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## LINKING NETWORK STRUCTURE WITH PROJECT PERFORMANCE

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**Abstract —** Innovation processes are the processes by which people and organizations interact with each other to put new knowledge to use. These interactions can be represented by networks, showing agents as nodes, and interactions as the links between them. Research-for-development projects attempt to foster and support innovation through research. It follows that project network structure, in terms of the types of organizations that work together to implement projects, and their patterns of interaction, should correlate with measures of project success. This paper finds evidence to support this premise through correlating the structure of networks drawn by staff of 29 projects of the Challenge Program on Water and Food (CPWF) and project performance, measured through a rating carried out by the program's research and development leadership. The analysis found that the more successful projects had comparatively larger networks – they had more network capital. Specifically the more successful projects tended to disperse funding to more partners, and those partners had more links to other organizations, than less successful ones, in particular more research links to Advanced Research Organizations and CGIAR Centres.

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<sup>1</sup> With advice and input from Abigail Barr, CSAE, University of Oxford

## **INTRODUCTION**

Innovation processes are the processes by which people interact with each other to put new knowledge to use. As a result people start doing things differently, often doing more with less. For example, some agricultural innovations allow farmers to do more work with less labour (by substituting fossil fuel for human effort) or growing more food with less water. By doing more with less, innovation can lead to economic and social development. The ability to innovate can ensure resilience by making individuals, communities, organizations and countries more able to adapt to and exploit opportunity and change. Indeed Mokyr (1990) argued innovation is the “lever of riches” and the difference between rich countries and poorer ones relates in part to whether national cultures allowed innovation to take place over extended periods of time.

Innovation is an evolutionary-like process in which people learn, experiment, and decide what is working and what is not. Research plays an important role in fostering innovation by generating new knowledge that becomes the focus of new experimentation and sense making by the people who could benefit. So whether research does or does not catalyze innovation and through innovation contribute to developmental change, depends critically on the interactions between the different agents involved, e.g., researchers, extension workers, traders and farmers to mention just a few.

In research carried out for development ends, or research-for-development for short, much of the interface between research on one side and development on the other, happens in projects. The interactions between the organizations working in projects and their wider institutional environment can be modeled using network maps. If interaction is important it follows successful projects should have different patterns of interaction between organizations, and hence quantifiably different network maps, than less successful ones. The objective of this paper is to test this premise, that is, to test whether project network structure can be correlated to project performance. The second objective is to derive implications for research management.

This is the first time that network data, derived from project staff drawing their own project networks, has been analyzed in this way. Increasingly partnerships and networks are seen as important in putting research outputs into developmental use, but little analysis has yet been done on what types of network and partnership are effective.

## **METHODOLOGY**

### **Analysing a natural experiment**

The data for testing the premise comes from the CGIAR Challenge Program on Water and Food (CPWF). The CGIAR launched the Challenge Programs in 2001 as a means for the CGIAR System as a whole to work with a wider range of partners. The CPWF began with the largest call for proposals in CGIAR System history. It eventually funded 32 projects with grants between US\$ 400,000 and US\$ 2 million for 3 or 4 years. The call stipulated that at least one of the five convening CG Centers should be involved and at least two NARES partners should also be involved and should receive a minimum of one third of the funding requested from the CPWF. When the so-called ‘first-call’ concept notes were evaluated, 20% of the scoring was assigned to the selection criteria of “establishment of new partnerships or different use of existing partnerships; proactive encouragement of stakeholder participation; appropriate plans for dissemination and capacity building; and, cross-cutting research integrating several scales, basins or themes.”

### **Project ranking as a measure of performance**

In 2008 the CPWF rated the performance of all its projects, including the 32 First Call ones. The ratings were given by nine 'basin coordinators', six 'theme leaders' and two members of senior program management. Basin coordinators were responsible for ensuring coordination amongst the CPWF projects working in their respective basins, while theme leaders were responsible for research quality.

