

A practical framework to Identify the drivers of the genetics industry in Iran

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ABSTRACT

Developing a technology roadmap is a common approach in various industries for strategic and long-term planning. This approach provides tools to examine and identify the relationship between emerging markets, products and technologies over time. One of the most important elements in creating a road map is to identify the main driving factors in an industry. Coordination with strategic policies and plans is also necessary. The conceptual model presented in this research has been validated using the focus group method by experts in the field of technology, and then by collecting information through a questionnaire from among the experts in the field of specialized genetic services, the data required in the framework of prioritizing drivers has been extracted. In this research, more than 50 drivers of the genetics services industry in Iran, were identified and prioritized based on the main strategies classified in 12 topics and we showcased if they are pushing demand and market or pulling technology for new innovations. Borda technique as a sequential group consensus technique and questionnaire tools were used to prioritize the motivating factors in order to collect experts' opinions.

Keywords: Technology driver, Borda technique, Demand push, Technology pull

Introduction

Genetics is one of the most influential sciences that has led to changes in people's lives during human history. It is predicted that in the coming decades, our lifestyle will undergo fundamental and widespread changes compared to the past due to the daily development of genetic technologies. Genetics is a vast subject related to diversity and inheritance in all living things, but medical genetics deals with the genetic variation in humans that is important for medical treatment and research. The proper use of this science requires the formulation of large research programs in the form of roadmaps in which the manner of the path, the resources and facilities required, the division of labor at the national level, and the requirements along this route are clearly and precisely defined. For this reason, it is necessary to formulate vision and strategies for science and technology at the macro level.

Genetics has a huge impact on human life and will change our lifestyle in many ways in the coming decades. So strategic planning and proper utilization of genetic technologies are essential. Large scale research programs are needed to determine

the resources, division of labor, and requirements to achieve the goals of genetic research and applications. Vision and roadmaps for the development of genetics should be formulated clearly so that progress can be made efficiently.

Technology roadmaps are a useful tool for businesses and organizations to plan how new technologies will fit into their goals and strategies over time. Roadmaps typically show the technological requirements for a product or innovation along a timeline, outlining when key technology advances are needed [1]. They provide strategic and tactical benefits in several ways [2]:

- Guiding technology investments and R&D efforts towards what's most critical for the business
- Helping align different parts of the organization around a shared technology vision
- Allowing businesses to prepare for and capitalize on upcoming technological changes

Thus, there are two main types of successful roadmaps [3]: First generation roadmaps focus on stable, established technology platforms like those used in the semiconductor industry [4]. They help businesses scale and optimize mature technologies. Second

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generation roadmaps focus on emerging disruptive technologies like MEMS or nanotechnology [5]. They allow businesses to get in early on the next wave of innovation.

Regardless of the type, effective roadmaps reflect the nature of the technologies and products they serve. They act as a blueprint for how an organization will navigate both present and future technological possibilities.

Technology roadmap is a flexible approach that is widely used in various industries for strategic and long-term planning. It provides structured tools to explore and analyze relationships between evolving and maturing markets, products and technologies over time. A technology roadmap has a layered structure where markets and products sit at the top layer. Based on foresight and a breakdown structure, they feed into the lower layers of science, technology and resources needed to develop these products [6]. The development programs of various technologies in an industry directly influence each other and developing a technology roadmap is related to strategic plans of organizations. So, it is inevitable to consider all those pillars and strategies as an input in order to identify reliable drivers in the market.

Due to the strategic importance of this issue and the need to develop a technology roadmap in the field of genetics, especially due to the complexity of the product market, the diversity and variety of services on the one hand and on the other hand, the coordination of existing programs at the macro level based on international markets, Technology development trends at the world level, external drivers and motivators such as economic, social and technological infrastructure development factors, the issue of most critical drivers of the genetics industry can be studied and examined.

By providing a technology development program for these components, the identification of markets and threats of international markets, the possibility of commercializing has been considered.

