To Determine the Challenges in Commercialization of Nanotechnology in Agricultural Sector of Iran

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Abstract: Faculty members in agricultural colleges and research centers in the Mazandaran Province were surveyed in order to explore their perception about the challenges influencing the commercialization of the data was analyzed by using ordinal factor analysis technique. Based on the perception of the respondents and ordinal factor analysis, factors were categorized into eight challenges namely, infrastructural, production, business, management, economic, technical, social/cultural and research challenges nanotechnology in agricultural sector in Iran. The challenges were then ordered by the magnitude of their impact.

Key words: Nanotechnology, commercialization, challenges, agricultural sector, technical, Iran

INTRODUCTION

Modern technologies can play an important role in increasing production and improving the quality of food produced by farmers. Many believe that modern technologies will secure growing world food needs as well as deliver a huge range of environmental, health and economic advantages (Wheeler, 2005).

Nanotechnology as the latest innovation has the potential to bring about changes as big as the European industrial revolution in the late 18th and early 19th century. Almost 100 and 50 years ago, the mechanization of industry, the introduction of steam power and improved transportation systems brought huge technological, socioeconomic and cultural changes. Today, nanotechnology is forecast to underpin the next industrial revolution, leading to far reaching changes in social, economic and ecological relations (Miller and Senjan, 2006).

Nanotechnology has the potential to revolutionize agriculture and food systems. Agricultural and food systems security, disease treatment delivery system, new tools for molecular and cellular biology, new material for pathogen detection, protection of environment and education of the public and future work force are examples of the important links of nanotechnology to the science and engineering of agriculture and food systems (Scott and Chen, 2003).

UN survey on potential applications of nanotechnology in developing countries have identified agricultural productivity enhancement as the second most critical area of application for attaining the millennium development goals while energy conversion and storage was ranked 1st and water treatment as the 3rd areas needing focus (Sastry et al., 2007).

However, the full potential of nanotechnology in the agricultural and food industry has still not been realized (Joseph and Morrison, 2006). Therefore, it is necessary to remove the impediments faced by farmers and provide basic information to enable the spread of nanotechnology. This would enable nanotechnology to be part of a comprehensive development strategy for agricultural sector.

A major issue that will affect successful applications of new technology such as bio and nanotechnologies to agriculture is the regulatory climatic governing the release of new products. Developing societies will need to develop and implement regulatory measures to manage any environmental, economic, health and social risks associated with genetic engineering (Ozor, 2008).

But the challenges of bringing new technology to market in the agricultural industry are changing, it is no longer adequate to conceive a new invention and convince farmers with a strong marketing campaign that they should adopt the technology that results from this invention. The business challenges in the commercialization of agricultural technology are both more complex and broader with respect to those who will be impacted by that technology (Boehlje, 2004).

The commercialization of new technologies or the process of introducing new technology to market has been a particular facet garnering much attention. Patent

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protection and capital investment are necessary components for the effective commercialization of innovations (Boulay *et al.*, 2008). Commercialization entails a sequence of steps to achieve market entry of new technologies, processes and products. Jolly (1997) outlined a 5 stage model of the commercialization process. Technology exploration begins with the imaging stage. This stage primarily addresses the basic research related to a new concept. The 2nd stage proposed by Jolly is the incubating stage in which generic market applications and technology concepts are examined. In the demonstrating stage, the technology is moved into products with market application through various means such as prototyping. The promoting stage is the beginning of market entry and expansion. Finally, the sustaining stage focuses on the long-term market placement of the products. New technologies are a part of each of these stages at some point in their development (Boulay *et al.*, 2008).

The most basic business challenge in introducing any new technology is that of creating value for the customer. But even if the technology will create value for the customer the rate of adoption and speed of commercialization in essence the time to market may dramatically impact the financial/business success of the technology. Technological innovation typically requires large capital outlays and consequently access to capital/financial markets is critical to the success of discovery and commercialization of new technology. Some have argued that technology and biotechnology in particular is best served by patient and private capital rather than impatient public capital providers.

