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Conceptual Issues in the Evaluation of Formal Research Networks

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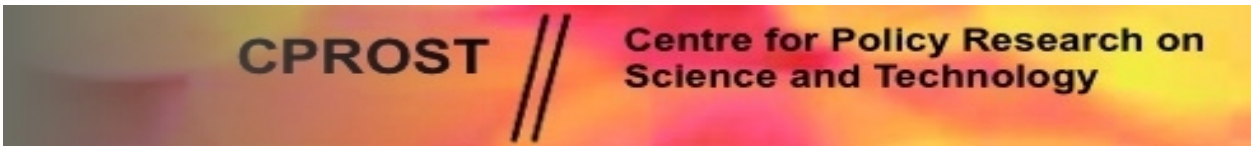

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Abstract

The literature on the evaluation of the benefits of public research continues to expand rapidly. However, although governments in OECD countries are turning more and more towards creating formal networks as a means of organizing research, there is little in the way of analysis of how such networks might be evaluated in terms of the policy objective *to network*. This paper seeks to both define the concept of formal research networks and map the conceptual issues in evaluating them. We suggest a model for analysing research networks based on the properties of their interactions between researcher and stakeholder communities.

1. Introduction

Across a range of Organisation for Economic Cooperation and Development (OECD) countries there has been continued expansion since the early 1990s of government programs that support the development of 'networks' as a mechanism to organise funded research in general and support research that addresses specific public policy objectives in particular. Such 'knowledge' or 'research' networks cover a spectrum of activities from pre-research capability development, to structured research programmes. As Rogers et al. (2001) note:

> *"….the basic assumption of network approaches for any set of social phenomena is that the whole is more than the sum of the parts. In other words ..., the nature of the links between actors takes priority over their individual characteristics."*

While there has been much discussion around the importance of networks in innovation and knowledge development, the evaluation of networks remains little explored. Most evaluations of publicly funded R&D are conducted to assess the performance of individuals and/or specific institutions and, therefore, do not provide guidance on the value of the networked R&D activities. Even in the case of evaluation of larger entities — such as research centres or programs — they are treated as 'super-individuals', the sum total of their members, for evaluation purposes (Rogers et al. 2001). This tradition does not help in the specification of relevant boundaries for network analysis of R&D systems that may lead to evaluation based on their structural properties.

The majority of the investigations that has been done on the structure of scientific research, for example by Bozeman and Rogers (2002) and others have been done on what could be described as informal networks. In this paper we make an important distinction between informal and formal networks[1]. The former consist of the small networks of collaborating[2] individuals (colleagues and research assistants etc) involved in most scientific projects and papers (including where some research time is paid). Most often projects that involve some level of collaboration could typically be thought of as, being an informal network. On the other hand, formal networks can be understood as a form of organisation in their own right, typically reviewed and funded by government agencies to encourage research where there is a need, in, for example, nascent fields, gaining critical mass, linking researchers spread across a large geographical area, or to increase the involvement of stakeholders including indirect stakeholders.

In this paper we first explore briefly the place of networks in science policy. However, in contrast to recent articles on network evaluation (Rogers et al. 2001 and Mote et al. 2007) we develop a different line of argument. In those two papers there was an extensive review of network-related literatures and both concluded that there was little in the way of extant analysis of relevance to the needs of evaluators. We therefore take a different route and review the fundamentals of research organisation evaluation, summarising the key findings and practices as they relate to organisation size and structure, and from this

[1] In various literatures there are distinctions between various types of networks such as the differences between social and business networks, but our focus is on networks for the creation and diffusion of knowledge.

[2] We have created a glossary of terms for this paper – see below.

foundation outlining why the characteristics of networks need a unique approach. Our research leads us to suggest a model for evaluation that is neither based in mapping the individual associations within a network (social network analysis) nor is it purely interested in the power and transformations that networks generate (actor network theory) but seeks to adopt elements of both.

2. Innovation Infrastructure and Science Policy

Knowledge and especially new knowledge is now typically understood as an important input into societies to enhance their capacity for economic growth and social development. Because of this governments seek to promote the generation of knowledge and its application to the economy. As part of their mission to increase economic well-being, social well-being, national security and administrative efficiency, governments use a variety of policy options to implement their national vision. Over the second half of the 20th century national and regional governments have invested in universities, government funded laboratories and other public programmes including defence related activities (Freeman 1968) or what Smith (2007) calls infrastructure. It has become a key concern of science policy makers in recent decades as to how to join up these infrastructures with other stakeholder communities; particularly business and industrial (see OECD 2006 and see e.g. literature on the so called 'triple helix' (Etzkowitz and Leydesdorff 2000, Leydesdorff 2006).

One key approach to foster this joining up of the system has been the relatively recent development of large scale (national) formal research networks (FRNs). Examples of such research networks include:

- Networks of Centres of Excellence (Canada);
- Major Collaborative Research Initiative (Canada)
- Cooperative Research Centres (Australia);
- Research Networks (Australia); and
- European Framework programmes (European Union).

Research networks are part of the system of innovation at the level of geography in which they operate. Thus a nation-wide research network is part of the national system of innovation, while a local research network is both a part of the local system of innovation and the mosaic of policies and structures which forms the national innovation system. But at whatever level they operate, they are part of the infrastructure of that system of innovation, just as research councils, research organisations and key laboratories can be understood as infrastructure that supports innovation. Thus research networks need to be analyzed within their respective system of innovation and tested as to the contribution they, as infrastructure, make to those systems of innovation.

In this paper we aim to both map the complexities of evaluating formal research networks and to suggest a path for future research to pursue. We can define our interest in the 'formal' and 'research' components of networks as follows.

Table 1: Description of Formal Research Networks

Definition types	Description
Formal Condition 1	The network is *funded* for a set purpose for a set period of time. Most often they are a creation of a government research grants organisation, although they could, for example, be funded by large non-profit foundations.