The major services provided in the field of human genetics include preventive genetic tests, carrier, prenatal and newborn, diagnostic, pharmacogenomic, cytogenetic, biochemical, molecular, chromosome analysis, diagnosis of genetic diseases, diagnosis of cardiovascular diseases, etc. [7]. Performing all these tests requires laboratory materials, laboratory kits and suitable equipment and technology. These genetic tests and services help detect diseases, disorders and health conditions early. They can determine risks for inherited conditions, provide information to guide medical decisions and management, and predict how individuals may respond to medications and therapies.

New technologies are continuously being developed to improve genetic testing. Technologies like next-generation sequencing, whole genome sequencing, non-invasive prenatal testing now provide more accurate and comprehensive results.

Innovation can be driven by two different forces: technology push and demand pull. Technology push refers to new technologies that are being developed and applied to existing or new markets. Demand elasticity refers to a situation where market needs or customer preferences stimulate the

development of new technologies [8]. Therefore, in addition to identifying the importance of propellants, we also identify the type of propellant based on its traction and coverage

To develop human genetics services, attention must be paid to ensuring access to high-quality diagnostic laboratory kits, modern equipment and advanced genetic testing technologies. Infrastructure, expertise and standard protocols also need to be in place to effectively utilize these technologies for the benefit of patients. With a strong foundation in place, human genetics research can then progress and innovations can be made to improve people's lives.

We provide a case study of the new pharmaceutical innovation process to develop and test new road mapping tactics. This helps us create an improved third generation road mapping model. Current road mapping techniques fail for many new pharmaceutical innovations in the following ways:

- New pharmaceuticals often arise from the intersection of multiple technologies, not a single root technology.
- Drivers are more important for next generation roadmaps.

To address this, we collected data and did a wholesome literature review to identify drivers and trends in the field nevertheless we identified genetics industry drivers using case-based techniques then we prioritized the market drivers in order to assure balanced growth for nurturing the industry based on long term strategic goals using multi criteria decision making techniques.

Materials and Methods

In this research, we use specialized literature in the field of genetic services to identify the drivers of the industry, and according to the strategic goals, we prioritize and compile the drivers at the national level for the development of a technology roadmap for specialized genetic services in Iran. For this purpose, we extracted criteria with interviewing experts of the field of genetics.

The current research is an applied type of research and in terms of decision-oriented or result-oriented research, this research was conducted with the aim of further developing and analyzing the issue, and it is also considered decision-oriented. The approach of the present research is considered to be deductive reasoning based on referring to literature and experts' opinions regarding market drivers, but inductive reasoning has also been used to identify effective drivers. In this research, policy making and macro strategy in the scientific field of genetics is discussed. This research will be done in a long-term horizon and in an applied manner.

The population sample of the research will consist of experts in the field of policy making and strategy selection, which is used to collect information from interview and questionnaire tools. The collected data is quantitative and qualitative. Regarding the validity control process of the questionnaires from the experts' point of view, and regarding the reliability, statistical indicators such as kurtosis and skewness indicators and Cronbach's alpha

method is used. In order to prioritize, they are questioned based on their importance and relevance to the subject of the current research.

In order to finalize our conceptual model on market drivers we applied Borda technique as a sequential group consensus

technique group decision making to define most important drivers based on criteria explained by the experts [9].

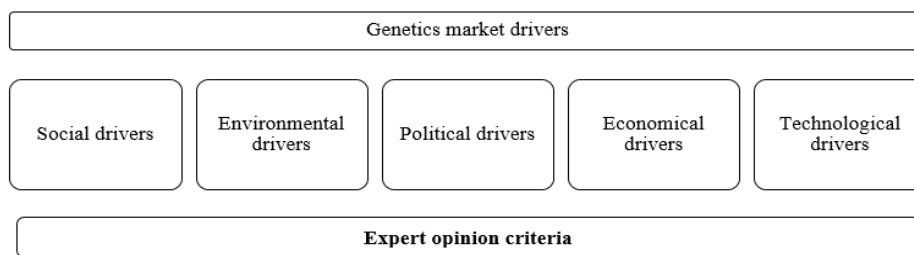


Figure 1. preview of proposed conceptual framework

Identifying key drivers in the literature

Many researches have discussed the important role of drivers in developing a technology roadmap; Albright mentions laws and regulations, individual and organizational culture and market drivers [10]. In his article, Shin discusses the role of leading players and key users in the market [11]. Hernandez expresses the importance of the supply chain members in the use and use of technology and its acceptance as a driver [12]. This is despite the fact that many of the drivers developed in the classic models of developing technology roadmaps have been market drivers [13].