The 4th challenge in commercializing agricultural technology is that of value capture. Even though, new technology may create value for the user if the provider does not have a mechanism for capturing some of that value, it is unlikely that the technology will be commercialized. Consequently, technology that has value only if it can be marketed worldwide faces more difficult commercialization challenges compared to technology that is commercially viable based on introduction and utilization in markets that will protect intellectual property. A final challenge in the commercialization of technology is the decision process by which R and D expenditures are allocated and commercialization is funded.

Technology development and commercialization is clearly an issue of making critical and costly strategic decisions in a profoundly uncertain environment; uncertainty associated with the breakthroughs necessary to develop the technology, uncertainty associated with the market acceptance of the technology and uncertainty associated with the ability of competitors to bring similar technology to market (Boehlje, 2004). Naseri in his thesis

entitled commercialization, processes and models in developing and developed countries introduced some factors as the main challenges in the way of commercialization of nanotechnology: human, management, social, cultural and economic factors (Droby *et al.*, 2009).

Oriakhi (2004) in his research about commercialization of nanotechnologies reported that beliefs and convictions of consumers about nano, cultural and social challenges, lack of coordination between agencies, lack of targeted research projects, management challenges, lack of financial resources and uncertainty of industies about universities have affected agricultural commercialization in nanotechnology.

Different factors influence the process of commercialization of nano product. The most important factor in launching a new business is intellectual property rights which is the 1st step in commercialization of nano (Palmintera, 2007).

Iran has adopted its own nanotechnology programs with a specific focus on agricultural applications. The Iranian Agricultural Ministry is supporting a consortium of 35 laboratories working on a project to expand the use of nanotechnology in agro sector (Joseph and Morrison, 2006).

In the year 2001, the Iran presidential technology cooperation office initiated a smart move in the field of nanotechnology. Through these efforts, nanotechnology gained national priority in the country and in 2003, the Iranian Nanotechnology Initiative was set up with the aim of pursuing the development of nanotechnology in Iran. The question is what are the challenges in commercialization of nanotechnology in agricultural sector. The purpose of this study is to determine the challenges in commercialization of nanotechnology in agricultural sector.

MATERIALS AND METHODS

A series of in-depth interviews were conducted with some senior experts in the nanotechnology to examine the validity of questionnaire. A questionnaire was developed based on these interviews and relevant literature. The questionnaire included both open-ended and fixed-choice questions. The open-ended questions were used to gather information not covered by the fixed-choice questions and to encourage participants to provide feedback. The total population for this study was 14 faculty members of universities and research centers in the Mazandaran Province. Data were collected through interview schedules by Delphi tehnique. The data was analyzed by using ordinal factor analysis technique. The

basic idea of factor analysis is the following. For given set of observed variables $Y_1,...,$ Yn, one wants to find a set of latent variables $\xi_1,.....,\xi_k,$ k<n that contain essentially, the same information. The last version of their statistical software named LISREL 8.8 can handle such analysis. Briefly, researchers used goodness of fitness which its null hypothesis shows that the model is valid (researchers prefer to accept the null hypothesis, i.e., p>0.05). RMSEA (Root Mean Square Error of Approximation) which takes into account the error of approximation in the population and asks. How well would the model fit the population covariance matrix if it were available? (p-value <0.05 indicates good fit and >0.08 represents reasonable errors of approximation in the population).

RESULTS AND DISCUSSION

The results of descriptive statistics indicated that average age of respondents were 43 years old and all of them had a PhD degree majoring in agriculture. Table 1 shows the grouping of factors (determined via ordinal factor analysis) into 6 latent variables. As the ordinal factor analysis showed the factors were categorized into eight groups, namely infrastructural, production, business, management, economic, technical, social/cultural and research factors ordered by the magnitude of their impact.

As the ordinal factor analysis showed, factors were categorized into 8 challenges namely infrastructural, production, business, management, economic, technical, social/cultural and research challenges. The challenges were then ordered by the magnitude of their impact (Fig. 1). A wide range of economic, social, physical and technical challenges influences adoption of agricultural production technology. Wheeler (2005) and others

(Rogers and Pannell) pointed the factors which influence the adoption of new innovations by farmers. She mentioned factors such as perception about risk and profitability; uncertainty and certainty about adoption; amount of required information and attitude about risk and uncertainty.

