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The "Efficient Boundaries" of International Agricultural Research: A Conceptual Framework with Empirical Illustrations

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ABSTRACT

The role of international agricultural research centers (IARCs) has long been a subject of discussion, often with emphasis that they should conduct research that produces international public goods (IPGs). However, centers still face a dilemma on how to balance between IPGs and location-specific work. This paper contributes to the development of principles by which they should position themselves. Transaction cost economics was applied to develop a framework, which is then illustrated with an empirical case study of legume research at the International Crops Research Institute for the Semi-Arid Tropics. A participatory mapping technique (Net-Map) was combined with key informant interviews in India, Malawi and Ethiopia. We find that IARCS play an important role in germplasm improvement, the field in which they have a comparative advantage. However, due to insufficient capacity of national systems, they also engage in downstream activities. This reduces incentives for governments and donors to overcome governance challenges.

Keywords: *Agricultural innovation; comparative advantage; research spillovers; transaction costs; CGIAR*

JEL codes: Q16

1. Introduction

The first millennium development goal aims to halve the proportion of people who suffer from extreme poverty and hunger. The 2008 World Development Report (World Bank, 2007) stresses the importance of agriculture-led growth to achieve these targets. Although there are differences across regions, productivity growth has driven agriculture's global success. This success has been closely linked to investments in agricultural research and development (R&D) (Alston et al., 2000; Pardey et al., 2006; Raitzer and Kelley, 2008; Renkow and Byerlee, 2010). International agricultural research, therefore, plays an important role in exploiting advances in agricultural science to improve the lives of the poor in developing countries (Zeigler and Mohanty, 2010).

The international agricultural research centers (IARCs) that form the Consultative Group on International Agricultural Research (CGIAR) evolved as the main international system of agricultural research with the aim to reduce poverty and achieve food security while sustaining natural resources. To achieve these goals, priority setting for the CGIAR[1] must have a clear direction in pursuing long-term strategic goals. The CGIAR centers face the challenge of finding a balance between system-level goals resulting from basic and strategic research activities, which are located on the upstream side, and involvement in delivery programmes located downstream. The general consensus has been that the CGIAR should concentrate on the upstream side, conducting research that produces international public goods (IPGs). However, there is often no functional research-development (R-D) pathway, which would ensure that CGIAR research results are implemented on the ground. In particular, there is often no well-defined link between the outputs of the CGIAR and complementary activities that are expected to be conducted by national and local entities, such as national agricultural research and extension organizations (Sagasti and Timmer 2008). Downstream, the lack of adoption is attributed to the institutional context, especially the failure of government to provide the enabling conditions for uptake.

The alternative view is that achieving impact requires involvement by international centers in activities such as adaptation, dissemination, extension, technical assistance, policy advice, and training (Pingali and Kelley, 2007). Therefore, even though they should have a clear direction in

[1] It should be noted that although the discussion focuses on the CGIAR, the international agricultural research system also includes other centers which are not part of the CGIAR.

pursuing long-term strategic goals, this should also encompass some degree of flexibility. In order to effectively address agricultural development concerns, the centers are expected to be open to change and respond sensitively to the wishes of a broad array of local stakeholder groups (Horton and Mackay, 2003).

To take full advantage of talents and opportunities of different actors in the wider agricultural innovation system, a reform process of the CGIAR was initiated in 2009 (CGIAR SRF, 2011). The CGIAR Fund was established to finance thematic CGIAR Research Programs (CRPs) that involve several centers. Funding is allocated through two funding windows, one channeling funds to the overall system, and one to specific CRPs, with the goal to ensure increased and coordinated funding linked to system agenda and priorities. However, donors preferred to have a third window to be able to channel funds directly to specific centers and projects. This suggests that there is still tension between the focus on the generation of international public goods (IPGs), as guided by the strategy and results framework (SRF), and more location-specific activities to be funded under bilateral projects in Window 3 through which donors pursue their priorities.

It is therefore crucial, as the CGIAR undergoes this reform process, to analyze the outstanding debate on the comparative advantage of the international centers, and the question of what activities they should focus on. So far, the international public goods (IPG) concept has been put forth to guide decisions on what the CGIAR centers should do, but as will be discussed in section 3.2, there are contrasting views on this criterion. This paper aims to contribute to this debate by developing a framework based on concepts of the New Institutional Economics to identify the factors that determine the comparative advantage of IARCs. This framework is illustrated with an empirical case study conducted in India, Ethiopia and Malawi.

From a normative point of view, the comparative advantage of IARCs is related to the question as to what governance structure is best suited for the different types of transactions involved in research and in the implementation of research findings. Transaction cost economics, a branch of the New Institutional Economics, offers an analytical approach that aligns transactions that differ in their attributes with governance structures that differ in their costs and competence so as to achieve a cost-effective result (Williamson, 1991). The paper adapts this transaction cost economics framework to the specific features of agricultural research organizations with the aim to provide conceptual guidance on how impact from international agricultural research can be

achieved in the most cost-effective way. In order to use this approach, it is necessary to specify the different transactions involved in the development and uptake of products from international agricultural research. An empirical case study of an important area of agricultural research was conducted for this purpose: research that aims to improve legume crops, which is supported by one of the fifteen CGIAR centers, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Legumes, which include crops such as beans and lentils, also referred to as the "meat of the poor", make significant contributions in developing countries as a source of protein. They also play an important role in maintaining soil fertility as they are able to fix nitrogen.

In the empirical case study, an innovative empirical research tool called "Net-Map" was used. Net-Map is a participatory mapping technique (Schiffer and Hauck, 2010), which was applied in three developing countries to identify the different activities (transactions) and organizations involved in research on improved legumes and their promotion. After developing a typology of transactions based on the empirical study, a transaction cost economics framework was developed and used to analyze the comparative advantage of different organizations in conducting the different types of transactions. By integrating contextual factors, the framework also serves to identify why international centers engage in activities for which they are not expected to have a comparative advantage vis-à-vis national or local organizations, as was the case in all three case study countries.

The paper is structured as follows: Section 2 provides a brief account of the evolution of the international agricultural research centers (IARCs), their rationale and their governance challenges. Section 3 reviews the concept of "international public goods", which has so far dominated the debate on what IARCs should and should not do. Section 4 presents the methodology, and Section 5 presents the case study of groundnut improvement, taking Malawi as an example. Section 6 develops the conceptual framework based on transaction cost economics, using the empirical case study for illustration. Section 7 discusses the application of the framework, and Section 8 concludes.

2. The international agricultural research system: Rationale, evolution and governance challenges

The origins of international agricultural research centers (IARCs) date back to the work of the Rockefeller and Ford Foundations in the 1940s and 1950s, which saw the establishment of overseas rural development activities aimed at increasing the agricultural productivity in developing countries (Herdt, 2012). In 1971, international agricultural research became institutionalized in the form of the CGIAR system, which between the 80s and 90s expanded to 15 different centers, each focusing on one key area of agricultural research. Over time, the mandate of IARCs in the CGIAR has expanded to include reduction of rural poverty, increasing food security, improvement of human health and nutrition, and ensuring more sustainable management of natural resources. These goals are also emphasized in the World Development Report 2008 on "Agriculture for Development", which stresses the importance of agriculture-led growth for reducing poverty, achieving food security and contributing to sustainable resource management (World Bank 2007). It has long been acknowledged that productivity improvements, based on investments in agricultural research, are key drivers for this growth (Alston et al., 2000). The CGIAR system plays an important role in this regard, as it employs almost 10,000 scientists and staff and has a funding volume of more than 870 million US$ (CGIAR, 2012: 3).

