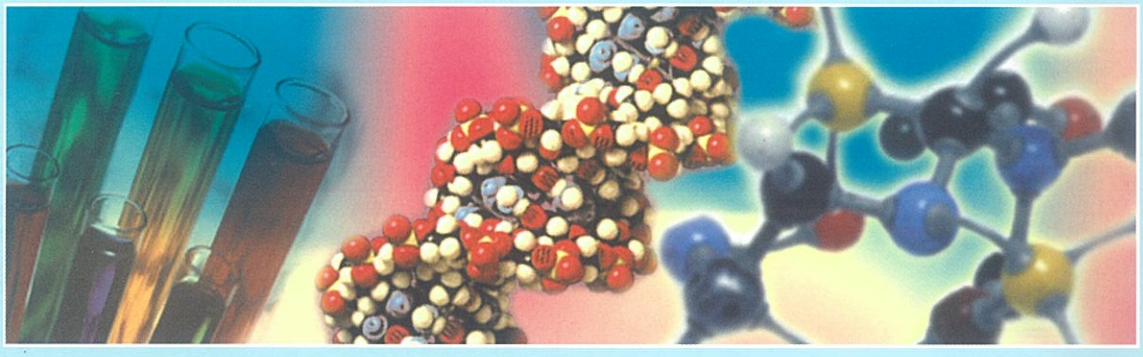
TÜSİAD

TURKISH INDUSTRIALISTS' AND BUSINESSMEN'S ASSOCIATION



COMPETITIVENESS STRATEGIES: BIOTECHNOLOGY

TÜSİAD'S COMPETITIVE STRATEGIES SERIES-7

Executive Summary

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FOREWORD

TÜSİAD (Turkish Industrialists' and Businessmen's Association), founded in 1971, according to rules laid down by The Constitution and the Association Act, is a non-governmental organisation working for the public interest. Committed to the universal principles of democracy and human rights, along with the freedoms of enterprise, belief and opinion, TÜSİAD tries to foster the development of a social structure which conforms to Atatürk's principles and reforms, and strives to fortify the concept of a democratic civil society and a secular state of law in Turkey, where the government primarily attends to its main functional duties.

TÜSİAD aims to establish the legal and institutional framework of the market economy and to ensure the application of internationally accepted business ethics. TÜSİAD believes in and works for the idea of integration within the international economic system, by increasing the competitiveness of the Turkish industrial and services sectors, thereby guaranteeing itself a well-defined and permanent place in the economic arena.

TÜSİAD supports all the policies aimed at the establishment of a liberal economic system which uses human and natural resources more efficiently by means of latest technological innovations and which tries to create the proper conditions for a permanent increase in productivity and quality, thus enhancing competitiveness.

TÜSİAD, in accordance with its mission and in the context of its activities, initiates public debate by communicating its position supported by scientific research on current issues.

The following report entitled "Competitiveness Strategies: Biotechnology" is the executive summary of the original report prepared by Professor Hüveyda Başağa and Associate Professor Dilek Çetindamar in Turkish.

June 2001

Prof. Hüveyda Başağa

Hüveyda Başağa obtained her B.Sc. Degree in Pharmacology (1975) from Ankara School of Pharmacy and her Ph.D. Degree in Biochemistry (1980) from Brunel University, London with the grant provided by British Council. Previously she taught and carried out research at Middle East Technical University and Bosphorus University, and conducted research intermittently at Brunel and Torino Universities with collaborators of both institutes. She has taught graduate and undergraduate level courses on chemistry, biochemistry and free radical biology. She has been appointed to Sabanci University since 1998. Her research topics cover oxidative stress and the effects of antioxidants on cellular functions, specifically on the role of signal transduction mechanisms effecting gene expression patterns. Her research has been funded by Nato, Unesco and Tubitak. She is a member of the International Society for Free Radical Research, the International Biochemical Society and she is a founding trustee of TED İstanbul College.

Assoc. Prof. Dilek Çetindamar

Dilek Çetindamar: She received her B. S. degree from Industrial Engineering Department at Boğaziçi University in 1989, her M.A degree from Economics Department at BU in 1992, and her Ph.D. degree from Management Department at Istanbul Technical University in 1995. Before her appointment to the Graduate School of Management at Sabanci University in 1999, she worked in the following universities: Boğaziçi University, Case Western Reserve University (USA), Portland State University (USA), and Chalmers University of Technology (Sweden). She participated in many international projects, including United Nations and European Union projects. Her main interest and research topics are Technology Management, Strategy Management, Development Economics, and Industrial Economics. She has memberships in the following associations: Technology Management Association, International Association for Management of Technology, Schumpeterian Society, and Academy of Management.

CONTENTS

1. OBJECTIVES

This **'Competitiveness Strategies: Biotechnology'** report is an independent study conducted by two academics working at Sabancı University, upon the request of TUSİAD. The developments in biotechnology (BT) will affect the whole world in the 21st century and change the lives of millions of people, both in developed and developing countries. This report aims to present an overview of BT from a wide perspective that will contribute to the discussion of how to ensure and enhance the future competitiveness of major sectors of Turkish industry in order to maintain an expanding and permanent position in the global economy.

