

**ORIGINAL RESEARCH**

## Relevance of technological innovation and entrepreneurship to biotechnology in Iran

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*Date Received: January 2018*

*Date Accepted: May, 2018*

*Online Publication: December 20, 2018*

### Abstract

One of the latest and most controversial areas of science is biotechnology. Genetic engineering concerns with the manipulation of DNA molecules to modify plants, animals and other creatures. Scientists are now able to isolate a gene or genome in an animal or plant to another one, based on the traits they want to transfer. The movement of a gene from a living creature to another one is called the recombinant DNA technology. The technology is developing rapidly. Regarding the specific features of biotechnology, opportunities are being created for the emergence of technological entrepreneurship projects in countries that have developed the logic science which provides the necessary capacity to establish connections to the international biotechnology network. This article seeks to find the relevance of technological innovation and entrepreneurship criteria to different technologies, including biotechnology. By improving sub-indicators of innovation and creating technological entrepreneurship units in businesses, we can increase the growth speed of their technologies. Moreover, some reports of global innovation indicators suggest the growth of Iran in technological areas from 2014 to 2017. This is due to the entering of technological entrepreneurship units in these areas, particularly biotechnology.

**Keywords:** Technological entrepreneurship, Biotechnology, Innovation, Commercialization

## Introduction

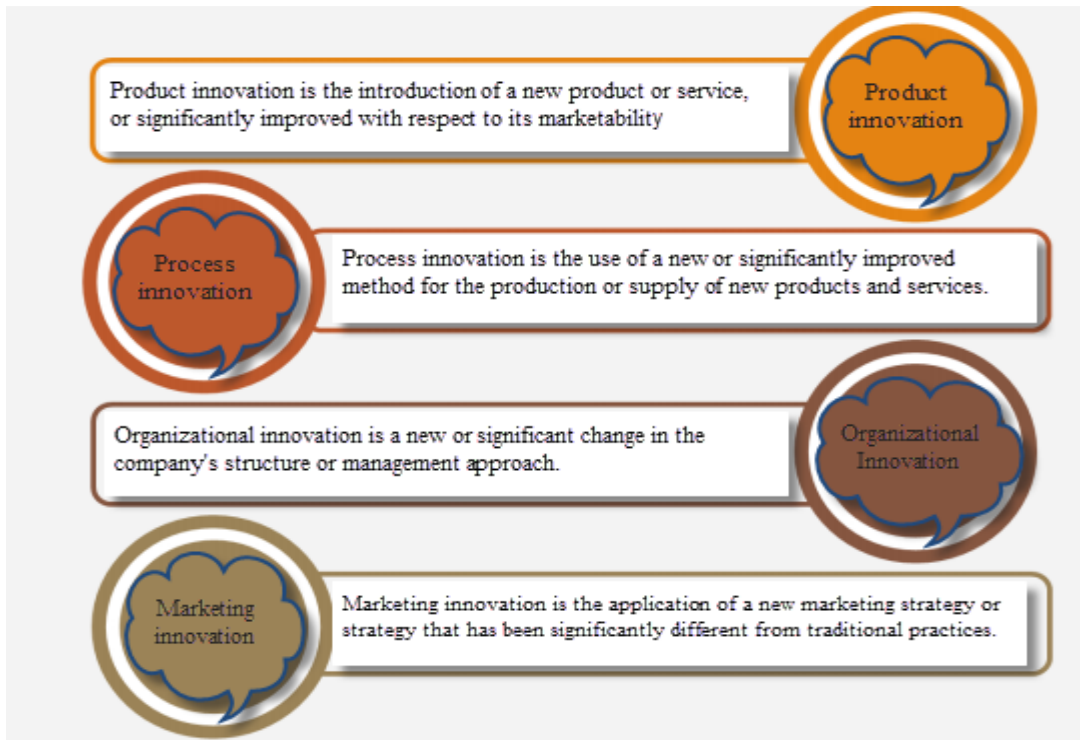
The technological entrepreneurship is a phenomenon that has been very important in recent decades. One of the main reasons of this is the role of this phenomenon in industrial modernization and economic growth. While traditional and matured industrial sectors are experiencing widespread recessions, technology-based and knowledge-based sectors are experiencing a significant growth. This can be attributed to the importance of technological entrepreneurship, which we will explain its dimensions below, or generally the growing importance of technology and entrepreneurship, which has caused the emergence of the growing area of technological entrepreneurship. Technological entrepreneurship has been defined as a style in business leadership, which involves identifying highly entrepreneurial opportunities with high growth potential, collecting resources such as capital and professionals, and ultimately rapid and considerable growth by employing special decision-making skills. Today, we live in the era of technological and global economy where competition is based on knowledge. Nowadays, competitions are built based on technology and it is not a matter of choice, but a matter of survival in a competitive market. Since technology has different effects on competition components in different stages of its life cycle, the employed technologies need some management and modification to be updated. Technology is a crucial factor, and has a decisive role, in making the industries and companies competitive. On one hand, technology is changing and its life cycle is also rapidly changing, particularly in high-tech areas [Chen et al. (2010)]. Today, the best opportunity that industries in developing countries are facing, is employing advanced technology or