The evaluators were asked to evaluate each of a sub-sample of projects (sub-sample sizes varied between two and 36) according to seven criteria. Their evaluations were elicited as scores between 1 and 4 indicating how much they agreed with a statement corresponding to each of the criterion. The seven statements were as follows:

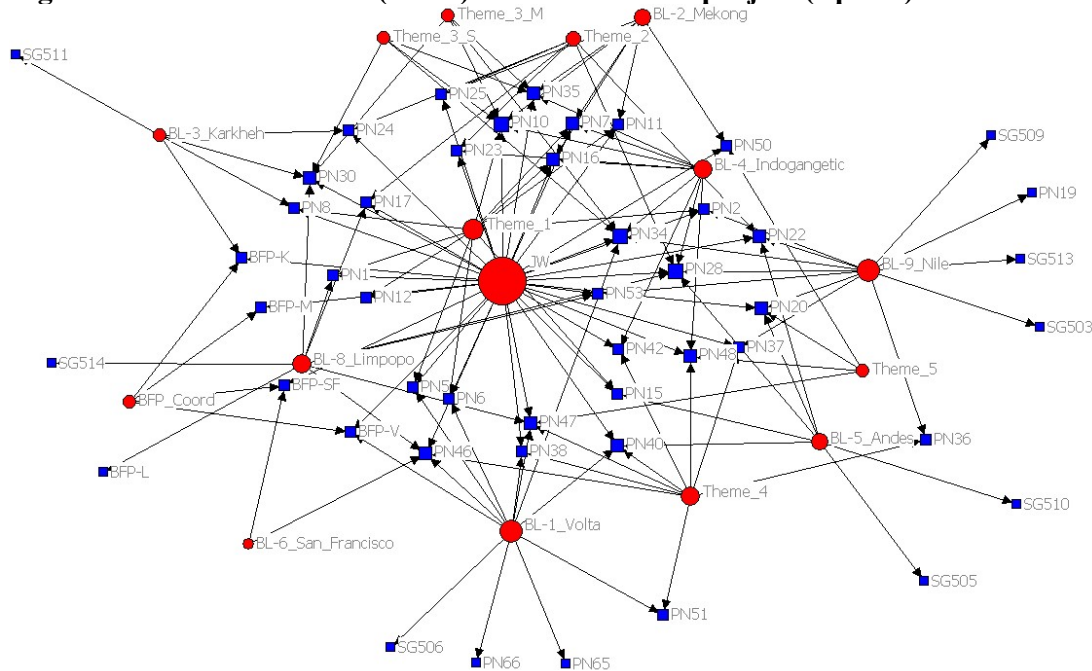
1. The project will produce significant new research that did not exist before the inception of the CPWF;
2. The project is adapting existing technologies and strategies;
3. The project research has the potential to produce large scale developmental impacts (e.g., on farmers' livelihoods);
4. The likelihood of large-scale impact is high;
5. The likelihood of pilot site impact is high;
6. The project is well managed; and
7. The project has the necessary links to other organizations to achieve impact.

The scores relating to statements 1 and 2 identify the perceived type of project rather than evaluating the project's performance. Scores relating to statements 3, 4, and 5 are evaluations of the project's potential impact. The scores relating to statements 6 and 7 evaluate the quality of the project's managerial and networking inputs. We calculate the overall project rating as the mean-adjusted average of the evaluators' scores for statements 3 to 7.

The word 'adjusted' in 'mean adjusted evaluation scores' refers to the fact that we adjust to take into account differences in evaluator style. Some evaluators tend to score higher than others and, this being the case, taking simple average scores can be misleading: projects that are evaluated by harsher evaluators will appear to perform less well than project that are evaluated by more lenient evaluators. By using regression analysis we can statistically control for variations in evaluator style and thereby construct more comparable project mean scores. Applying the same logic, we also construct means that take account of scores relating to more than one criterion, while controlling for the possibility that some criteria are easier to fulfill than others. We also control for evaluator bias towards or against their own projects. For example, we find that basin coordinators are favorably biased towards projects in their own basins, and so we control for this.

There is one necessary condition that has to be met before this method of statistical control can be relied upon - there must be no sub-sample, A, of projects evaluated by sub-sample B of evaluators such that none of the projects in A are evaluated by evaluators outside B and none of the evaluators in B evaluate projects outside sub-sample A. Put another way, all projects and evaluators must be part of the same, connected network and there must be no isolated segments of the network. Figure 1 shows that this condition was met.

**Figure 1: Which evaluator (circle) evaluated which project (square)**



**Note:** Projects indicated by blue squares, evaluators indicated by red circles. Circle size indicates the number of evaluations undertaken by each evaluator.

A full description of the method used is available in the report “An Analysis of First and Second Round Evaluations” by Abigail Barr, February 2008. The analysis was conducted using Stata version 10.0. The compiled dataset is available in Stata format or in Excel from Boru Douthwaite or Sophie Alvarez ([b.douthwaite@cgiar.org](mailto:b.douthwaite@cgiar.org), [b.sophie.alvarez@gmail.com](mailto:b.sophie.alvarez@gmail.com)). The program written for Stata is available from Abigail Barr ([abigail.barr@economics.ox.ac.uk](mailto:abigail.barr@economics.ox.ac.uk)).

