INTERNATIONAL SERVICE FOR NATIONAL AGRICULTURAL RESEARCH (ISNAR) DIVISION

September 2006

ISNAR Discussion Paper 7

On the Uneven Distribution of Innovative Capabilities and Why That Matters for Research, Extension and Development Policies

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Abstract

Agricultural development policies and programs, including extension and support for innovation, implicitly assume that the whole target population has the ability to innovate. Recent research in neuroscience, education, social sciences and psychology has shown that innovative capabilities are distributed very unevenly. We explored the distribution of innovative capabilities and the ability to integrate a technological package in a sample of commercial lemon producers in Mexico. We have found that the ability to explore new techniques is different from the ability to integrate an efficient production and commercial package. The ability to explore follows an exponential distribution while integration of the package follows a bimodal distribution. The ability to explore depends on the farmer's connection to a variety of information sources, but not to his/her ability to integrate a technical package. Exploration is also not linked to education, age or credit access. Integration of a production package, on the other hand, depends on more traditional variables such as credit access. These findings have important implications for the design of development programs, including extension and participatory research.

Key words: innovation, exploration, participatory research, creativity, absorptive capabilities

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1. Introduction[1]

Agricultural development policies and programs, including extension and support for innovation, implicitly assume that the whole target population has the ability to innovate. This is evident in Rogers (2003) classification of innovators, early adopters, early majority, late majority and laggards; a category of never adopter is not included. Recent research in neuroscience (Camerer, Loewenstein and Prelec 2005; Vandervert 2003), education (Renzulli 2003) and psychology (Shavinina and Seeratan 2003), however, has shown that innovative capabilities are distributed very unevenly. Even more, innovative capabilities are specific to certain areas of activity; in other words, creative scientists or artists usually have very poor capabilities to innovate in business and vice versa. Recognition of these differences and their influence on innovation capabilities can spur growth and poverty alleviation through better targeting of development programs and the design of new instruments.

It is evident that people innovate often in many aspects of life (e.g., buying new computers or adopting new consumption patterns). At the same time, a cursory observation of developed economies indicates that very few people are entrepreneurs or innovators; most people are employees, professionals or self employed in small enterprises. These observations suggest that there may be different types of innovative capabilities.

Innovation has been defined in different ways. In psychology and education it has been defined as the ability to think new things, which may lead to new products or processes. In the innovation systems literature, several definitions have been proposed (OECD 1999); in this paper we define an *innovation as anything new successfully introduced into an economic or social process*. Our definition leaves out an important set of innovations: those that improve individual lives but do not have an impact on society. In other words, it does not include personal improvement. It also stresses that

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an innovation is not just trying something new but successfully integrating a new idea or product into a process that includes technical, economic and social components.[2]

Our definition also differs from the traditional view that sees innovations as discrete, finished outputs, as reflected in the terms "product" and "process" innovations, or diffusion of technologies. The traditional view also influenced traditional research management procedures that focus on research outcomes (Alston, Norton and Pardey 1995) and extension programs that stress passing technical packages to farmers. Even modern extension approaches, such as Farmer Field Schools, seek to help farmers adopt specific techniques or develop definite skills (Tripp, Wijeratne and Viyadasa 2005) rather than develop long term innovative capabilities.

This simplistic view of innovation, however, is not supported by the development and diffusion of several important innovations, such as no-till agriculture (Ekboir 2002), computers and hydraulic excavators (Christensen 2003). These experiences show that particular innovations should be seen as components in long and complex processes where technical, commercial and social factors have to be integrated.

Developing innovations that have an economic or social impact requires innovators to be able to outperform other potential innovators. The reason why few people are entrepreneurs is that competitive forces operate as a selection mechanism attracting entrepreneurs into occupations where they can profit from their skills. Non-entrepreneurs cannot survive in dynamic markets, because competition forces agents to innovate often to maintain or increase their competitive advantages.[3] In static markets, though, non-innovators can survive because the pace of change is slower. This is especially valid for small farmers who produce their own food, while small businesses in other sectors have to make enough profits to cover, at least, the owner's food needs.

The capabilities to innovate have two dimensions: individual and collective. Collective innovation capabilities are important because actors seldom innovate in

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[2] Schumpeter (1950) introduced this distinction when he distinguished invention (a new idea) from innovation (implementation of the idea).