Formal Condition 2	The network is required to establish a formal *administrative structure*.
Formal Condition 3	The network is established, in part, to meet a *policy objective.* Examples include: encouragement of linkages between researchers and user communities, encouragement of communication across a geographically spread population.
Probable Condition	The network will likely be formally evaluated at some point.
Interpretative Condition.	Even if all these conditions are met there will be a need to distinguish between *collaborations* across organisations, space or discipline and networking. Although, the analysis presented in this paper is of relevance to large collaborations[3] it is most relevant to situations where there is an expectation of formal network construction that reaches beyond researchers into the stakeholder communities.

Table 2: Definition of 'research' in our classification of networks

Definition types	**Definitions**
Condition 1	The network will be established to generate new knowledge, using the OECD Frascati Manual definition of R&D (and will likely have as a policy objective, the diffusion of new knowledge)
Condition 2	An element of the network's mandate will be to train, encourage or mentor new researchers.

The nature of networks being what they are, there are scale and boundary effects to be understood, which we address specifically in section 5. For evaluation purposes it is worth noting that within the formal organisational entities of networks there are many informal networks of the kind Bozeman and others describe, but our interest here is at the level of the organisation.

In addressing the topic of the evaluation of networks it is also important to acknowledge and analyse the relevance of the current prevailing paradigms in research organisation evaluations. Both a science production and an economic value perspective have come to dominate the field of research program evaluation (see Freeman 1968 and Godin 2007). Therefore, before focussing attention on the general field of science policy evaluation, we feel it is valuable to re-introduce into the discussion a broader perspective on the variety that exists in evaluation strategies.

3. A Taxonomy of Evaluation

A distinction must be made between strategic policy reviews and program evaluations. The former represents analysis of the big picture; what has worked and what has not worked. Such analyses often

[3] We are thinking here of 'team science' type projects of the kind funded by agencies such as the Canadian Institutes of Health Research – in these situations the network (collaborative partners) for the most part need to be in place before the grant is offered. Our observation is that in many network grants there is some expectation that during the course of the research project there will be attempts to reach out to new partners and expand the network.

encompass elements of program evaluation with future policy development suggestions. An example might be the federal review of the Australia's innovation policies and support program conducted in 2008.[4]. These reviews address the strategic question for a given situation, namely; what is the right organisational structure for this issue, or even is this the right issue to address? In such analyses there is a requirement to have a considerable amount of information to identify a particular gap in a system and thus to initiate something new or given enough time to evaluate the history of the organisations.

The latter category (program evaluation) can be defined as the ongoing regular review of programs or organisations (e.g. research councils). In the literature on evaluation there are a large number of taxonomies of types of evaluation, even if the theoretical development of evaluation frameworks has lagged behind (see Demarteau 2002). Hansen suggests that three meta issues need to be addressed in designing evaluations. They are:

- 'evaluation design should logically be based on the purpose of carrying out an evaluation;
- evaluation needs to based in the characteristics of the evaluand; and
- characteristics of the problem that the programme or organization under evaluation aims to resolve need to be incorporated' (Hansen: 2005: 451).

Such questions of evaluation purpose and design can be understood through various lenses on evaluation methodologies, such as those presented in Hansen's paper (page 449). They include evaluations of the results (based on initial goals), process models, system models, economic models, actor models and program theory models. Hansen's taxonomy facilitates a clearer analysis of the worldviews of evaluators. Science grants are assessed through an actor approach (peer review) while much of the impact of science and technology oriented organisations is assessed for government economic ministries through economic models (with the push in this direction seemingly increasing (see, OECD 2007 and OECD 2008[5]).

We argue in this paper that the structure and nature of research *networks* require evaluation approaches that are multi-faceted, adopting a number of the 'evaluation models' in Hansen's taxonomy rather than simply picking one off the shelf.

4. Research System Evaluations

As noted already, there is a long tradition of attempts at understanding the benefits of R&D and what could loosely be described as the economics of science[6]. Within this category of work it is possible to distinguish between three overlapping areas of research which have emerged over the last thirty years or so. The first can summarized as studies that are interested in the economics of R&D and in particular assessing it through various metrics such as patenting, bibliometrics and return on investments in the private sector (see Pavitt 1991, Dasgupta and David 1994, Stephan 1996 and Audretsch et al. 2002). A second tradition has been built up around the practical problems of assessing particular government programs (for examples see section 3.3 below). Often performed by consultancy businesses (see for e.g. ACIL Tasman 2006) as well as academics, this literature often draws upon published research in peer reviewed journals but it has also been more 'innovative' in the search for methods and data that reveal the value of particular programs and organisations.

[4] http://www.innovation.gov.au/innovationreview/Pages/home.aspx
[5] http://www.oecd.org/document/7/0,3343,en_2649_34273_40469255_1_1_1_1,00.html accessed 19 August 2008.
[6] The term 'economics' is used here advisedly as a catch all for analysis that attempt to capture the inputs and outputs in a broad productivity based framework.. Much of the work has indeed been on the benefits to the economy (Nelson 1959) or specific firms arising from this public research, see eg. the Department of Trade and Industry (2005) this framework can be pushed too far and become worthless s (see e.g. Corbyn 2008).

The third stream of work appears as an attempt to bridge and synthesise these two worlds and re-formulate the primary question of policy makers in assessing where to continue or discontinue funding by addressing what can be expected of R&D programs in public sector. For example, Salter and Martin (2001) have argued that there are six principal types of impact of public research which can be can be summarised as:

- increasing the stock of useful knowledge;
- training skilled graduates;
- creating new scientific instrumentation and methodologies;
- forming networks and stimulating social interaction;
- increasing the capacity for scientific and technological problem-solving; and
- creating new firms.

Noting their inclusion of networks in the key benefits, we observe that Salter and Martin state:

'*Networks have been the focus of much empirical research.' …..This work indicates that firms and industries link with the publicly funded science base in many different ways and these links are often informal*.' (p523).

