How productive are academic researchers in agriculture-related sciences? The Mexican case

UNITED NATIONS UNIVERSITY

UNU-MERIT

Working Paper Series

#2009-038

How productive are academic researchers in agriculture-related sciences? The Mexican case

René Rivera, José Luis Sampedro, Gabriela Dutrénit, Javier Mario Ekboir and Alexandre O. Vera-Cruz

United Nations University - Maastricht Economic and social Research and training centre on Innovation and Technology
Keizer Karelplein 19, 6211 TC Maastricht, The Netherlands
Tel: (31) (43) 388 4400, Fax: (31) (43) 388 4499, e-mail: info@merit.unu.edu, URL: http://www.merit.unu.edu

How productive are academic researchers in agriculture-related sciences? The Mexican case

July 2009

René Rivera[1], renerivera72@yahoo.com
José Luis Sampedro[1], sampedroh@yahoo.com.mx
Gabriela Dutrénit[2], gdutrenit@laneta.apc.org
Javier Mario Ekboir[3], jekboir@prodigy.net.mx
Alexandre O. Vera-Cruz[2], veracruz@correo.xoc.uam.mx

Abstract

This paper explores the effect of commercial farmers-academic researchers linkages on research productivity in fields related to agriculture. Using original data and econometric analysis, our findings show a positive and significant relationship between intensive linkages with a small number of commercial farmers and research productivity, when this is defined as publications in ISI journals. This evidence seems contrary to other contributions that argue that strong ties with the business sector reduce research productivity and distort the original purposes of university, i.e., conducting basic research and preparing highly-trained professionals. When research productivity is defined more broadly adding other types of research outputs, the relationship is also positive and significant confirming the argument that close ties between public research institutions and businesses foster the emergence of new ideas that can be translated into innovations with commercial and/or social value. Another important finding is that researchers in public institutions produce several types of research outputs; therefore, measuring research productivity only by published ISI papers misses important dimensions of research activities.

Keywords

agriculture sector, research productivity, university-business sector interaction

JEL codes

031, 032, Q16, Q18

[1] Masters/Doctorate in Economics and Management of Innovation at Metropolitan Autonomous University, Campus Xochimilco, Calzada del Hueso 1100, Col. Villa Quietud, Coyoacán, Mexico City, CP. 04968. Tel: +5255 5483 7100.
[2] Masters/Doctorate in Economics and Management of Innovation at Metropolitan Autonomous University, Campus Xochimilco, Calzada del Hueso 1100, Col. Villa Quietud, Coyoacán, Mexico City, CP. 04968. Tel: +5255 5483 7100. Visiting fellows at UNU-MERIT.
[3] Private consultant. Bosques de Fontainebleau 48, Casa G, CP. 53297, Naucalpan, Edo. de México, Mexico. Tel: +5255 5364 1323.

UNU-MERIT Working Papers
ISSN 1871-9872

Maastricht Economic and social Research and training centre on Innovation and Technology, UNU-MERIT

UNU-MERIT Working Papers intend to disseminate preliminary results of research carried out at the Centre to stimulate discussion on the issues raised.

Introduction[4]

In the modern knowledge-based economy, knowledge and intellectual talent have increasingly been recognized as the main determinants of growth and development (Fagerberg, Mowery and Nelson, 2005). Universities play a key role in this process, as they prepare highly trained professionals and generate scientific knowledge. However, universities have recently been called to focus more on generating knowledge that can have direct economic or social impacts. This is particularly important for developing countries, where universities are expected to actively contribute to development (Arocena and Sutz, 1999).

In this context, it has been argued that the creation of ties between universities and the business sector could foster the emergence of new ideas that could lead to innovations with commercial and/or social value. This argument is supported by the impact of linkages in several industries, as illustrated by the Silicon Valley (California) and the Route 128 (Boston) (Florida, 1999). This new approach to the role of universities has been welcomed by policy-makers and governments. Therefore different types of programs (e.g. contract research, consultant relationship, technological transfer and joint-ventures) to foster closer linkages between universities and public research centers (PRC)[5] on the one hand, and businesses on the other have been implemented. These policies have indeed resulted in more fluid linkages between academic researchers and firms (Mowery, 1996; Lund Vinding, 2004; Patel and Calvert, 2003).

However, this new role has not been accepted by the whole scientific community (Florida, 1999; Hicks and Hamilton, 1999). In fact, critics contend that growing ties with the business sector could distort the original purposes of university/PRC if their researchers become more concerned with sponsored research, licensing their technology and creating spin-off companies to raise money, than with conducting basic research and preparing highly trained professionals. It has

[4] This paper is part of a research project "Mejorando la Administración del Conocimiento en el Sistema de Innovación Agropecuario Mediante el Fortalecimiento de las Capacidades de las Fundaciones Produce, el SNITT e Institutos de Investigación" carried out in UAM and funded by SAGARPA-CONACYT (Project num. 2006-C01-48511).

[5] The nature of Mexican Public Research Centers as legal entities is defined by federal law. The law allows them greater independence in managing their resources than traditional public offices do. Most Public Research Institutes and research labs in Mexico operate under this legal regime.

also been argued that this strategy could, in the long run, generate more costs than benefits (Florida, 1999).

University/PRC-business sector linkages can be analyzed from different perspectives, one of which is how they affect research productivity. Indeed, there is a growing body of literature about the determinants of research productivity, including, the impact of collaborations. Most authors have focused on linkages between academic researchers, using as an indicator of productivity the number of papers in ISI journals.[6] Some authors found that this type of academic collaborative activity increases research productivity (Bozeman and Lee, 2003; Crane, 1972; Defazioa, Lockett and Wright, 2009; Zuckerman, 1967; Rijnsoever, et al, 2008; Czarnitzki and Toole, 2009).

On the other hand, the impact of collaboration with other agents on research productivity, for instance, the business sector, has been less explored. On this respect, Rijnsoever et al (2008) and Czarnitzki and Toole (2009) have found that university-business sector collaboration has a negative impact on research productivity, measured by publications in ISI journals. However, researchers generate a variety of academic products, some of them oriented to move the scientific frontier, and others looking to address social or economic issues. Because of this diversity, the value of the number of ISI papers as the only measure of research productivity is limited (Perkmann and Walsh, 2009).

This paper is a first exploration of how research productivity in agriculture related fields is affected by collaborations between academic researchers and commercial farmers.[7] More specifically, we explore the following questions: Do interactions between commercial farmers and academic researchers hamper research productivity in agriculture knowledge fields? What types of academic outputs are associated with these linkages?

[6] Institute of Scientific Information.

[7] The term agriculture is used in a generic sense and includes, in addition to crop and plant research, livestock, aquaculture, forestry, and other scientific disciplines (e.g. biology, biotechnology and physics) that generate research outputs that can be used in more applied agricultural research.

Research is a process in which inputs (e.g., the knowledge base as well as physical and financial resources) are combined to produce outputs (e.g., scientific information and university graduates). From the perspective of research productivity, the nature of inputs and outputs and their relation is not uniquely defined, as the variables can play different roles; for instance, research productivity can be analyzed as a dependent variable to be explained, and as a causal variable in other processes, such as academic hiring or career advancement (Granovetter, 1973; Keith et al, 2002; Bonaccorsi et al, 2007; Cruz and Sanz, 2009). Additionally, authors on this topic have focused on different units of analysis: academic institutions, research teams, research areas or individual researchers, and have largely explored collaboration between academic researchers. When analyzing contract research or academic researchers-business sector collaboration, most of the literature has focused on the manufacturing sector or on new technologies. The topic has not been thoroughly explored either in the agricultural sector and agricultural research, or in Mexico and other developing countries. We found only one paper that analyzes the determinants of research productivity and impact of individual Mexican researchers (measured by indexed publications and citations), but it only explores the impact of as a function of age and reputation (Gonzalez-Brambila and Veloso, 2007).

This paper studies the productivity of individual researchers that reported working on topics related to agriculture, and how this productivity is influenced by their collaboration with commercial farmers. Different types of linkages intensity and research outputs are analyzed. The empirical analysis is based on a survey of 310 researchers working in public universities or PRC. Among other questions, the researchers were asked to identify how many of four types of outputs (papers published in ISI journals, crop varieties, agricultural recommendations and new techniques) they produced in the three years previous to the survey; the researchers were also asked to identify different types of interactions with farmers.

