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IDENTIFICATION OF PERSONAL FACTORS CONTRIBUTING TO COMMERCIALIZATION OF NANO TECHNOLOGY IN IRAN'S FOOD INDUSTRY

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ABSTRACT

Convergence of nanotechnology and food science creates a lot of potentials. Manipulation of food polymers and polymer sets has led to improvement of food quality and consequently consumer's health. Nanotechnology can create materials with self-assembling, self-healing and self-maintaining properties which have wide applications in food industry. With the help of scientists, governments and large food corporations are willing to identify the applications of nanotechnology in food industry in order to satisfy their needs and demands. Commercialization of new technologies such as nanotechnology is a sensitive issue. Without proper identification of effective factors in commercialization of nanotechnology and its obstacles, there can be no appropriate strategic solution for introduction of this technology to the market. This issue is one of the struggles ahead of our country. Every year, companies, inventors, or private and governmental research institutes invent products in this area; yet due to a variety of reasons most of these products and inventions could not make it to the market and become commercialized. This article addresses four personal factors contributing to commercialization of Nano-food industry in our country. These four factors have been identified through interviews with experts

of the matter; the significance of these factors has then been analyzed using multiple regression method.

Keywords: Nano, Nano-food, commercialization, technology, invention

INTRODUCTION

Nanotechnology is a new issue which has gained prominence all over the world. To be completely clear, it is not a part of the future, it is the whole future. It has been described as the new industrial revolution in which both developing and developed countries have made extra ordinary investments in order to reserve a share of future markets. New technologies such as Bio and Nano have great potentials to systematically change food industry and agriculture [Hosseini, 2011]. With the help of nanotechnology it is possible to make changes in taste and quality of foods and also reduce the amount of fat, salt, and sugar, or increase vitamins and nutrients in the food [House of Lords, 2010]. New technologies such as Bio and Nano can play an important role in increasing the extent and quality of agricultural products. It is widely believed that modern technologies will secure growing world food needs and deliver a huge range of environmental, health and economic advantages [Wheeler, 2005].

Nanotechnology offers the ability to create and control materials, instruments, and systems in an atomic and molecular level and use them in nanometer scales [Bouwmeester et al. 2009]. Nanotechnology can be used for different purposes such as development of minute-scale material, optimization, control and delivery, pollution detection, and development of Nano-tools in cellular and molecular biology. This technology includes invention and use of organic and inorganic materials in nanometer scale [House of Lords, 2010]. Food security has always been one of the main concerns of industrial sector. With problems such as lack of food resources and growing population alongside spread of diseases, development of food sectors seems to be a crucial industrial issue. Use of modern technologies in this sector is a new approach which can provide solutions [Wheeler, 2005]. Convergence of nanotechnology and food science creates a lot of potentials. Manipulation of food polymers and polymer sets has lead to improvement of food quality and consequently consumer health. Nanotechnology can create materials with self-assembling, self-healing and self-maintaining properties which have wide

applications in food industry [Wheeler, 2005]. Nanotechnology has great potentials to make changes in global food system. Novel agricultural and food safety systems, disease-treatment delivery methods, tools for molecular and cellular biology, sensors for pathogen detection, pesticides, packaging materials, environmental protection, and education of the public and future workforce are examples of the important impact that nanotechnology could have on the science and engineering of agriculture and food systems [Bouwmeester et al. 2009]. Commercialization of new technologies such as nanotechnology is a sensitive issue. Without proper identification of effective factors in commercialization of nanotechnology and its obstacles, there can be no appropriate strategic solution for introduction of this technology to the market. This issue is one of the struggles ahead of our country. Therefor identification of effective factors and appropriate policies for commercialization of nanotechnology is a national necessity. Commercialization of ideas and research results is a crucial and inevitable issue which should be accompanied by rational decision-making and suitable strategies by managers and decision-makers in our country [Rezaei, 2010].

1- RESEARCH LITERATURE

2-1- Definition of commercialization

Commercialization of innovation includes activities and tasks which contribute to successful introduction of innovations to the market. It is consisted of activities such as: marketing, trademark, promotion and distribution of products which increases customer demands [El-Haj-Hassan, 2012].