Some models of developing a technology roadmap include political drivers and drivers related to laws and regulations as market drivers in the framework of the roadmap. Considering political drivers and issues related to laws and regulations, on the one hand, it can create the need and demand for technology, and on the other hand, it can be placed as an obstacle in the way of technology development [14].

Identifying key drivers in the field of genetics

In Tierney's article entitled "Technology Roadmap of the Pharmaceutical Industry", it is stated that despite the high inclusion of market drivers and governance policies, none alone can include all industry drivers in the process of innovation and technology development [15]. Therefore, in this research, using two stages of research, drivers have been identified and placed in the first layer of the perspective of the pharmaceutical industry. These drivers are summarized in **Table 1**.

Table 1. pharmaceutical industry drivers [15]

New human therapeutics are moving toward molecular level therapy.	Treatment methods have changed from intervention to preventive and non-invasive methods.	New drugs have changed from chemical structure to biological structures.
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Development of therapeutic methods and not drugs	Laboratory methods versus clinical methods	Customer interaction with suppliers
Pharmaceutical differentiation	Personal care	Patient-directed care
Changes in intellectual property ageing population	Diagnosis is not enough	Remote care
	Population increase	Cost of drug development

In research done by Ghazi Nouri *et al.*, regarding drivers in the process of developing a road map, by referring to the strategic importance of this layer in the road map and also identifying the important global markets for products, with the aim of achieving a 3% market share for biotechnology products, the drivers were identified that these propellants are based on environmental forces and analysis of the external environment [16]. In this article, drivers and obstacles have been identified by classifying social, technological, economic, environmental, political and legal substrates, which can be seen in **Table 2**.

Table 1. Drivers of biotechnology industry [16]

Political	Social	
Ensuring health security		
The strategic nature of the vaccine field		
Slow development of new drugs due to ambiguity and lack of transparency of laws	Population increase	
Long and time-consuming requirements related to the establishment of standards in the field of products that are related to human consumption.	Prevalence of chronic diseases	
Intellectual Property Rights	Aging in the age pyramid	
The void of legal and ethical laws required in the field of regenerative medicine	The existence of specialized workforce and education and technical skills	
Supportive policies that encourage the market	Society's desire to change the style and increase the quality of life	
Dealing with imports and rents.	Lack of insurance support for users of drugs and biological vaccines	
	Lack of public awareness about probiotic products	
Environmental	Economic	Technological
Probability of side effects and ethical and health considerations in biopharmaceuticals and regenerative medicine	WHO's impact on reducing vaccine prices	Having a knowledge background
	Reluctance of the private sector to	Infrastructural and complementary technologies

The need to replace and reduce the consumption of chemical and non-biodegradable products with biological products in line with sustainable development	invest in the vaccine sector due to high operational costs and lack of confidence in the market Difficulty managing research Production and sale of biological drugs	Long development phases of biological products
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The field of genomics has exceeded expectations over the past three decades due to massive changes in technology that have allowed researchers to interrogate larger parts of the human genome. The modern era of genomics began in the mid-1980s with the development of the polymerase chain reaction (PCR) technique, which enabled researchers to characterize the genome at the candidate gene level. In the early 1990s, scientists used semiconductor manufacturing techniques to develop microarrays that enabled large-scale genotyping and gene profiling studies. In 2003, at a cost of about \$3 billion, the first human genome was sequenced. Since then, next-generation sequencing (NGS) has come down dramatically in cost, and recently it can be done for less than \$1,000 [17]. Other drivers in the article of the editor of bioprocess online are as follows:

- Use NGS as much as possible
- Moving towards single cell biology
- Richness of sampling in order to know more about the cell
- Molecular differentiation of genome structure
- Very sensitive genomic technologies
- The emergence of RNA biology
- Emergence of molecular stethoscope phenomenon
- Mendelian genetic test

By examining other studies, we reached the drivers related to specialized genetic services, which are summarized in the **Table 3**.