investing in innovative activities with existing technologies [Badaway (2009)]. Technological innovations are needed to be applied in order for an organization to remain competitive. Hence, innovation in technology is necessary to improve the performance of a company against competitors and maintain its competitive ability. Thus, a concept called corporate technological entrepreneurship is formed, which is necessary to survive in a competitive environment. In the corporate technological entrepreneurship, companies have to adopt adaptive and innovative strategies of technology, in order to response to rapid changes in customer needs as well as to environmental uncertainties.

## Theoretical basis

### 2-1. Innovation concept

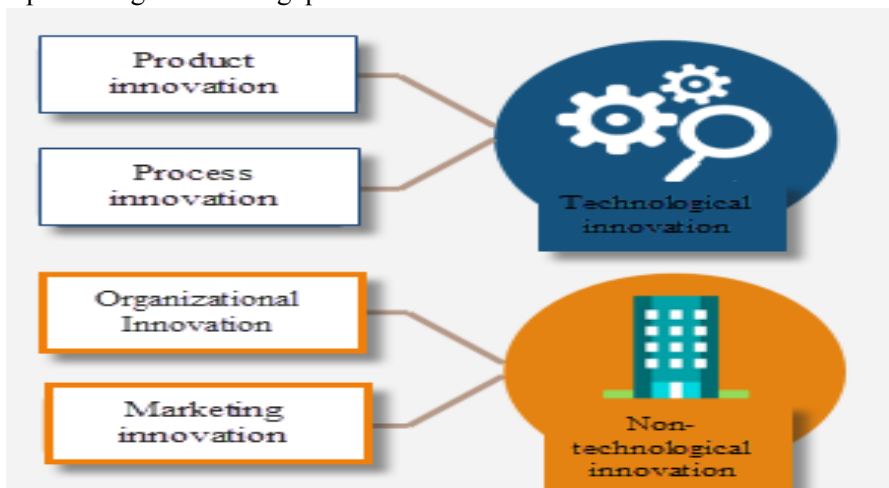
In general, innovation means offering a new or considerably improved product (goods or services), a new marketing method or a new organizational method in business practices of an organization with external communications [Drucker, 2014]. Innovation (new or improved) need to be new to the organization and it does not need to be new to the industry or market sector. In other words, if an organization makes an important change or improvement in its products, processes or working methods (including marketing activities or organizational procedures), it can be said that innovation has occurred. According to the Oslo Manual [Guidelines for Collecting and Interpreting Innovation Data, 3rd Edition], innovation has been divided into four categories including product, process, organizational and marketing innovation. Figure 1 displays each of these types of innovation along with a brief definition.



**Figure 1: Definitions and categories of innovation (Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, 3rd Edition)**

Innovation systems, mainly driven by market forces and high-risk players, are realized with widespread differences in terms of power [Anadon, et al., 2016]. Entire activities that are done for producing and offering products or services, and new processes for producing or offering products

or services in companies, are called technological innovations. As it was stated, another category of innovative activities is non-technological innovations, which include marketing and organizational innovations (Figure 2).



**Figure 2: Technological and non-technological types of innovation**

## Innovation in Iran

### Innovation according to the World Economic Forum

The World Economic Forum annually ranks countries in terms of their competitiveness in an international level with an index called the Global Competitiveness Index. According to the report, factors such as companies and institutions, infrastructure, macroeconomic environment, basic health and education, higher education, efficiency of commodity market and labor market, efficiency of financial markets, capacity to attract technology and innovation in competition with other countries are considered. In general, it can be said that the basis of comparing the countries are 114 indicators in 12 categories.

According to the latest report of the Global Competitiveness Index in 2014, Iran ranked 86 among the 144 countries in terms of the innovation indicator. According to the 2013

report, the Iran position in terms of this indicator has weakened compared to its rank 71th in 2013 (among 148 countries).