The findings show that infrastructural factors are the most important challenges a result that echoes the findings of Oriakhi (2004) and Droby *et al.* (2009). A regulatory process should ensure the democratic control of and public participation in decision making on nanotechnology and other new technologies. It is recommend, the initiation of a wide range of participatory processes to enable direct input from the general public into new technology assessment and determination of priorities and principles for public policy, R and D and legislation (Johnston *et al.*, 2007).

Production factors are always potentially important challenges in development of modern technology such as nano. It is well known that uncertainties and lack of knowledge of potential effects and impacts of new technologies or the lack of a clear communication of risks and benefits can raise concern amongst public (Chaudhry *et al.*, 2008).

The findings also reflect an important fact that negative attitudes of consumers and producers directly impacts the commercialization of nanotechnology in agricultural sector. This has been pointed out by Droby *et al.* (2009).

Like any other new technology, public confidence, trust and acceptance are likely to be one of the key factors determining the commercialization of nanotechnology in agriculture and the public should be educated that explain the value added of nanotechnology (Scott and Chen, 2003).

Table 1: Classification of challenges that Influence the commercialization of nanotechnology by using ordinal factor analysis

Categories	Variables	Variance by factor
Infrastructural	Lack of trademark, lack of appropriate mechanisms, no central authority to issue licences and standardized the technology, lack of clear policy in demand and supply equilbruim in executive agencies, lack of experienced and skillful human resources	16.57
Production	Marketing strategy, competitive environment, communication skills, knowledge about IPR and available physical facilities	16.01
Management	Lack of centralized management on projects, Inappropriate management of technological parks, maintaining the inappropriate management of projects, lack of clear expectation of producers, lack of knowledge about business models, lack of appropriate program planning	13.26
Business	Lack of negotiation skills, weak knowledge about signing contracts, weak distribution systems, difficulty in marketing products	14.99
Economic	Limited financial resources, lack of appropriate financial and credit systems to support the R and D, lack of interest in long term investement, weak participation of private sector in investment, high risk of investment, economic sanctions, complex rules and regulation	12.75
Technical	Difficulty in producting the first sample, lack of appropriate design for new products, difficulty in producing products with low cost, weak capacity, weak maintenance system and lack of IPR	9.19
Social/ Cultural	Weak knowledge of consumers, negative attitudes, negative beliefs of consumers and producersabout nano, lack of knowledge about advatnges of nano, differences in satisfaction of consumers and technophobia	8.75
Research	Lack of participation by private sector in research, lack of applied approach in research, lack of coordination among researchers, no relevancy between research and market	7.51
Total		99.03

The value of RMSEA was 0.726 which shows the reasonable fit of model
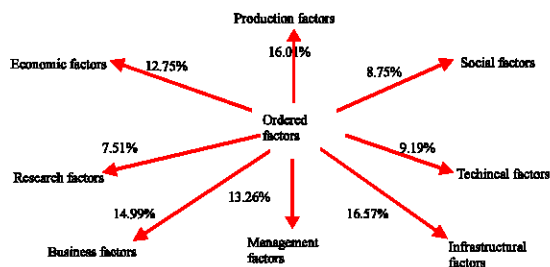
Fig. 1: Classfication of factors by using ordinal factor analysis

CONCLUSION

It is observed from the study that commercialization of nanotechnology requires a holistic and tightly integrated regulatory framework for dealing with the range of health, ecological, economic and socio-political issues that this technology raises (Johnston *et al.*, 2007).

As in the case of any complex technology impacting wide range of processes and developments, the gains from modern biotechnology are accompanied with certain negative effects and concerns. The nature and extent of the positive and negative impacts will depend on the choice of the technique, place and mode of application of the technique, ultimate use of the product, concerned policies and regulatory measures including risk assessment and management ability and finally on the need, priority, aspiration and capacity of individual countries (Ameden *et al.*, 2005).

RECOMMENDATION

Overall, these findings suggest the commercialization of nanotechnology in Iran faces challenges and obstacles. The constraints and opportunities vary from country to country and therefore require location specific approaches.

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