In addition to this introduction, this paper has five sections. Section I reviews the particularities of agricultural research. Section II reviews the literature and presents the conceptual framework. Section III explains the research methodology. Section IV presents and discusses the main findings, and Section V contains final reflections.

I. Particularities of agricultural research

Patterns of research and innovation vary across sectors (Malerba, 2005; Pavitt, 1984). A great deal of variation also characterizes research useful to farmers, which includes disciplines such as chemistry, soil sciences, engineering, plant and animal physiology, plant breeding, biotechnology, entomology, weeds and pests dynamics, agronomy, veterinary sciences, animal production, ecology, and fisheries and forest management. Three essential features of agricultural research are that: 1) the abovementioned disciplines study isolated parts of complex processes; the information generated by research has to be integrated by an actor (usually farmers) into a production package; 2) when a practice is massively used by farmers in a particular location, it creates the conditions for the emergence of pests and diseases adapted to that practice; therefore, a steady stream of innovations is necessary to sustain agriculture in the medium term and not all of those innovations originate in formal research; and 3) agricultural research is expected by stakeholders to contribute to solve farmers' problems, create new business opportunities and address environmental issues; therefore, the most applied researchers are expected to show the impact of their research.

The nature of the expectations about agricultural research and of the links researchers establish with other agents in the innovation system has changed over time as new insights on innovation processes were gained. In particular, the organization of agricultural research has changed in the last three decades because of a broader mandate, rapid advances in global science and growing privatization of science (Byerlee, Alex and Echeverria, 2002).

Until the early 1990s, public research systems in most developing countries sought mainly to increase the productivity of staples (Byerlee, Alex and Echeverria, 2002). In general, the public research institutes were organized along the linear vision of science, which induced researchers to work in the experimental stations and discouraged them from linking directly with farmers (Ekboir, 2009). Since then, the mandate of public research expanded to include more sophisticated agricultural products and markets, sustainability and poverty alleviation. Tackling these issues required developing research capabilities in new products (especially, high value products), post harvest, sustainability and social sciences. Although public agricultural research systems in developing countries (including Mexico) were expected to address a broader range of issues, they weakened as budgets shrank and researchers aged (Eun, Lee and Wu, 2006; Pardey, Alston and Pigott, 2006; Ekboir et al., 2003); in fact, very few research institutions were able to develop the new capabilities they needed (Ekboir et al., 2009; World Bank, 2006; Byerlee et al., 2002).

Policy makers, some researchers and other stakeholders soon realized that the techniques developed by the public agricultural research institutes were not massively adopted by farmers, and a perception that these institutes were not fulfilling their mandate emerged (Ekboir et al., 2003; Byerlee, Alex and Echeverria, 2002). This perception, combined with new trends in the management of science, induced major changes in the organization of agricultural public research, which included a shift from “blind” funding of research institutions to project funding where policymakers set more specific targets (Lepori et al., 2007). Competitive funds and new incentives based on research productivity were introduced in the Mexican case. The latter, however, was defined very narrowly because it was measured only by publications in indexed journals (Vera-Cruz et al., 2008).

Agricultural research products available to developing countries’ farmers are generated in four types of institutions: private firms, international research institutes, advanced research institutions from developed countries, and domestic research institutions. In general, private firms conduct research on products that can be commercialized, including agrochemicals, equipment and improved seeds of certain crops. Of these, only agrochemicals are routinely patented (Ekboir, 2003). Some plant varieties are also protected by legislation, especially varieties of high value crops; however, the effect of plant protection on commodities’ research seems to be limited, with the exception of genetically modified crops (Tripp, Louwaars and Eaton, 2007; Pray and Fuglie, 2001).

The most important international research institutes belong to the Consultative Group on International Agricultural Research (CGIAR). These centers are mandated with generating research results that can contribute to poverty alleviation in developing countries and, in general, they make those results freely available. Initially, these centers’ activities were restricted to genetic improvement of staple crops, especially, wheat, maize and rice. Over the years their mandate expanded to include a large number of staples and high value crops, livestock, fisheries, market development, irrigation management, forestry and sustainable use of natural resources (Ekboir, 2009). Several of these centers actively collaborate with Mexican universities and PRC.

The advanced research institutes (mainly research universities in developed countries) investigate on a large variety of topics covering commodities and high value crops, often in partnership with private companies (Fuglie et al., 1996). Most of their research results are available to Mexican researchers and farmers, sometimes for a fee and sometimes for free.

Agricultural research is conducted in Mexico in three types of institutions: 'general' universities and PRC, sectoral universities and PRC, and other regional organizations (universities, PRC and institutes) that also research non-agricultural topics or conduct other types of activities such as extension. The first group is integrated by large federal universities and PRC; they have a well diversified research portfolio that can include chemistry, physics, medicine, biology, social sciences and humanities. Usually, their research related to agriculture covers science-intensive topics, such as biotechnology and biology.[8] The sectoral universities and PRC only work on topics closely related to agricultural production, such as agronomy, crop rotations and plant breeding, but they do little work on post harvest and transformation of agricultural products.[9] Finally, the other regional organizations may have a diversified research portfolio, but their activities related to agriculture deal only with post harvest issues and processing of agricultural products.

Two agencies fund most of the agricultural research in Mexico: CONACYT and the Produce Foundations (PF). CONACYT is the national science and technology council, which has a fund specific for agriculture research and another for basic research that is also finances projects related to agriculture. The PF are farmer-managed foundations who administer public resources

[8] The largest 'general institutions' are Centro de Investigación y de Estudios Avanzados, Universidad Nacional Autónoma de México and Universidad Autónoma Metropolitana.

[9] The most important agricultural PRC is the National Institute for Forestry, Agricultural and Livestock Research (INIFAP); other relevant sectoral universities are the Postgraduate College, Chapingo Autonomous University and Antonio Narro University.

to fund research, extension and innovation projects in the agriculture sector; there are 32 PF, one per state. Both agencies' programs offer incentives to agricultural researchers (Vera-Cruz, 2008; Ekboir et al., 2009); but it has not been analyzed in detail yet what these incentives are and how they influence research. In addition to the aforementioned incentives, there is another important incentive for Mexican researchers: the National Researchers System (NSR), which is managed by CONACYT.[10]

Researchers respond to the incentives offered to them by generating different outputs, which, in the case of our study, were grouped into four categories: papers in scientific journals, new recommendations, new techniques and new plant varieties. Papers are valuable (for the public incentives system) only when published in ISI journals; new recommendations include novel ways of using known inputs or crops, such as new ways to apply fertilizer; new techniques include new inputs, new equipment or substantially new ways of using known inputs, such as no-till practices;[11] and new plant varieties are seeds or plants developed to express a particular property, such as higher yields or resistance to a disease. Each type of output requires particular interactions with farmers, as analyzed in section IV.

II. Academy-industry linkages, research collaborations and research productivity

Increasingly interdisciplinary, complex, and costly characteristics of modern science encourage scientists to get involved in collaborative research (Lee and Bozeman, 2005). Collaboration among different types of agents is often viewed as a positive factor for knowledge creation and problem-solving (Heinze et al., 2009).

---

[10] The NRS was created in 1984 and its main objectives include supporting the formation, development and consolidation of a critical mass of high-level researchers, mainly inside the public system. It grants researchers pecuniary (monthly compensation) and non-pecuniary (status and recognition) incentives based on their productivity and the quality of their research.

[11] No-till is an agricultural technique in which seeds are planted in undisturbed soil. No-till is a complete agronomic package that requires adapted techniques for all stage of the plants' cycle, planting, plant and weed management, crop rotations, fertilization, and harvesting. Traditional planting, on the other hand, involves reducing the soil to a fine powder through intensive plowing and harrowing.

For almost a century (see Lokta, 1926) the literature on the effect of collaboration on research productivity has mostly focused on collaboration between academic researchers. Bozeman and Lee (2003) argue that the reason for this focus is to determine the extent to, and the ways in which, collaboration contributes to scientific growth and productivity.