The focus of much of the investigation into networking has thus been on the necessity of the private and public sectors to network and/or collaborate in problem solving and technological communities to foster the development of new products and services etc. It is critical to note that they suggest that many of the links are informal and thus do not fit the criteria established for our study. This would indicate that the evaluation of related programs is important yet largely unexplored, as we have already suggested.

However, even within the confines of a typical research and development program (i.e. a centre as against a network) there are particular challenges in assessing the outcomes. Beyond the type of evaluation and the impacts being examined, there are practical challenges to understanding the success of research activities. Some of the key challenges of the evaluation of knowledge creation activities (see e.g. Fahrenkrog et al. 2002: 13) can be understood as:

- Attribution — is it possible to ascribe a particular output, outcome or impact to a particular research project or programme? Such benefits may (probably are) derived from the accumulated experience derived from multiple projects while a given project may have an impact on, or contribute to multiple outputs;
- Appropriation — the danger of finding the benefits being looked for (i.e. misappropriating good news as indicators of program effectiveness);
- Timing — research impacts often become clear long after the evaluation process is complete;
- Inequality — a small number of research projects may account for most of the measurable effects (but it is not possible to judge the value of the majority of projects in the terms of the process of knowledge accumulation);
- The project fallacy — it is often assumed, hoped or demanded (i.e. policy makers often expect) that everything will have an identifiable benefit, which can then be attributed equitably and in a timely fashion.

In essence these to some degree all emphasise the challenge of accounting for the interactions between science projects and between these projects and external knowledge sources and the wider economic context. These challenges have been addressed in various ways by different organisations, but it is important to note that the structure and scale of the project / program / organisation being evaluated are

important characteristics. Single organisations or programs offer specific challenges, but as we shall describe networks by their nature generate a level of challenge of analysis that makes these issues of second order importance.

While it is acknowledged within the S&T indicators field (see particularly Geisler 2000) that organisational size and structure matters for evaluation, little has been done to construct an overarching framework of which indicators are useful in specific circumstances. As a first step in this direction, both to highlight the role of available knowledge sources and the gaps Table 3 is provided as a map of how particular research organisations have been evaluated[7].

Organisational structure and size matters, as the smaller and more diffuse the organisation; the more conventional metrics become increasingly problematic and lose relevance. As Glaser et al. (2004) point out there are 'least evaluable units' (LEU) where publication measures of scientific output and impact become unreliable. Their analysis of the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO) discovered that these LEUs may be surprisingly large. At the other end of the spectrum, as the scale of activity increases the specificity of the assessment must necessarily decrease.

The following table (Table 3) lays out a range of different organisational structures and scales with examples of the evaluation indicators and approaches being used. We have focussed our attention on examples from Australia, Canada, UK and USA where the authors have the most experience, but in the expectation that the findings have wider relevance. Research networks are not included in this section but a similar representation is produced in section 5.3 (below).

There is a general trust in 'metrics' for evaluation but we also note that a number of organisations are developing evaluation systems in a style that is not dependent on metrics. Political changes play a part in evaluation structures (Australia and the Research Quality Framework) as does the occasional push back from researchers on perceived inappropriate frameworks (UK's impact framework).

Table 3: Evaluation schemes applied to research organisations of different structures and size

Scale	Form and/or Function	Examples	Types of evaluation (measures & procedures)
Micro	University research centre or sub-departmental unit	U.S: research centre faculty and non centre faculty[8] CSIRO[9]	Case studies; output metrics (CVs)
Meso	Department of an organisation	UK RAE; Specific NRC lab or department	UK Research Assessment Exercise (RAE) - increasingly driven by metrics[10, 11]

[7] This will assist in understanding the differences for evaluation between centres and large programs and networks.
[8] See e.g. Gaughan and Ponomariov (2008).
[9] See Glaser et al. (2004)
[10] See Barker 2007.
[11] Following the 2008 round of reviews, the Higher Education Funding Council for England (HEFCE) has proposed moving from the research assessment exercise to the research excellence framework. This has been attacked by the Research Councils of the UK 'The proposals from HEFCE for a new Research Excellence Framework to replace the Research Assessment Exercise are not acceptable to RCUK in their current form' RCUK (2008).

			Australian Res Quality Framework Metrics & peer review[12]
	Networks (see Table 4 below for detailed analysis)	Networks of Centres of Excellence (NCEs – Can) Genome Canada[13] Cooperative Research Centres – Aust.	NCEs - scientific panel examinations – no public detailed analysis.
Macro	Stand-alone research organization in the national system of innovation	NRC CSIRO[14] (Australia) -	Metrics, case studies etc
Granting Councils (Provincial, State or National)		Canada – CFI [15] CIHR[16] - (Canada) NHMRC[17] (Australia) US NIH[18] RCUK – Econ Impact Framework[19]	CIHR & NIH – mostly Peer review audits. NHMRC – mixed case studies & metrics.

The analysis presented here of evaluation strategies reinforces the point made by Rogers et al. regarding the unity (super-individuals) of evaluation units. It also again highlights the lack of development of network specific measures. What then of research networks: what frameworks and models are available?

5. Networks: Form and Function

The foregoing discussion raises a number of issues for the evaluation of formal research networks. A consideration of the conceptual issues in building an evaluation model must address the following issues:

1. the purpose of the networks and the purpose of the evaluation (Hansen's three meta issues);
2. scale and form of the networks;
3. program outcome attributes

In the section that follows we examine the first two points, leaving the last for the final section. First let us establish something of the nature of networks.

[12] See http://www.dest.gov.au/sectors/research_sector/policies_issues_reviews/key_issues/research_quality_framework/ Following the election of a new government in Australia in late 2007 the RQF has been abandoned.
[13] Genome Canada does not use the term networks but many of its projects are networks.
[14] ACIL Tasman 2006.
[15] See Hickling Arthurs and Low 2002.
[16] http://www.cihr-irsc.gc.ca/e/30324.html and Bernstein et al. 2006.
[17] See Garrett-Jones, Wixted and Turpin (2004), Turpin et al. (2003) and Butler and Biglia (2001).
[18] See U.S. Department of Health and Human Services (2007), the analysis is primarily based on progress toward goal attainment..
[19] See Office of Science and Innovation (2007) and Department of Innovation, University and Skills (2007). It has been reported recently that the RCUKs have decided to reject the use of economic impact framework as too problematic (see Corbyn 2008).