Commercialization is to transform new findings and ideas into products and services which re presentable to the market. In other word, commercialization of researches and studies is a collection of efforts to sell research activities with the aim of gaining profits and further linkage of research and education with economical and social goals. Concerning the definitions presented above, commercialization can be defined as delivering an idea or innovation to the market [Jahandideh, 2005].

2-2- Importance of commercialization

Countries which are more inclined toward innovation have higher per-capita indices, productivity and living standards [El-Haj-Hassan, 2012]. Commercialization of research results is an important step in innovative systems which ensures

sustainability and continuance of research and development as well as provides considerable economic values for organizations and accelerates development of knowledge-based economy in the society [Khalil, 2010]. While during the process of development, researches have no economical value, their commercialization can create revenues. If left on the shelves, technology creates no revenue [Enayati, 2007].

2-3- Commercialization of Nanotechnology

A simple model for commercialization of nanotechnology is presented in Figure 1. Since nanotechnology is a science, it requires theoretical understanding and especial equipment. This means that the progress of nanotechnology occurs in universities, research institutes and company laboratories. The product of this stage is intellectual property and ownership, which is a kind of invention patent. The exclusive right for technical use of an innovation in a certain time period is then transformed by a company into a product which can be bought and sold. A company usually acquires a technology in order to expand its own business. Concerning its resources and forethought, that company may develop technologies which have the potential to create new businesses. Each of these mechanisms should be able to create economic benefits from nanotechnology [Crawley, 2007].