Along this line, research productivity has been analyzed at different levels using different units of analysis. It has been argued that collaborations among scientist enhance research productivity because the greater 'interdisciplinary' brings special expertise and knowledge not otherwise available but crucial to research outcomes (Goffman and Warren, 1980; Thorsteinsdottir, 2000; Beaver, 2001; Bozeman and Lee, 2003; Heinze, 2009). In other cases, it was found that collaboration is an important mechanism for mentoring graduate students and postdoctoral researchers, enhancing the productivity of individual scientists (Melin, 2000; Beaver, 2001). The productivity of individual researchers has also been found to depend on institutional and organizational factors, including communication patterns, the degree of freedom to define personal research agendas, the recognition of the department in which researchers work, human resources, instrumentation, funding, mobility, teamwork and the size of research teams (Heinze, 2009). Recruiting policies by academic departments have been found to be particularly important in influencing the productivity of individual researchers (Dill, 1985).

Rijnsoever et al. (2008) analyzed the factors that influence the intensity of the interactions that academic researchers have with academic colleagues and with firms. They found that science–science collaboration is related to the development of an academic career, while science–industry collaboration is not. At the same time, they found that university network activity and industrial network activity have no influence on academic rank. According to these authors, all levels of network activity within the scientific community are positively related to each other; and academic rank and networking activity are strongly related, but interactions with industry show no relationship with academic rank.

In synthesis, the main reasons mentioned in the literature for getting involved in collaborative research are the following: to access special equipment, special skills or unique materials; to gain recognition, prestige or visibility; to attain efficiency in the use of time or labor; to gain experience; to access trained researchers; to sponsor a protégé; to avoid competition; to surmount intellectual isolation; to confirm the evaluation of a problem; to share the escalating costs of fundamental science at the research frontier; to improve access to funds; to learn tacit knowledge about a technique; and to establish contacts for future work (Beaver and Rosenm, 1978; Fox and Faver, 1984; Katz and Martin, 1997; Bozeman and Lee, 2005 and 2003; Rijnsoever et al., 2008). Despite the many reasons to expect collaborations to increase research productivity, the relationship is not obvious (Bozeman and Lee, 2003). In fact, the benefits of collaboration for science have been more often assumed than deeply investigated (Lee and Bozeman, 2005).

Collaborations between universities and businesses have been analyzed both from the universities' and the businesses' perspectives, but, as Bozeman and Lee (2003) argue, the empirical evidence, in particular that related to collaboration patterns and publishing productivity, is scant. Some authors found that these collaborations have positive effects on scientific production, development and economic growth (Perkmann and Walsh 2009). For this reason, some governments have introduced policies to promote university-businesses linkages, and foster technology transfer from universities to firms (D'Este and Patel, 2007). Recently the Triple-Helix model (Etzkowitz and Leydesdorff, 1995 and 2000) has addressed the importance of the interaction between universities, industries and governments in the processes of knowledge creation and diffusion.

Some scholars have argued that faculty members who found or join firms may actually become more productive in terms of the quantity and quality of their publications (Zucker and Darby, 2007; Lowe and Gonzalez-Brambila, 2007). Czarnitzki and Toole (2009) analyzed how permanent versus temporary employment in firms affect the productivity of individual researchers. They explored if researchers who worked in industries and returned to the university increased their research productivity, while researchers who never returned followed a new career path in the industry where publications were less important. They found that academic researchers benefited from their industry experience as measured by publications. In contrast, other studies argue that university researchers who create or join firms reduce their research productivity (Stern, 2004; Toole and Czarnitzki, 2008). Goldfarb (2008) found that when researchers follow goals that are not purely academic (e.g., contract research) their productivity (measured by academic indicators such as papers) falls. Finally, Perkmann and Walsh (2009) indicate that while collaboration with non-academic partners may not result in direct academic benefits, i.e. journal publications, they often yield indirect benefits that may eventually enhance academics' research output; these benefits result from exposition to a broader set of ideas and problems than those encountered while conducting only curiosity-driven research. However, micro evidence on impacts of collaboration with the business sector over research productivity is still limited.

There are different reasons to collaborate with businesses, such as seeking external funding, disclosing inventions, entering into consulting arrangements, and participating in commercialization activities (Czarnitzki and Toole, 2009). Other reasons for collaboration include accessing research inputs, accessing new networks, acquiring organizational methodologies, and opening channels for mobility of researchers into the business sector (Powell and Grodal 2005).

Regarding other specific variables that affect research productivity, Ben-David (1960) argued that the productivity of medical researchers in France, Germany, Britain, and the United States can be explained by the various degrees of competitiveness for research, the academic systems of these countries, the creation of specialized scientific jobs and facilities for research, and the introduction of large-scale systematic training. In addition, Henderson and Cockburn (1996) found that size (larger research efforts) and scope (diversified programs) influence research productivity in the pharmaceutical industry, and Borokhovic et al. (1995) report that faculty size and academic accreditation are important for obtaining high publication productivity and impact.

At the level of individuals, some scholars explored whether the scientists' age, sex, rank and status affect their productivity. Bozeman and Lee (2003) found that older scientists, or at least those who had longer careers, had more time to develop 'scientific and technical human capital' and to build up their professional networks; therefore, it was not possible to distinguish the effect of age and career length on productivity increments from collaboration. Levin and Stephan (1991) found that life-cycle effects are present, and the expectation that the latest educated are the most productive is not 'generally supported by the data'. Simonton (2003) and Weisberg

(2003) noticed that researchers' productivity peaked about ten years after they obtained their doctoral degree, generally around their 30's or 40's, and that in the last decades of their scientific life, their productivity was about half the rate observed in their peak years. Gonzalez-Brambila and Veloso (2007) found that age does not have a substantial impact on research output in the Mexican case.

III. Methodology

a) Description of the data

The data used in this paper were obtained through a survey of two partially overlapping groups of Mexican researchers who work on topics related to agriculture. The first group was identified from the NSR Database and the second group is made up of researchers who had received at least one grant from the PF in the last decade. The survey, conducted in 2008, contains 310 observations, representing 19.4 percent of the universe; 292 researchers in the sample received funding from the PF and 18 did not; finally, 69 belong to the NRS.[12]

Most studies of research productivity have focused on researchers with doctoral degrees, and have showed that research productivity (as measured by publications) increases over time, reaching a peak between eight and ten years after the researcher finishes his/her studies. In our survey, only 60.3 percent of researchers have a PhD degree, 32.6 percent have a Masters and 7.1 percent have a first college degree. Between 2006 and 2008, 25.5 percent of the researchers in the sample did not publish any papers in ISI journals, 52 percent published between one and five, 16.5 percent published between six and ten papers, and 6.0 percent published between eleven and sixteen papers.

Related to the other research outputs, table 1 shows the relative participation. Without regard to the researchers that do not produce any research output, and considering the rest, most of them produce between one and five; few of them produce between six and ten; and less than 0.6 percent produce more than eleven varieties of seed liberates, or new recommendation, or new techniques.

[12] Researchers can both receive funding from a PF and belong to the NSR.

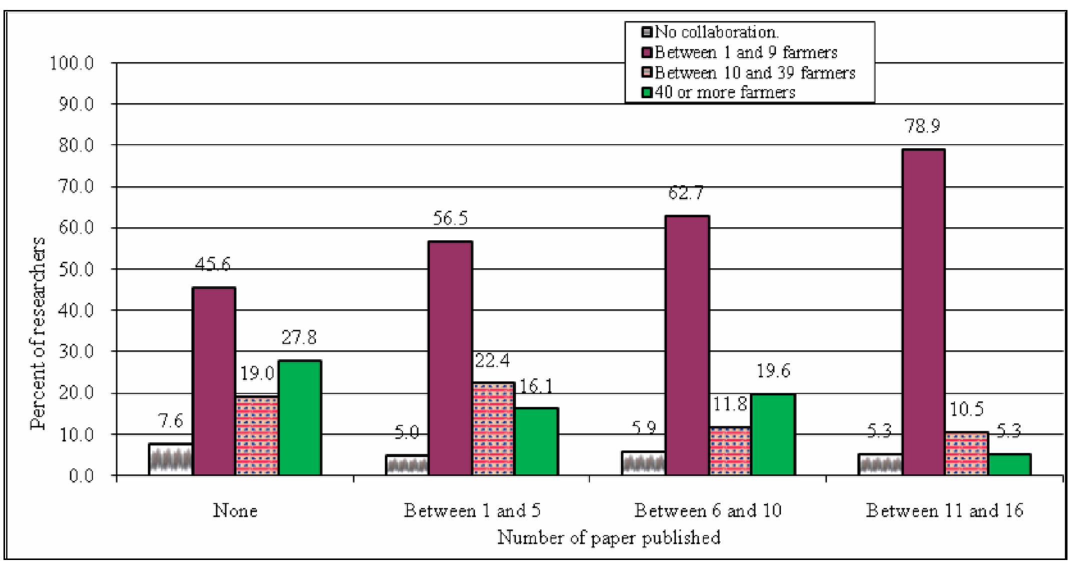
Table 1.Distribution of researchers by research output

Research outputs	Ranges				Absolute number of researchers
	None	Between 1 and 5	Between 6 and 10	More than 11	
Variety of seed liberated	84.8%	12.6%	1.9%	0.6%	310
New recommendation	38.7%	55.8%	5.2%	0.3%	310
New techniques	47.4%	49.4%	2.9%	0.3%	310

From the total sample, 18 researchers do not have any collaboration with farmers, 174 collaborate with small-size farmer groups (between 1 and 9 farmers), 59 interact with medium-size farmer groups (between 10 and 39 farmers), and the same number of researchers partner with large-size farmer groups (more than 40 farmers).