5.1. Formal networks: purpose and design

Formal or at least semi-formal networks that use and develop the knowledge of their members can be roughly divided into two types: knowledge / research networks, which carry out collaborative research and information exchange and propagation, and policy networks which can consist of communities of policy researchers who carry out research for "evidence-based policy", (Nutley, et al., 2007) or alternatively advocacy and issue-based communities that have the aim of influencing government policy. Although research is common to both, we are primarily interested in those networks that have as a prime objective the creation of new knowledge and the diffusion of that new knowledge or the building of research capacity in new fields of science.

Formally organised research networks, in contrast to self-organising informal networks, (which are typically the professional and co-publishing networks of individual academics) are typically established to meet a range of policy goals. Some of those goals include: encouraging the connection of researchers and users (and other stakeholders) and building multidisciplinary research agendas. Although FRNs can be funded for these purposes in any jurisdiction, they are politically necessary in geographically large jurisdictions particularly where there are widely distributed (relatively small) populations. In this light it is interesting to note that it would appear that national FRNs are a Canadian invention. Although a number of 'networks' programs preceded it (see Atikinson-Grosjean), the Networks of Centres of Excellence program established in 1988 appears to be the first significant public-private research collaboration model. Other nations (such as Australia) may have looked at Canadian networks to see how they could be adapted to their situations (Salazar and Holbrook 2007). It seems entirely possible that the Australian Cooperative Research Centres program was influenced by the development of the Canadian NCEs (compare Networks of Centres of Excellence of Canada 2004, and Slatyer 1994). In Australia networks meet the needs of a small population spread mostly along the east coast, while in Canada, networks address the needs of a population linearly spread across the northern US border, and meet the political needs within which most Canadian researchers operate (Salazar and Holbrook, 2007).

By way of examples, programs which build organisational entities with the qualities of research networks include:

- Cooperative Research Centres (Australia);
- Research Networks (Australian Research Council);
- Networks of Centres of Excellence (Canada);
- Major Collaborative Research Initiative (Canada – Social Sciences and Humanities Research Council);
- FRSQ Strategic Networks (Quebec, Canada)
- British Columbia Health of Population Networks (Canada);
- European Framework programmes (European Union); and
- The Economic and Social Research Council Priority Networks (UK).

The relevant stated objectives (networking and collaboration[20]) of a few of these examples are provided below.

- Canadian Networks of Centres of Excellence[21]

[20] We want to draw distinctions between networks of researchers (research collaboration) and networks designed to incorporate stakeholders that may bring access to national or regional decision makers or the views of particular community groups as their contribution to the work program.
[21] http://www.nce.gc.ca/about_e.htm

- ‘The NCE Program invests in national research networks that: stimulate leading-edge research in areas critical to economic and social development, develop and retain world-class researchers in areas essential to Canada’s productivity, create nationwide multidisciplinary and multisectoral research partnerships, and accelerate the exchange of research results within the Networks and the use of these results by organizations who can harness them for economic and social development’[22]
- ‘Excellence defines the individual researchers who have distinguished themselves through a record of peer-reviewed research. The Centres are created from this pool of excellent researchers who work together on common research projects. The Networks are institutes without walls, formed by Centres coming together to assemble a critical mass of intellectual capacity and to address strategic research questions deemed vital to Canada's social and economic development. Together, the Centres are capable of achieving more than the sum of their individual efforts’[23].

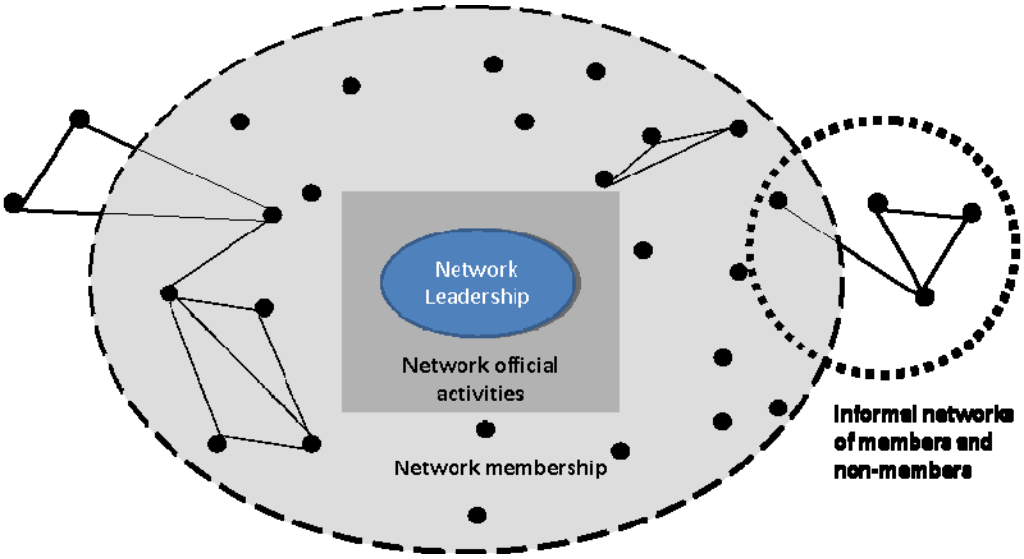
- British Columbia’s Health of Population (research) Networks[24]
  - Networks enhance knowledge transfer and policy impact, networks build or increase research capacity, networks promote collaboration and partnerships …
- Australian Cooperatives Research Centres[25]
  - to enhance Australia's industrial, commercial and economic growth through the development of sustained, user-driven, cooperative public-private research centres that achieve high levels of outcomes in adoption and commercialization
- Australian Research Council Research Networks[26]
  - The ARC Research Networks scheme builds on investments in excellent research undertaken by individual investigators and small teams to: Enhance the scale and focus of their research; Encourage more inter-disciplinary approaches to research; and facilitate collaborative and innovative approaches to planning and undertaking research.