Table 3. Other genetics industry drivers

Title	Description
DNA Sequencing [18]	Rapid sequencing of microbial genetics to diagnose infections or human DNA to characterize disease is increasingly driving hospital-bed care to the bedside.
Genetic groups based on large populations [19]	Large-scale research studies have the power and scope to fully investigate the genetic etiology of a disease, thereby creating more effective preventive strategies and treatments that translate into real improvements for patients and their caregivers.
DNA as data storage space [20]	Theoretically, it is hypothesized that 215 million gigabytes can be stored in each gram of DNA molecule.
CAR T-Cell immunotherapy [21]	A personalized medicine approach, as the patient's own T cells are genetically modified. In addition, CAR T-Cell treatment only requires the patient once because the modified cells can spread throughout the body over time and produce a sustained anti-cancer effect.
The effect of gut microbiome on drug efficacy [22]	Gut microbiome influences drug effectiveness, which helps boost the immune system. Checkpoint inhibition immunotherapy works to release the brakes on the immune system by cancer cells.

Based on these researches and literature we reach to more than 50 drivers which categorized in social, political, economic, environmental and technological market drivers.

Identifying key criteria

We interviewed more than 20 experts in the field of technology management to define most important criteria in selecting market drivers. These objects are mostly connected to long-term planning and strategic goals of the business.

Table 4. key criteria based on expert opinion

Code	Criteria	Description
RE.2	knowledge-based economy	Leading the knowledge-based economy, implementing and implementing the country's comprehensive scientific plan and organizing the national innovation system in order to improve the country's global position and increase the production and export share of knowledge-based products and services and achieve the first rank of the knowledge-based economy in the region.
RE.5	The fair share of factors in the production chain	The fair share of factors in the chain of production to consumption is proportional to their role in creating value, especially by increasing the share of human capital through the promotion of education, skills, creativity, entrepreneurship and experience.
RE.6	Increasing domestic production,	increasing domestic production of inputs and basic goods (especially in imported items) and giving priority to the production of strategic products and services and creating diversity in the sources of supply of imported goods with the aim of reducing dependence on limited and specific countries.
RE.10	Comprehensive export support	Targeted all-round support for the export of goods and services in proportion to the added value and with a net positive exchange rate through national production planning in accordance with export needs, forming new markets and diversifying economic ties with countries, especially with countries in the region.
CS.3	Orientation to science and technology	To direct the cycle of science and technology and innovation to play a more effective role in the economy.

CS.7	Research direction	Orientation of education, research, technology and innovation towards solving problems and meeting the real needs and requirements of the country with regard to the preparation of the land and innovation in the frontiers of knowledge to achieve scientific authority.
CS.11	Playing an effective role in the field of medicine and health	Orienting the cycle of science and technology and innovation to play a more effective role in the field of medical sciences and health
BI.1	Improving the scientific level and technical knowledge	Improving the scientific level and technical knowledge of biotechnology in the country and gaining a worthy scientific contribution in the world arena.
BI.2	Promoting the contribution of biotechnology	Promotion of the worthy contribution of biotechnology in the development of the health sector
BI.6	Cooperation with the global community	Cooperation with the international community for the development of bio-technology in the country and the peaceful use of this modern and strategic technology.
GH.2	Realization of comprehensive health approach	Prioritizing prevention over treatment, updating health and treatment programs, reducing risks and pollution that threaten health based on valid scientific evidence, preparing a health annex for major development plans, improving health indicators to achieve the first place in the Southwest Asia region, reforming and completing Monitoring, supervision and evaluation systems for the legal protection of the rights of people and patients and the correct implementation of general policies