Graphic 1 shows - for the period 2006-2008 - the relation between collaborations among researchers and commercial farmers on the one hand, and the number of papers published on the other hand. For any number of published papers, researchers who collaborate with small groups of farmers (between 1 and 9) tend to publish more than researchers who collaborate with large groups (more than 40 farmers). In other words, it seems that the intensity of the relationship, which is larger when researchers interact with small groups of farmers, has a larger impact on publishing than the number of interactions (see section IV).

Graphic 1.
Relation between collaboration and paper published (percents)

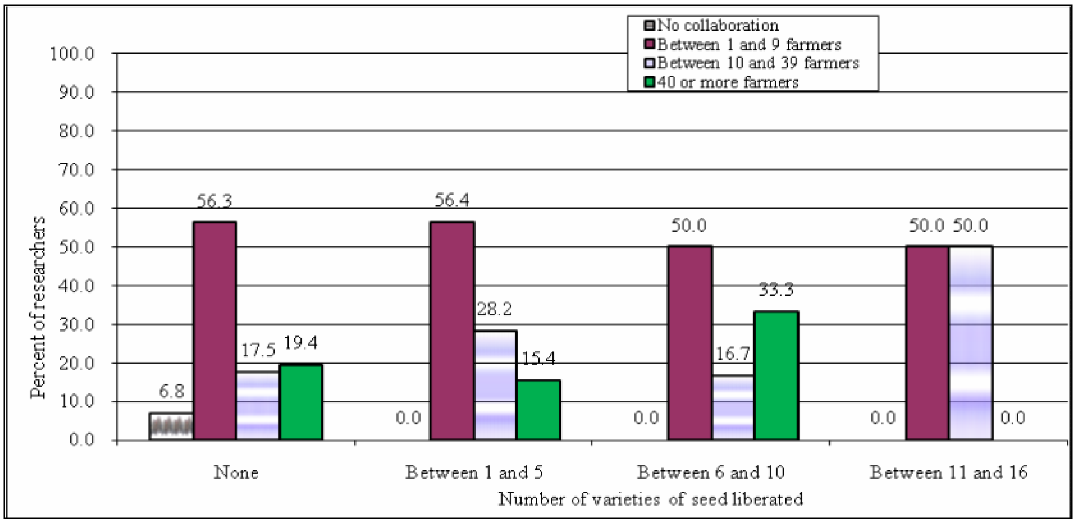


Absolute number of researchers	None	Between 1 and 5	Between 6 and 10	Between 11 and 16
	79	161	51	19

Source: own elaboration.

The relation between collaborations and the number of seed varieties liberated shows that researchers' productivity (measured by the number of seed varieties liberated**)** is independent of the number of farmers with which researchers collaborate (see graphic 2).

Graphic 2.
Relation between collaboration and number of seed varieties liberated (percents)

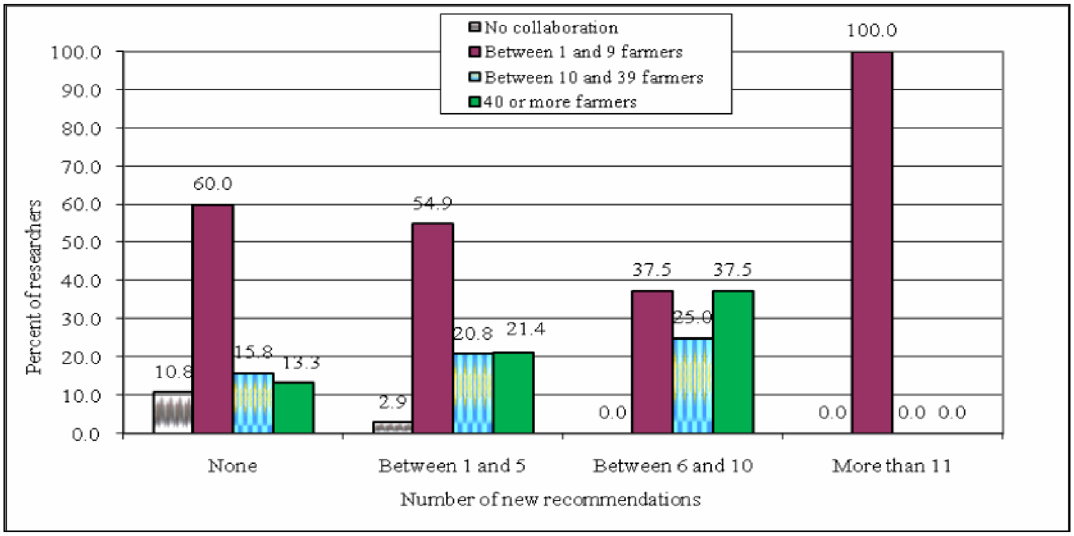


Absolute number of researchers	None	Between 1 and 5	Between 6 and 10	More than 11
	263	39	6	2

Source: own elaboration.

The relations between collaboration and new agricultural recommendations, and also between collaboration and new techniques, show a similar pattern. The most productive researchers (measured by the number of recommendations or techniques) interact with few farmers (1-9 farmers). Additionally, there are a few highly productive researchers that interact with a large number of farmers; while they represent a large proportion of the group, the absolute numbers are small (graphics 3 and 4).

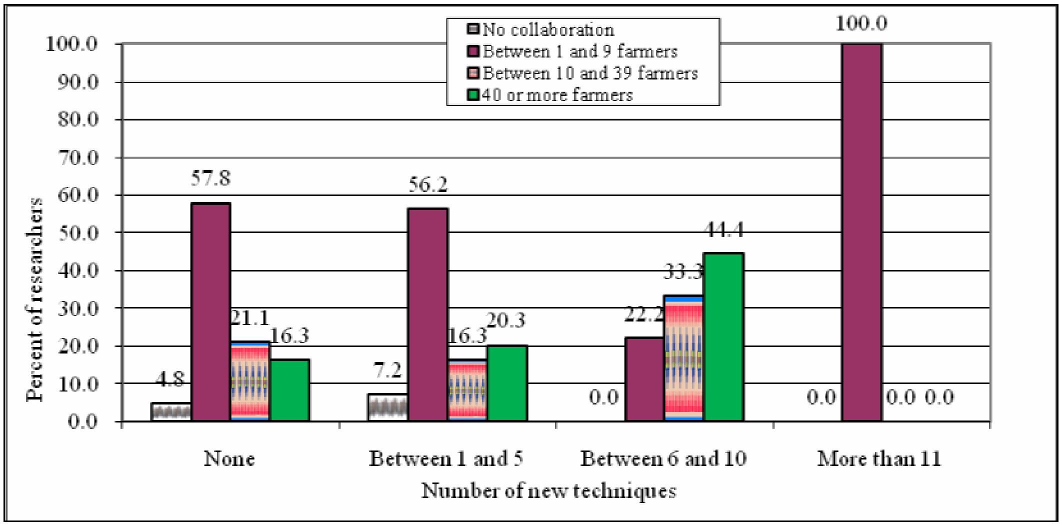
Graphic 3.
Relation between collaboration and new recommendations (percents)



Absolute number of researchers	None	Between 1 and 5	Between 6 and 10	More than 11
	120	173	16	1

Source: own elaboration.

Graphic 4.
Relation between collaboration and new techniques (percents)



Absolute number of researchers	None	Between 1 and 5	Between 6 and 10	More than 11
	147	153	9	1

Source: own elaboration.

b) The econometric model

The effect of collaborations between researchers and commercial farmers on research productivity was analyzed with econometric techniques. As was mentioned in section I and described above, we identified four types of research outputs: papers published in ISI journals, new seed varieties, new agronomic recommendations and new techniques. We estimated separate 'production' functions for each of these outputs.