Design Features

There are two particular features that separate formal from informal research networks. The first is that the former is often established with the purpose of improving the embedding of players and of increasing the numbers of players. The second is that FRN are established with an explicit management structure. Taking this second issue, we can build a model of the formal knowledge network organisation; although at the edges they have loosely defined and porous boundaries

Figure 1: The structure of networks

[22] National Centres of Excellence (undated) annual report 2006-2007.
[23] This is taken from a previous version of the NCE website see *planeacion.cicese.mx/RNGCI/docsreferencia/NCE.pdf accessed 17 November 2008.*
[24] MSFHR HoPN PIWG 2008
[25] https://www.crc.gov.au/Information/ShowInformation.aspx?Doc=about_programme&key=bulletin-board-programme&Heading=The%20Program accessed 19 March 2008. As of August 2008 the program had been reviewed but the government had determined its response..
http://minister.industry.gov.au/Carr/Pages/GOVERNMENTWELCOMESRELEASEOFCRCREVIEW.aspx
[26] http://www.arc.gov.au/ncgp/networks/networks_default.htm



At the core of a formal network is the leadership team consisting of principal investigators and administrative staff. Beyond this team is the 'stuff' of *the* network. These are the members of the network engaged in network supported and endorsed *activities* (researchers and stakeholders). However, beyond perhaps a few core fully paid researchers and doctoral students, network *membership* typically includes many individuals who devote only a small percentage of their time to official network work. Thus while they exist within the network, their work is often a grey zone of semi-related activities (often unfunded but often attributed to the network). Lastly, these members will often have their own formal /informal connections to research beyond the walls of the network (other paid research grants etc). Understanding this complex structure of relevant, irrelevant and ambiguous activities is critical for developing an evaluation structure. It is also why we suggested earlier that the project attribution issues are complex and secondary to import policy objectives noted above.

5.2 Networks - the design of evaluations

Given, as we have just outlined formal networks are organisationally unclear, it unsurprising that such little attention has been paid to constructing appropriate evaluation frameworks. Rogers et al. make the following observation.

> *"Most evaluation of R&D is conducted to assess the performance of individuals and, therefore, does not provide guidance on the value of structural properties of R&D activities. Even in the case of evaluation of larger entities — such as centers or programs — they are treated as 'super-individuals' or the sum total of their members for evaluation purposes. This tradition does not help in the specification of relevant boundaries for network analysis of R&D systems that may lead to evaluation based on structural properties" (2001: 167).*

Over the past few years there has been little evidence for suggesting that this comment by Rogers et al. has become invalid[27]. The emphasis and focus of Mote et al. (2007) supports this. However, there are a few examples of network evaluation worth drawing attention to, that span different scales and purposes.

We have alluded already several times to the work of Bozeman and colleagues on informal networks, so here we want to acknowledge what he does say. Bozeman conceptualises the 'value' of knowledge as

[27] This is not to suggest that there are not bibliometric studies of the network of scholars working in the same fields, so called invisible colleges Crane (1972) and many since then.

being embedded within groups of users and producers of that knowledge – an entity that he calls 'knowledge value collectives'.

> *'knowledge value is not transitive among users. In our theory, the value of scientific knowledge is socially embedded in a collective of producers and users (many of whom play both roles). Scientific knowledge is developed through the transformation of extant knowledge into diverse new uses, uses that may have little or nothing in common with previous applications of knowledge' (Bozeman and Rogers 2002: 770)..*

The significance of this model of scientific activity is that it puts at the centre of the endeavour, networks of individuals who generate new knowledge, use knowledge and generate again. However, it does not addressing the networking of FRNs.

One interesting variant of network evaluation analysis has been carried out on what we might call action networks[28]. Creech (2001, and Creech and Ramji 2004, etc.). Creech notes:

> *There is a fundamental gap in the current practice of networking. At present, most organizations are experimenting with models of collaboration for the sharing of information and expertise. … Many researchers are beginning to investigate the value of these models as a means of changing public and private sector actions to be more supportive of sustainable development. But we continue to see organizations struggle with the problem of working together to increase their collective effectiveness, not just to achieve their immediate research objectives but to fulfill their vision of having real influence on decision-making for sustainable development (2001: 1).*

Creech's insights into evaluation as seen here are based on the difficulties of networks meeting the objectives of the network. From this she has developed useful concepts of network governance rather than network outcomes per se. We discuss these in further detail below (section 6.1).

Finally, we come to the European Framework Programme (FP) projects as examples of formal research networks. The FPs have consistently required successful project teams be networks that span the geographic dimensions of the EU and link researchers with stakeholders. Further, there has been considerable analysis of the Programmes in general (see Arnold 2005 for a summary). However, although networking is apparently a key policy dimension, the evidence on the benefits of networks is thin. Arnold notes that they generate new contacts and that smaller networks appear to work better than larger ones, but otherwise he also notes:

> *'A factor promoting stability among a core of frequent participators is the fact that (like other network R&D programmes) the FP does not generate wholly new R&D networks, but causes network extension. Evaluations of network R&D tend to find that R&D networks evolve over time, rather than being newly constructed for each funding opportunity' 2005: 14).*

So what have evaluations of specific networks and network programmes discovered?

5.3 Network structures and scales

What we note from our research on evaluations of existing network programs is distinct lack of focus on the networking of these networks with stakeholders, although internal collaboration between researchers was considered.

Table 4: Evaluation of Research Networks

[28] This is not the name used by the authors. Their evaluation work has been on networks associated with the International Institute for Sustainable Development. Creech calls these networks 'knowledge networks' because their goals are to create knowledge to effect particular changes in lifestyle or international development policy.