## Mapping project networks

Project network maps were constructed by project staff as part of a participatory process of constructing project logic and network models. Staff from each of the 32 first call projects were invited to one of the Participatory Impact Pathways Analysis (PIPA) workshops held in eight of the nine river basins in which the CPWF works (no workshop was conducted in the Sao Francisco river basin as there was only one first call project in that basin, and this project joined the nearby Andes workshop). Staff from 29 of the projects attended. In the workshops, participants were asked to draw their project networks in terms of four relationships: funding flows; research partnerships; extension of project outputs (scaling out); and, political lobbying (scaling up). These last two relationships are combined in the analysis reported in this paper.

We carried out network mapping to help project staff make explicit their *theory-in-use* of their project networks and changes required. Theory-in-use is the usually tacit understanding that project staff has of how change happens (Argyris and Schön, 1974), and affects how they implement the project. This is different from a project's espoused theory which is what is written into it project documents and logic models.

In the mapping two to eight project staff worked together to first draw their “now” project network showing how the project was configured at the time of the workshop (Figure 2). The method

used for drawing the networks is described in detail at <http://impactpathways.pbwiki.com>. The data from the workshop-drawn network maps was coded and analyzed using UCInet and NetDraw (Borgatti et al., 2002, Borgatti, 2002).

**Figure 2: Drawing network maps in an impact pathways workshop in the Yellow River basin**



It was only after this data was collected that we thought to test if a correlation exists between the networks the projects drew and how the evaluators rated the projects. Based on a combination of our own experience and network literature we developed hypotheses about how network structure is likely to influence project performance. Table 1 shows the main variables used for testing.

The hypotheses were tested by calculating the pairwise correlation coefficients between the rankings of the projects which mapped their networks and each of the network indices shown in Table 1. The hypotheses tested can be seen in the results table (Table 2). The first two of these hypotheses were tested by using data from the original project documents that gave the total project budget and the number of partners to which the funds were dispersed. The rest of the hypotheses were tested with relation to two networks:

1. Boundary-partner network: The network of organizations made up of the core partners (organizations that received project funding, as listed in the original project proposals) and the organizations that workshop participants showed directly linked to them in the network maps they drew.
2. Whole network: The whole network drawn in the workshops, including links drawn between boundary partner organizations.

Table 1: Network Indices

	Network indices	Description
1	Funding received from CPWF	Amount (\$USD) received by each project from CPWF donors
2	Number of core project partners	Number of partners that receive funding directly from CPWF, through the project lead partner
3	Number of boundary partners of project	Number of boundary partners drawn in project network
4	Number of overall partners drawn	Number of all partners drawn in project network
5	Number of total links drawn	Number of links drawn in project network
6	Number of research links drawn	Number of research links drawn in project network
7	Number of scaling links drawn	Number of scaling links drawn in project network
8	Number of funding links drawn	Number of funding links drawn in project network
9	Number of research organizations in networks drawn	Number of research (CGIAR, ARIs, Universities and other ROs) organizations in project network
10	Number of scaling organizations in networks	Number of scaling organizations (NARES, Government Organizations, End user

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	drawn	groups, NGOs) in project network
11	Number of in-basin organizations	Number of organizations based in the basin countries where the project is implemented
12	Number of out-of-basin organizations	Number of organizations based outside the basin countries where the project is implemented
13	Number of international research organizations in networks drawn	Number of international research (CGIAR and ARIs) organizations in networks drawn

## RESULTS

The results are summarized in Table 1. The first significant finding is that total project budget did not influence project rating as might have been expected. Rather, what mattered was how widely the funds were shared, that is, the number of organizations written into the original proposal as project partners and therefore in receipt of at least some project funds. We found that the top six ranked projects shared project funds between twice as many partners as the six projects ranked at the bottom. The top six shared funds amongst an average of 8.8 partner organizations.

The second significant finding is that successful projects drew bigger boundary partner networks, that is, they had more core partners (organizations receiving project funding) linked to more boundary partners. Boundary partners are defined as the direct users, co-developers and enablers of the information, insights and technologies that projects develop.

Interestingly, the total number of organizations in their complete networks did not correlate significantly with the rankings, showing that it was not raw network size that mattered. Rather successful projects concentrated on drawing research and scaling links between the project implementing organizations and their boundary partners while less successful projects put more emphasis on drawing identifying funding flows and drawing linkages between boundary partners. Lastly, we found that successful projects put relatively more emphasis on drawing research links than scaling ones and successful projects also identified more research organizations in their boundary partner networks, in particular CGIAR Centres and Advanced Research Institutes.