[3] This phenomenon has been recognized, at least, in since Marx. Cochrane's model of the technology treadmill (1958) is a modern version of the process.

isolation, but interacting with other actors in formal or informal networks (Christensen and Raynor 2003; Ekboir 2002). Understanding individual innovative abilities is important because organizations learn through their members and because most farms (especially, small farms) in developing countries are managed by a single farmer or household.

This paper analyzes the nature of innovative abilities and their distribution among commercial farmers. The remainder of this paper is organized as follows. Section 2 analyzes the nature of innovation capabilities. Section 3 reviews the literature on individual innovation abilities while section 4 reviews recent discussions on collective innovation capabilities. Section 5 describes the data used in the empirical analysis presented in section 6. Section 7 concludes discussing the importance of incorporating the differences in innovation capabilities in the design and implementation of development programs, especially those targeted at increasing agricultural production and development of high-value agriculture.

2. The Nature of Innovative Capabilities

The nature of innovative capabilities is the same in all innovators; the difference lies in the strength of those abilities and the particular areas in which they are applied (see sections 3 and 4). Even though the nature of the capabilities is similar, the strengths determine the types of innovations individuals and organizations can develop; that is, the “quantitative” differences have major “qualitative” consequences. For example, many people can design a billboard for an advertisement, but very few can paint a masterpiece. Also, the areas in which innovators operate influence the expression of those capabilities; for example, scientists usually follow stricter rules to innovate than artists (see sections 0 and 0).

Also, what is defined as an innovation depends on the particular context in which it is introduced. In science and arts the main criteria for an innovation to be accepted as such is novelty to the world. In these cases, innovation is a process of rare events and only very few people are recognized as real innovators. On the other hand, in most other areas of human activity, and especially in the innovation systems literature, an innovation has to be new only to the adopting agent (Nelson and Rosenberg 1993).

For example, in the 1990s many Ghanaian small farmers adopted a no-till package for maize production. One important component of the package was a sighting pole that helped farmers walk in a straight line and plant the maize in rows (Ekboir 2002).

In areas other the arts and science, an innovation has two dimensions: one is the innovation itself and the other the ability to integrate it into an effective package. While the former is no longer a rare event, the second is. And the degree of novelty required to succeed increases with development and globalization. Because the benchmark for an innovation is not novelty to the world, but improvement of a process in prevailing local conditions, many people qualify as innovators in local isolated markets. But as these markets integrate into globalized ones, the marketing skills required to succeed in large, anonymous markets are increasingly sophisticated. For example, a small farmer selling maize in Nigeria needs different skills to sell in his village market than to Cargill.

This means that the capabilities to develop social or economic innovations are intrinsically similar to those required for successful adoption, but used with different goals and applied to different environments. To innovate, agents (e.g., individuals, private firms or research institutes) must have the ability to create something new; to achieve this they must integrate into formal or informal collaborations because individually they usually do not have all the resources required (Ekboir 2002; Christensen and Raynor 2003; Rycroft and Kash 1999). To use an innovation developed by someone else, more than the ability to "create" new things, actors must have the ability to integrate existing technical, managerial and marketing components into an efficient package. In order to access the technical and commercial information farmers need to adopt an innovation, they also have to integrate into formal or informal networks.

Recognition of the differences in innovation capabilities across actors has led to a review of the principles of the firm. It has been found that many farmers carry out experiments on their own (Bellon 2001); however, few farmers are recognized as technology leaders, and even fewer, have been able to develop new technologies. This casual observation coincides with findings in other economic sectors that identified persistent differences among firms in the same productive sector (Christensen 2003; Henderson and Cockburn 2000; Teece Pisano and Shuen 2000).

This fact led to a new characterization of the firm, called the resource-based vision of the firm. Rather than considering that firms maximize an objective function subject to external constraints (a static vision), it is assumed that firms invest resources to create idiosyncratic capabilities that enable them to relax the external restrictions and create long-term competitive advantages (a dynamic and strategic vision). These capabilities are unique to each firm, are difficult to copy or buy (Dosi, Nelson and Winter 2000), and depend on individual and collective capabilities to innovate.

3. Understanding Individual Innovation Abilities

Almost every person is born with the basic physiological apparatus to innovate (Vandervert 2003). In fact, people innovate continuously. Most innovations, however, are not socially "important" because they do not transcend the innovator's personal experience (e.g., becoming better at yoga); on the other hand, some innovations are "important" because they have an influence beyond the innovator (e.g., creating a successful firm) and very few are "extremely important" because they have major economic or social impacts (e.g., developing an AIDS vaccine). "What makes an innovation an 'important' innovation or a deeply experienced 'insight' is a matter of its cultural or organizational context, and its degree of generalization" (Vandervert 2003). In this section we are concerned with the abilities of individuals who are capable of creating "important" innovations; i.e., innovations with the potential of having social or economic impacts.