While contribution of the CGIAR to agricultural development has been widely acknowledged[2], the organizational structure of the CGIAR system has been subject to debate and reform efforts for decades. As a recent review by McCalla (2014) indicates, these reform efforts did not lead to major changes in the institutional structure of the system. Being a large institution comprising diverse interest groups of political players (donors) as well as operational ones (centers and their research partners) and strategic ones (advisory bodies), the CGIAR is inevitably confronted with governance and co-ordination challenges (Kassam, 2006; Alston et al. 1998). In the first quarter of the century after their establishment, the centers remained under a loosely-knit, decentralized structure and received a large share of unrestricted funds based on voluntary contributions (Anderson, 1998). The centers were independently governed and research programs were

[2] The CGIAR played a prominent role in the "Green Revolution" in Asia, the unprecedented increase in food production in Asia starting in the 1960s that was made possible by the promotion of high-yielding varieties. According to the CGIAR's website, the current overall benefits of CGIAR research in Asia are estimated at US$10.8 billion a year for rice, US$2.5 billion for wheat, and US$0.8 billion for maize (see http://www.cgiar.org/who-we-are/).

directed by centre boards and management (Herdt, 2012). Over time, poor coordination among donors and an increasing amount of "special project" funds reduced the ability of the centers to pursue long-term priorities. The result has been a lack of a system-wide vision and strategy for impact, limited sense of overall ownership, duplicate mandates and loss of system efficiency, complex and cumbersome governance and lack of accountability. At a meeting of stakeholders of the CGIAR system in 2008, rising concerns over these problems and stagnating funding levels led to the decision to promote a fundamental institutional reform of the CGIAR system (BCG, 2009:5).

A key factor affecting the desired outcomes from the CGIAR is the role played by donor countries and other organizations and their indirect influence on the CGIAR research agenda. First, investment patterns still reflect the dominant position and contributions of a small group of donors (Table 1). Secondly, the UN bodies, aside from providing financial resources that support the CGIAR's science advisory body, also nominate the members and chair of the Independent Science and Partnership Council (ISPC) for approval by the CGIAR (Herdt, 2012). Third, US grant-making foundations operate under legal constraints that do not give them a free hand in deciding what projects they should fund (Council on Foundations, 2011).

Until the Gates Foundation came in as a key donor, the relative importance of private foundations and support from national governments to the CGIAR had weakened (Pingali and Kelley, 2007). The private sector has also not provided substantial financial support to the system, even though they also benefit from it (Alston et al., 1998). These financial constraints and the requirement by donors to show impact pushed centers down the Research-Development (R-D) continuum (see next section), inducing them to engage in more location-specific research and extension activities (Bertram 2006). Katyal and Mruthyunjaya (2003) observed that centers were overstretched and compelled by donors to oblige to pet downstream projects. This is a shift from way the CGIAR system was initially crafted to encourage funding of long-term research institutes, but keeping aid professionals from setting research agendas and hiring scientists (McCalla, 2014).

[Table 1 here]

In 2008, a comprehensive review of the structure and activities of the CGIAR was carried out (CGIAR Independent Review Panel, 2008). The review noted that there was proliferation of CGIAR programs and dispersal of research focus, which impeded effectiveness. The reform

process was initiated to effectively harness strengths and assets of different CGIAR centers and improve the organizational structure of the system (CGIAR SRF, 2011). The CGIAR Consortium now provides a single contact point for donors and organizes the work of the 15 centers under the cross-cutting CGIAR Research Programs (CRPs). Donors are expected to channel their funds through the newly established CGIAR Fund, which has three funding windows[3]. Window 1 provides unrestricted contributions to be to CRPs, while Window 2 allows donors to target specific CRPs (CGIAR SRF, 2011). Even though these two windows provide a the opportunity to finance research in accordance with the strategy and results framework (SRF) of the system, a significant proportion of funding is still allocated through Window 3. Moreover, in 2012, more than half of the funds provided to the CGIAR system were still provided through bilateral funding from donors to centers outside these funding windows. This indicates that, so far, a major element of the reform has not yet been implemented.

There is still uncertainty on how the relationship between the Consortium and the centers will evolve over time, especially regarding oversight and accountability (Ozgediz, 2012). In 2015, the structural reforms implemented in the previous years were still subject to discussion and potential revisions. Ultimately, the reform aims to result in a more centralized system of CGIAR governance. This move has not been without criticism. Hartmann (2009) sees the CGIAR reforms as moving research decisions too far away from center scientists, who interact more frequently with national colleagues, farmers and national governments and therefore understand local needs. Ekboir (2009) argued that it will be vital to develop a coordinated system of decentralized experimentation with centralized learning to address the challenges that prompted the reform process. Against this background of a major reform, which has remained contested and only partly implemented, it seems important to reconsider the question of the comparative advantage of the CGIAR centers, as it is essential for current and future reform efforts. The next section reviews the concepts that have, so far been applied to deal with this question.

[3] According to the CGIAR Fund update for February 2014 (p. 2), the total inflows as of December 31, 2013 comprised USD 292.3 million for Window 1, 149.8 million for Window 2 and 253.5 million for Window 3. Besides the window funding, there is still a large contribution from bilateral projects, which in 2013 accounted for 45% of all CRP funding (CGIAR Financial Report, 2013: 18).

3. Assessing the comparative advantage of CGIAR centers

The question of the comparative advantage of the CGIAR centers vis-à-vis national agricultural research and extension organizations has been subject to long-standing debate. Two concepts have been developed in this context: the concept of a research - development continuum, and the concept of International Public Goods.

3.1. The agricultural research - development continuum

The concept of the research-development continuum is displayed in Figure 1. It outlines the primary domains of advanced research institutes (ARIs), a term used for research organizations located in industrialized countries, the IARCs, the national agricultural research and extension systems (NARES), non-governmental organizations (NGOs) and farmers (Craswell and de Vries', 2001; cited in CGIAR, 2006). Four types of research are identified: basic, strategic, applied and adaptive. Basic research is designed to generate new understanding, strategic research aims for the solution of specific research problems, applied research aims to create new technologies and participatory-adaptive research is needed to adjust the technologies to the specific needs of a particular set of users (in this case, farmers) within their specific environmental conditions.

[Figure 1 here]

According to this concept, the CGIAR should concentrate on strategic research, which is located between the basic and the applied. This type of research is to be carried out in different countries and focuses on technologies that fit relevant ecological and production conditions across the developing world (CGIAR Science Council, 2006). The centers should collaborate with ARIs, who have their focus on basic research, and with the NARES, who cover the spectrum from strategic to applied and participatory-adaptive research.

3.2. The concept of international public goods (IPGs) in the CGIAR

To provide guidance on the question as to where in the research-development continuum the IARCs should locate themselves, the concept international public goods (IPGs) has played a prominent role. It has been used as a major criterion to for setting priorities in the CGIAR system (CGIAR Science Council, 2005). The concept of public goods, as used by economists, can be

traced back to Samuelson's (1954:387) theory of public expenditure. According to his theory, pure public goods differ from private goods by the two criteria of being non-rivalrous in consumption and at the same time non-excludable. Non-excludability implies that it is either impossible or very costly to exclude those who do not pay for the good from utilizing it, and once the good has been produced its benefits (or harm) accrue to everyone. The non-rivalry criterion means that any one person's consumption of the public good has no effect on the amount of it available for others. The other goods in this classification are common-pool resources (non-excludability, but rivalry in consumption), and club goods (non-rivalry in consumption, but excludability).

The rationale for public sector involvement in agricultural research is based on the fact that agricultural technologies have characteristics of public goods, especially if they are not embodied in a particular technology, or – as in case of seeds – if they can be reproduced by the farmers themselves. Accordingly, the rationale for the CGIAR in producing public goods stems from the fact that private firms have limited interest in agricultural technologies that are relevant to smallholders in developing countries since they do not have the capacity to capture much of the benefit through proprietary claims (Pingali and Kelley, 2007). There are also coordination problems that render the development of such technologies unattractive to individual governments and private agents (Spielman, 2007). Since farmers in many developing nations still mainly rely on the public sector for agricultural technology (Pineiro 2007), publicly funded research centers are expected to step in to fill this gap.