### Innovation according to the World Intellectual Property Organization

Because of its special importance, innovation indicator is used as a basis to compare countries in the annual report of the Global Innovation Index (GII). This report is published every year by the World Intellectual Property Organization (WIPO) along with other international institutions. The Global Innovation Index is formulated based on 81 sub-indicators in 7 categories (2 categories for outputs from, and 5 categories for inputs into, the innovation system). The main sub-indicators are: institutions, human capital and research, infrastructure, market sophistication, business sophistication, knowledge and technology outputs and creative outputs. Table 1 displays the sub-indicators related to the mentioned index.

Global Innovation Index						
Sub-indicators of innovation inputs					Sub-indicators of innovation outputs	
Institutions	Human capital and research	infrastructure	Market sophistication	Business sophistication	Knowledge and technology outputs	Creative outputs
Political environment	Education	Information and communication technology	Credibility	Knowledge workers	Knowledge creation	Intangible assets
Regulatory environment	Higher education	Public infrastructure	Investment	Innovation links	Influence of knowledge	Creative products and services
Business environment	Research and development	Environmental protection	Trading and competition	Knowledge attraction	Knowledge publication	Online creativity

**Table 1. Components of the Global Innovation Index**

The Iran's ranking in each of the sub-indicators related to the global innovation index is presented in table 2.

**Table 2. Iran's ranking in each of the sub-indicators related to the global innovation index**

Main sub-indicators	Innovation Efficiency Ratio	Institutions	Human resources and research	Infrastructure	Market sophistication	Business sophistication	Knowledge and technology outputs	Creative output
Iran's ranking (among 143 countries) in 2017	16	106	45	99	112	115	47	65
Iran's ranking (among 143 countries) in 2016	51	112	48	91	102	111	65	75
Iran's ranking (among 143 countries) in 2016	103	126	46	68	139	130	90	116

Source: The Global Innovation Index, 2015, 2016, and 2017

### Findings

As it was said in the previous section, innovation and technological entrepreneurship indicators directly influence on biotechnology-based organizations and companies, and according to the global innovation indicators, they have caused to improve technological businesses in Iran from 2015 to 2017. Besides, it can be said that the reasons for using innovation in technological businesses are as follows:

1. It is true that advanced economies more benefit from innovation as compared to less-advanced countries, but this does not mean that innovation is less important for the latter. In fact, imitative innovations and copycats are very important for the compensatory growth.
2. The absorption capability is important. The ability of an organization to identify, absorb and utilize the knowledge of its surroundings (Food et al.) is very important. Moreover, the trust, social capital, governmental and non-governmental organizations, human resources development, technical and managerial competencies and both speed and intensity are more important than the external technologies (Kemeny, 2010).
3. The nature of innovation is related to growth and efficiency and changes over time

(Tang & Hussler, 2011). China has now more than 1000 investment funds for new businesses, which help them in raising capital as business angels (Fonseca, 2011).

According to the literature on technological entrepreneurship, some dynamic capabilities have been interpreted as "hidden and secret" (Itami & Roehl, 1987), "complex and implied" (Dierickx & Cool, 1989, Williamson, 1999, Teece, 1997-2007). Four skills have been identified for dynamic capabilities.

- (1) measurement capability
- (2) learning capability
- (3) integration capability
- (4) coordination capability

Many studies on biotechnology in herbal and animal products have caused to improve biotechnology-based industries, and the improvement is due to the attention of technological businesses to innovation and building technological entrepreneurship units in their organizations. Among the achievements of biotechnology, we can mention the following:

Potatoes: *Bacillus thuringiensis* bacteria naturally exist in soil and prevents potatoes from rust. The bacteria can solve the serious

problem in potatoes, which causes to crop pest, and produce the protein by genetic engineering and the interesting point is that it is not harmful for humans, other mammals, birds, fish and beneficial insects. In the future, genetically modified potatoes will be entered into markets that are resistant to viruses and pathogens.

**Tomatoes:** Since tomatoes are harvested green and kept at a low temperature (10 °C), their flavor and taste would be destroyed. The “flowersaver” tomato has been produced by genetic engineering. In this crop, the polygalacturonase enzyme, which leads to the breakdown of cell walls and the curing of tomato, has been reduced, so the tomato last for a longer time, and sugar is transferred to the tomato to preserve its flavor and taste.