An individual's ability to innovate is not only innate, but also results from the specific organization of idiosyncratic cognitive experiences. These experiences influence the individual's representations of reality, i.e., how an individual sees, understands and interprets the environment in which he/she is immersed. The cornerstone of individual innovation is the originality of the representations an individual creates (Nickles 2003). Intelligent people, and particularly innovators, see, understand and interpret their reality differently than the rest of the population. Their representations are general, categorical, conceptually rich, complex and unique, all which enables exceptional performance and achievements (Shavinina and Seeratan 2003). This unique representation is the basis for "seeing" what other people do not see.

Describing their representations as unique, does not mean that innovators have supernatural abilities (Nickles 2003). They are human beings with a unique combination of abilities operating in a particular environment that result in extraordinary outcomes. Innovative individuals have above average general and specific abilities (but not necessarily exceptional), show strong task commitment, and are creative (Shavinina and Seeratan 2003; Renzulli 2003). The talent for innovation results from the interactions among these three factors and not from being exceptional at one or two. Two other factors that influence innovative abilities are personality and the environment (Georgsdottir, Lubart and Get 2003).

The general abilities are the capacities to process information, to integrate experiences and to have abstract thoughts, while the specific abilities are the capacities to acquire specialized knowledge or skills.[4] It has been shown that intellectually talented individuals have an adequate, sophisticated and well structured knowledge stock, which they can easily access. Task commitment is also defined as perseverance, specialized practice and self confidence. There is no universally accepted definition of creativity, but it is recognized that it is related to the ability to think what nobody else thought (Georgsdottir, Lubart and Getz, 2003).

Even though there are no methods to measure these traits quantitatively, it is accepted that innovators fall within the top 20 percent of each trait's distribution (Renzulli 2003). This implies that less than 1 percent of the general population can be described as innovators.

Innovative abilities are not necessarily linked to formal education or good grades, but to learning processes (Renzulli 2003). This does not mean that formal education is not important. Formal education has an indirect effect on innovation by enhancing the individual's ability to process information and often by increasing his/her specialized knowledge. In other words, innovative individuals can make better use of information than most people.

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[4] Academic skills are one of the most important general abilities while the specific abilities include artistic or sports skills.

Creativity is highly variable. Even the most consistently creative individuals have non-creative periods after intense and long creative experiences. Also, creativity varies over lifetime. Einstein had his first idea of relativity when he was 16 years old; in 1905 (at the age of 25) he published three papers, each one worth a Nobel Prize. He wrote his last major contribution in 1915, but remained a professor at renowned universities for another forty years. The great majority of innovators in art and science had similar experiences of decreasing innovative abilities over time (Miller 2000).

Task commitment and creativity can be developed in some people if they are properly stimulated and trained in those activities in which they are talented, and if they develop appropriate links with the environment (Renzulli 2003; Vandervert 2003). But individual responses to the same stimuli are highly variable; even more, it is not possible to predict which individuals will respond favorably to specific stimuli.

The nature of the training to develop innovative capabilities depends on the particular areas in which those capabilities will be applied, for example, scientists receive a more formal training than artists. There is strong evidence, though, creative scientists benefit from being good artists and vice versa (Simonton 2003).

Some people (not all people) are innovative in certain occasions (not all occasions), in certain moments (not all the time), in certain environments and in particular areas of activity, e.g., dancing, biology or business (Renzulli 2003). No one is an innovator or not an innovator in the same way as one is talented for sciences or acting. Some people have a unique episode of important innovation in their lives, while others maintain their innovative capabilities for a long time.[5]

The bases of an individual‘s innovative abilities are his/her ability to conceptualize situations, the possession of specialized knowledge (in quantity and quality) and the existence of a subjective mental space.[6] The ability to conceptualize is linked to the organization of the individual’s intellectual activity. The specialized knowledge plays a critical role in intellectual performance and in the acquisition of new

[5] For example, Giusepe Tomasi de Lampedusa wrote only one novel that became a literary masterpiece, while Edison was granted more than 2000 patents, more than any other individual in history.