	"Individual" Formal Research and Collaborations	**Network Programs**
Micro	Multiple investigator grant applications and projects	NSERC/SSHRC/CIHR team science – review framework under development[29]
Meso	➢ British Columbia - Health of Population networks [30] - mostly narrative with some stakeholder assessments. ➢ Australian Research Networks - no framework yet[31] ➢ Canada – National Centers of Excellence[32]. Individual NCE mid term reviews	➢ Australian Research Networks - no framework yet[33] ➢ CIHR team grants programs – evaluation system under development[34]
Macro	➢ Particular EU Framework based networks[35].	➢ Canada – National Centers of Excellence. – Evaluations in 1997 & 2002, mixed quantitative & qualitative information[36] ➢ Australia – Cooperative Research Centres[37] - previously a mixture of metrics and qualitative analysis, a recent strategic assessment of the program has also been undertaken[38] ➢ MCRI program review[39] ➢ CIHR team science – review framework under development[40] ➢ Austrian Research Networks – research collaboration analysis[41] EU Framework programme

[29] Personal communications
[30] Evaluation framework determined – see MSFHR PIWG (2008)
[31] http://www.arc.gov.au/ncgp/networks/networks_default.htm
[32] Individual Centres have the opportunity to go for a second round of funding. The report on the assessment process – see e.g. http://www.nce.gc.ca/pubs/reports/2007/selec-renewal-oct07_e.pdf provides no detailed notes and provides no explanation as to why one proposal was not renewed.
[33] http://www.arc.gov.au/ncgp/networks/networks_default.htm
[34] Private correspondence
[35] See Arnold 2005.
[36] E.g. http://www.nce.gc.ca/pubs/reports/2007/evaluation/NCEEvaluationReport2007-eng.pdf - noting that the analysis of the networking (collaboration between researchers and partnering with outside organisations) are far less developed than analysis of scientific output.
[37] See Insight Economics 2006.
[38] http://minister.innovation.gov.au/carr/Pages/GOVERNMENTWELCOMESRELEASEOFCRCREVIEW.aspx noting in particular the recommendation (8.2) "i. a common core of broad evaluation measures be developed that would apply across all Government innovation funding programs (especially programs involving collaboration) and their projects, iii iii. a much improved capacity to review innovation funding programs (especially schemes involving collaboration) be developed along with a robust capacity to cease funding weaker projects. Sometimes international review mechanisms are needed".
[39] http://www.sshrc.ca/web/about/publications/mcri_performance_e.pdf The analysis of networking with stakeholders is weak.
[40] Personal communications
[41] Particularly focused on co-publication analysis see Elder and Rigby 2004 and Rigby 2005.

An important contrast of styles between the research centre and granting council evaluations and those of network programs is that the former have typically a structured use of metrics while the evaluations in the latter category are based more on expert opinion with looser terms of reference.

6. A conceptual framework for evaluation

With this background of relevant literature we can summarise the three current spheres of evaluation analysis as being; first, productivity models (scientific output), second, governance evaluations, and third, attempts at mapping collaborations (Elder and Rigby 2004, Rigby 2005 and Ryan 2008). We will quickly review the first two but concentrate where we think there is the most significant need – evaluations of the networking.

6.1 Managing networks

As indicated earlier, productivity frameworks dominate the evaluation of science systems. Although such measures are build at least implicitly on logic models which examine the 'plausible and sensible model of how the program will work under certain conditions to solve identified problems' (McLaughlin and Jordan 1999: 66) these can be particularly problematic when it comes to research networks. What is the output of a research network; new science measured by papers, new members embedded in networks, new networks etc?

In an evaluation of the Austrian research networks, Rigby reports that there was a heavy emphasis placed bibliometric analysis.

> *'This bibliometrics review was based on a method employed by PREST for comparing scientific outputs under programme funding with those outputs arising without funding. ... The method involves three types of analysis: a) a review and assessment of the differential citation rates between the authors' project and non project publications; b) a review and assessment of the difference in citation rates between those papers published by the authors and those published by non-project authors (in this case also from Austria, but from no other countries) within the same journals; and c) a review and assessment of co-publication patterns from within the project. All the analysis is subject to the availability and the reliability of the data provided by the project interim and final reports under the two programmes' (2005: 6).*

While this analysis provides an argument for the synergy and additionality of research networks it is only useful for the knowledge creation aspects of networks. This approach is not useful in evaluating the effectiveness of networks beyond the walls of academia which is the raison d'être of so many network programmes.

A completely different model for evaluation rests on an assessment of the governance of networks. Creech and Ramji, (2004), in analyzing networks for the development and dissemination of information for international development have suggested that network evaluation be based upon:

- Effectiveness: changes in knowledge base, communication practices, relationships; strategic plan
- Structure and governance: network formation, relationships, governance
- Efficiency: interaction among members, institutional support, systems and procedures
- Resources and sustainability: human and financial resources, timelines, sustainability
- Lifecycle: life-cycle analysis

Although, these are valuable criteria, applying them to research networks is challenging due to a lack of detailed criteria against which they could be tested. However, researchers who have worked in research networks would agree that governance is an importance aspect of network success (see e.g. Atkinson-

Grosjean 2006). It is all the more important given that so many networks appear to be relatively short lived. We will return to this issue of governances again at the end of our paper.

6.2 Research networks as policy instruments for cooperative research

The authors received valuable insights into how it might be possible to understand networks as networks from reviewing the results a workshop on evaluation for eight diverse Health of Population Networks developed and funded in British Columbia. These innovative and relatively unique networks are funded to promote the development of linkages between researchers and stakeholders with the goal that these linkages will foster new research questions, projects and teams. The eight networks cover the diverse population areas of: children and youth, environmental and occupational health, mental health, aging, rural and remote health disabilities health, aboriginal health and women's health.