The dependent variables are the number of papers published in ISI journals (regardless of the number of coauthors), the number of seed varieties liberated, the number of new recommendations made and the number of new techniques developed, in all cases, produced in the three years previous to the survey (2006-2008). Based on the analysis of the funded projects in the last 10 years, we can assume that researchers have had links along several years, so the research outputs of the last 3 years can be related to their linkages in the same period. The independent variables are:

- *research_team*: is a dummy variable with value 1 if the individual belongs to a researcher team and 0 otherwise.

- *link_producers*: this variable accounts for the number of linkages or interactions with producers that each researcher reported for the year of the survey.

- *dummy_link_0*: is a dummy variable with value 1 if the researcher reports no linkages with farmers and 0 otherwise.

- *dummy_link_1*: it is a dummy variable with value 1 if the researcher reports between 1 and 9 interactions with farmers; this is the control group.

- *dummy_link_2*: is a dummy variable with value 1 if the researcher reports an intermediate number of linkages (10-39) and 0 otherwise.

- *dummy_link3*: is a dummy variable with value 1 if the researcher reports a large number of linkages (40 or more) and 0 otherwise.

- *dummy_inst_1:* this set of variables seeks to capture institutional effects. The value 1 corresponds to researchers belonging to general universities and 0 otherwise.

- *dummy_inst_2*: the value is 1 if the researcher belongs to a sectoral PRC or university and 0 otherwise.

- *dummy_inst_3*: the value is 1 if the researcher belongs to small institutes that also conduct some research, 0 otherwise.

- *time_last_degree*: number of years between obtaining the highest academic degree and the year of the survey. We used this specification rather than age because graduate students from developing countries tend to be older than their counterpart from developed countries.

- *sqrtime*: the square of *time_ last degree* .

- *Mex degree:* it is a dummy variable with value 1 if the individual obtained her/his last degree in Mexico and 0 otherwise

- *num_research_team*: is the number of researchers that participate in the research team, regardless of their academic degree.

- *sqr_num_research_team*: the square of *num_research_team*.

- *research_activity 1*: is a dummy variable with value 1 when the researcher conducts basic research

- *research_activity 2*: is a dummy variable with value 1 when the researcher conducts applied research

- *research_activity 3*: is a dummy variable with value 1 when the researcher specializes in technology development

To write a paper, researchers only need to conduct experiments or collect information. They can do both of them without interacting with farmers. On the other hand, strong interactions can help researchers to focus their research, experiment with alternative approaches and identify new research questions. As was mentioned in section I and II, there is a general consensus between agricultural researchers that stronger collaborations with industries hamper the researchers' ability to publish; this belief is shared by authors for other knowledge fields. Therefore, we expect a negative correlation between collaborations and publications.

To develop a recommendation or a new technique, researchers need to understand the complex production processes in which they hope the innovations will be integrated. They can gain this understanding following different paths: the researchers can be farmers themselves, they can interact with farmers or, if the production process is relatively stable and well known (such as planting cereals and oilseeds), they can read books or talk to other researchers. But the odds that the recommendations or the techniques will be adopted increase when researchers develop them under farmers' production conditions, in other words, interacting actively with few farmers. Therefore, we expect a positive correlation between collaborations with few farmers and issuance of recommendations or techniques.

Finally, to develop a new plant variety, breeders need to have a clear understanding of what they are looking for (e.g., resistance to a disease, better industrial quality or a taste more acceptable to consumers). Again, they can get this understanding from a number of sources that may include farmers. But once they define the objective, the usually do not need to interact with farmers until the final stages of the development process (usually, after eight cycles of genetic improvement), and even at this stage the advantages of collaboration are not clear (Atlin, Cooper and Bjørnstad, 2001). Thus, we expect no correlation between the release of new varieties and collaborations with farmers.

Because all dependent variables have a skewed distribution with a long tail to the right, the model was estimated with a negative binomial distribution using Maximum Likelihood estimators. We chose this distribution over a Poisson function because the former is more flexible; a likelihood ratio test of over-dispersion supported this decision.[13] A few researchers did not complete the whole questionnaire; therefore, only 290 observations were used in the estimations.

IV. Analysis and findings

The estimations clearly show that the productivity of researchers conducting different types of research is influenced by different factors. Table 2 shows different specifications for the "production" of ISI published papers..

[13] See Encaoua et al. (2006) and Lanjouw and Schankerman (1999). All the estimations in this section were performed using Stata 9.0.

Table 2. ISI published papers

	1	2	3
time_last_degree	0.039	0.028	0.022
	-1.47	-1.05	-0.85
sqr_time_last_degree	-0.002	-0.001	-0.001
	(1.99)*	(1.65)+	-1.47
Mex degree		-0.321	-0.334
		(2.31)*	(2.39)*
dummy_link_0	-0.058	-0.086	-0.06
	-0.22	-0.33	-0.23
dummy_link_2	-0.234	-0.193	-0.235
	-1.35	-1.12	-1.35
dummy_link_3	-0.345	-0.282	-0.247
	(1.96)+	-1.6	-1.38
dummy_inst_2	-0.267	-0.275	-0.362
	(1.88)+	(1.96)+	(2.62)**
dummy_inst_3	0.161	0.158	0.107
	-0.69	-0.68	-0.46
num_research_team	0.04	0.037	
	(3.52)**	(3.19)**	
sqr_num_research_team	-0.0005	-0.0004	
	(2.68)**	(2.33)*	
researchactivity2			-0.481
			(1.95)+
researchactivity3			-0.751
			(2.50)*
Constant	1.131	1.429	2.188
	(5.24)**	(5.72)**	(6.94)**
Observations	290	290	290
LR chi2(7)	39.83	45.2	39.88
Prob > chi2	0	0	0
Pseudo R2	0.0285	0.0324	0.0285
Absolute value of z statistics in parentheses			
+ significant at 10%; * significant at 5%; ** significant at 1%			

The first column indicates that, in accordance with Simonton (2003) and Levin and Stephan (1991) but contrary to Bozeman and Lee (2003), publishing follows a life-cycle pattern where researchers become more productive as they consolidate their careers but at a decreasing rate. The marginal significance of the coefficients, though, does not allow making a strong claim. The coefficient for having a Mexican degree in column 2 is clearly significant with a negative sign indicating that researchers who studied abroad have a preference for academic career paths and publishing papers. Introduction of this variable makes the coefficient for the years as professional non significant, indicating that there is collinearity between the years a professional spends publishing and his/her career path. We also found that the size of the research team has a positive effect on publications, but at a decreasing rate. This is in line with a large body of literature that stresses the importance of scientific networking (e.g. Bozeman and Lee, 2003 and 2005; Rijnsoever et al., 2008).

The coefficient of the variable *dummy_link_0* (i.e., which identifies researchers who do not interact with farmers at all) is not significant; the small number of observations in this category probably causes this result. At the same time, having a large number of collaborations negatively affects the propensity to publish. However this result deserves to be analyzed in the agricultural arena. In general, researchers can relate to farmers in two ways. On the one hand, they can interact intensively with a few farmers and, often, conduct experiments in their fields. On the other hand, they can develop weak interactions, like presentations in “massive” events or field days, or report as interactions work they expect will benefit farmers without interacting with the farmers themselves. In fact, while checking the survey data for errors, this was the explanation researchers gave when asked how they could interact with thousands of farmers. In other words, these researchers work along a linear vision of science, generating scientific information and expecting that other agents (usually an extension agent) will make the information available to farmers. Having this in mind, the indicator variables for the interactions clearly show that the researchers who have large numbers of interactions (in other words, weaker interactions) tend to publish less than researchers who interact closely with a few farmers. Thus, strong interactions relate positively with high research productivity.

As expected, there is a strong institutional effect. Sectoral universities and PRC (dummy_inst_2) perform more applied work and conduct more extension-like activities; therefore, they tend to publish less than ‘general’ university researchers. Additionally, belonging to “regional universities, PRC and institutes” (dummy_inst_3) does not influence publication rates. This is an ill defined category that includes highly regarded institutes as well as small teams that develop engineering processes. Similarly, in column 3 the dummies indicating applied research and technology development have negative signs and are significant; in other words, the type of research conducted influences publication patterns.