[6] Specialized knowledge is not equivalent to scientific knowledge.

knowledge. It has been shown that "intellectually gifted people are distinguished by an adequate, well structured, well-functioning and elaborate knowledge base, which is easily accessible for actualization at any time" (Shavinina and Seeratan 2003).

The conceptual structures and the stock of knowledge create subjective mental spaces, a key component of cognitive experiences. Idiosyncratic differences in flexibility, differentiation, integration, and hierarchical structures of the mental spaces influence the cognitive attitude of individuals, and, thus their intellectual and creative abilities.

In a study of African innovative farmers, Reij and Waters-Bayer (2001) found that in most cases (a) they were male (probably reflecting gender biases in asset ownership, education and cultural values); (b) they had strong personalities; (c) they were relatively old and experienced; (d) they were relatively rich (which enabled them to experiment more; (e) they had links with other regions (which served as sources of new information); (f) they were full time farmers; (g) innovativeness and formal education were not correlated; and (h) they tended to develop integrated agricultural systems.

4. Collective Innovative Capabilities

Similarly to individuals, organizations have strong or weak innovative capabilities. These capabilities are embedded in individuals (including managers, technical personnel and line workers), the organization's technology and structure, its routines, culture and coordination procedures (Argote and Darr 2000). Even though innovative organizations must have at least a few innovative individuals, this is not required for the vast majority of members (Christensen and Raynor 2003). What is required is that the organization creates an environment in which innovative individuals can express their abilities and influence the organization.

Organizational factors and culture play a pivotal role because they define how individual and collective capabilities are structured, coordinated and communicated. For example, in 1973 the Xerox laboratory in Palo Alto developed a personal computer with a graphic interface and a mouse (the basis for the first Apple computer), an operating system that allowed running several programs simultaneously (bought by Bill Gates who used it as the basis for Windows), Ethernet connectivity and the first WYSIWYG word processor (Carayannis, Gonzalez y Wetter 2003).[7] But Xerox's institutional culture, centered on photocopies and mainframe computers, prevented the senior management from seeing the potential of these discoveries.

As was mentioned above, individuals and organizations (including firms and informal networks) do not innovate in isolation, but interacting with other actors. The ways in which these actors interact define their collective capabilities to innovate.

Individual abilities to innovate depend, partially, on innate characteristics. Collective capabilities, on the other hand, are not constrained by given features because organizations can incorporate individuals with required abilities. Their assimilation into existing structures, however, can be difficult.

Collective capabilities depend on the collective culture of the institution or network, and this culture changes very slowly (Schein 1991). Usually institutional cultures value adherence to routines that have proved successful in the past. In other words, organizations value stability over innovation (Bailey and Ford 2003). Creating spaces where creativity can flourish in established organizations has always been challenging.

By investing in the creation of innovative capabilities, groups of actors improve their collective capability to absorb information generated by other actors and to use the knowledge developed internally. The development of collective innovative capabilities depends on the organizational culture and the existing capabilities; in other words, it is a path dependent process.

Similar to individuals, organizations can seldom innovate in isolation and integrate into innovation networks. Innovation networks are informal organizations that succeeded in implementing collective action through consensus. The consensus is based on trust among the members (Ekboir 2003; Rycroft and Kash 1999). In general, it is

[7] WYSIWYG is the acronym for "what you see is what you get".

more difficult for networks than individual organizations to survive long periods because of the decentralized nature of the decision making process in the former. However, several examples show that their emergence is relatively common (Ekboir 2002; Christensen 2003).

Even though formal education is not correlated with individual innovative abilities, an educated work force is fundamental to develop collective innovative capabilities. A more educated workforce can master sophisticated technologies more easily, can better understand norms and rules that differ from the traditional culture and can better interact with external sources of information, especially codified information.

5. The Data

The data were originally collected to map the technical and commercial networks in which commercial lemon producers in the state of Michoacán, Mexico, operate. The producers included in the survey were selected with a combination of methods. First, an exploratory workshop with key experts was used to identify farmers recognized as technological leaders. The second method was to draw a random sample from the 4,762 lemon plots registered in the state in 2002. The third method, known as snowballing, is commonly used in Social Network Analysis (Scott 2000). The farmers selected with the first two methods were asked to identify their sources of technical and commercial information (e.g., researchers, other farmers or input suppliers). These sources were then surveyed and asked to identify their sources. The process was repeated until the latest interviewees identified few new names. The final sample had 21 technological leaders, 66 farmers from the random sample and 44 identified by other farmers.