Public goods can be defined at the local, national, regional, international or global levels. Local public goods are available within a district, municipality or state; national public goods only within the borders of a country; regional public goods to two or more contiguous countries within a geographic or political environment; international public goods to two or more countries across geographic, political or continental divides; and global public goods are available to all countries (Ryan, 2006). The view that CGIAR centers should focus on provision of public goods at the international level (IPGs) began to be explicitly mentioned in the late 1990s and early 2000s (Sagasti and Timmer 2008). This concept has since been subject of discussion in various fora (CGIAR Science Council, 2006; 2008). Harwood (2006, pp. 381) defines IPGs in the CGIAR context as:

"*Research outputs of knowledge and technology generated through strategic and applied research that are applicable and readily accessible internationally to address generic issues and challenges consistent with CGIAR goals*".

According to this definition, it is not sufficient that the CGIAR outputs are available internationally (in fact, every document placed on the internet with free access would fulfill this criterion), they also have to address generic problems, indicating that they do not focus on location-specific solutions. This criterion is linked to the rationale for an international system of agricultural research, which is justified by economies of scale in agricultural technology development (e.g., in germplasm improvement using modern breeding techniques, and by "spillovers", i.e. benefits that accrue to other regions than those for which the agricultural research was conducted.

3.3. Drawbacks of the IPG criterion

The IPG criterion has been criticized for not being refined enough to provide clear guidance for the priority setting of the IARCs. Ryan (2006: 5) noted that "The IARCs (and the Science Council) are currently wrestling with both the identification of these boundaries (of the different types of economic goods) and how to weigh up choices about the focus on the more obvious "public" outputs, versus other goals of the CGIAR related to impacts on poverty, food and nutrition security and the environment". This concept can be more easily applied to traditional CGIAR research, like germplasm improvement and development of new crop varieties, for which economies of scale and spill-over effects can be determined more easily compared to other types of technologies or knowledge, such as natural resource management.

The IPG concept has also been criticized for not adequately taking into account what is required for the IARCs to achieve impact. IPGs have to be utilized by national programs, organizations or individuals in a specific location to achieve impact. The impact pathways for IPGs will be influenced by the institutional context, including policies and political systems (Kherallah and Kirsten, 2001). Some critics consider the IPG criterion as "a conceptual barrier[4] with an unrealistic division of labor between research and development" (CGIAR Science Council 2008, p. 3). Since obstacles to achieving impact are particularly pronounced in developing countries, it

[4] Jonathan Wooley, during Special Session on IPGs at the CGIAR AGM, Maputo, Mozambique November 27, 2008

has been argued that "IPGs should not be a shelter to hide behind the institutional bottlenecks"[5]. For instance, if seed markets are a limiting factor, would producing improved lines be a 'relevant' IPG? Some critics[6] argue that "the most significant transformations led by the CGIAR took place before the advent of 'IPGs'" (CGIAR Science Council 2008, p. 4).

These arguments show that there are contrasting views on whether the IPG concept should be the key criterion that offers strategic direction on what the CGIAR centers should do or not do. Against this background, this paper therefore develops a more refined conceptual framework to provide conceptual guidance for assessing the comparative advantage of IARCs.

4. Methodology

The research presented in this paper consists of two components: (i) A case study, which aims to provide a detailed account of the research and dissemination process of improved technologies produced by international agricultural research centers, and (ii) a conceptual framework, which defines the functional boundaries of IARCs based on their comparative advantage, taking the case study results into account. The case study focused on examples from the breeding program for legume varieties at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). The fieldwork was conducted in three countries that differ with regard to the capacity of their agricultural research systems and the state of their seed systems: India, Malawi and Ethiopia. This choice of countries enabled the authors to compare how differences in capacity influenced decision-making on the activities that ICRISAT was involved in. The three countries were also chosen since they are leading producers of either groundnut or chickpea in their respective regions, and because ICRISAT has a country office in each of them.

Data collection methods included a review of adoption studies, the use of a participatory mapping tool called Net-map. and key informant interviews. Respondents included ICRISAT scientists, national partners, non-governmental organizations (NGOs), seed companies and certification agencies, male and female farmers and other stakeholders involved in the research and promotion of improved groundnut and chickpea varieties. For the development of a transaction costs framework, it was important to understand all transactions involved in the R-D process. In order

[5] Gebisa Ejeta, during Special Session on IPGs at the CGIAR AGM, Maputo, Mozambique November 27, 2008
[6] Same as footnote above

to achieve this understanding in a participatory manner, the Net-map procedure was chosen. It involved asking a series of questions regarding the main actors, their linkages, and the level of influence of each actor on the intended outcome (adoption of new varieties). Follow-up questions were asked on governance challenges involved in the process. Intensive interviews were conducted during the Net-map exercise, which were then recorded and transcribed to provide qualitative information for further analysis. This information was supplemented by a review of supplementary documents including project reports, working papers and workshop proceedings. For reasons of space, this paper reports in detail only the findings from the Net-Map approach that focused on the groundnut variety CG 7[7] in Malawi, as an example to identify the different research and dissemination steps to be considered (i.e. the transactions). Information on the other two case studies is reported in more condensed from and in a comparative perspective.

To develop the conceptual framework for analyzing the comparative advantage of the CGIAR centers in conducting different activities along the research-impact pathway, the case study was combined with an application of the fiscal federalism literature (Oates, 1972) and transaction cost economics (Williamson, 1991; Birner and Wittmer, 2004). This approach follows earlier applications of the fiscal federalism literature and transaction costs economics to analyze the appropriate level of decentralization for different types of rural services (Bardhan, 2002; Birner and von Braun, 2009).

5. Case study: The legumes improvement program at ICRISAT

Improved legume varieties with higher productivity and disease resistance can make a substantial contribution to the well-being of poor farmers. Legumes, however, have two characteristics that make their seed production not very attractive to the commercial seed industry, leading to market failures. These are the self-pollinating nature, which implies that farmers can reproduce their own seeds, and the low seed multiplication ratio, i.e. the low number of seeds to be produced from one single seed when it is sown and harvested, which renders seed production relatively expensive. Hence, breeding, adaptation, multiplication and dissemination of improved legumes typically relies on publicly funded international and national agricultural research and distribution systems. ICRISAT currently leads the CGIAR research program on grain legumes and collaborates with

[7] This variety is also known as ICGV-SM 83708 and ICGMS 42.

three other CGIAR centers and partners to increase the production, value and nutritional quality of grain legumes cultivated in the poorest regions of the world.

The results from using the Net-map tool to understand all the transactions involved in research and uptake of the CG7 groundnut variety are presented in Figure 2. The diagram shows the different transactions and the actors performing them, including ICRISAT, donors, relevant ministries, NARS and agricultural universities, extension systems, seed companies, NGOs, farmers and farmer organizations.

[Figure 2 here]

The arrows indicate the different transactions, and the numbers indicate the sequence of activities, which are explained at the bottom of the diagram. The circles indicate the rating of influence of the actors (on a scale of 1-8) by the respondents of the Net-map tool. They rated their influence on the final outcome, which was defined as the goal that the improved seed varieties are actually adopted by the farmers. The stars represent governance challenges in extension and seed systems that were identified by the respondents.

The following transactions were identified: (i) The first step was the identification of the production constraints faced by farmers and the breeding objectives to be pursued; (ii) The variety was bred at the ICRISAT headquarters in India in 1977/78 by the crossing two lines (USA 20 and TMV 10); (iii) Breeding material was supplied to different regions; in Southern Africa it was introduced by ICRISAT in 1982 under the Southern African Development Community (SADC) Groundnut Project, which involved nine countries and was funded by the German Society for International Cooperation (formerly GTZ) and later the International Development Research Centre (IDRC); (iv) Starting from the 1983/84 growing season, yield trials, testing and adaptation were conducted across locations against existing varieties; (v) The CG7 variety was released and notified in 1990 upon approval by a varietal release committee; the release was based on submission of performance data reflecting a yield advantage of between 11 and 35%. In 1991 it was released as MGV 4 in Zambia and in 1999 as Serenut 1R in Uganda. (vi) Breeder and foundation seed were produced by ICRISAT, while the National Seed Company of Malawi produced certified seed, but there was low demand from farmers; (vii) The variety was promoted by ICRISAT and partners to create awareness among farmers through the distribution of small seed samples, field days, on-farm demonstrations, farmers field schools, the media and

other means; (viii) Further foundation and certified seed production was carried out through ICRISAT's revolving scheme that involved contract growers who got seed on credit. ICRISAT also established community seed banks to hasten the diffusion of the variety. NGOs (World Vision, CARE, Plan International, ActionAid, CADECOM) and smallholder farmer and seed producers associations like the National Smallholder Farmers' Association of Malawi (NASFAM), and Association of Smallholder Seed Multiplication Action Group (ASSMAG) also started producing seed; (ix) Private seed companies (Peacock Enterprises, CPM Agri-Enterprises, Demeter Agriculture, SeedCo, Pannar Seed, Funuwe, Pantochi etc) joined in certified seed production as legumes got included in the government subsidy program in 2009 and created high demand for new varieties; (x) The variety was taken up by farmers, with incentives from the input subsidy program (coupons), and also through farmer to farmer exchange. (xi) Several organizations in the seed sector came together to sell CG7 and other varieties under the Malawi Seed Alliance (MASA) umbrella.