Following analysis of the responses to a worksheet aimed at assisting the workshop participants build an indicator set representing multiple possible outputs of their activities some interesting differences between the networks became apparent. Some networks clearly had a strong sense of the research possibilities, while others saw strong stakeholder interest in the network activities. These responses suggested a possible taxonomy of network attributes which focuses not on the individuals but upon the communities of actors inside them.

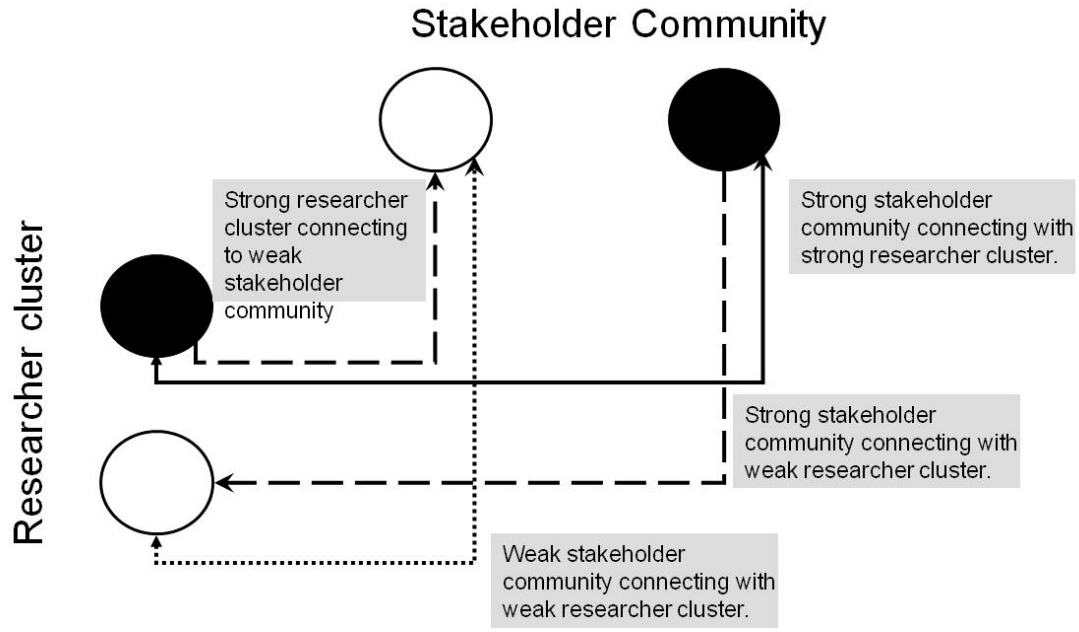
In the most simple modelling of this approach we have two stakeholder communities (researchers and others (industry or populations) and we have two starting positions for each community (strong and weak). This gives a two by two matrix of combinations (Table 5). The examples given do not reflect actual positions of the networks represented at the workshop but characterise the reflection of the authors on the *risks* in terms of a network's ability to network which we have associated with various examples from the field of health and medical research.

Table 5: Identification of Researcher/Community combinations

	Weak stakeholders	**Strong stakeholders**
Strong Researcher Community	'researchers' are relatively easy to define, but the population communities are more diffuse on a comprehensive basis (e.g. gerontology, rural etc)	formal networks where there are two strong poles.(e.g. AIDs researchers and AIDs support organizations)
Weak Research Community	there is both a disparate researcher community and a diffuse stakeholder community (e.g. women's health)	the research community is more disparate but there is a strong emphasis on community engagement and support. (e.g. First Nations)

We said at the beginning of this paper that networks should be assessed for their contribution as research infrastructure, facilitating communications. Therefore, from this matrix we can propose that the properties of the ties between the different communities for networks that inhabit the four positions will likely have particular characteristics (Fig. 3).

Figure 3: Network Structure Typology



From this initial taxonomy of networks we have begun to build a systematic approach to network evaluation. Evaluations built on this model look at the strength of the communities of actors in the networks and degree of connectedness between the start-up network and potential partners and would extend to include the strength of relations within nodes (including the areas of special capacity and interest). Evaluations using this approach have the strength that they would attempt to answer one of the central evaluation questions of formal networks – i.e. did they network?

On this basis, assessment of the network performance could be differentiated according to the different starting conditions. For the different quadrants of our 2X2 (Table 5) we suggest the following:

Quad 1. How well did the research community do in locating and embedding within the network appropriate community members?

Quad 2. How well did the initial team do in building a coalition of researchers and community stakeholders focussed on an appropriate issue of concern or practical research problem.

Quad 3. Given, the strong starting conditions for success, what were the outcomes, was their sufficient partnering and if so was there discernable progress in research and knowledge translation.

Quad 4. Were the community stakeholders able to identify and attract researchers to the network and was there any change in research agendas?

One of the main benefits of such an approach is that we can differentiate networks on the basis of their level of outputs in comparison to what may be expected of them. In some situations it is conceivable that a network with a weak starting position can make greater progress towards the goals of their network than a group that were already highly achieving and the network made not discernable difference.

The specific challenges in working with this model for network are three fold.

1. measuring the strength of the network communities,
2. measuring the tie strength, and

3. measuring the communications content (quality and quantity).

The first two of these points can be approached through data collection exercises as well surveys of participants and non-participants of the networks. Point 3 requires detailed surveys but this challenge is not different.

This is a simplified model. There are different types of research 'networks' – ones where the core group is expected to remain relatively fixed for the life of the grant and ones where there is an expectation of growth, for example. Clearly there can also be variations on the model; for example there could be cases where there are both strong researcher and client nodes but there is a misalignment of research interests.

With this taxonomy of networking in place and with our notional basic 'evaluation' model, we can now return to earlier themes in this paper and incorporate into the evaluation approach both a guide to the 'results' of networks and the performance of governance of the network.

Returning to Salter and Martin we can create a network specific table of results.

