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Appropriate Technologies in Developing Countries: The Role of an Innovation Project in Rural Colombia

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Abstract
Appropriate technologies have been identified as ways in which developing countries can rely to reduce technological gaps, have affordable and efficient solutions for problems. This paper described the mechanisms used in an innovation project in rural Colombia to develop appropriate technologies using by-products of the fish production. This new technology involves the development of a pellet to feed animals and the creation of a new manufacturing plant to produce the new product. In this study the innovation process has as one, of the collaborative network, exchanged and learning processes happen. This paper shows how innovation generated in a collaborative way among universities, rural enterprises, NGOs, and governmental organisations.

Keywords
Appropriate technology, developing country, new product development

1 Introduction
Many rural developing economies depend on rural enterprises engaged in small-scale production. These enterprises usually have limited market reach, inadequate financial margins, and low value added products. In this context, rural small scale producers have dependence on government financial support.

However, in spite of the importance of technology transfer for production improvements by enterprises in rural economies, little is known about how the two sides interact when technologies to fit the small-scale production context are developed and transferred. To address this knowledge gap, this study focuses on how rural enterprises adapt and use technologies that are collaboratively developed with universities with the support of governments and non-governmental organisations (NGOs). Empirically, the study analyses technology transfer aimed at improving trout, production in Cauca, a Department of Colombia.

Some areas in rural developing economies face a particular dilemma as far as technology development. These economies are often ethnically and/or culturally diverse, based on small scale production, and their industries typically produce products using low levels of specialization. In addition, the socio-economic situation in many rural developing economies is

often precarious. Basic needs (e.g. healthcare, infrastructure, education, etc.) may be barely met (UNIDO, 2008). Moreover, most rural, small-scale producers lack the scientific knowledge and financial resources to create technologies by themselves. Therefore, the acquisition of new technologies and the access to international innovation systems for such producers is a critically important aspect of economic policy (Keller, 2004; Nabin et al., 2013).

The present paper answers the research question: what mechanisms are used to involve producers in the development of appropriate technologies in rural developing economies?. To answer this research question a study was conducted following the execution of an innovation Project that develop a new producto based on by-products of fish production such as bones, visceras and skin.

Firstly, this paper presents the theoretical framework explaining the concept of intermediate technology, innovation and rural enterprise. Secondly, the paper shows the qualitative method used in the study, characterized by the use of an interventionist approach. Thirdly, findings of the study are presented, deploying them according to the participation mechanisms identified in the empirical setting. Finally, conclusions are described.

2 Theoretical Framework

Intermediate and low technologies

In this study, we have used a definition of technology suggested by Burgelman et al. (2004, p. 2):

"the theoretical and practical knowledge, skills, and artefacts that can be used to develop products and services, as well as their production and delivery systems. Technologies can be embodied in people, materials, cognitive and physical processes, plant, equipment and tools. Key elements of technology may be implicit, existing only in an embedded form (like trade secrets based on know-how) and may have a large tacit component. Technology, thus, is the means to fulfil a human purpose, and as such can include artifacts or know-how" (cf. Arthur, 2009).

This study focuses on technologies that are used and diffused in rural developing economies. Technology in rural developing economies was introduced to promote development around five decades ago by developed countries hoping to industrialize agriculture. Subsequently, local organisations with the government support began to develop solutions using research and development techniques and solutions (Campbell, 1990).

Currently, with the diversification of productive activities in rural areas of developing economies, technologies are diverse. Usually they involve both a hard and a soft component interacting as a technological package.

Less sophisticated technologies are identified in this paper as "intermediate technologies". This is a term that developed following Schumacher (1973). Schumacher (2011, p. 149) wrote: "We can call the indigenous technology of a developing country-symbolically speaking-a £1 - technology, while that of the developed countries could be called a £1000 - technology. The gap between these two technologies is so enormous that a transition from the one to the other is simply

impossible. If effective help is to be brought to those who need it most, a technology is required which would range in some intermediate position between the £1 - technology and the £1000 - technology. Let's us call it - again symbolically speaking - a £100 -technology."

According to Schumacher, (2011), intermediate technologies would be more productive than indigenous technology (which is often in a condition of decay). Intermediate technologies would also be much cheaper than the sophisticated, highly capital-intensive technology of modern industry. With the use of intermediate technologies, many workplaces might be created within a fairly short time and would be within reach of the more enterprising minority people in a region, not only in financial terms but also in terms of their education, aptitude, organising skill, and so forth. Furthermore, intermediate technologies also take into account people's opinions and capabilities and not just the machinery or abstract descriptions.