The Net-map exercise also served to identify the governance challenges involved in the different transactions. As the capacity of the national system in Malawi for testing of the new variety was rather limited, ICRISAT decided to post a groundnut breeder from its Indian headquarters to Malawi. He spent five years in Malawi to initiate and coordinate regional testing of material and facilitate varietal release, and after he returned to India, ICRISAT maintained the scientist position at the Chitedze Agricultural Research Station. During an interview he explained "Each country has its own protocol for variety release. CG 7 was selected among the several hundred breeding populations carried by me to Malawi in 1982/83. It was evaluated in Cooperative Regional Yield Trials in the SADC region during 1983/84 - 1986/86. After this, it was further evaluated in national trials / on-farm verification trials in some countries (in Malawi 1988/89 and in Zambia 1987/88 -1988/89). In 1988, it was accepted as pre-release cultivar in Zambia and was named as MGS 4. Varietal release is a long drawn process in some countries". CG7 was released in 1990 and for a long time was a typical case of a variety that remained on the research station shelf long after its release even though it had a proven yield advantage. As can be seen from steps 8-13 in Figure 2, the variety was only adopted after donors provided resources for seed multiplication and promotion to ICRISAT, NGOs and other seed producers. The National Seed Company of Malawi that had initially produced foundation and certified seed was taken over by Monsanto in 1999. It took further interventions by ICRISAT and partners in the area of

agricultural extension (e.g., field demonstrations) as well as a subsidy program to get the variety adopted.

To date, even though government institutions like the Extension Department and Department of Agricultural Research Services (DARS) do exist, capacity gaps still remain and the ICRISAT Malawi office continues to be engaged in downstream activities. This explains why the Center was ranked highest in terms of level of influence on the desired outcome, i.e. wide adoption of CG7 among farmers (Figure 2).

For reasons of scope, the findings from the other Net-map exercises are not reported here, but the main steps in the research and promotion process were similar. Both in India and Ethiopia, varieties were tested by agricultural universities or research stations and the results submitted to a varietal release committee. However, unlike Malawi, seed corporations played an important role in seed multiplication. With regards to technology dissemination, all the chickpea and groundnut varieties required promotion efforts by ICRISAT and partners, even in countries with a higher capacity of the National Research and Extension Systems.

In the next section, the findings from the case studies are used to develop a conceptual framework to analyze the comparative advantage of IARCs in conducting the different transactions that were identified, taking the governance challenges revealed by the case study into account.

6. Conceptual Framework

The transaction cost economics approach used here is based on the so-called "discriminating alignment hypothesis" developed by Williamson (1991), according to which "transactions that differ in their attributes are aligned with governance structures that differ in costs and competence so as to achieve an economizing result" (Williamson, 1991, p. 281). The first sub-section introduces the basic structure of this framework, and the following sub-sections apply the framework using the case study results.

6.1. Determining the comparative cost-effectiveness of IARCs versus national systems

The decision on whether a transaction should be carried out by a an international research center or a national organization can be conceptualized as a choice between a more centralized (international) and a more decentralized (national) governance structure. The choice between

these governance structures is influenced by the attributes of the respective transactions Figure 3, which is based on Williamson's (1991) original approach, illustrates this choice problem in a cost-effectiveness diagram.

[Figure 3 here]

The vertical axis displays the total cost involved in achieving a specified result of the respective transaction, including transaction costs and other costs. They include direct costs that can be directly assigned to the respective activity (such as the salary of the researchers and the cost of the research infrastructure) as well as the transaction costs, e.g., the costs of planning, coordination and supervision.

The horizontal axis depicts the level of the attributes that influence the comparative advantage of different governance structure. The figure displays two different hypothetical cost curves[8], which show how the total costs arising for achieving a specified result change, depending on the level of the attribute displayed on the horizontal axis. One curve depicts the costs arising for carrying out the transaction by an IARC (TC^i), and the other depicts the total costs for carrying out the same transaction by a National Agricultural Research and Extension System (NARES) (TC^n).

The fiscal federalism literature (Oates, 1972) identifies economies of scale and potential for spillovers as important factors, which influence the appropriate level of decentralization. These factors are considered as attributes of transactions here. In the example displayed in the figure, the costs of providing the transaction increase more rapidly for the governance structure of the NARES (i.e. to the more decentralized governance structure), if the level of the respective attribute, for example, *economies of scale*, increases (moving to the right-hand side on the horizontal axis). This is indicated by the relatively steeper slope of the TC^n cost curve. If the potential for economies of scale is low (moving to the left-hand side on the horizontal axis), the transaction is more economically provided by NARES. From point a_1 onwards, it is more economic to assign the transaction to the IARC (i.e. to the more centralized governance structure), because the IARC will achieve the same result at a lower cost. Phrased differently, the diagram shows that from point a_1 onwards, the governance structure of the IARC has a comparative advantage over NARES for carrying out the respective transaction.

[8] While the above comparison considers IARCs and NARES, we recognize that there are many other actors in the agricultural R&D process. IARCs often work in collaboration with partners on joint research projects.

Following the considerations of the IPG criterion explained above, the rationale is that the IARCs have higher set-up costs and higher running costs than NARES. Taking the case study as example, the salaries of ICRISAT researchers are much higher than those of staff employed in the NARES in Malawi. IARCs have a comparative advantage if they use their more expensive set-up to engage in activities with high economies of scale, such as applying expensive breeding techniques for crops that can be grown in different regions. The same argument applies to the attribute of *spill-over effects*, as indicated above. The term "spillovers" has been used in the international agricultural research community since the 1980s (Davis et al., 1987). Bantilan and Davis (1991) identify three types of spillovers: across-location, across- commodity and price spillovers. Technologies are said to have spillover potential if they have applicability to other agro-ecological locations or for a different crop (Deb and Bantilan, 2001; Shiferaw et. al, 2004). Price spillovers occur when the technological change at a specific location increases supply of the commodity and changes the price at other locations through trade. As long as the expected outputs are intended to be relevant to many agro-climatic conditions and achievable through spillovers, the location where research activities are carried out is of little significance (Ryan 2006). Since the CGIAR centers have a global mandate, the research objectives and associated outputs are more likely to benefit other regions or countries (i.e. the potential impact domain is wider). It can, therefore, be expected that more farmers will be reached resulting in lower costs for a given outcome (level of adoption). The literature on decentralized governance also indicates that heterogeneity of local needs is an attribute that increases the comparative advantage of decentralized governance structures (see Birner and von Braun, 2009 and the fiscal federalism literature quoted there).

The framework also identifies the role of contextual factors, in particular, the capacity of the respective organizations carrying out the transaction. In a cost-effectiveness diagram, low levels of achievement due to capacity constraints are depicted in form of a higher level of costs, since the diagram displays the costs for a defined unit of output. Figure 3 displays a case of low capacity of NARES, resulting in an upward shift of the respective cost curve (TC^c). Accordingly, the point from which onwards IARCs have a comparative advantage over NARES moves towards the left-hand side to point a_2. A reform or investment that results in increased capacity of the NARES would have the opposite effect (moving the TC^n curve downwards and shifting the intersection of the curves to the right-hand side).