Table 6: Network outputs

Salter and Martin (2001)	**Networks**
➢ increasing the stock of useful knowledge	➢ How much was produced? ➢ Was it a similar of different trajectory (i.e. did the networking shift the direction of research)?
➢ training skilled graduates;	➢ did the network produce new graduates? ➢ are they now doing research (see Holbrook *et al*. 2008)? ➢ were they embedded into the network – co-published etc?
➢ creating new scientific instrumentation and methodologies;	➢ as appropriate for individual networks?
➢ increasing the capacity for scientific and technological problem-solving; and	➢ was the network simply diffusing new knowledge (researcher outwards) ? ➢ was there knowledge exchange? ➢ was there knowledge transformation (awareness of needs and capabilities and thus generating new problem definitions and new solutions)?
➢ forming networks and stimulating social interaction;	➢ were the *right* stakeholders included? ➢ did new networks or projects grants spin-off this project
➢ creating new firms.	➢ as appropriate for individual networks?

We can then add to these output measures, tests to measure the performance of the network's governance structures and procedures (adopting a modified version of the Creech list – see section 6.1).

Table 7: Governance performance measures

Governance Issues	**Performance Issues (examples)**
Resources (e.g. financial, human)	➢ in the first term of the network, were enough resources devoted to the networking?
Structure & governance	➢ was the research conducted with efficiency ➢ were the graduate students incorporated effectively?
Effectiveness	➢ What was produced? ➢ Did the researchers connect to the stakeholders? ➢ was the research effort discernibly different for being conducted as a network?
Lifecycle and Sustainability	➢ have new networks or projects spin-off?

Our conceptual model of network evaluation thus comprises three major components:

- what was the structure of the research network relationships, *both internal to the research effort and in its relations with its clients;*
- how did these relations impact on the outputs of the network; and,
- how do the outputs reflect on the leadership and governance of the network?

7. Conclusions

We have shown in this paper that while there is an extensive literature on the evaluation of publically funded scientific research, there has not been a focus on the properties of formal research networks. This appears to have resulted in evaluations that for the most part overlook the policy attributes of FRNs. Further, we have shown that research networks driven by policy considerations (those that have identifiable clients) are special and need consideration on their own merits.

The challenge with such evaluations is that there are three crucial phenomena to assess:

- what were the actual and implied objectives of the funders?
- did the network succeed in its primary objectives?, and
- was it successful in developing and embedding connections and collaborations between mainstream and new members of the network?

To address these specific issues ongoing research on evaluation systems for formal research networks should address three different approaches:

1. ‘network’ analysis (based on the relations between the communities of participants) as outlined in section 6.2.
2. governance analysis, initially suggested by Creech and Ramji (2004), should be examined and adopted with modifications gained from experience of applying it in the science and technology community; and
3. A continued development of indicators that capture the inputs and outputs of networks but with the caution that there are particular limitations to this approach;

One caution of note here is that this overall framework for the evaluation of networks, is just that a framework. We would suggest based on preliminary analysis that research networks in different fields (e.g. social sciences, natural sciences and engineering and medical) each require a more developed strategy and analytical tools than those provided here. Each broad area of science has its own capital intensity, its own stakeholder community structures and the knowledge – problem frontier is different. In the natural sciences it is evolutionary whereas in the social sciences it is co-evolutionary (knowledge changes the actions of the researched subject – e.g. economic actors).

Evaluators interested in the mechanisms of research networks must incorporate more of the sociology of networking operations, structures and mechanisms. Social network analysis and Actor Network Theory (ANT) were both developed as philosophical exercises arising from empirical observations. Neither were developed with evaluation in mind but both offer a rich set of concepts with which conduct more compete analyses of the sociology of formal research networks Network mapping tools may be better suited for within community collaborations analysis (see Mote et al. 2007: 199, Neurath and Katzmair 2004, or Ryan 2008). However, we think ANT (see eg. Latour 1996 and Atkinson-Grosjean 2006), can provide particularly useful information on the challenges faced in network evaluation, by addressing the much neglected area of networking between researchers and stakeholders. Crucially, it is not biased towards case studies of collaborations which already have strong internal ties. It may be possible to use the results for a framework for evaluation of changes over time (what level of change over the grant period was evident),

Application of ANT leads also directly into the analysis of governance. Funding agencies and senior government officials are often as concerned about governance as they are about actual outputs. Focussing, at least partially, on governance can go a long way to providing them with the information on which they can base funding and policy decisions. Such a richer understanding more hopefully eventually feed back into a research management practice within networks that makes them more effective.

As always, more and better indicators are desirable, but this area has been pursued by many authors over the past couple decades. At the same time public sector managers have been less inclined to fund additional indicator research and data collection. Arguably a fresh approach to an understanding of the internal operations of research networks might rekindle their appetite for such management information.

We intend to implement the approach into a few trial projects. Our assessment model is built on the premise that it is possible to narrow down a target group of potential research, industry and community partners and to evaluate the network on its success in reaching and including and /or generating a wider milieu of informed but unconnected partners. This approach does not emphasise the productivity model so prevalent in evaluation studies at the moment but looks to understand the question of performance – what did the network achieve? We will be reporting on our research results in this area in the near future.

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Glossary

CIHR – Canadian Institutes of Health Research;
CRCs – Cooperative Research Centres (Australia);
CSIRO – Commonwealth Scientific and Industrial Research Organisation (Australia);
Formal network – formally funded, structured and organised with a mission to network;
HOPNs – Health of Population Networks funded by the Michael Smith Foundation for Health Research;
Informal network – whether funded as a research project or not it includes work with research assistants, graduate students and stakeholders), regardless of whether they occur as a component of a formal network or not, this network;
MSFHR – Michael Smith Foundation for Health Research;
NCEs – Networks of Centres of Excellence (Canada);
NHMRC – National Health and Medical Research Council (Australia);
NIH – National Institutes of Health (USA);
NSERC – Natural Sciences and Engineering Research Council of Canada;
RAE – Research Assessment Exercise (UK);
Research collaboration – the basic unit of analysis - peer to peer academic co-publishing; and
SSHRC – Social Sciences and Humanities Research Council (Canada).

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