The sampling methodology used in this paper is unusual because of the inclusion of the leaders. It is known that the snowballing method can miss specific groups of actors, if they are not very well connected or if the sample does not include a large share of the network (Scott 2000). The technological leaders were included to assess whether their patterns of interaction were different from the rest of the population. Dummy variables were defined for each of the three categories of farmers.

The assumptions about farmer types used to design the sample were not confirmed by the econometric analysis (see below). This fact, however, does not invalidate the sampling procedure. The sample was designed to identify patterns of interaction, not to estimate population parameters; thus, the sample did not have a statistical design and the results cannot be extrapolated to the population. This is a feature common to most samples in social network analysis (Scott 2000). The fact that some of the farmers used to start the snowballing process were selected randomly, allowed a "good estimate" of the interactions (Frank 1979). The addition of the leaders only added to the sample information that would probably not have been obtained with the random sample alone.

Participants in the workshop identified 30 good practices for the production of lemon. Each farmer was asked which of those practices he/she used, in which year he/she adopted the practice and who did he/she learned it from. This paper focuses on the first seven adopters of each practice.

The survey showed that no farmer used the 30 practices identified in the workshop. Even though this shows that the "experts" probably did not have a good understanding of the economic value of each practice, it does not invalidate the analysis. The practices that are not used are simply irrelevant for the analysis of adoption patterns.

6. The Nature and Distribution of Innovative Abilities

It was argued above that the innovative capabilities required for the adoption of innovations are basically the abilities to search for new information, to integrate components into an efficient package, and to establish stable links with sources of commercial and technical information. This section examines the determinants of farmers' exploration patterns and of integration of technical packages.

The section also explores whether farmers recognized as technology leaders by their communities have the strongest innovative capabilities. Understanding whether these farmers are really the most innovative is important because researchers and extension agents usually seek to collaborate with them.

The list of the first seven farmers to adopt each innovation contains 80 names, 65 percent of the farmers surveyed. In other words, about two thirds of the farmers often explore new, untested techniques. Considering that the leaders are only 16% of the sample and those mentioned by other farmers represent 34%, farmers of all three categories are among the explorers, indicating that the categories used to define the sample do not fully reflect the farmers' innovative capabilities. This finding is confirmed by the econometric analysis below.

Table 1 shows the descriptive statistics of the variables used in the econometric analysis. The dependent variables are the number of times a farmer was among the first seven adopters of a particular technique and the total number of techniques a farmer uses. The variables input supplier, technical advisor, yourself and another producer are the number of techniques the respondent learned from each source. The total number of techniques used by a farmer is larger than the summation of these variables because farmers have learned some techniques from other sources (family, technical trips and other sources). The variable "in degree" is the number of farmers that mentioned a particular farmer as a source of technical information, representing how well connected the farmer is in his/her community. Equipment is an index indicating how much farm machinery such as a pick up or a tractor the farmer owns, a proxy for the farmer's wealth. Administration index indicates the number of management innovations adopted by the farmer, indicating how good a manager he/she is. Rents, an index with value 1 if the farmer rents land to produce lemon, is an indicator of profitability. Total external references indicates the number of sources of technical information a farmer uses.

Table 1: Descriptive statistics

Variable	Mean	Standard deviation
Number of times among first 7 adopters (dependent variable)	3.5	2.89
Input supplier	0.34	0.79
Other farmer	1.1	1.29
Technical advisor	0.58	1.02
Yourself	1.4	1.60
Publication	0.05	0.27
In degree	2.79	0.47
Number of techniques used	11.11	4.17
Equipment index	0.71	0.04
Administration index	0.50	0.04
Rents	0.16	0.04
Total external references	9.49	0.64

The system consisted of two equations, one for the number of times a farmer was among the first seven adopters and the other for the number of techniques a farmer used; the first equation is a proxy for the farmer's exploration propensity and the second of the farmer's ability to integrate an effective production package. The equations were estimated by OLS; a test for heteroskedasticity rejected the hypothesis of a non-identity covariance matrix. The equations were also estimated as a system with three stages least squares, but the results were basically identical to the OLS estimation.

The results of the estimation of the equation for the number of times a farmer was among the first seven adopters are presented in table 2.