Intermediate technologies are crucial in the development of rural economies (e.g. Cimoli et al., 2005; Saad and Zawdie, 2005). Thus, the topic warrants further investigation. In particular, many authors (e.g. Rodrik, 1999; Spithoven et al., 2011) argue the factors that facilitate the transfer of technology to rural enterprises in developing economies merit further study.

In small-scale production activities in rural developing economies, the producers often operate independently although, at times, organisations coordinate many of their activities. The producers, governments, or NGOs may create these organisations.

A specific type of technology is intermediate technology, which is also known as appropriate technology. Intermediate technology refers to technology that is "labour-intensive and will lend itself to use in small-scale establishments" (Schumacher, 2011, 148). Specifically, in relation to the rural context, Wood (1984, p. 320) describes intermediate technology as "a level of technology better than the simple methods used in the rural hinterland, more productive than the traditional tools, but far simpler and less capital-intensive than the modern technology imported from the West".

According to Wood (1984, p. 321), intermediate technologies are "… relatively small, simple, capital-saving, labour-intensive, and environmentally less-damaging technologies, suitable for local, small-scale application". Intermediate technology was identified as one way to fill the gap created by the disparate knowledge levels between the participants in developing countries (Bennett et al., 2002; Schumacher, 2011; Wicklein and Kachmar, 2001).

Kinsey (1987) stated that developing countries should develop intermediate technologies that are intensive in the use of abundant factors (labour and natural resources) but economic in the use of scarce resources (capital and highly trained personnel). The abundant factors offer advantages in terms of employment, improved income distribution, and relief of migration problems from rural to urban areas. Jedlik (1977) suggested that intermediate technologies can be indigenously produced through the creation of research and development institutions that can provide R&D services. Similarly, Burch (1987) described the need for an indigenous technological capability

that can adapt and develop the technology according to the local conditions, enabling its assimilation. Strong institutional infrastructure is important for effective R&D and its use by the recipients.

Another way to approach less sophisticated technologies is based on the R&D intensity in manufacturing sectors. Low technology differs from high technology by the less advanced level of sophistication or scientific knowledge used in operations (Czarnitzki and Thorwarth, 2012; Hirsch-Kreinsen, 2008). In support of this idea, the OECD (2011) classified manufacturing industries into categories based upon Research and Development (R&D) intensity. According to this classification, food production, one of the most common activities in rural environments, is considered low technology. However, in this study, low technology is more used in non-manufacturing industries, such as rural mining, rural construction, agriculture, rural tourism, etc.

Low technologies in this classification are connected to low levels of investments in R&D. As a consequence, low-technology companies compensate for their lack of R&D by developing other resources and other innovative capacities (Palmberg, 2001).

Innovation

Technology transfer has great potential for promoting innovation and competitiveness at regional and national levels (Bennett and Vaidya, 2005). In this study, innovation is based on the Schumpeterian defined as "the commercial or industrial application of something new- a new product, process or method of production; a new market or source of supply; a new form of commercial, business, or financial organisation". (Schumpeter, 1934, p. xix).

Diffusion of innovation has been characterized "as the process by which an innovation is communicated through certain channels over time among the members of a social system" (Rogers and Shoemaker, 1971, p. 35). Conceptually, diffusion of innovations can be connected with diffusion of technologies (Williams and Gibson, 1990) and the involvement of the user.

In the attempt to analyse technology transfer processes, this study identifies the development of new products, with embedded technology transfer activities, that could become innovations. These product development processes are completed in the R&D phase and implemented for the launch of the new products. The facts needed to demonstrate which innovations should be promoted through technology transfer in the rural context can be problematic. The reasons include, for example, the lack of reliable information about market impact and the projected revenue for the rural enterprises.

Rural enterprises

Studies on technology transfer tend to describe the dynamics and behaviours of individuals such as farmers. However, they usually do not deal extensively with the nature and role of rural enterprises, which is a family-oriented production unit immersed in a community-based context. Such enterprises are often less developed but operate in urban areas. Unfortunately, Henry and

McElwee (2014) argue that the concept of rural enterprise is not well understood. To deal with this issue, I use the description of rural enterprise from Kinsey (1987, p. 4):

"Agribusiness and rural enterprises are small-to-medium scale enterprises located predominantly in non-metropolitan areas. While they typically process agricultural raw materials - including food, fibre and forest and livestock products, many do not produce any product but instead provide marketing, transport or other services."