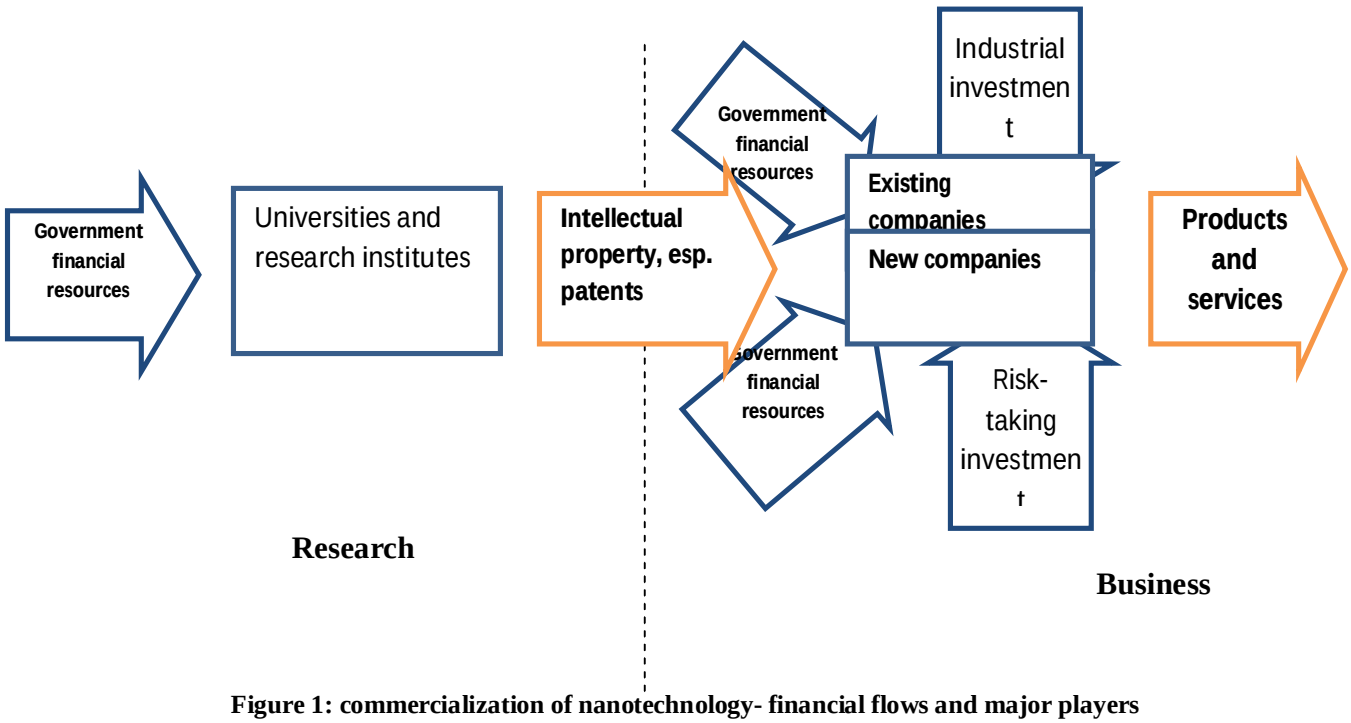

Figure 1: commercialization of nanotechnology- financial flows and major players

METHODS OF NANOTECHNOLOGY COMMERCIALIZATION

Most attempts on commercialization of nanotechnology follow a procedure as explained below: [Waitz et al. 2003].

Inception: most attempts on commercialization begin with protection of IP through the filing of patents. A lot of startups in nanotechnology get at least their initial IP from universities or by government labs. Another way to form nanotech startup companies is by a parent company spinning-out a business unit. The final way is through the independent entrepreneur who generates IP [Waitz et al. 2003].

Funding: there are many sources of funding. The most common sources for a nanotech startup are: friends and family, venture capitals, government and corporate partners. There are many success factors in funding. In government funding, writing a good proposal is the best one [Waitz et al. 2003].

Growth: there are a few different strategies used by nanotech startup executives to grow their companies. The first one is to partner with a larger corporation. Partnering can give a company access to manufacturing and sales channels, both of which are expensive for a startup. Another growth strategy is to spin off important technologies from common technologies. The single most important success factor in this stage is having a strong management team with market knowledge [Waitz et al. 2003].

Exit: few nanotech companies have had successful exits so far. This depends on a combination of the state of nanotechnology and the state of the economy. Therefor it is difficult to discuss the success factors regarding exits for nanotech companies [Waitz et al. 2003].

From general investment standpoint it is vital to identify challenges of nanotechnology commercialization. A large extent of public budget (more then 4 billion Euro worldwide in 2005) has been spent to support nanotechnology research and development [Waitz et al. 2003]. Calculations indicate that commercialization of nanotechnology can return these investments by direct economic growth and indirect social advantages [Waitz et al. 2003].

2-5- Nanotechnology commercialization and open innovation network

Nanotechnology requires equipment and instruments which quickly become obsolete and frustrated. By creating a network based on sharing of ideas industrial performance can be achieved. Nanotechnology needs the expertise of physicists, chemists, bio-

chemists, molecular biologists, and pharmaceutical scientists. It also requires the cooperation of higher management to synchronize and coordinate different branches of science [Hansen et al. 2001].

Creating an open innovation platform provides opportunities to acquire foreign technologies and resources. The largest potential lies in creation of domestic innovation platforms to satisfy particular needs of a firm or company. Chesbrough observed that even the smaller firms can create open systems [Chesbrough, 2006]. Unfortunately this may be difficult for young nanotechnology companies especially in developing countries due to specialized knowledge and the necessity to attract attention of geographically dispersed communities of experts. Participation in open innovation systems increases flexibility. Companies may adapt their technology to changing market conditions and obtain more value from innovation [Przemyslaw, 2012]. Participating in networks and open systems is also critical in commercialization (Figure 2). Networked technology and knowledge is vital revenue generating models. The application of innovative technology in industrial settings requires multidimensional expertise that can be provided by members of the network. The participation in open innovation systems creates further opportunities to increase the value of the innovation.