Results and Discussion

In order to check the validity of the data obtained from the questionnaire to identify the important drivers of the genetics industry, we checked the statistical indicators such as skewness and elongation of the collected data. To check the normality of the data, the results of the questionnaires were controlled in the Likert scale based on the skewness index (-7, +7) and the skewness (-2, +2) [23]. In order to calculate the priority of each of the options using experts' opinions, we use the Borda method, and by forming the option-expert matrix and considering only one indicator, the importance of drivers in the industry of specialized genetic services, we create Borda numbers for each

expert; Then, through the row sum vector obtained from the option-expert matrix, we form the option-index matrix, which due to having only one index, we will have the option-expert vector; In this part, it is calculated by calculating the ranks of options based on group agreement. Borda method has been used in prioritizing drivers and criteria. To test the reliability of the questionnaire, we use the Cronbach's alpha method to measure the consistency of the answers received [24]. For each segment of the questionnaire the coefficient was more than 0.7 and results are considered reliable in consistency.

Our final list of drivers extracted from the literature and business articles are classified in political, social, technological, and economics and environment are showed in **Tables 5-8** respectively.

Table 5. Political drivers

Code	Driver
PO.1	The strategic nature of the vaccine field
PO.2	Ensuring health security
PO.3	Intellectual Property Rights
PO.4	The void of legal and ethical laws required in the field of regenerative medicine
PO.5	Supportive policies that encourage the market
PO.6	Long and time-consuming requirements related to the establishment of standards in the field of products that are related to human consumption.
PO.7	Slow development of new drugs due to ambiguity and lack of transparency of laws
PO.8	Dealing with imports and rents.

Table 6. Social drivers

Code	Driver
SO.1	Customer interaction with suppliers
SO.2	Population increase
SO.3	Changes in intellectual property
SO.4	Society's desire to change the style and increase the quality of life
SO.5	ageing population

SO.6	Laboratory methods versus clinical methods
SO.7	Aging in the age pyramid
SO.8	Prevalence of chronic diseases
SO.9	Lack of insurance support for users of drugs and biological vaccines
SO.10	Lack of public awareness about probiotic products
SO.11	Remote care
SO.12	Personal care
SO.13	The existence of specialized workforce and education and technical skills

Table 7. Technological drivers

Code	Driver
TE.1	CAR T-Cell immunotherapy
TE.2	DNA as data storage
TE.3	Applying NGS as much as possible
TE.4	The effect of gut microbiome on drug effectiveness
TE.5	Mendelian genetic test
TE.6	Diagnosis is not enough
TE.7	Molecular differentiation of genome structure
TE.8	Development of therapeutic methods and not drugs
TE.9	Moving towards single cell biology
TE.10	New drugs have changed from chemical structure to biological structures.
TE.11	Having a knowledge background
TE.12	New human therapeutics are moving toward molecular level therapy.
TE.13	Treatment methods have changed from intervention to preventive and non-invasive methods.
TE.14	Long development phases of biological products
TE.15	The emergence of the molecular stethoscope phenomenon
TE.16	The advent of RNA biology
TE.17	Sampling richness in order to better understand the cell
TE.18	DNA sequencing technology
TE.19	Infrastructural and complementary technologies
TE.20	Very sensitive genomic technologies
TE.21	Large population-based genetic groups
TE.22	Patient-directed care

Table 8. Economics and environmental drivers

Code	Driver
EC.1	WHO's impact on reducing vaccine prices
EC.2	Production and sale of biological drugs
EC.3	Difficulty managing research
EC.4	Reluctance of the private sector to invest in the vaccine sector due to high operational costs and lack of confidence in the market
EC.5	Cost of drug development
EN.1	Probability of side effects and ethical and health considerations in biopharmaceuticals and regenerative medicine
EN.2	Pharmaceutical differentiation
EN.3	The need to replace and reduce the consumption of chemical and non-biodegradable products with biological products in line with sustainable development

In order to prioritize the criteria, we again asked the experts to prioritize our 12 key criteria to find the most important and leading metrics of the strategic goals.