Table 2: Regression of the number of times a farmer is among the first seven adopters on farmers' characteristics

Variable	Regression 1	Regression 2	Regression 3	Regression 4
Constant	0.54	0.46	0.54	3.37
	(2.98)	(0.59)	(2.94)	(7.37)
Leader			-0.32	2.34
			(-0.66)	(2.74)
Referred farmer				-0.75
				(-1.14)
Input supplier	0.63		0.62	
	(3.60)		(3.51)	
Technical adviser	0.57		0.54	
	(5.62)		(5.64)	
Yourself	0.85		0.86	
	(9.37)		(9.36)	
Other farmer	0.66		0.65	
	(5.63)		(5.53)	
Publication	1.20		1.15	
	(2.42)		(2.28)	
In degree	0.10	0.26	0.12	
	(2.95)	(3.73)	(2.60)	
Number of techniques used		0.21		
		(2.91)		
Adjusted R2	0.86	0.31	0.86	0.12

Note: in all cases the number of observations is 80; t statistics are in parenthesis. The estimation method is OLS.

Regression 1 shows that the trial of new techniques is linked to the use of a number of different sources of technical information and to the pattern of interactions with other farmers. In other words, exploration is an attitude that involves actively searching for new information from different sources and using that information to identify potential new technologies.

A comparison between equations 1 and 2 shows that the trial of new practices (exploration of emerging technical opportunities) is not linked to the total number of techniques a farmer uses, which we use as a proxy for the quality of the technical package used. The workshop of experts (including farmers and agronomists) identified 30 practices a good lemon farmer is supposed to use; thus, we assumed that the more practices a farmer used the better the package was. This is a strong assumption since the selection of the practices was not based on economic considerations, as shown by the fact the no farmer uses all 30 practices. For the producers in the sample, however, the practices not used are irrelevant for their exploration routines. In the absence of more complete data on the farmers' decision making process, we accepted the opinion of the experts.

The coefficient for the number of practices a farmer uses in equation 2 is significant but the R^2 dropped substantially relative to equation 1, indicating that exploration of new techniques is not influenced by the sophistication of the production package the farmer is already using.

Regressions 3 and 4 show that the categories used to design the sample cannot successfully explain the exploratory behavior of farmers. The coefficient for leaders in equation 3 is not significant. Equation 4 regresses the times a farmer is among the first adopters on the three categories used to select the sample. Even though the coefficient for the leaders is significant, the R^2 is only 0.12. This finding is important because extension agents and researchers usually work with the recognized technology leaders.[8] In other words, to increase the effectiveness of participatory research and extension, it is necessary to define better criteria to identify innovative farmers and to target research and extension programs.

The expected profitability of lemon production was captured by a question on whether the farmer was willing to invest in lemon production in the near future. Another important economic question was whether the farmers had access to credit. Both variables were not significant (the results are not reported).

Regression 5 in table 3 shows that the number of techniques a farmer uses can be explained by the farm equipment a farmer owns, his/her use of administrative techniques, his/her attitude towards exploration (measured by the times he/she figures among the first adopters) and whether he/she rents land for agricultural use. In regression 6, the coefficient for the leaders is significant but has the wrong sign. Finally, equation 7 shows that the categories used to define the sample have little explanatory value; even though the coefficients are significant, the R^2 is low.

[8] In fact, extension agents in the survey area were asked to select from among the interviewees, farmers whom they would approach; the extension agents y mostly selected the technology leaders.

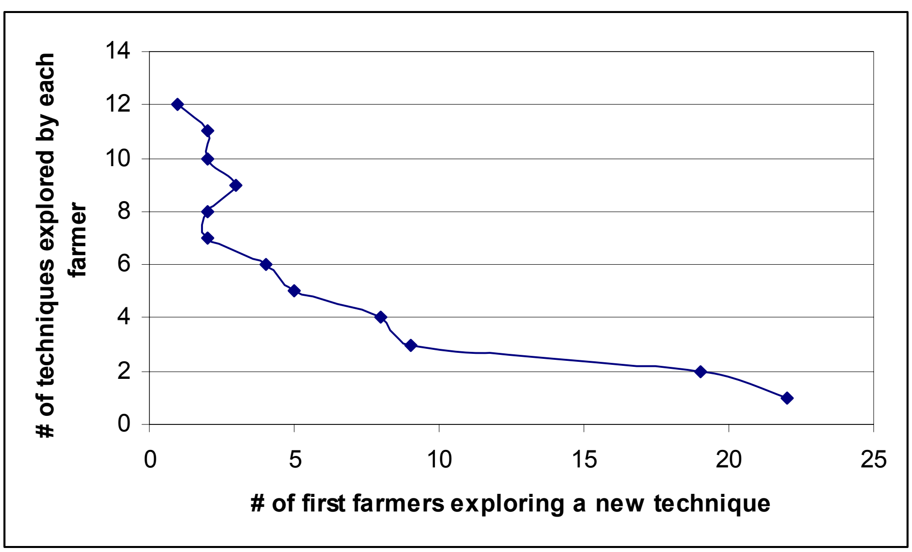
Table 3: Regression of the number of techniques a farmer uses on farmers' characteristics