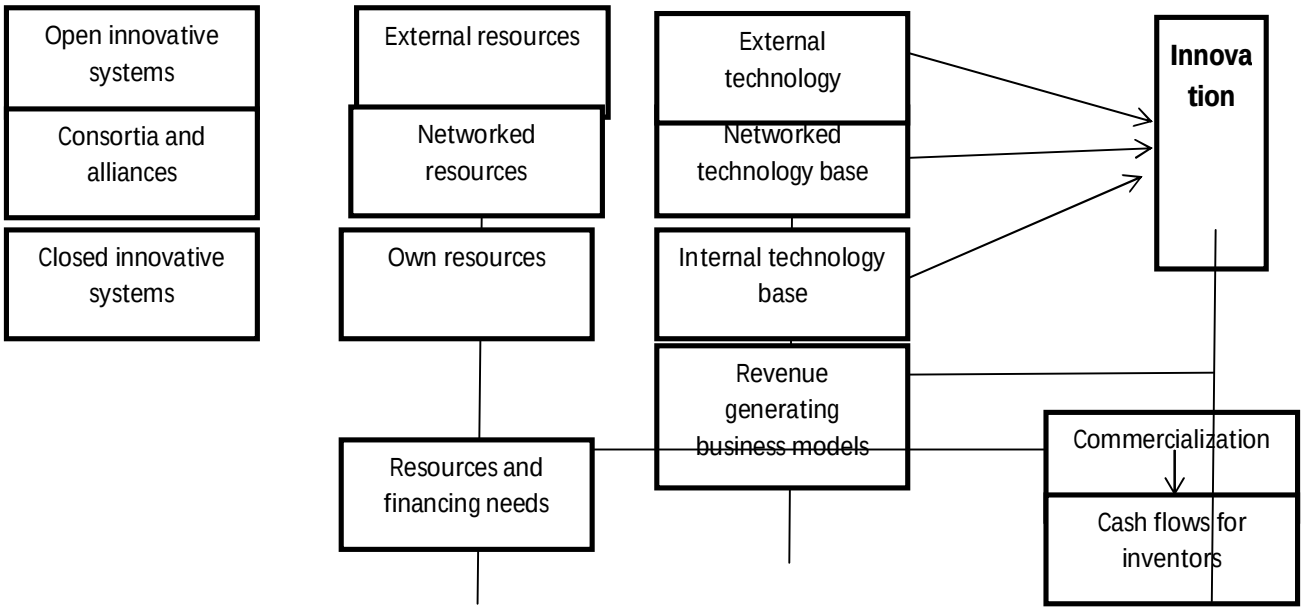

Figure 2: Closed innovation systems, consortia and alliances and open innovation systems in nanotechnology commercialization

2-6- Personal factors

Basics and theories of personal factors which contribute to commercialization indicate that there are personal characteristics which affect and individual's points of view, values, performance and life style; these characteristics can predict one's success or failure in a certain activity [Jahed et al. 2011].

These factors and characteristics are summarized below.

Self-efficacy: The concept of self efficacy refers to one's belief in his/her ability to successfully carry out certain tasks.

Control center: Control center is a personal variable which refers to one's expectation to control real-life phenomena. Commercialization efforts require belief in one's ability, responsibility, and internal control center.

Creativity and innovation: Creative and innovative people can introduce research outcomes to customers and investors in an interesting manner which provides better opportunity for commercialization.

Concerning technological entrepreneurship in a personal level, the focus is on scientists (engineers), entrepreneurs, investors and other people who start and propel technological innovations [Pette & Zhang, 2011].

Personal factors include technical skills (nanotechnology education, nanotechnology expertise, and nanotechnology work experience) managerial skills (planning, organizing, leadership, and control) personal traits (creativity and innovation, opportunism, adventurous, success-seeking, and self-reliance) and demographical characteristics (age, sex…) [Zarnegarian, 2012].

2-7- Commercialization experience

The obvious pre-requisite for commercialization of research results is the familiarity of companies with the concept of commercialization [Bandarian & Ghabezi, 2009]. Another obstacle in front of commercialization is the lack of experience. Individuals with more commercialization experience are more successful [Mansoor Hosseini, 2011]. Table 1 presents various researches which have been previously conducted on the subject of personal factors contributing to commercialization.