The contexts behind this definition are the developing economies in which interventions that harness the local communities for solving their problems are emphasized. These interventions are thought to offer opportunities to rural inhabitants to own their businesses. The interventions include training, research services, management advisory services, marketing or technical support, loan programmes, and assistance with the procurement of raw materials and equipment. The marketing support includes helping with access to market information and to sales outlets and with subcontracting from large manufacturers to small enterprises that permits flows of information.

Rural enterprises are collective enterprises that organise economic activity (Arnold, 1994). In rural cooperatives, trust is the foundation of the cooperation that also reduces internal transaction costs (Liu, 2011). Salavou and Sergaki (2013) identified some characteristics of agricultural cooperatives that include production orientation, vertical integration from farming to after-sales services, maximization of member benefits, limited access to capital, and low interest in long-term investments. These characteristics have implications for the technology transfer process owing to the interaction between the rural cooperatives and other organisations. This process gives the cooperatives access to the new technologies. The recipient of technology can be explained on two levels of analysis: the farms as productive units and the cooperative as the organisation that unites the farms.

3 Methodology

In the study we adopted an interventionist approach (Bell, 2004), descriptive perspective and employed a qualitative analysis (Bryman, 1988; Patton, 1990). A single experience study was used to gain a deep understanding of a complex situation such as the collaborative process among producers and researchers in order to develop a new product and the technologies to manufacture it. The selection principles for this experience were: rural firm based in a introduce productive activity (nontraditional), experience in projects with external institutions, approximately 10 years of existence, to be considered successful in terms of sustainability and participation in different markets. The time frame of the study was three years. A project was selected and the empirical data were gathered via interviews with producers, staff and support institutions (Universities, Non-governmental organisations, Governmental organisations, etc.), ten workshops with multiple producers, eight visits to 46 farms, participant observation and document of systematization of experience from 1998 to 2012.

Connecting situated learning theory (Wenger et al., 2002) as the main theory in this study, the methodology followed the idea that development of appropriate technologies has a strong relationship with the participation of the involved actors, it requires social interaction, collaboration and are functions of the activity, context and culture in which these occur. In this study the analysis level considers the individuals involved in a project that developed a new product.

The intervention was mainly conducted as a moderating role from the research team. That is, the research team developed the mechanisms in workshops and town hall meeting together with the producers, as opposed to designing the mechanisms pre-ante to be implemented as a full concept.

An intervention approach using two mechanisms developed from theory and previous experience were used in order to study the participation of actors in a project to develop appropriate technologies.

Data Collection and Data Analysis

To analyze the empirical data collected in concordance with the situated learning theory and the studio phenomena (appropriate technologies development), the study during its first stage created the categories analysis of interest for the producers and other participants; specifically, their explicit assumptions about each category of analysis (Miles and Huberman, 1994). The coding procedure was discussed with a committee conform by 5 cultivators and 1 member of the research team. They had meeting every 4 months to discuss the analysis and progress of the study and the information codified by four researchers of different disciplines (engineering, social communication, business administration). This practice helped to the analytical generalization of the data precedent from empirical sources (Yin, 2003). The table 1 shows the techniques were developed.

Table 1. Techniques used in the study to analyze data

Source/Activity	**Technique/ Tools**	**Comments**
Interviews	Open questions interviews with questions related with their internal relationships, their organisations and the connection between them and the external partners.	This was important to clarify incomplete information register in the documents. This gave sense to the projects and activities registered in previous processes. The producers don't have the practice to talk and express all their ideas easily. In this case, structured interviews won't give useful information.
Visits to farms	Field notes were developed using photos and interpretations about the type of knowledge exchange between the actors.	In the micro context of the cultivators, the differences and similarities showed gaps among the perspective of the producers as users of the technology and the researchers as developers of the new

		solution. In practical sense, the effect of the visits in the cultivators was extremely positive. They recognize the other members and become more open to share their knowledge.
Participant Observation	Field notes were written after certain periods of time (4 months)	It was used to gather direct evidence of the processes and activities involved in the technology and knowledge transfer between producers and organisations.
Workshops	Memories with the synthesis of the information	The interaction to discuss and analyze the organisation gave the opportunity to identify the individual and the collective knowledge about the key processes analyzed.
Documental analysis	Template with coded categories for knowledge transfer and technology transfer	Most of the reports and documents were not available in the firm's office. The source for these documents was in the university that executed the project. Usually, the rural firm did not review the information in these reports or proposal to use it because they did not have the common knowledge base to understand the documents.