The application of the transaction costs framework to the question of decentralization has shown that the effect of some attributes on the level of decentralization depends on contextual factors (Birner and von Braun, 2009). This is in particular the case for the following two attributes:

- *Transaction-intensity*: This attribute refers to transactions that have to be carried out frequently (transaction-intensity in terms of time) and in large areas (transaction-intensity in terms of space). Transaction intensity has been used to characterize transactions in service delivery (Pritchett & Woolcock, 2004; Birner and Linacre, 2008; Birner and von Braun, 2009). The effect of transaction-intensity is ambiguous: One the one hand, this attribute increases the comparative advantage of NARES, because they have lower costs for carrying out a large number of transactions. On the other hand, the costs of supervising and ensuring the quality of activities with high transaction-intensity is high. This increases the comparative advantage of organizations with high capacity that are able to provide strong performance incentives for their staff. In case of low capacity of the NARES, transaction-intensity will increase the comparative advantage of the IARCs.
- *Scope for elite capture and corruption*: If transactions are subject to these hazards, the extent to which a more centralized or a more decentralized organization has a comparative advantage depends on the capacity of the respective organizations to deal with these issues (Bardhan, 2002, Birner and von Braun, 2009).

6.2. Types of transactions and their attributes

6.2.1. Overview

This section discusses how the approach outlined above can be applied in determining the comparative advantage of IARCs versus NARES in carrying out the agricultural research and development activities identified in the case study. For simplification, one can classify the types of transactions identified in the case study into the following types:

- **Planning and priority setting**: The identification of breeding objectives (Step 1 in Figure 2) can be considered as a planning and priority setting transaction. Some breeding objectives can be considered rather universal, such as yield potential, while others are affected by a diversity of local preferences, such as taste and color.

- **Technology development**: Technology development transactions included activities such as setting up and maintaining the required infrastructure, getting access to genetic resources, establishing the partnerships required for research, as well as all activities involved in conducting the actual breeding activities. In Figure 2, activities from the initial crossing at the ICRISAT headquarters until the variety was incorporated into national breeding programs for evaluation (step 2-3) can be classified under technology development transactions. As shown in Figure 1, these activities range from basic and strategic research to participatory/adaptive research. The centers collect and maintain germplasm accessions, carry out crosses depending on breeding objectives, and release advanced breeding lines for adaptation, testing and release.
- **Field testing and varietal release**: Promising cultivars were initially tested at the ICRISAT experiment stations before further testing on a larger scale in different agroecologies, and later in farmers' fields. Varieties were approved for release if data from multi-locational testing indicated that they performed better compared to the existing best variety (steps 4-5 in Figure 2).
- **Multiplication**: To obtain the required volumes of improved seed for sale/ distribution, seed multiplication is carried out in seed company farms or by using contract growers. Decentralized seed multiplication can also be carried out by small-scale farmers who then sell the seed locally. Many of the activities between step 6-15 in Figure 2 involved seed production, processing, storage and distribution.
- **Certification**: Since most characteristics of improved seed are not outwardly visible, information asymmetries are likely as the knowledge on seed quality is retained by sellers (Byerlee et al., 2007). Seed certification, usually by an independent body, is used as a means of quality control. Multiplication transactions and certification are specific to embodied technologies such as seeds, whereas the other types of transactions identified above are equally relevant for disembodied types of technologies that the IARCs also develop, such as natural resource management practices.
- **Promotion**: ICRISAT has received funding from various donors including the Norwegian Development Fund, Irish Aid, BMGF, the McKnight Foundation and the Australian Agency for International Development (AusAID), for seed multiplication and promotion of CG7.

Details of the activities conducted by ICRISAT together with NGOs and various departments under Ministry of Agriculture and Food Security (MoAFS) can be seen in steps 8-13 of Figure 2. The beneficiaries also had to undertake certain activities and incurred some costs aside from the cost of seed, e.g. they had to spend time and money to travel and to access extension agents.

- **Evaluation and impact assessment**: Impact assessments (ex-post or ex-ante) are carried out to identify and measure the economic, social, and environmental consequences resulting from a program or project's interventions (Walker et al. 2008). Expost evaluations serve as a means of showing accountability to donors and other stakeholders, and also help in learning on how to make agricultural research more effective (Horton and Mackay, 2003). Resource allocation and targeting decisions for research can be guided by rigorous ex ante evaluation of impacts, including spillover benefits across regions.

Having categorized these activities, we can now make an assessment of the relevance of each attribute identified in sections 6.1 for the each of the of transactions in the agricultural research-development continuum. The results are summarized in (Table 2).

Table 2 about here

6.2.2. Planning and priority setting transactions

Priority setting activities together with resource mobilization require interaction with donors and other stakeholders who have knowledge on constraints facing the farming communities. Planning is carried out at the centre level to develop the global research agenda, and at the regional level to set priorities that address location-specific needs. These activities are associated with decision costs such as the direct costs of attending meetings (e.g. for strategic planning) and time spent in donor relations. The new system under CRPs exploits economies of scale and reduces transaction costs of interface activities. From a cost-effectiveness[9] point of view, the risk of incurring decision failure costs (Birner and von Braun, 2009) arises if the research agenda is not driven by local needs leading to suboptimal decisions.

[9] Costs associated with achieving a set outcome are analyzed the outcome being held constant

Tools used for priority setting such as models for forecasting, scenario analysis and ex-ante impact assessment can be applied elsewhere, representing a spillover potential. Planning transactions at the centers can therefore be associated with attributes of economies of scale and potential for spillovers and a more centralized approach is likely to reduce the costs. However, planning for the purpose of pursuing location-specific goals can be done more cost-effectively by the relevant government agencies in each country as it would otherwise involve high transaction intensity for the centers.

6.2.3. Technology development transactions

The running costs for research activities conducted by national system scientists may be lower compared to those of IARCs. However, depending on the sophistication of the techniques required, the results may be below expectations if research is delegated to a partner that does not have the required skill sets. In terms of a cost-effectiveness consideration, this loss in achievement can be expressed as "decision failure costs". The research lag may also be longer resulting in higher overall costs for a given research output, if the NARS do not have sufficient capacity.

The capacity to exploit economies of scale in agricultural R&D at a global scale is linked to the specialized assets that the centers possess. In the case study, considering that ICRISAT has a specific mandate on groundnut research (also chickpea, pigeonpea, sorghum and pearl millet), the physical and human assets that the institute possesses are specialized. For example, the gene bank contains germplasm accessions for these mandate crops that cannot serve other crops' needs in terms of seeds[10]. On the other hand, agricultural research, requires a multidisciplinary approach, e.g., an integrated genetic and natural resource management approach (Twomlow et al., 2008). Some form of site-specificity is required where synergy across themes is to be achieved. This is possible when stations are located in a "cheek-by-jowl" relation to complement each other and economize on inventory and transportation expenses (Williamson, 1991). For instance, ICRISAT has facilities like a gene bank, a molecular lab and a greenhouse as well as human resources comprising molecular scientists, breeders, pathologists and agronomists all working on the same crop.

[10] This statement applies with the exception of cases where there are across-commodity spillovers representing benefits for multiple crops

Where technical knowledge is relevant, such as in case of basic research activities (Figure 1), IARCs may be more suited to exploit economies of scale in providing or utilizing this knowledge. An example is the ICRISAT genomics research that is based at its headquarters in India, but serves the needs of both Asia and sub-Saharan Africa.

Where the potential for spillovers is high, research programs and infrastructure can be centrally set up with assurance that the products can be transferred and applied in similar environments elsewhere. For example, Maredia and Byerlee (1999) quantified spillover benefits for improved wheat germplasm across agro-ecological boundaries. Spillovers from research in one region within a country to another have also been estimated. For example, Alston et. al (2011) measure the returns to the United States public agricultural research with spillover benefits across states. Developed country agricultural research systems also benefit from the technology spillovers generated by the CGIAR; Brennan (1986) measured the benefits to Australian wheat breeding programs of access to breeding materials from CIMMYT. Brennan and Bantilan (2003) and Brennan et. al. (2003) use case studies of production spillovers to Australia from the work of ICRISAT and the International Centre for Agricultural Research in the Dryland Areas (ICARDA), respectively. Pardey et al. (1996) measured benefits to US wheat and rice production from germplasm developed at CIMMYT and IRRI. In the case of CG 7, the variety was not only released in Malawi, but also Zambia as MGV 4 in 1991, and Uganda as Serenut 1R in 1999 (Shiferaw et. al, 2004).