Other achievements that have been mass produced in Iran are as follows:

- Manufacturing odor detection tests
- Multi-purpose guidance, control and navigation system, suitable for a variety of drones
- Manufacturing light emitting diodes of power led and SMD
- Intelligent mining system
- Designing and manufacturing online GPS devices
- High-power DC supplies
- Manufacturing rice weeding equipment
- Localization of technical knowledge to produce UV lacquers
- Manufacturing and marketing smart electricity and water meters
- National project of human recombinant coagulation factor VIIa
- Production of herbal medicine for disposal of kidney stones
- Manufacturing electronic valves with the capability to save in water consumption by 70%
- Designing and modelling a network for automatic scheduling of university courses
- Processing platform based on VIREX-6 and DSP
- Dressing trolley and automatic washing
- Production of the AngiPars medicine
- Designing and manufacturing sound and image compressor
- Production of biological fertilizers and biological pesticides
- Two-cylinder three-dimensional advertising billboards
- Manufacturing laboratory equipment
- Black-box accident-resistant mechanical protection
- Recyclable magnetic nanocomposites to remove environmental pollutants
- Mechanized cabins to issue and printing gift cards

### Conclusions and analysis

Iran is a country with rich natural resources, a strategic geographical location and skilled and efficient human resources. These factors along with the appropriate business environment, governmental support for entrepreneurship, technology development and facilitating scientific and technological communications with the developed world, can promise a dynamic and effective industry in the world. Islamic Republic of Iran looks to develop high-tech industries, as one of the most important axes of economic development, and to keep pace with global technological developments. Thus, at the legislative level, in the third development plan, the importance and role of developing advanced industries, and in the fourth development plan, its development have been emphasized. Biotechnology industry has a special position among the modern industries. The industry has brought in scientific disciplines and a new attitude, and in less than three decades, the rate of growth and development in its applied fields appears to be surprising. In today's world, biotechnology products cause significant changes in human social life in various aspects, from improving healthcare to increasing agricultural corps and building a clean environment. Therefore, we can consider biotechnology as an important and future-making technology, which itself a result of abilities and its broad scope.

Despite the recession that dominated the biotechnology domain in 2003, global investments flood toward this technology in 2004 and 2005, so it is predicted that the global market value of the technology would be increased from \$31 billion USD in 1997 to \$120 billion USD in 2010. Therefore, based on the presented statistics, the basic growth rate in the biotechnology industry is more than 15% annually, which has one of the highest growth rates among the industries, which is an evidence of the importance of the above industry and its impact on the global economy.

According to Philip Calinger (2008), although, according to the nature of technology, the two words of “Innovation” and “Technology” are interchangeably used partly, however, according to various definitions of innovation, you can make an innovation without using technology and only through a change. Therefore, we could consider technology as a probable output from each innovation. For advancing the technological entrepreneurship in biotechnology, a combined strategy is required that includes local scientific abilities and capacities, integration with multinational societies, and potential to help the formation of industrial capabilities in the advanced technologies such as biotechnology. However, the potential of exploiting the plans that employ a group of individuals, especially entrepreneurs, is possible. Based on the available key assets, local knowledge, and good international networks and then evolution of companies in response to a series of challenges from local institutions and entrepreneurs / company, their efforts may lead to the emergence of an entrepreneurial biotechnology.

Finally, since the technological entrepreneurship is a relatively new subject and it is considered as one of the most important factors of regional development, we should identify its key components and understand how the components are influencing. One of the main concerns of scholars in the field of science and technology, is the application of science and knowledge in order to fulfill human needs. Special

characteristics of the entrepreneurial biotechnology are as follows: medium to long time needed for developing a product, large investments needed, unexpected results of biotechnology research, a lot of regulations, broad skills and technical knowledge needed, one of the most studied industries in the world, the requirement to comply with ethical rules in many cases, such as human and animal experiments, the much importance of intellectual property protection for success, strong ties and strategic alliances with universities, institutes and other biological companies, the increased need for capital and resources over the life of a company or organization. Given that the most important part of a biotechnological entrepreneur is the entrepreneur itself and has a crucial role, providing conditions for them is very important. Biotechnological entrepreneurs are in the highest educational levels; thus their vast majority have high-level degrees, like PhD.

The word “technology development” makes sense mainly in developing countries. The meaning of the word “technology development” in these countries is efforts and actions along with industrial advanced countries to fill the “technological gap”. Based on this viewpoint, the technological development increases the level of national technology, and prepare a country for entering into the commercial markets of the world.

Moreover, according to the global innovation indicators and the growing trend of Iran in the fields of the innovation of companies and organizations from 2015 to 2017, we can conclude that the economic policies of Iran are effective in the financial markets of innovation- and technological entrepreneurship-based companies and also enhance the transfer of the latest technologies of the world to technological entrepreneurship-based organizations, institutions, and companies, particularly in the field of biotechnology in Iran. On the other hand, the growth of global innovation indicators reflects the increasing desire of institutions and

companies to create innovations and better utilization of the vast resources of Iran.

### Conflict of interests

Authors declare no conflict of interest.

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