Table 3 shows the estimation of the ‘production function’ for new seed varieties, new recommendations and new techniques. The regressions (columns 1 and 2) show that the release of new varieties of seed liberated is not affected by a life-cycle effect, by membership to a research team, by having a Mexican degree, by the type of research conducted by the researcher or by interaction patterns and depends only on institutional factors. This was expected because in Mexico only sectoral institutes have plant-breeding programs.[14]

The development of new recommendations is not influenced by professional experience or by having a Mexican degree. On the other hand, interacting with farmers has positive effects; even more, not interacting with farmers (dummy_link_0) has a negative effect. These results provide additional evidence that solitary geniuses locked in their laboratories do not advance agricultural sciences as much as research networks. We do not have a good explanation for why interacting with large numbers of farmers fosters developing new agronomic recommendations. As expected, there are strong institutional effects (column 3), since the mandate of sectoral universities and PRC include attending the farmers’ agronomic needs. The negative coefficient for the “regional universities, PRC and institutes” reflects the fact that these do not research on agronomy but on other stages of agricultural chains. Finally, the size of the research team (column 4) has a positive effect on the development of new agricultural recommendations.

[14] There are a few private nurseries and international breeding programs but they were not captured by our sample.

Table 3. New seed varieties, new recommendations and new techniques

	seed varieties	seed varieties	Recommendations	Recommendations	new techniques	new techniques
	1	2	3	4	5	2
time_last_degree	0.045	0.014	0.024	0.021	0.04	0.041
	-0.51	-0.16	-0.99	-0.86	-1.48	-1.53
sqr_time_last_degree	-0.0004	0.001	-0.0004	-0.0002	-0.001	-0.0005
	-0.15	-0.21	-0.62	-0.39	-0.77	-0.66
research_team	0.585		0.452		0.57	
	-1.2		(2.72)**		(3.01)**	
Mex degree	-0.544	-0.766	0.088	0.065	0.103	0.089
	-1.03	-1.51	-0.51	-0.38	-0.54	-0.47
dummy_link_0	-17.126	-16.796	-0.699	-0.737	0.326	0.281
	-0.01	-0.01	(1.85)+	(1.96)+	-0.93	-0.81
dummy_link_2	0.331	0.23	0.06	0.107	-0.174	-0.108
	-0.62	-0.43	-0.31	-0.55	-0.76	-0.47
dummy_link_3	-0.671	-0.592	0.39	0.401	0.331	0.477
	-1.15	-1.1	(2.07)*	(2.12)*	-1.54	(2.23)*
dummy_inst_2	2.519	2.245	0.367	0.408	0.408	0.457
	(4.57)**	(3.99)**	(2.21)*	(2.46)*	(2.14)*	(2.38)*
dummy_inst_3	-15.761	-15.982	-0.656	-0.659	0.468	0.371
	-0.01	-0.01	(1.89)+	(1.90)+	-1.44	-1.14
num_research_team		-0.065		0.028		0.032
		-1.53		(2.13)*		(2.17)*
sqr_num_research_team		0.0008		-0.0003		-0.0003
		-1.39		-1.54		-1.16
researchactivity2	1.374		0.56		0.349	
	-1.22		-1.58		-0.9	
researchactivity3	1.313		0.287		0.613	
	-1.04		-0.72		-1.42	
Constant	-4.339	-1.866	-0.841	-0.164	-1.349	-0.82
	(2.82)**	(2.09)*	(1.96)+	-0.59	(2.75)**	(2.68)**
Observations	290	290	290	290	290	290
LR chi2(7)	41.62	39.64	35.21	29.8	25.07	23.07
Prob > chi2	0	0	0.0002	0.0009	0.0089	0.0105
Pseudo R2	0.0964	0.0918	0.0342	0.029	0.0276	0.0254

The development of new techniques is positively influenced by belonging to a research team, by interacting with large numbers of farmers and institutional factors (column 5). As in the previous cases, we do not have a good explanation for the positive effect of interacting with large numbers of farmers; this is left for further research. The size of the research team (column 6) also has a positive effect in this case.

The fact that having a Mexican degree is significant only in the equation for the number of papers published reflects the fact that in sectoral universities and PRC as well as in regional universities, there are several researchers that do not have a doctoral degree (which hampers integration into research networks) and also that the pressure to publish is weaker in these institutions than in general universities.

V. Conclusions

The analysis of research productivity has attracted the attention of several researchers. One factor that has been assumed to influence research productivity is the linkages researchers establish with other academics and also with the business sector. While there is consensus among researchers on the positive impact of academic collaboration on research productivity is quite robust, there is no such agreement on the effect of academy-business sector interactions; even more, the empirical evidence on this relationship is scant.

Most empirical analyses have used a rather narrow definition of research productivity, i.e., number of papers published in indexed journals. Our results show that this definition is a poor indicator of productivity. Researchers generate a variety of products, some of them oriented to move the scientific frontier, and others seeking for solutions to production problems. In this sense, different types of research should be measured by the outputs they produce.

The relation between research inputs and outputs also changes according to the type of research conducted. Some types of research require a closer interaction among academic researchers and users of their outputs, while others can be conducted with more distant relations. This is true not only for broad definitions of research areas (such as space exploration and medicine) but also for narrowly defined lines of research as, in our case, research in agricultural basic science (such as plant physiology), crop improvement, issuance of agricultural recommendations and development of new techniques. Our results indicate that the influence of interactions between academic researchers and farmers is specific for each type of research. Thus, it is positive for published papers when they link intensively with a small number of farmers, positive for agricultural recommendations and techniques, and not significant for developing new varieties of seed liberated. But the influence of interactions becomes negative when researchers interact with larger number of farmers, and therefore, the interactions become less intense. Additionally, our research confirms that interactions among researchers unmistakable have a positive effect on research productivity for most research outputs.

Our findings have important policy implications. In many developing countries, Mexico included, incentives offered to researchers are based on the number of papers published in ISI journals. While this fosters publications, it does not favor the development of solutions to problems faced by businesses, society or, as in our case, farmers. Therefore, incentives for other research products, such as new recommendations and techniques in the case of the agricultural fields, should be included.

Our results are preliminary in nature. Our research will explore the shape of the research production function, in particular, if it follows a power law distribution. We will also explore the joint influence of other variables on research productivity, in particular, the influence of not only the number of linkages but also of their nature, and to what extent there are different profiles of researchers that require different measures of research productivity.

References

Arocena, R. and Sutz J. (2001), "Changing knowledge production and Latin American universities", *Reserch Policy*, Vol. 30, p. 1221-1234.

Atlin G.N., M. Cooper and Å Bjørnstad (2001), A comparison of formal and participatory breeding approaches using selection theory. *Euphytica*, Vol.122 (3), p. 463-475.

Beaver, D. (2001), "Reflections on Scientific Collaboration (and its study): Past, Present, and Future. Feature Report", *Scientometrics*, Vol. 52 (3), p. 365-377.

Beaver, D. and R. Rosen (1978), "Studies in scientific collaboration: Part I-The professional origins of scientific co-authorship", *Scientometrics,* Vol. 1, p. 65-84.

Ben-David, J. (1960), "Scientific productivity and academic organization in the nineteenth century meeice", *American Sociological Review*, Vol. 25 (6), p. 828-843.

Bonaccorsi, A., C. Darai and L. Simar (2007), "Efficiency and productivity in European universities: exploring trade-offs in the strategic profile". In Bonaccorsi, A. (ed.), *Universities and Strategic Knowledge Creation,* USA: Edward Elgar.

Borokhovich, K.A., R.J. Bricker, K.R. Brunanski and B.J. Simkins (1995), "Finance research productivity and influence", *Journal of Finance*, Vol. 50, p. 1691-1717.

Bozeman, B. and S. Lee (2003), "The Impact of Research Collaboration on Scientific Productivity", Paper prepared for presentation at the Annual Meeting of the American Association for the Advancement of Science, Denver, Colorado February,

Byerlee, D., G. Alex, and R.G. Echeverría (2002), "The Evolution of Public Research Systems in Developing Countries: Facing New Challenges", in Byerlee, D. and R.G. Echeverría (eds.) *Agricultural Research Policy in an Era of Privatization,* Wallinford, UK: CABI Publishing.

Crane, D. (1972), *Invisible Colleges*, Chicago: University of Chicago Press.