Putting this all together, an ideal project in this particular context is one in which:

- Funds are shared widely, between on average 8.8 organizations;
- Project staff see their organizations linked to a wider network of boundary partners;
- Project staff are more aware of functional linkages (research and scaling links) rather than funding links, and
- The project has more (>20%) advanced research institutes and CGIAR centres in its boundary partner network.

**Table 1: Results**

	<b>Hypothesis</b>	<b>Result</b>
b.	Hb: Projects that disperse funding more widely are more successful	Significant (<10% confidence level (cl))
c.	Hc: Successful projects will have bigger networks	Projects that drew larger boundary-partner networks were more successful (<5% cl) but drawing larger whole networks was not correlated. Projects that drew more research and scaling links in their boundary partner networks were more successful (10% cl) while downplaying funding links (<1% cl)

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e.	He: Successful projects put more emphasis on scaling links than research ones	The opposite was significant: projects that drew more research links compared to scaling links in their whole network were more successful (<5% cl)
h.	Hh: Successful projects will have a higher number of CGIAR and international research organizations in their networks	Significant (<10% confidence level (cl))
a.	Ha: Better-funded projects will be more successful	Not significant
d.	Hd: Successful projects will have relatively more scaling organizations in their network than research ones	Not significant
f.	Hf: Successful projects will have more of their total research links between research and scaling organizations	Not significant
g.	Hg: Successful projects will have more of their total links between in-basin organizations and out-of-basin ones	Not significant

## DISCUSSION

The results show that a coherent set of correlations exist between a measure of *likelihood* of project success and project networks as perceived by project staff. According to our literature survey, this is the first time such a correlation has been looked for and found.

What this relationship means – its importance – depends on both the measure of success and what the network maps analyzed actually represent. The measure of success is the rating given to the projects by people whose job it was to mentor, oversee and know the projects. They rated the projects on whether they thought the projects were likely to produce good science and achieve impact in the ultimate beneficiary groups. It was not a measure of actual performance because when the rating was done it was too early to evaluate on actual impact, which can take fifteen to twenty years to play out when starting with basic research (Collinson and Tollens, 1990).

The networks analyzed were those drawn by project staff in a network mapping exercise. Again, what were analyzed were people's perceptions of how their project networks are configured. When project staff put an organization on the map and drew lines indicating its relationships to other organizations, they did this on the basis of their implicit understanding of these relationships, not on any objective measure.

There are two possible explanations for the correlations between evaluator ratings and network structure, between which the data does not allow us to distinguish. The first is that the correlation worked as intended – that subjective opinion matched objective reality. In other words projects that were carrying out quality research likely to achieve local and widespread impact were correctly rated by the evaluators as such, and part of what made them successful was having greater network capital, which our network analysis was able to measure. The other explanation is that the better projects tended to send more knowledgeable people to the Impact



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Pathways Workshops who were able to draw more detailed network maps. However we see no evidence of this when looking at who attended the workshops. The top six and bottom six projects were both attended by the same number of people (4) with roughly the same number of project leaders and principle investigators present.

The importance of the findings is that it supports the premise that this paper set out to test – that project network structure is linked to project success – and that this premise has far reaching implications. Much of the millions of dollars invested worldwide in research-for-development are spent through projects. This money can be better spent if greater care is given to how projects are configured in terms of who works with whom. As it possible to measure project performance and project network structure and correlate the two, it is possible to develop better theory and evidence as to what configurations work best for different types of intervention in different contexts. Hence the research reported in this paper suggests that it is possible to become much better at project design and implementation.

## CONCLUSIONS

This paper finds a correlation between project network structure and project success. It is the first time that such a correlation has been sought and found. It is important because it suggests that more of the same type of research can build better understanding of the trade-off between working in partnership and transaction costs in research-for-development projects. Better understanding of what partnerships work best with which type of intervention in which contexts will improve project design and implementation, make it more likely that research triggers innovation processes. This will improve one of the main *modus operandi* of delivering benefits to the rural poor.

The Challenge Program on Water and Food is using the results in the design of its Phase 2 research for development programs. The Program is using network analysis and measures of network centrality to help select organizations to lead projects. It makes it a condition that projects form consortia of a minimum of three organizations made up of an out-of-basin research organization, an in-basin research organization and a scaling organization. The Program sets expectations for budget sharing. Each of our research for development programs is made up of four or five projects. One of them is responsible for actively maintaining and building networks through which research can better link to potential users, and vice versa.

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