Table 1: Summary of prior researches on the impact of personal factors on commercialization of technology

Researcher	Year	Title	Outcome
Zarnegarian	2012	Identification of factors affecting commercialization of scholarly findings of bio-technology industry in Iran's agriculture	The effective factors are: 1- individual factors: demographical characteristics, psychological characteristics, experience and prior knowledge, motivation 2- organizational factors 3- institutional factors 4- environmental factors
Jahed et al.	2011	Determining and explanation of personal factors affecting commercialization of research findings; case study: Islamic Azad University, research and development unit	The effective personal factors are: 1- control center: self esteem and belief, self-control, self-orientation, and competence 2- self-efficacy: responsibility toward problems of society, field knowledge and scientific acquisition, commercialization knowledge, personal communication and networking, familiarity with market demands, marketing skills, work experience in the industry, negotiation skills and persuasive abilities 3- power-seeking: independence and growing interest in research and technology, self-orientation and competence, seeking fame and power 4- success-seeking: perseverance and effort to obtain desirable results, personal persistence, risk taking in order to succeed, creative thinking and avoiding conservatism, different point of view, creative and innovative spirit
Zahedi Anbardan	2011	Identification of requirements and prerequisites for commercialization of research findings in Iran's Gas industry	-Institutional factors -Researcher factors: participation, pioneering, credibility, realistic expectations -Technological factors -Market factors -Intellectual property -Structure of the industry
Meigounpoory et al	2012	IDENTIFICATION OF THE FACTORS THAT AFFECT IN CHOOSING THE UNIVERSITY RESEARCH COMMERCIALIZATION STRATEGIES	Effective factors are: 1- organizational factors 2- environmental factors 3- technological factors 4- personal factors: demographical characteristics, knowledge and experience, psychological traits, motivation, networks 5- institutional factors

2- Research necessity and importance

Commercialization of technology is a part of innovative process. If we consider innovation to be a link from bringing up ideas to introduction to the market, then there would be no innovation and technology without commercialization [Radfar et al. 2009]. Nanotechnology has come to be known as a progressive technology in the past few years and its applications in industry are constantly increasing. In Iran, nanotechnology is an up-and-coming technology which has attracted the attention of decision-makers due to its strategic importance. Considering its novelty, application of the potentials and opportunities of nanotechnology in food industry calls for comprehensive studies. Various policies and programs are implemented by different governments to use this technology; and numerous researches by

different institutes and individuals are moving from development phase to application phase. Finding suitable grounds for transfer of technological findings to area of industry is particularly important. Due to the novelty of nanotechnology, its commercialization is a complicated issue affected by infrastructural, cultural, social, economical, legal, and financial factors. These factors can either help commercialization success, or prevent it. Considering the importance of nanotechnology in food industry and improvement of social welfare, and due to importance of technology commercialization as the link between technology and the market, this research focuses on commercialization of nanotechnology in food industry. Here, in an applied approach, factors contributing to commercialization of nanotechnology are identified, analyzed and prioritized in order to assist institutes to successfully introduce their products to the market.

3- Research questions

Which personal factors contribute to commercialization of nanotechnology in Iran's food industry?

How is the ranking and prioritization of those factors?

4- Research hypothesis

There is a significant relation between the identified factors and commercialization of nanotechnology in Iran's food sector.

5- RESEARCH METHODOLOGY

This is an applied research which uses a mixed method (qualitative and quantitative) for data collection. The statistical population in the qualitative section of this study is consisted of managers of Nano-food companies; the statistical population in the quantitative section of this study is consisted of managers and experts in Nano-food companies. The statistical population in the quantitative phase is consisted of 70 individuals among whom some 60 have been selected as the sample members using Cochran formula. The sampling in the qualitative section has been done using snowball sampling method (chain-referral sampling). Data collection has been carried out through literature review, semi-structured interview and questionnaire, after extracting survey items, a questionnaire with 4 items concerning personal factors and 11 items concerning commercialization was handed out to the subjects. To assess the validity of the interviews in the qualitative section of this study, re-test and intra-subject agreement methods have been used. The interviews

employed in this study have 92% validity. Since this value is more than 60%, it is considered to be acceptable [Kvale, 1996].

Using snowball sampling, a semi-structured interview was conducted with the experts of commercialization and nanotechnology. After interviewing the ninth participant we reached data saturation. The stated factors are explained below.