Cruz, L. and L. Sanz (2009), "Does mobility pay? Career paths, scientific productivity and academic rewards", working paper, CSIC, Spain.

Czarnitzki, Dirk and Andrew Toole (2009), Is There a Trade-Off Between Academic Research and Faculty Entrepreneurship? Evidence from U.S. NIH Supported Biomedical Researchers, ZEW Discussion paper No. 09-022, Mannheim.

D´Este, P. and P. Patel (2007), "University–industry linkages in the UK: What are the factors underlying the variety of interactions with industry?", *Research Policy,* Vol. *36, p. 1295–1313.*

De Solla Price, D and Beaver D (1966), "Collaboration in an invisible college", *American Psychologist*, Vol. 21, p. 1011-1018.

Defazioa, D. A. Lockett and M. Wright (2009), "Funding incentives, collaborative dynamics and scientific productivity: Evidence from the EU framework program", *Research Policy,* Vol. 38 (2), p. 293-305

Dill, D.D. (1985), "Theory versus practice in the staffing of R&D laboratories". *R&D Management* 15, p. 227–241.

Dosi, G. (1998), "The contribution of economic theory to understanding of a knowledge-based economy". In Dale Neef, et al (eds), *The economic impact of knowledge*, Ed. Butterworth-Heinemann.

Ekboir, J.M. (2003), "Innovation Systems and Technology Policy: Zero Tillage in Brazil", *Research Policy,* Vol. 32, p. 573-586.

Ekboir, J.M. (2009), The CGIAR at a Crossroads: Assessing the role of international agricultural research in poverty alleviation from an innovation systems perspective, ILAC working paper 9, Rome: ILAC.

Ekboir, J.M., G. Dutrénit, G. Martínez V. A. Torres Vargas and A. Vera-Cruz (2009), *Successful Organizational Learning in the Management of Agricultural Research and Innovation: The Mexican Produce Foundations*, IFPRI research report 162, Washington DC: IFPRI.

Ekboir, J.M., J.A. Espinoza García, J.J. Arellano Espinoza, G. Moctezuma Lopez and A. Tapia Naranjo (2003), Análisis del Sistema de Investigación Agropecuario, CEP working paper 03-01, Mexico, D.F.: CIMMYT.

Encaoua D., B. Hall, F. Laisney and J. Mairesse (eds) (2006), *The Economics and Econometrics of Innovation*, Kluwer Academic Publishers.

Eun, J.H., K. Lee and G. Wu (2006), "Explaining the "University-Run Enterprises" in China: A Theoretical Framework for University–Industry Relationship in Developing Countries and its Application to China", *Research Policy*, Vol. 35, p.1329–1346.

Fagerberg, J., D. C. Mowery and R. R. Nelson (2005), *The Oxford Handbook of Innovation* (First ed.). New York: Oxford University Press.

Florida, R. (1999), "The Role of the University: Leveraging Talent, Not Technology". In Branscomb, L. and F. Kodama (eds.), *Industrializing Knowledge: University-Industry Linkages in Japan and the United States*, USA: MIT Press.

Foray, D. and B-A. Lundvall (1998), "The knowledge-based economy: from the economics of knowledge to the learning economy". In Dale Neef, et al (eds), *The economic impact of knowledge*, Ed. Butterworth-Heinemann.

Fox, M.F. and C. A. Faver (1984), "Independence and Cooperation in Research: The Motivations and Costs of Collaboration", *Journal of Higher Education*, Vol. 55, p. 347-359.

Freeman, C. (1991), "Networks of innovators: A synthesis of research issues", *Research Policy*, Vol. 20 (5), p. 499-514.

Fuglie, K., N. Ballenger, K. Day, C. Klotz, M. Ollinger, J. Reilly, U. Vasavada, and J. Yee (1996), Agricultural Research and Development: Public and Private Investments Under Alternative Markets and Institutions. Agricultural Economics Report No. (AER735), Washington, D.C.: USDA. http://www.ers.usda.gov/publications/aer735/

Goffman, W. and K.S. Warren (1980), *Scientific Information Systems and the Principle of Selectivity*, New York: Praeger.

Goldfarb, B. (2008), The effect of government contracting on academic research: Does the source of funding affect scientific output? *Research Policy*, Vol. 37, p. 41-58.

Gonzalez-Brambila, C. and F. M. Veloso (2007), "The determinants of research output and impact: A study of Mexican researchers", *Research Policy*, Vol. 36, p. 1035–1051.

Granovetter, M. S. (1973), "The strength of the weak ties", *American Journal of Sociology*, Vol. 78 (6), p. 1360-1380.

Heinze, T., P. Shapirab, J.D. Rogers and J.M. Senker (2009), "Organizational and Institutional Influences on Creativity in Scientific Research", *Research Policy, Vol.* 38, p 610–623.

Henderson, R. and I. Cockburn (1996), "Scale, Scope, and Spillovers: The Determinants of Research Productivity in Drug Discovery", *Rand Journal of Economics*, Vol. 27, p. 32-59.

Hicks D. and K. Hamilton (1999), "Does University-Industry Collaboration Adversely Affect University Research?", *Issues in Science and Technology*, Vol.15 (4), p. 74-75.

Ikpaahindi, L. (1987), "The relations between the Needs for Achievement: Affiliations, Power, and Scientific Productivity among Nigeria Veterinary surgeons", *Journal of Social Psychology*, Vol. 125 (5), p. 535-537.

Katz, S.J. and B.R. Martin (1997), "What is research collaboration?", *Research Policy*, Vol. 26, p. 1-18.

Keith, B., J.S. Layne, N. Babchuk and K. Johnson (2002), "The Context of Scientific Achievement: Sex Status, Organizational Environments, and the Timing of Publication on Scholarship Outcomes", *Social Forces*, Vol. 80 (4), p.1253-1281.

Lanjouw, J.O. and M. Schankerman (1999), "The quality of ideas: measuring innovation with multiple indicators", Working Paper 7345, NBER Working Paper Series, National Bureau of Economic Research.

Lee, S. and B. Bozeman (2005), “The impact of research collaboration on scientific productivity”, *Social Studies of Science*, Vol. 35 (5), p. 673-702.

Lepori, B., P. van den Besselaar, M. Dinges, B. Potì, E. Reale, S. Slipersæter, J. Thèves and B. van der Meulen (2007), “Comparing the Evolution of National Research Policies: What Patterns of Change?”, *Science and Public Policy*, Vol. 34 (6), p. 372–388

Levin, S.G. and P. Stephan (1991), “Research productivity over the life cycle: evidence for academic scientists”, *The American Economic Review*, Vol. 81 (1), p. 114–132.

Long, J. S. and M. Robert (1981), “Organizational context and scientific productivity”, *American Sociological Review*, Vol. 46 (4), p. 422-442.

Lotka, A. J. (1926). “The frequency distribution of scientific productivity”, *Journal of the Washington Academy of Science*, Vol. 16, p. 317-323.

Lowe, R.A., and C. Gonzalez-Brambila (2007), “Faculty entrepreneurs and research productivity”, *Journal of Technology Transfer*, Vol. 32, p. 173-194.

Lund Vinding, A. (2004), “Interaction between firms and Knowledge institutions”, *Research on Technological Innovation and Management Policy*, Vol. 8, p. 257–283.

Malerba, F. (2005), “Sectoral Systems. How and Why Innovation Differs across Sectors”. In Fagerberg, J., D.C. Mowery and R.R. Nelson (eds.), *The Oxford Handbook of Innovation*, Oxford; New York: Oxford University Press.

Melin, G (2000), “Pragmatism and self-organization Research collaboration on the individual level”, *Research Policy*, Vol. 29, pp. 31-40.

Mowery, D., et al (1996), “Strategic Alliances and Interfirm Knowledge Transfer”, *Strategic Management Journal*, Vol. 17, p. 77-91.

Nelson, R. R. (ed.) (1993), *National Innovation Systems: A Comparative Analysis*, New York: Oxford University Press.

Pardey, P. G., J. M. Alston and R. R. Piggott (eds) (2006), “Agricultural R&D in the developing world: Too little, too late?”, Washington DC: IFPRI.

Patel, P. and Calvert, J. (2003), ‘University-Industry research collaborations in the UK: bibliometric trends’, *Science and Public Policy*, Vol. 30 (2), p. 85–96.