Variable	Regression 5	Regression 6	Regression 7
Constant	3.20	2.78	8.90
	(5.07)	(4.37)	(13.14)
Leader		-1.69	4.81
		(-2.33)	(3.96)
Referred farmer			3.13
			(3.36)
Equipment	1.64	1.77	
	(2.14)	(2.37)	
Administration	3.60	4.14	
	(4.40)	(5.00)	
Times among first	0.24	0.29	
adopters	(2.64)	(3.19)	
Total external references	0.41	0.43	
	(8.61)	(9.16)	
Rents	1.53	1.13	
	(2.33)	(1.72)	
Adjusted R2	0.74	0.76	0.18

Note: in all cases the number of observations is 80; t statistics are in parenthesis. The estimation method is OLS.

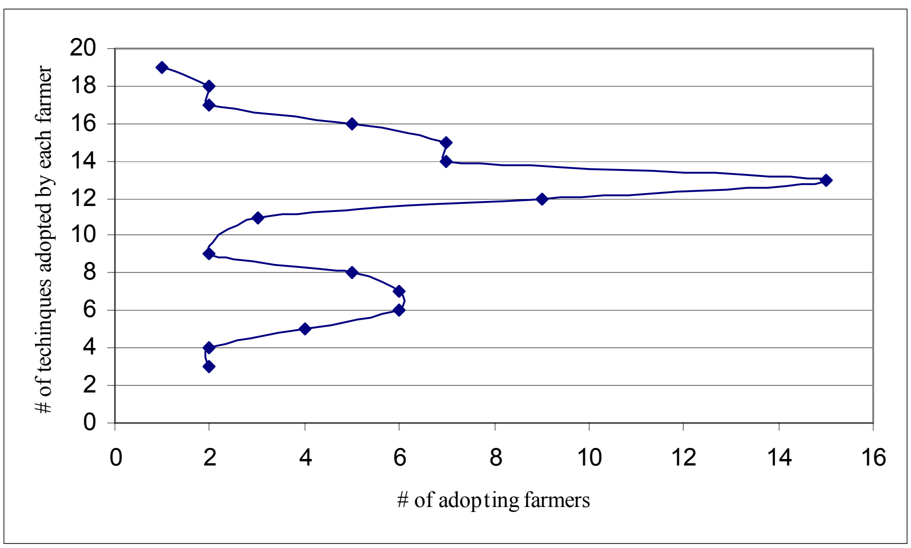
In the discussion on individual innovative capabilities it was argued that these abilities had a very skewed distribution. If this were true, it should be expected that exploration of new techniques should also have a skewed distribution. This hypothesis is confirmed by the data. The adoption of new techniques by the first adopters follows an exponential distribution with an exponent of -0.74 (t coefficient = -10.34) and a constant of 2.73 (t coefficient = 22.24); the R^2 is 0.90. The number of observations is small, but still, they fit the exponential distribution very well (figure 1).

Figure 1: Distribution of farmer's exploration of new techniques



Exploration of new alternatives is different from the ability to integrate an efficient package. Figure 2 shows the distribution of the number of techniques used by each farmer. The distribution has two modes, what we call a high technology package with 13 practices and a low technology package with 6 or 7 practices. As was mentioned above, the sample included only commercial farmers; in other words, farmers who have competitive skills. Since this requires integrating several techniques, few farmers can survive in the lower part of figure 2; in fact 31 farmers (39 percent of the sample) use between 12 and 14 practices (the high technology package) and only 17 farmers (21 percent of the sample) use between 6 and 8 practices (the low technology package). In a less competitive environment we would expect the low technology mode to be much larger.[9] Testing this hypothesis is left for further research.

Figure 2: Adoption patterns



A comparison of figures 1 and 2 clearly shows that the distribution of techniques adopted by each farmer is different from the ability to explore.

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[9] We expect this statement to be valid, independently of how the effectiveness of the technology package is measured. More efficient packages can actually reduce the number of practices required to produce the same output, as evidenced by no-till. But, we would still expect a two mode distribution (one mode for commercial farmers and the other for non-commercial farmers).