Table 2: effective personal factors according to experts

Factors	code	Frequency
Managerial skills (organizing, leadership etc.)	**FA1**	3
Marketing skills (advertisement, distribution, sales, etc.)	**FA2**	8
Commercialization experience	**FA3**	4
Personal characteristics of the researcher (creativity and innovation, opportunism, adventurousness, etc.)	**FA4**	2

6- Impact of the identified factors on commercialization

In this section, the variables of this study are examined. Since the data on some of the variables do not follow normal distribution, to examine the variables first Spearman's correlation test and then univariate and multivariate regression have been used.

7-1- Spearman's test to assess the correlation between dimensions of personal factors and commercialization

Bivariate correlations are consisted of distance and serial correlation. We use Pearson's test to assess distance correlation, and Kendall's Tau and Spearman's correlation test for assessment of serial correlation. They measure the paired ties between sets of variables and display the results in am matrix and indicate the power and direction of the tie between two variables.

Table 3: results of Spearman's test for correlation between dimensions of personal factors and commercialization

Variable		Commercialization
Commercialization	**Correlation coefficient**	**1.000**
	Level of significance	**.**
Managerial skills	**Correlation coefficient**	**0.614****
	Level of significance	**0.000**
Marketing skills	**Correlation coefficient**	**0.559****
	Level of significance	**0.000**
Commercialization experience	**Correlation coefficient**	**0.683****
	Level of significance	**0.000**
Researcher's personal characteristics	**Correlation coefficient**	**0.607****
	Level of significance	**0.000**

The results of correlation test indicate that there is a considerable correlation between the variables of the study. They also point to a direct and positive relationship between

dimensions of personal factors and commercialization. As demonstrated in the table above, the positive signs indicate the direct relationship between dimensions of personal factors and commercialization. In other words, it is expected that improvement in each aspect of personal factor improves lead to increase in commercialization.

7-2- Multivariate regression test for identification of factors affecting commercialization

Multivariate regression has been used to examine the variance of commercialization through independent variables.

Table 4: general indicators of regression analysis of personal factors and commercialization

Statistical index	R^2	Adjusted R^2	F	Level of significance
	0.563	0.531	17.722	0.000

R^2 is the estimated variance of commercialization explained by independent variables. In this study 56% of the variance in commercialization is explained by independent variables i.e. personal factors. Considering the value of F=17.72 and Sig=0.000 which is significant in the level of Sig<0.05, it can be concluded that the independent variables i.e. personal factors can explain the variance of commercialization.

Table 5: statistical indices, the measure and direction of the impact of independent variables on commercialization

Statistical index model	Regression coefficient	Std. error	Standardized Beta	t	Sig
intercept	0.681	0.032	-	21.545	0.000
Managerial skills	0.208	0.036	0.246	5.824	0.000
Marketing skills	0.320	0.033	0.379	9.655	0.000
Commercialization experience	0.175	0.029	0.208	6.057	0.000
Researcher's personal characteristics	0.146	0.029	0.183	5.064	0.000

According to the above table, T statistic for managerial skills equals 5.82, which is higher than critical value; and the level of significance for this statistic equals 0.000 which is less than 0.05. Therefor it can be said that managerial skills have significant impact on commercialization of technology. Moreover, considering the positive sign of standardized Beta coefficient it can be concluded that the relationship between this variable and commercialization of nanotechnology is positive, or direct. In other words, as managerial skills improve, so does commercialization of technology.

Considering the value of this coefficient which is 0.208, it is expected that as managerial skill is increased by one unit, commercialization success increases by 0.208.

The same argument can be applied to other variables which are: marketing skills, commercialization experience, and researcher's personal characteristics. Since their T statistic is higher than the critical value and level of significance is less than 0.05 it can be said that all three variable have significant relationships with commercialization of nanotechnology in food industry; and as those variables increase, so does commercialization success. When each of the three variable increases by one unit, commercialization success will increase by the respective value of their regression coefficient.

7-3- Spearman's test for correlation between personal factors and commercialization

Bivariate correlations are consisted of distance and serial correlation. We use Pearson's test to assess distance correlation, and Kendall's Tau and Spearman's correlation test for assessment of serial correlation. They measure the paired ties between sets of variables and display the results in am matrix and indicate the power and direction of the tie between two variables.