Pavitt, K. (1984), “Sectoral Patterns of Technical Change: Towards a Taxonomy and a Theory”, *Research Policy*, Vol. 13, p. 343-373.

Perkmann, M. and K. Walsh (2009), The two faces of collaboration: impacts of university-industry relations on public research, *Industrial and Corporate Change*, forthcoming.

Powell, W.W. and S. Grodal. (2005), “Networks of Innovators”. In Fagerberg, J., D.C. Mowery and R.R. Nelson (eds.), *The Oxford Handbook of Innovation*. Oxford; New York: Oxford University Press.

Pray, C.E. and K. Fuglie (2001), Private Investment in Agricultural Research and International Technology Transfer in Asia. Agricultural Economic Report No. 805. Electronic Report from the Economic Research Service; USDA. http://www.ers.usda.gov/publications/aer805/aer805.pdf. Last accessed 7/7/2009.

Rijnsoever, F., L. Hessels, and R.L.J. Vandeberg (2008), “A resource-based view on the interactions of university researchers”, *Research Policy*, Vol. 37, p. 1255-1266.

Shenhav, Y. A. and Y. Haberfeld (1988), “The various faces of scientific productivity: a contingence analysis”, *Quality & Quantity*, Vol. 22 (4), p. 365-380.

Simonton, D.K. 2003. Exceptional Creativity Across the Life Span: The Emergence and manifestation of Creative Genius. In Shavinina, L.V. (ed.), *The International Handbook on Innovation*, UK: Pergamon.

Stern, S. (2004), “Do scientist pay to be scientists?”, *Management Science*, Vol. 50 (6), p. 835-853.

Thorsteinsdottir, O. (2000). “External research collaboration in two small science systems”, *Scientometrics*, Vol. 49, p. 145-160.

Toole, A.A. and D. Czarnitzki (2009), “Exploring the relationship between scientist human capital and firm performance: the case of biomedical academic entrepreneurs in the SBIR program”, *Management Science*, 55 (1), p. 101-114.

Tripp, R., N. Louwaars and D. Eaton (2007), “Plant variety protection in developing countries. A report from the field”, *Food Policy*, Vol. 32 (3), p. 354-371.

Vera-Cruz, A.O. et al (2008), “Virtues and limits of competitive funds to finance research and innovation: the case of Mexican agriculture”, *Science and Public Policy*, Vol. 335 (7), p. 501-513.

Weisberg, R.W. (2003), Case Studies of Innovation: Ordinary Thinking, Extraordinary Outcomes. In Shavinina, L.V. (ed.), *The International Handbook on Innovation*, UK:Pergamon

World Bank (2006), *Enhancing Agricultural Innovation: How to Go Beyond the Strengthening of Research Systems*, Washington DC: World Bank.

Wu, W. (2007), “Cultivating Research Universities and Industrial Linkages in China: The Case of Shanghai ”, *World Development*, Vol. 35 (6), p. 1075-1093.

Zucker, L.G. and M.R. Darby (2007), “Virtuous circles in science and commerce”, *Papers in Regional Science*, Vol. 86 (3), p. 445-470.

Zuckerman, H. (1967), “Nobel laureates in science: patterns of productivity, collaboration, and authorship”, *American Sociological Review*, Vol. 32 (3), p. 391-403.

The UNU-MERIT WORKING Paper Series

2009-01 *Effectiveness of R&D Tax Incentives in Small and Large Enterprises in Québec* by Rufin Baghana and Pierre Mohnen
2009-02 *Bridges in social capital: A review of the definitions and the social capital of social capital researchers* by Semih Akçomak
2009-03 *The Role of Firms in Energy Transformation* by Radhika Perrot
2009-04 *Standards as a platform for innovation and learning in the global economy: a case study of Chilean salmon farming industry*
2009-05 *Consumer behaviour: evolution of preferences and the search for novelty* by M. Abraham Garcia-Torres
2009-06 *The role of consumption and the financing of health investment under epidemic shocks* by Théophile T. Azomahou, Bity Diene and Luc Soete
2009-07 *Remittances, lagged dependent variables and migration stocks as determinants of migration from developing countries* by Thomas H.W. Ziesemer
2009-08 *Thinking locally: Exploring the importance of a subsidiary-centered model of FDI-related spillovers in Brazil* by Anabel Marin and Ionara Costa
2009-09 *Are International Market Demands Compatible with Serving Domestic Social Needs? Challenges in Strengthening Innovation Capacity in Kenya's Horticulture Industry* by Mirjam Steglich, Ekin Keskin, Andy Hall and Jeroen Dijkman
2009-10 *Industrialisation as an engine of growth in developing countries* by Adam Szirmai
2009-11 *The motivations, organisation and outcomes of university-industry interaction in the Netherlands* by Isabel Maria Bodas Freitas and Bart Verspagen
2009-12 *Habit Formation, Demand and Growth through product innovation* by M. Abraham Garcia-Torres
2009-13 *The Diffusion of Informal Knowledge and Innovation Performance: A sectoral approach* by M. Abraham Garcia-Torres and Hugo Hollanders
2009-14 *What does it take for an R&D tax incentive policy to be effective?* by Pierre Mohnen and Boris Lokshin
2009-15 *Knowledge Base Determinants of Technology Sourcing in the Clean Development Mechanism Projects* by Asel Doranova, Ionara Costa and Geert Duysters
2009-16 *Stochastic environmental effects, demographic variation, and economic growth* by Théophile T. Azomahou and Tapas Mishra
2009-17 *Measuring eco-innovation* by Anthony Arundel and René Kemp
2009-18 *Learning How to Consume and Returns to Product Promotion* by Zakaria Babutsidze
2009-19 *Strengthening Agricultural Innovation Capacity: Are Innovation Brokers the Answer?* by Laurens Klerkx, Andy Hall and Cees Leeuwis
2009-20 *Collinearity in growth regressions: The example of worker remittances* by Thomas H.W. Ziesemer
2009-21 *Foreign Direct Investment in Times of Global Economic Crisis* by Sergey Filippov and Kálmán Kalotay
2009-22 *Network-independent partner selection and the evolution of innovation networks* by Joel Baum, Robin Cowan and Nicolas Jonard
2009-23 *Multinational enterprises, development and globalisation: Some clarifications and a research agenda* by Rajneesh Narula and John H. Dunning
2009-24 *Why Rural Rich Remain Energy Poor* by Bilal Mirza and René Kemp
2009-25 *Compliance with the private standards and capacity building of national institutions under globalization: new agendas for developing countries?* by Michiko Iizuka and Yari Borbon-Galvez
2009-26 *The Impact of the Credit Crisis on Poor Developing Countries: Growth, worker remittances, accumulation and migration* by Thomas H.W. Ziesemer

2009-27 *Designing plans for organizational development, lessons from three large-scale SME-initiatives* by Tinne Lommelen, Friso den Hertog, Lien Beck and Raf Sluismans

2009-28 *Growth with imported resources: On the sustainability of U.S. growth and foreign debt* by Thomas H.W. Ziesemer

2009-29 *Innovative Sales, R&D and Total Innovation Expenditures: Panel Evidence on their Dynamics* by Wladimir Raymond, Pierre Mohnen, Franz Palm and Sybrand Schim van der Loeff

2009-30 *Malthus' Revenge* by Luc Soete

2009-31 *Preparing for the Next, Very Long Crisis: Towards a 'Cool' Science and Technology Policy Agenda For a Globally Warming Economy* by Paul A. David

2009-32 *Innovation and Economic Development* by Jan Fagerberg, Martin Srholec and Bart Verspagen

2009-33 *Attracting and embedding R&D by multinational firms: policy recommendations for EU new member states* by Rajneesh Narula

2009-34 *Student Network Centrality and Academic Performance: Evidence from United Nations University* by Ying Zhang, Iman Rajabzadeh and Rodolfo Lauterbach

2009-35 *Reverse knowledge transfer and its implications for European policy* by Rajneesh Narula and Julie Michel

2009-36 *Innovation for the base of the pyramid: Critical perspectives from development studies on heterogeneity and participation* by Saurabh Arora and Henny Romijn

2009-37 *Caste as Community? Networks of social affinity in a South Indian village* by Saurabh Arora and Bulat Sanditov

2009-38 *How productive are academic researchers in agriculture-related sciences? The Mexican case* by René Rivera, José Luis Sampedro, Gabriela Dutrénit, Javier Mario Ekboir and Alexandre O. Vera-Cruz