Basic and strategic research transactions can therefore be associated with attributes of high economies of scale and high potential for spillovers. Since a lot of interaction with farmers or travels to dispersed field locations is not required at this stage, basic and strategic research activities can be characterized by low transaction-intensity. In this case, a more centralized governance structure is likely to reduce transaction costs. However, participatory and adaptive research activities have lower economies of scale and a lower potential for spillovers. Hence, ceteris paribus, they can be carried out most cost-effectively by the decentralized national systems. The same applies for the evaluation of breeding lines in different agro-ecologies across the country

6.2.4. Field testing and varietal release transactions

Field testing transactions have similar attributes to participatory and adaptive research since they involve testing of selected varieties across environments. However, the application of tight controls on variety release and seed trade presents a scope for elite capture and corruption. Plant breeders from the public sector may be protected from competition, as only varieties approved by the varietal release committee can be sold. These committees are typically composed of officials, and release is based on yields documented in government-run trials (Tripp and Rohrbach, 2001). In the case of the groundnut variety ICGV91114 in India, the performance of the variety was evident. Still, it may not have been released without lobbying from ICRISAT and the intervention of the Chief Minister (Birthal et al., 2012). The implication is the following: NARES would have a comparative advantage in field testing and varietal release based on the attributes of low economies of scale, low potential for spillovers and high transaction intensity. However, if the the scope for elite capture and corruption is taken into account, this comparative advantage will only prevail if they have a strong organizational capacity to address these challenges.

6.2.5. Multiplication transactions

Seed multiplication is carried out based on demand projections for a specific country. Accordingly, breeder and foundation seeds are produced by the research station or university that released the variety, while certified seeds are produced by state corporations or private firms. Seed production under centralized seed company farms may have higher economies of scale, but depending on the location of processing, storage and distribution facilities, there will be additional costs of transportation. The use of decentralized systems, such as contract growers, involves a high transaction-intensity, as constant supervision is required. These factors imply that seed multiplication can be carried out most cost-effectively by NARES, rather than IARCs.

However, as was observed in Malawi, the local NARES organizations often lack the resources and incentives to perform this function as required. From the case studies, we noted that breeder seed production is not funded separately from the actual breeding activities. Moreover, case studies also showed that the NARES have insufficient numbers of research and seed technicians, and they lack processing, storage and distribution infrastructure. Breeders are rewarded for varieties they release and not seed multiplied, a system that does not create incentives for

promoting adoption. For these reasons, ICRISAT felt compelled to engage in seed production activities, even though they are characterized by high transaction-intensity.

6.2.6. Certification transactions

Seed certification is characterized by a medium level of transaction-intensity. Certification involves field inspections of the seed crop to guarantee the identity of the variety. Moreover, laboratory tests are required for quality attributes such as germination percentage, purity, seed health and moisture content. However, the transaction-intensity is lower than that of promotion transactions that require frequent interactions with a large number of farmers. Still, a decentralized governance structure involving smaller regional laboratories and locally based inspectors would provide a rapid response to seed producers. However, this approach is likely to present challenges in monitoring and maintaining quality standards (Cromwell et al., 1992). The responsibility for seed certification was placed on independent agencies in India (Andhra Pradesh State Seed Certification Agency) and in Malawi (Seed Services Unit), while in Ethiopia a quality assurance department was set up within the Ethiopian Seed Enterprise (ESE) itself. While this separation aims to avoid that the certification is compromised, the case study showed that this governance arrangement was not sufficient to guarantee seed quality. The fact that certification agencies are mostly financed by the government makes them vulnerable to budgetary constraints. For example, seed production plots in Malawi were visited fewer number of times than what is stipulated in the regulations, as the resources available were too limited. Moreover, inspectors with poor salaries are likely to engage in rent seeking behavior that might compromise the transparency and effectiveness of the certification procedure (cf. Tripp and Louwaars, 1997). Hence, certification transactions pose similar challenges as multiplication transactions. Decentralized governance structures (NARES) only have a comparative advantage if they have sufficient capacity to deal with the governance challenges involved, especially providing sufficient funding and avoiding bribery in the process.

6.2.7. Promotion transactions

Technologies that are available for dissemination require further local development and adaptation. This makes it difficult to standardize activities such as extension, which reduces the economies of scale and the likelihood of spillovers. Promotion programs are characterized by high transaction-intensity in terms of time and space, as they require frequent interactions with

farmers and the deployment of large staff numbers throughout the country on a daily basis. These transactions should, therefore, be the responsibility of national systems who have local offices to facilitate monitoring and supervision and reduce transaction costs.

Still, the transaction intensity varies depending on what is being promoted. For example, information on new varieties can be provided using mass media, whereas guidance on crop management practices such as tillage operations, spacing or methods of seed placement and fertilizer application requires more interactions with farmers (Birner and von Braun, 2009). There are situations where NARES may lack sufficient capacity to promote certain techniques. Until this capacity is developed, IARCs may have a comparative advantage in carrying out promotion activities, as has been seen in many natural resource management research projects (Harwood et al., 2006). The case study showed that competition between the international centers and the national system can also result in constraints. In the case of ICGV91114 in India, the variety faced a backlash from the national partners who have been reluctant to promote it alongside varieties such as K6 that were released by the local universities. ICRISAT made efforts to promote the variety through NGOs, but it still faces an adoption lag and has not been taken up on a large scale in the formal seed production process. Considering that India has a national system with a significantly higher capacity than the other two case study countries, this example raises the question of whether ICRISAT had a comparative advantage in developing and promoting its own variety in India. Seed promotion activities, such as agricultural extension services, are less prone to corruption than regulatory activities such as seed certification, at least as long as they do not involve the distribution of inputs. However, they are subject to problems of elite capture, since larger farmers and politically well-connected farmers are often more likely to benefit from extension services (Birner et al., 2009, Feder et al., 2011). Hence, as in case of multiplication and certification activities, governance problems, more centralized governance structures may gain comparative advantage if they are better able to deal with these challenges, e.g., by involving NGOs that have a strong dedication to work with poor and disadvantaged farmers.

6.2.8. Evaluation and impact assessment transactions

Impact assessment and project reporting activities involve costs for data collection, analysis and write-up. These costs escalate when the centers have a large number of bilateral projects with small budgets that need to be reported separately. Projects that do not budget for evaluation

activities may be unable to show accountability to donors and therefore run the risk of losing additional funding. In terms of transaction-intensity, these projects can be assessed to have an intermediate level, since evaluation transactions are less frequent than promotion transactions. Still, they are also subject to governance challenges, since organizations have incentives to report good results in order to secure funding. As in case of certification transactions, limited organizational capacity will reduce the comparative advantage that more decentralized organizations would otherwise have.

6.3.Summary of attributes of transactions

Table 2 above summarizes the findings from the above discussion. The examples in the case study as well as the theoretical and literature-based assessment presented above shows that the attributes of economies of scale and potential for spillovers increase the comparative advantage (cost-effectiveness) of IARCs over NARES in carrying out the transaction. This finding is consistent with the literature on international public goods. What the framework adds to this literature is the identification of transaction-intensity and the scope for elite capture and corruption as important attributes. Unlike in case of spillovers and economies of scale, the effect of these attributes for the comparative efficiency of different governance structure is ambiguous: If intermediate or high transaction-intensity is combined with scope for elite capture or corruption, it will depend on the context whether the international centers or the national system will be more cost-effective. This topic is further discussed in the next section.

6.4. The role of contextual factors

An important factor emerging from the case studies and the hypothetical cost curves above is the influence of contextual factors, especially capacity of national systems as compared to those of international systems. Comprehensive cross-country data on the capacity of national research and extension systems are limited. The Rate of Return to investment may be seen as one indicator. As von Braun et al. (2008) found, the average rate of return (ROR) to NARS in developing countries is much lower than that of IARCs. In Africa, the median ROR for IARCs was found to be 83 percent higher than that of NARS, while in Asia and Pacific the gap was 72 percent (von Braun et al., 2008).