Table 6: results of Spearman's test for correlation between personal factors and commercialization

Personal factors	Commercialization		Variable
	1.000	Correlation coefficient	Commercialization
	.	Level of significance	
1.000	0.720**	Correlation coefficient	Personal factors
.	0.000	Level of significance	

As the above table shows, the correlation coefficient for variables of personal factors and commercialization is 0.720; this indicates a powerful relationship between the two variables. Considering the positive sign of the obtained coefficient it is concluded that the relationship between the two variables is direct. And therefor improvement of personal factors leads to increase in commercialization success.

7-4- Univariate regression test for identification of the factors affecting commercialization

In order to assess the variance on commercialization caused by personal factors variable, univariate regression has been used.

Table 7: general indices of regression analysis of personal factors on commercialization

Level of significance	F	Adjusted R^2	R^2	Statistical index
0.000	73.837	0.552	0.560	

R^2 is the estimated variance of commercialization explained by independent variables. In this study 56% of the variance on commercialization is explained by independent variables i.e. personal factors. Considering the value of F=73.837 and Sig=0.000 which is significant in the level of Sig<0.05, it can be concluded that the independent variables i.e. personal factors can explain the variance on commercialization.

Table 8: statistical indices, the measure and type of the impact of independent variables on commercialization

Level of significance	t	Standardized Beta	Std. error	Regression coefficient	Statistical index Model
0.137	1.506		0.375	0.564	intercept
0.000	8.593	0.748	0.099	0.853	Personal factors

According to the above table, T statistic for managerial skills equals 8.59, which is higher than critical value; and the level of significance for this statistic equals 0.000 which is less than 0.05. Therefor it can be said that personal factors variable has a significant impact on commercialization. Moreover, considering the positive sign of standardized Beta coefficient it can be concluded that the relationship between this variable and commercialization is positive, or direct. In other words, as personal factors improve, so does commercialization of technology. Considering the value of this coefficient which is 0.853, it is expected that as personal factors increase by one unit, commercialization increases by 0.853.

7- Ranking of the impact of components

Since this study aims to prioritize the factors contributing to commercialization, therefor Friedman's test has been employed for ranking and prioritization of the variables in terms of their impact on the dependent variable. Friedman's test is a well-known non-parametric test. If there is an association between different groups, Friedman's test can be employed for ranking of those groups.

Items	Mean Rank	Internal ranking
Managerial skills	35.76	2.56
Marketing skills	32.85	2.47
Commercialization experience	33.43	2.48
Researcher's personal characteristics	34.45	2.50

8-1- The ranking order of personal factors affecting commercialization of nanotechnology in food industry

1- Managerial skills
2- Researcher's personal characteristics
3- Commercialization experience
4- Marketing skills

As indicated, according to experts and professional staff of our country's Nano-food industry, among 4 personal factors affecting commercialization of nanotechnology, managerial skills have the highest impact.

8- CONCLUSION

Nowadays, nanotechnology is an advanced and growing technology which will soon be involved in all industries in every country. As it has become in some industries, nanotechnology will become an instrument of competition in other industries as well. Statistics suggest that most of developed countries have paid a great deal of attention to Nano-food sector, and large food corporations are already using this technology to produce high-quality and healthy food products. In developed countries, all levels of management and policy-making are aware of the importance of nanotechnology and the potentials of research institutes for improvement of industrial sectors. Yet the question that remains is that, why the outcome of nanotechnology, especially Nano-food is not visible in everyday life and in people's welfare? The challenge is to transform the knowledge into technology, and the technology into business. Introduction to market in a way that is popularly accepted is the newest challenge in front of nanotechnology in our country. In this study, four personal factors which contribute to commercialization of nanotechnology in food industry were identified. Among these factors, researcher's managerial skill has the highest impact. The reason is that most of the researchers (inventors) have no scholarly background in management; also development of nanotechnologies may happen in firms which spin off from universities. As a solution, the government of private or public universities can hold management workshops and educate the researchers on appropriate managerial skills. Creating networks for commercialization of nanotechnology, team participation, or transferring a part of the work process to companies and institutions which are active in the field of commercialization are other instances of the solutions for this problem.

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