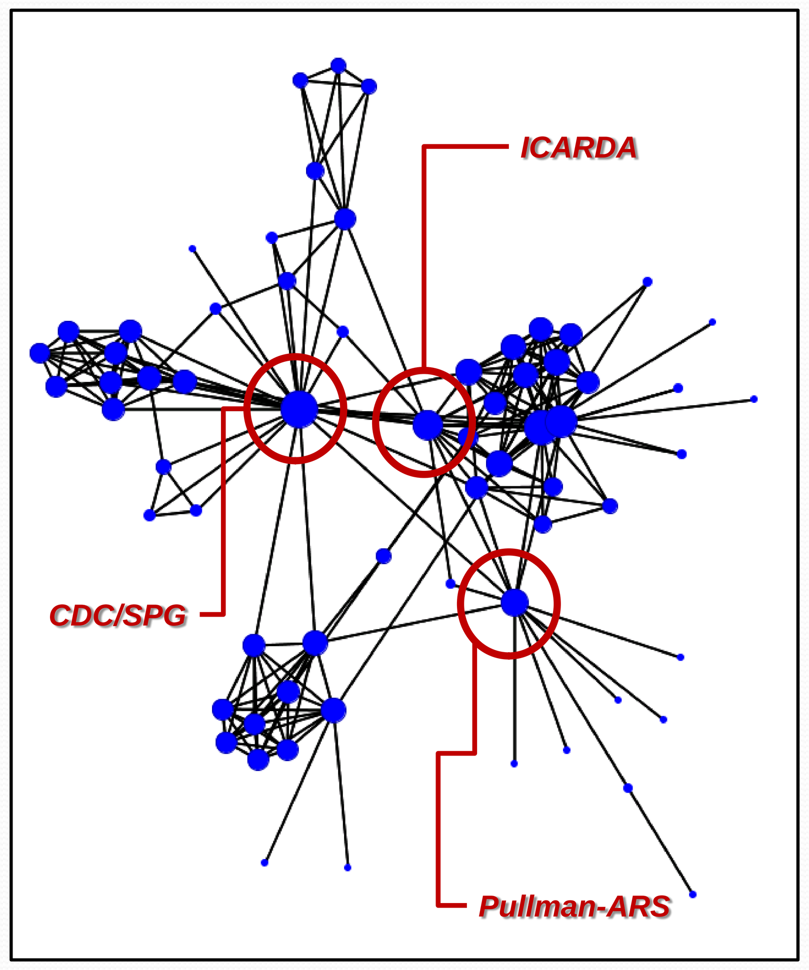
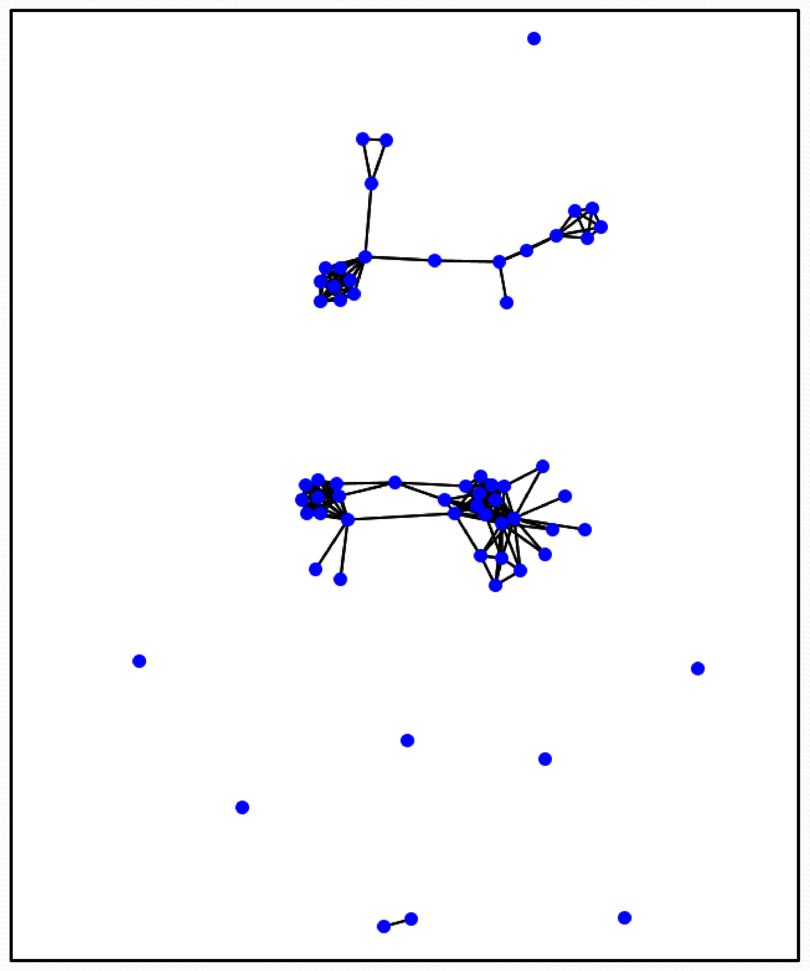