The relatively lower returns to investments in national systems create a vicious cycle, since donors are less inclined in investing in these centers, hence their capacity remains low. As staff in national systems are often poorly compensated and have limited career options based on merit, they typically lack strong incentives to perform effectively. Until the world food crises of 2007-2008, public funding for agricultural research declined considerably, especially in agriculture-based countries (World Bank, 2007; Lynam et al., 2012).

The example of the Green Revolution in Asia shows that developing countries can be successful in increasing the capacity of their national research and extension systems, if they have strong political incentives to do so. The Green Revolution is often seen as a technological revolution. However, it is equally the success of institutional capacity building. Much of its success can be attributed to India's political interest to become food sufficient as well as the willingness of the US government and donors such as the World Bank, and Rockefeller and Ford Foundations to provide support. C. Subramanian, the then Indian Minister for Agriculture, championed a range of institutional reforms in the agricultural research, extension and education system of India that enabled the Green Revolution to materialize (Banerjee, 2013; Bhagat, 1998).

The above framework suggests that the higher the institutional capacity of national systems, the less the IARCs should engage in downstream activities of seed multiplication and promotion. The fact that ICRISAT engaged in promoting its own variety in India indicates that the CGIAR centers may not base their engagement of a thorough analysis of their comparative advantage, taking context-specific factors into account. The reasons may be explained on political economy rather than efficiency grounds. The IARCs have to respond to donor demands to secure their own funding, even if there are trade-offs in terms of competition with national systems. They may find it more convenient to use donor funding to work with NGOs, rather than engaging in the difficult process of assisting government agencies to increase their institutional capacity and meet their governance challenges.

7. Applying the Framework

The empirical case studies presented in this paper were used to develop and illustrate the conceptual framework presented above. Further empirical research will be required to apply and test this framework. Different methodological approaches are available for this purpose. The

standard approach in empirical transaction cost economics does not require a measurement of transaction costs. The approach is rather to formulate hypotheses on the comparative advantage of different governance structures, depending on attributes and contextual factors, and then test these hypotheses empirically by finding out whether the governance structures with a predicted comparative advantages are indeed found more frequently in practice (Shelanski and Klein, 1995). However, empirically quantifying attributes of transactions may also be challenging since variables such as asset specificity are difficult to measure. Although some surveys have used scaling methods (Brown and Potoski, 2003), such data are subject to the general limits of survey data since that they are based on the stated beliefs of respondents rather than those revealed through choice. The measurements, based on ordinal rankings, are also difficult to compare across institutions (Shelanski and Klein, 1995).

In the case of agricultural research for development, an additional challenge needs to be considered: There is no market mechanism which ensures that the most efficient governance structures survive. Research managers, therefore, have to define the most appropriate institutional structures to achieve impact with a given set of resources. As discussed above, IARCs have to consider other factors than comparative efficiency when making these choices, and donors are likewise subject to political pressure to produce quick results rather than creating governance structures that are sustainable and efficient in the long run.

If we apply the conceptual framework derived above to the case studies, we would expect that international agricultural research should play an important role in upstream research such as breeding improved varieties, for which the centers clearly have a comparative advantage. We would also expect that the centers only engage in downstream activities such as seed multiplication and promotion of the national systems have limited capacity. However, as shown above, this was not the case. In India, ICRISAT even entered into a competition with the national system. In the other two case study countries, the focus of carrying out multiplication and promotion activities through parallel systems is likely to reduce the incentives for national governments to overcome the governance challenges in their own systems. The framework presented above suggests that the CGIAR and their donors should device ways of addressing the capacity challenges instead of incentivizing centers to replace the activities of national systems. This would in the long run shift the cost curve for national systems (Figure 3) downwards, and

allow them to carry out the activities for which they have a comparative advantage if they are able to meet the governance challenges identified above. This long term vision to build NARS capacity to do applied and strategic research was already expressed by the Technical Advisory Committee (TAC) of the CGIAR in the early 1990s (McCalla, 2014).

As the above discussion shows, the governance structures that are empirically observed may not be the most cost-effective ones. This has two methodological implications for further research. First, it will be useful to apply techniques to the measure transaction costs of the empirically observed governance structures directly to be able to compare their cost-effectiveness. While there are few empirical limitations so far, there is sufficient evidence that the empirical measurement of transaction costs is feasible (cf. Birner and Wittmer, 2004, and the literature quoted there). The second methodological implication is that there is a need to better understand the political economy underlying the decisions of donors and international research centers regarding the extent to which they engage in downstream activities.

8. Conclusion

International agricultural research aims to address a range of challenges facing resource-poor farmers in developing countries. For the intended benefits to be achieved, investments are required at all levels, from the international to the national. The analysis undertaken in this paper deals with long-standing concerns regarding governance of IARCs, which the currently ongoing CGIAR reform process aims to address. The review of past discussions in the literature and in various fora identified a gap in the available methodologies that would allow the CGIAR system to objectively tackle the dilemma of how the international centers should position themselves in the research-development spectrum. The IPG concept has been put forth as a criterion for identifying what the CGIAR centers should focus on, but there have been persistent difficulties in defining and operationalizing it. In this paper, a normative framework is developed to address the critical question of who should do what so that publicly funded international agricultural research can result in wider and sustained welfare benefits.

The framework presented here applies transaction cost economics perspectives to conceptually analyze institutional options for carrying out activities along the research-development chain. This approach is consistent with earlier approaches, especially the IPG criterion, but it provides

additional insights, especially regarding the role of governance challenges and capacity constraints in influencing the comparative advantage of the CGIAR. Thus, the framework can be expected to provide a useful basis for strategic discussions on how far downstream the CGIARs should go, in a particular context, to achieve impact from agricultural R&D most cost-effectively. Based on the consideration of the relevant attributes of transactions and contextual factors, the framework makes it possible to assess the trade-offs involved in assigning an activity to IARCs, NARS or other actors in the innovation system.

The differentiated approach used in the case studies shows that a complex set of factors, such as availability of funds and political pressure e.g. donor preferences will influence the decision to carry out specific activities. Donors have the goal to achieve impact in poor areas, but the main problem is the capacity gap of national organizations. There is a choice to be made between investment in the tedious and long-term task of strengthening local capacity, or avoiding these governance challenges by driving international centers into downstream activities. The example of ICRISAT's research on groundnut improvement and promotion illustrates how IARCs are involved in activities for which they would not have a comparative advantage if the governance challenges of local systems were addressed. The findings are likely to apply to other research areas in which the international centers are involved. Ultimately, the findings of this study suggest that, to make international investment in agricultural research sustainable in the long-term, the centers and their donors concentrate should concentrate on assisting national agricultural research and extension systems in building their own capacity, rather than substituting their activities.

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Tables

Table 1: Top Donors by Decade (Amount in US$ million)							
1971-1979		**1980-1989**		**1990-1999**		**2000-2010**	
United States	**105.7**	United States	**412.7**	World Bank	**426.8**	United States	**650.4**
World Bank	**42.9**	World Bank	**236.0**	United States	**392.3**	World Bank	**539.9**
Canada	**39.3**	Japan	**127.9**	Japan	**321.9**	United Kingdom	**389.4**
Germany	**33.9**	Canada	**103.0**	European Commission	**159.3**	European Commission	**337.5**
IADB*	**29.2**	IADB*	**88.8**	Switzerland	**149.7**	Canada	**298.2**
United Kingdom	**23.7**	Germany	**87.5**	Germany	**146.7**	BMGF***	**218.6**
Rockefeller Foundation	**21.2**	United Kingdom	**78.1**	Canada	**143.6**	Switzerland	**198.5**
Ford Foundation	**20.3**	UNDP	**72.1**	Netherlands	**110.3**	Netherlands	**185.6**
UNDP **	**19.3**	European Commission	**67.3**	United Kingdom	**109.7**	Japan	**184.0**
Sweden	**15.3**	Switzerland	**58.5**	Denmark	**102.8**	Germany	**170.6**
		Italy	**58.5**				
*Inter-American Development Bank, ** United Nations Development Program , *** Bill and Melinda Gates Foundation (Began contributing in 2004)							
Source: CGIAR Fund Office, 2011.							