Triangulation of sources was used to complement and verify the information. In fact, the individual opinions most of the time are not comparable between actors, the collective opinion of the cultivators were observed in the workshops. In order to assess effects from the invention of the mechanisms a protocol was developed. After the intervention interviews were conducted with participants from different levels in the agribusiness and with regional technology brokers. As only few written sources are available with full content, the interviews and the results of the analysis were discussed with participants for validation and further development.

The main categories of analysis were levels, type, effect and practices in the use of the new technology through the development of a project between the firm and other institutions. Two relevant effects were necessary in order to find significant findings: the increase of a common knowledge base and the trust to share knowledge among the participants and the research team.

4 Findings

A finding of this study is that the assumptions that most of the the producers are lack the academic education needed to participate in research and development process to fully understand the benefits (financial, market, technical, and managerial) the new technology can provide. The significant knowledge asymmetry between the actors in such economies creates difficulties in the negotiations and decision-making related to technologies and producto development.

From the begining the product development project considered the creation and consolidation of alliances among actors due to the nature of the Project. Each actor had to play an specific role.

The following findings were identified:

Type of Technology and Knowledge Transfer

The creation of common knowledge identified in the case has connection with Hayami and Ruttan (1971) phases in the technology transfer for international technology transfer, such as material transfer, design transfer and capacity transfer. The logic in the development of the introduction of the cultivation of trout in the RURAL ENTERPRISES case follow that logic (table 2).

Table 2. Knowledge and Technology Transfer per Stage

Stage	Type of Technology Transferred	Type of Knowledge Transferred
1. Learning on Fish Cultivation of Trout	• Technology package for trout cultivation.	• Insertion of a non-traditional productive activity. • Culture of fish consume in rural communities.
2. Learning to Create Networks with other Producers and Institutions	• Technology package for trout cultivation. • Substitution of pellets to feed the trout with sub products of the farms. • Systems of tanks for production. • Environmental aspects of the trout production.	• How to operate in networks among cultivators and cultivators among institutions. • Formalization of a firm to concentrated the representation of the cultivators in the market and institutional level. • Mechanisms to commercialize products.
3. Learning on Market Orientation	• Operation of a plant to transform and add value to products. • Norms for commercialization in different markets. • Yearly distribution of the production. • Technological assistance for cultivation and production. • Sustainable use of resources for cultivation.	• Management practices for cultivation and transformation of products. • Negotiation with different kind of customers. • Logistic for transportation of the product • Articulation with other

		producers outside of the firm.
4. Learning How to Add Value to the process and products	• Technological demands to work with universities. • Optimization of the tank design to use less water. • System for treatment of water after the production. • New products through the use of sub products of transformation process. • Norms for transformation with high standards (Certification).	• New products orientation. • Project design to find financial support. • Participation in the Regional University-Industry-Government Committee.

The level of technology in each stage increase the connection with the knowledge transferred. In other words, the first and second stages generated technology and knowledge transfer disconnected each other. However, in the third, both have more relationship and they look more interrelated. As a consequence, there is a balance in the level of the technology and knowledge achieve for the cultivators.

The stages 1 and 2 could be more related to a material phase of technology transfer and the type of common knowledge is in the domain of language and other forms of symbolic communication. The stages 3 and 4 have more relation with the phases design transfer and capacity transfer. In addition to the previous types of common knowledge, in the last two phases, are communality of specialized knowledge, shared meaning and recognition of individual knowledge domains.

The common knowledge started to develop trust in the participants in each stage of the process. However, the cultural gaps, the education differences between transferors and recipients, the relatively short time in the duration of the projects, etc. prevented a high level of common knowledge. Considering this situation, recent projects oriented the actions in the direction of new knowledge transfer practices suggested directly from the staff of rural enterprises and their members. The next paragraphs explain these mechanisms.