Figure 7: The Export System without ICARDA, Pullman & CDC/SPG



The Grains Legume Improvement Project (GLIP) is the top ranked actor across all 3 measures. As demonstrated graphically by the removal of GLIP, the EU pulse breeding network depends on GLIP for its structure. Removing GLIP creates over 40 isolates reducing the size of the EU network by about 30%. This is significant as GLIP, which is an EU program, was not refunded in 2008 and has ceased operations. The EU is a self-contained, autonomous network that is not interconnected to the other two global systems. Therefore, this may severely impact the efficacy of their research efforts due to the creation of a large number unconnected isolates.

Table 1: The EU System

Total degree centrality	Value	Context*	Eigen-vector	Value	Context*	Between-ness	Value	Context*
GLIP/FP6-P3	0.5789	*****	GLIP/FP6	1.0000	****	GLIP/FP6	0.7112	*****
INRA-HQ-Government	0.2331	***	CSIC	0.8243	***	INRA-HQ	0.1656	**
CSIC-Government	0.1654	**	Rennes	0.8016	***			
Mean	0.0397		Mean	0.1663		Mean	0.0119	
Std.dev	0.0605		Std.dev	0.2086		Std.dev	0.0637	

* Number of std. deviations from mean

ICARDA and ICRISAT are both P3s managed and financed by the Consultative Group on International Agricultural Research (CGIAR), and are the two key actors in this network. Their removal causes the disintegration of the Developing World system, explicitly demonstrating the critical role that P3s occupy in this network. Put simply, without ICARDA and ICRISAT, there is no Developing World System, rather a collection of nonconnected national systems operating in an environment of isolation. ICARDA, interestingly, is also a key structural component of the Developed World System as described below

Table 2: The Developing World System

Total degree centrality	Value	Context*	Eigen-vector	Value	Context*	Between-ness	Value	Context*
ICARDA-P3	0.6912	*****	ICARDA	1.0000	*****	ICARDA	0.7844	*****
ICRISAT-P3	0.4559	***	ICRISAT	0.7493	****	ICRISAT	0.3627	***
CLAN-P3	0.2353	*	CLAN	0.4979	**	CLAN	0.0969	
Mean	0.0550		Mean	0.1797		Mean	0.0190	
Std.dev	0.0968		Std.dev	0.1383		Std.dev	0.1030	

* Number of std. deviations from mean

With the exception of Pullman-ARS, a US Government research centre, P3s occupy all the top SNA measures in the Export System. The removal of two P3s, one each in Canada and Australia and the Pullman-ARS centre and the highly connected Export System collapses into two national networks, one each in Canada and Australia.

Table 3: The Export System

Total degree centrality	Value	Context*	Eigen-vector	Value	Context*	Between-ness	Value	Context*
CDC/SPG-P3	0.3692	****	GRDC	1.0000	**	CDC/SPG	0.4754	*****
GRDC-P3	0.3231	****	CLIMA	0.9049	**	Pullman-ARS	0.2265	**
CLIMA-P3	0.2923	***	PBA-P3	0.7482	*	GRDC	0.1353	*
Mean	0.1054		Mean	0.2411		Mean	0.0262	
Std. Dev.	0.0764		Std. Dev.	0.2575		Std. Dev.	0.0698	

* Number of std. deviations from mean

Conclusion: As hypothesized by theory and demonstrated by social network analysis, P3s occupy key positions in the structure and process of networked knowledge generation, controlling the flow of information. P3s and knowledge networks are a response to exogenous changes facilitated by the advent of communications and data process/handling technologies. Social network analysis offers a new methodology to understand and better manage the increasingly important research effort that drives the knowledge-based economy.