Table 2: Transactions and their attributes

Transactions	**Relevance of Attributes**			
	Economies of Scale (incl. asset specificity)	**Spillover Potential**	**Transaction Intensity**	**Scope for elite capture and corruption**
Planning and priority setting Generic goals	High	High	Medium	Low
Location-specific goals	Low	Low	High	Medium
Technology Development Basic - strategic	High	High	Low	Low
Adaptive - participatory	Low	Low	High	Medium
Field testing and varietal release	Low	Low	High	Medium
Multiplication	Low	Low	High	Medium
Certification	Low	Low	Medium	High
Promotion	Low	Low	High	High
Evaluation/impact assessment	Medium	Medium	Medium	Medium
Source: Authors				

Figures

Figure 1: Primary domains across the research continnum

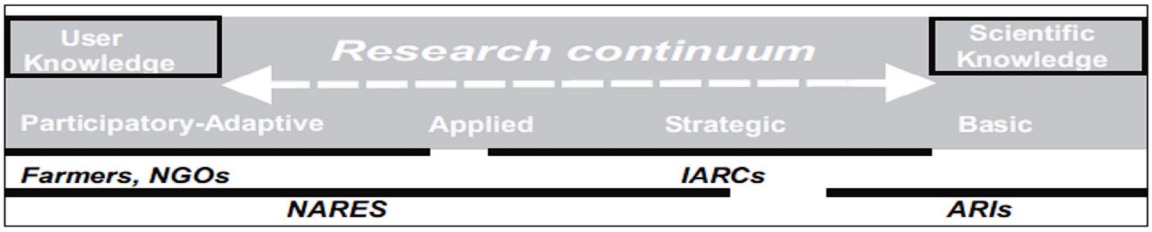
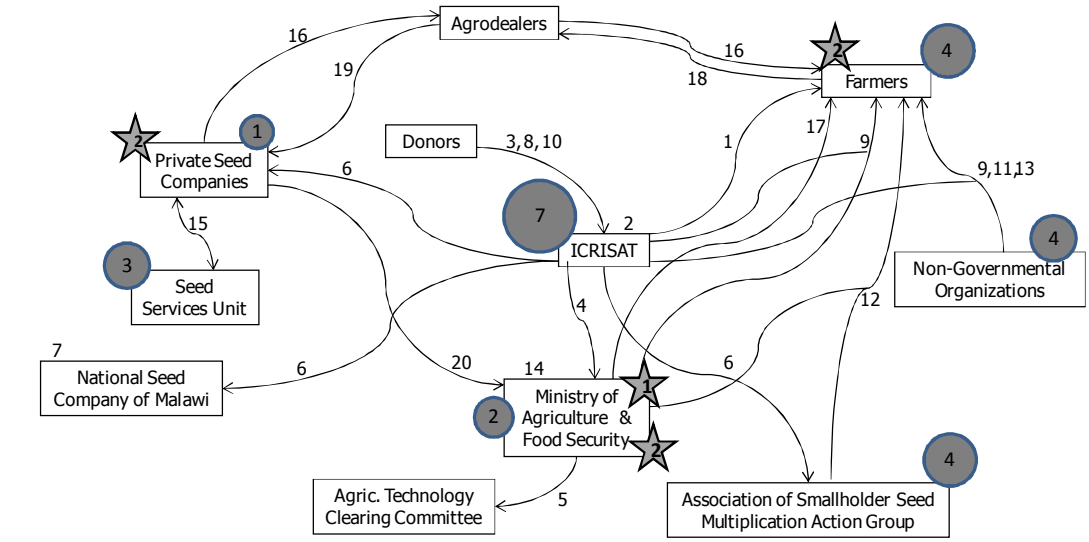
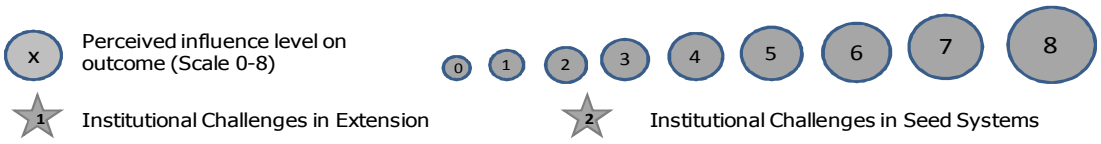


Figure 1: Primary Domains across the research continuum of INRM. Source: CGIAR Science Council, 2006.
ARI= Advanced Research Institute, IARC= International Agricultural Research Centre, NGO= Non-Governmental Organization, NARES= National Agricultural Research and Extension System (NARES)

Figure 2 Process-Influence Map for Research and Promotion of Groundnut Variety CG7 in Malawi

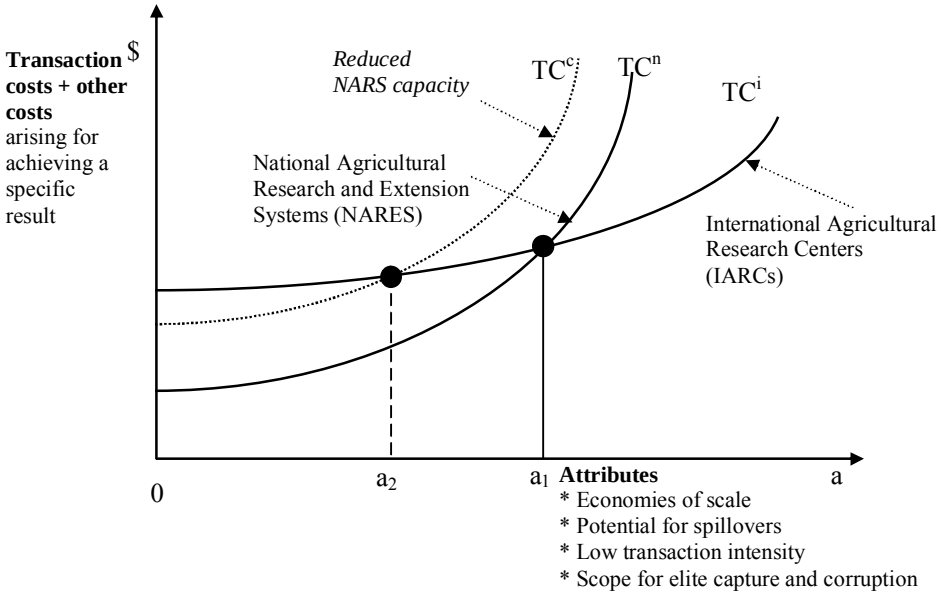


1. Identification of Breeding Objectives
2. Initial Crossing at ICRISAT, India
3. Funding for Adaptive Research
4. Regional Trials under Collaborative SADC Program
5. CG7 Release in Malawi, later Zambia and Tanzania
6. Breeder and Foundation Seed Production and Supply
7. Seed Multiplication and Supply; Low Demand
8. Funding for Projects with Promotion Components
9. Seed Exchange Model with Local Varieties, Community Seed Banks, On-Farm Demonstrations, Buy-Back
10. Seed Revolving Fund
11. Seed Production, On-Farm Demonstrations, Promotion, Aflatoxin Testing, Market Opportunities
12. Seed Production, Processing, Marketing, Farmer Education
13. FFS on Conservation Agriculture, Legumes in Rotation
14. Inclusion of Legumes in Subsidy Program
15. Certified Seed Production
16. Seed Sales
17. Seed Coupons Provided to Target Farmers
18. Seed Coupon and Top-Up to Agrodealer
19. Coupons to Seed Company that Supplied Seed
20. Coupons for MoAFS for Payment



Source: Authors

Figure 3 : Comparative cost-effectiveness of conducting research by IARCs versus NARS



Source: Based on Williamson (1991), Birner and Wittmer (2004) and Birner and von Braun (2009)