7. Conclusions

Rogers' (2003) classification of innovators, early adopters, early majority, late majority and laggards has been generally accepted as a true representation of a diffusion process. A tacit assumption underlying this classification is that eventually, the whole population will adopt the innovation. We have presented evidence that the assumption and the classification do not properly describe the diffusion of economically or socially "important" innovations, i.e., innovations that transcend the individual.

Important innovations cannot be characterized by the adoption of a single innovation but by the integration of an effective package that includes both technical and commercial components. To integrate these packages, innovators explore alternative innovations and interact with other agents to access information and resources. How early a farmer adopts a particular technique is only weakly related to his/her ability to ingrate an efficient package. Rogers' classification can be better applied to what we call exploration (i.e., the adoption of discrete innovations) than to integration of the whole package.

The exploration abilities have a very asymmetric distribution; in fact, we found that the distribution follows a power law.[10] A key feature of power laws is that most observations are below average. In other words, a few individuals are very active explorers, while some farmers explore sporadically and most farmers do not explore at all but copy what others have found useful. The power law implies that average or representative behaviors cannot properly represent exploration among farmers. In our sample, 51 farmers (39 percent of the sample) were not among the first adopters of any technique. Copying may not indicate that the farmer is not an innovator; his/her innovative capabilities may concentrate in combining what has been tested by others into an efficient technical and commercial package. A deeper exploration of the relationship between exploration and integration is left for further research.

It must be noted that our sample included only commercial farmers. Schumpeter and Cochrane argued that competition acts as a selection mechanism weeding out non-

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[10] The data does not allow us to test whether the data truly follow a power law or a log-normal distribution. But for the argument to be valid, all that is needed is a heavy-tailed distribution.

innovative actors from markets. If this argument is valid, the concentration of innovators among commercial farmers is larger than in the general population. The analysis of the distribution of innovative abilities among small farmers in developing countries is left for further research, but if our argument is valid, it can have major implications for the design of development policies (see below).

Exploration of technical alternatives in our sample depended on the farmer's ability to use a variety of sources of information, including the number of contacts he/she has with other farmers, but was not related to formal education, age, experience as a lemon producer, the expected profitability of lemon production or access to credit. This finding agrees with the literature on individual innovative abilities and the resource-based view of the firm that stress that the innovative abilities depend on innate and acquired idiosyncratic factors that influence the way innovators see and explore the world, and less with traditional external factors common to all producers, such as market conditions or policies. In other words, external conditions are similar for all, but the idiosyncratic factors determine how each actor can benefit or lose from the external conditions. Integration of an efficient package, on the other hand, depended on exploration abilities and on more traditional variables related to investment and commercial abilities.

As was mentioned above, our findings have three important consequences for the design and implementation of development policies and programs. First, contrary to Rogers' classification, some farmers in developing countries might not even have the ability to become laggards. Investing resources in programs to increase productivity in their farms would yield little economic growth (even though it may reduce food insecurity). Second, as developing countries embark in market-led agricultural development strategies, only a fraction of the farmers would be able to integrate into markets. Even though this would accelerate economic growth and create employment in rural areas, it would increase income discrepancies.

Third, what is an innovation is defined by the particular context in which the "something new" is introduced. The more backward the context, the easier it is to innovate. This means that many more people can benefit from training to improve production of staple for self consumption than from a program to develop high-value exports.

An adequate policy mix to accelerate growth and reduce poverty in rural areas should include targeting productivity enhancing programs to innovators and for the rest of the population implementing policies to reduce the cost of adjusting to a more competitive environment, such as technical training. Targeting programs to innovators is difficult as the literature on programs for gifted students has shown, but it could have major positive impacts on rural societies. Exploration of the dynamics of innovation in traditional societies and in emerging markets, and the analysis of specific policies based on our findings is left for further research.

Our results also show that farmers traditionally recognized as leaders are not the most active explorers of new technologies, do not have the best strategies to search for new information, and often do not use the most effective technologies. This is important for the design of participatory research and extension programs, because the extension agents usually work with recognized leaders. Better identification of innovative capabilities can increase the effectiveness of research and extension programs.

Understanding innovation capabilities is also important to assess the importance of community-based approaches to development. If innovative capabilities have a skewed distribution, these approaches may stifle innovation by forcing the most innovative actors to adapt to a more conservative community. On the other hand, community-based approaches may be effective to disseminate innovations that require less specific capabilities, such as better health practices.

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