Table 2. results of comparing key criteria of the industry

Code	Average	Standard Dev.	Kurtosis	Skewness	Borda
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RE.2	5.29	2.00	1.86	1.53	1
RE.5	10.60	3.10	1.04	(0.87)	11
RE.6	6.76	3.66	(0.69)	0.96	9
RE.10	5.71	1.79	1.68	1.36	3
RE.20	16.21	1.03	1.83	(2.25)	12
CS.3	5.90	3.22	1.48	1.74	4
CS.7	9.79	3.11	0.00	(0.72)	10
CS.11	5.50	2.89	1.26	1.66	2
BL.1	6.10	3.09	1.84	1.88	5
BL.2	6.29	3.06	1.44	2.08	6
BL.6	6.57	2.79	1.05	1.56	7
GH.2	6.69	3.10	1.92	1.74	8

Based on this data we can manage to find the order of drivers' classification in the industry which resulted in **Table 10**. Driver class prioritization based on industry criteria.

Table 3. Driver class prioritization based on industry criteria

Score	Driver Class	Code
1	Technological drivers	TE
2	Economical drivers	EC
3	Social drivers	SO

4	Political drivers	PO
5	Environmental drivers	EN

The final results of the study are shown in **Figure 2**, presenting the most important drivers in both demand push and technology pull with the orders calculated by borda method to show the most powerful drivers of the industry by focusing on nation-wide strategic goals in the field of innovation and technology development.

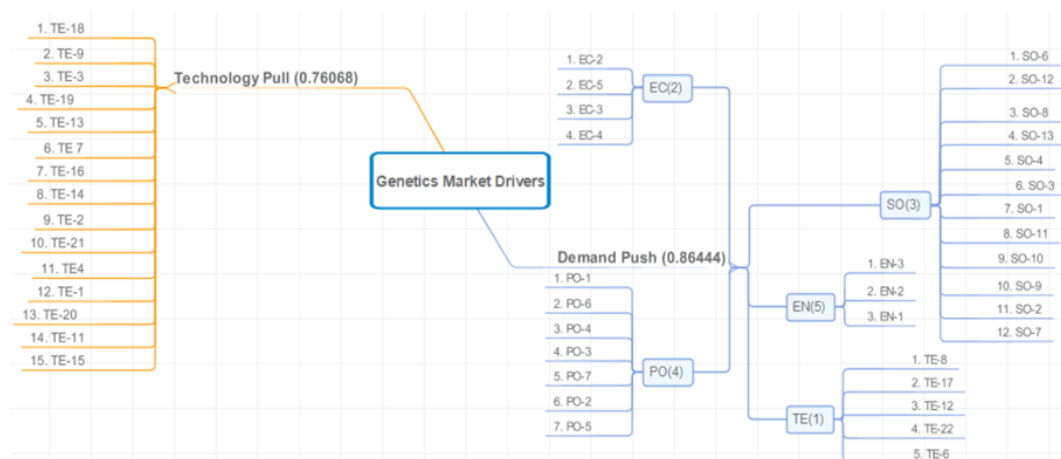


Figure 2. The proposed conceptual model of the genetics industry drivers

Conclusion

In this research, 51 cases of propellants and stimulants in the field of health and genetics were identified and discussed. With the conducted investigations, the relationship of these drivers with the relevant components extracted from the experts of the business was measured and prioritized. Among these, 27 main drivers with a high degree of importance were identified as demand drivers, which were classified into social, economic, political, environmental and technological categories. Most drivers were placed in the category of social drivers. Also, 20 drivers were identified as most important technological drivers, nested into 5 drivers related to demand push and 15 drivers identified as technology push, which are prominent due to the emergence of new technological trends, which somehow lead to

the attention of researchers and further developments in this field, and provide the possibility of developing new products in the future.

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Ethics statement: Hereby, the authors consciously assure that, material is the authors' own original work, which has not been

previously published elsewhere and the paper is not currently being considered for publication elsewhere. The paper reflects the authors' own research and analysis in a truthful and complete manner. The paper properly credits the meaningful contributions of co-authors and co-researchers. The results are appropriately placed in the context of prior and existing research. All sources used are properly disclosed. All authors have been personally and actively involved in substantial work leading to the paper, and will take public responsibility for its content.

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