Training Producers to Become Ambassadors

The role of brokers has been studied (Theodorakopoulos et al., 2012) as institutions which bring dynamic to the network. In the history of the rural organizations that are parto f this project, there was all kind of ambassadors as members of broker's institutions (Universities, PIRC, Governmental Offices, etc.). At the beginning the predominant idea was that ambassadors have more knowledge and the producers have to learn everything that is "right". With this premise, the results were poor and the producer's learning curve was flat. Subsequently, there was a transition period which it was possible to identify the interaction between the cultivators and members of other institutions in projects development. Progressively, the ambassadors tried to adopt a

different attitude. They spent time in the rural areas, listened and involved the producers in their activities. However, 6 years of collaboration the level of real participation of the producers was low and they acted more like beneficiaries in the projects and not like active actors in the process. Currently, there are two recent projects that gave more participation to the producers and requested from them, decisions, collective vision and actions to materialize their plans. In fact, the time that ambassadors and producers invest together finding new perspectives to analyze situations and design solutions or alternatives generates trust, facilitate to achieve goals and exchange knowledge.

The knowledge truck for visits to other farms

Many previous knowledge transfer efforts had focused on the transfer between university (often international level) and the producers. Thus a problem of lacking common knowledge base, and sometimes lacking trust, had been identified. This mechanism addresses this problem by focusing knowledge transfer between producers rather than from researcher to producer. The knowledge truck was a transportation system used for six months. It allowed 50 producers approximately and members of the research team to visit all the 46 farms that make up rural enterprises.

The visits were organized using a tour structure. The producers had never been to the other farms and they understood how difficult it could be to access several areas due to the lack of good road infrastructure. Some areas have difficult access and the producers have to walk with their product 45 min or 1 hour before to find a road to use other type of transportation. To be aware about the types of technologies, practices, experiences and ways to organize the production in other farms and the new plant increase significantly the trust and the desire to share their knowledge and to learn from each other.

The knowledge truck as a mechanism was designed by the research team in collaboration with rural enterprises staff. The idea to the knowledge truck was based on two empirical problems. The first, that the producers are so spread over a large geographical area and that the producers do now meet naturally visiting other producers. The second empirical problem is that the producers individually have developed knowledge over the years of experience that is not transferred between the producers to increase the general level of knowledge. Theoretically it draws on the assumptions that common knowledge base and personal interaction is crucial for the development of appropriate technologies.

Further the knowledge truck is based on two theoretical assumptions; the need of a common knowledge base for effective knowledge transfer and the need of trust between partners in the knowledge transfer process. Both these theoretical assumptions are solved with the truck as the producers have a similar common knowledge base and that the trust between the cultivators is generally high due to many years of cooperation in the joint fish by-products factory.

5 Conclusions

In this study process innovation "as the outcome of collaborative networks where information is exchanged and learning processes happen" (Knickel et al., 2009, p. 883). show innovation generated in a collaborative way among universities, rural enterprises, NGOs, and government organisations. Producers discuss their technology constraints with researchers, leading to researcher modifications in the technology so that producers can use it. This active role of the recipients has a positive effect on the cost and performance of the intermediate technology.

Rural enterprises are featured in this study, are generally small and medium-sized family or community ventures in developing economies (Martin, 2010). Very few rural enterprises are large enough to exploit economies of scale or to have international markets or suppliers. In this study, rural enterprises are organisations collectively operated by small-scale producers[1] such as, for example, the township village enterprises found in China (Dacosta and Carroll, 2001; Li and Karakowsky, 2001), community-based enterprises (Handy et al., 2011; Peredo and Chrisman, 2006), or community-based cooperatives (Li et al., 2013). What sets these enterprises apart from actors involved in product development studied in much of the literature is that they operate as collectives or collaborative networks rather than as stand-alone entities or as individuals.

In developed economies, sophisticated technologies are usually registered, thereby establishing intellectual property rights. Such registration indicates that the technology developer has highly specialized knowledge of some kind. However, less sophisticated technologies are commonly transferred to recipients as problem solutions in rural developing economies. In such economies, financial constraints or knowledge constraints mean the use of sophisticated technologies is impractical, even impossible.

Appropriate technologies have seen as mechanisms for developing countries to reduce technological gaps and use efficient and affordable solutions for their problems. The balance among the performance and potential to create innovation capabilities is still not well studied.

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[1] A producer is an individual, small-scale farmer who, as a member of a cooperative, produces the main product that the rural enterprise sells.

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