The report aims to answer the following five questions in accordance with the general objectives of the study:

- What is the importance of BT?
- What is the state of BT in the world?
- What is the importance of BT for the Turkish economy?
- What could be done in Turkey in terms of BT?
- What are the tasks of firms and financial, research, professional and state organisations in developing BT in Turkey?

In addition, a comperative study of Turkey with those countries that have been successful in BT applications was carried out. Individual stakeholders' strategies for success in BT which will affect the next century are outlined in this report.

2. DEFINITIONS

In this report, BT is defined as the application of science and engineering to the direct or indirect use of living organisms or parts of organisms in their natural or modified forms in the production of goods and services. This excludes traditional BT operations used by breweries and food processing companies but includes processes used by companies producing yeast and cheese starter cultures where novel cultures are the result of R&D activities. Therefore, BT is not considered as an industrial sector but as an enabling technology / technologies used to produce goods and processes where **'bio'** refers to a biological system or a process and **'technology'** refers to the production of useful substances. Through

the wide application of BT, health and health-related industries as well as the agriculture, food, environment and energy sectors have gained enormously.

Some of the advantages of BT for countries like Turkey can be listed as follows:

- Solutions to health and health related problems and development of new products such as therapeutics, diagnostics, vaccines or gene therapies.
- Increasing drought, pesticide and stress resistance in agriculturally important plants.
- Reduced use of agricultural chemicals and fertilizers.
- Production of economically important traits, increased desirable properties or lower cost of production.
- Production of new medicines, diagnostics, vaccines as well as improved characteristics of these, for animals.
- Bioremediation of industrial waste material.
- Use of environmentally friendly bioprocesses instead of chemical processes.
- Accessing and production of mineral ores by biotechnological processes otherwise impossible.
- Energy production and new energy sources.
- Increased economic output due to the production of high value added production of goods and decreased urbanisation.

3. METHODS

To be able to discuss the future of BT applications in Turkey, we have evaluated its present position by using the 'national innovation systems' approach where all stakeholders have been analysed. In this context the stakeholders are (a) firms; (b) organisations (research, finance, professional and state organisations); (c) collaborative arrangements and networks among firms and organizations and (d) institutions (such as those dealing with culture and patent laws). Because the topic has been approached from a wide perspective, a wide set of data has been obtained.

Both academic and non-academic studies as well as state Statistical Institution reports have been used in this study in order to present the conditions in Turkey in a realistic manner. The data obtained from 26 firms and 5 state organisations which is included in this report has not been published before. From the 26 firms, 12 individuals were interviewed. The others were asked to fill in a questionnaire. Furthermore, an international workshop with 60 participants was held on 6-7 October 2000 at Sabancı University. The participants were representatives from firms as well as national / international experts, and their views and the outcome of the workshop is documented in the report.

4. OUTCOME AND RESULTS

4.1. BT in the World

The BT market in the world for companies listed solely as BT firms, excluding sectors which depend on BT, has a market potential of 63 billion USD. This fast growing market is estimated to reach 151 billion USD in 2008. While world economies grew by an average of 2% during the period 1990-1997, the BT market increased by 32%. Considering the high growth rate in the BT market, economies with BT industries will grow faster.

Improved genome technologies and bioinformatics tools have revolutionised science, technology and global economies. This century is believed to be the century of biology. In the coming decades industries based on BT will produce new commodities, provide jobs and increase the economic output and the welfare of society at large by increasing the competitiveness of the country. Increased genetic knowledge as well as a technological infrastructure will enable the use of biological material for the production of pharmaceuticals, foods and useful chemical substances.

The essential infrastructure elements needed to provide economic growth based on successful BT applications can be classified into seven important categories, as follows:

1. A strong science base in private and public research institutions.
2. Risk taking financial institutions and encouragement of entrepreneurship.
3. The presence of voluntary and professional organisations that bring together all stakeholders and provide a platform for their operations.

4. State organizations which propose relevant legislation and control its effective applications as well as providing the necessary incentives.

5. Close collaboration between, and a harmonious working environment among university, industry and state organisations.

6. The raising of public awareness concerning the social and ethical issues related to BT and of solving problems by involving the public in an open and transparent debate.

7. The maintenance of economic and political stability of the country.

It is known that BT applications will change the lives and the environment of millions of people. However, the effects of this new technology on human health, the environment and the ecosystem are being widely discussed all over the world. For this reason, both the potential benefits and possible risks of this technology, as well as the ethical and social issues, need to be taken into consideration. A wide range of issues, including the complex nature of BT, pressure by society and the occasional lack of scientific information makes policy making difficult. For this purpose, international organisations such as the OECD approach the matter systematically and prepare the necessary guidelines for different countries.

4.2. Scenarios and Strategies for Turkey

This report presents an analysis of the possible future scenarios for BT in Turkey based on the interviews with individuals in firms and data collected during the research. As shown in Table 1, three scenarios are developed by using some assumptions and a European scenario study which are extensively discussed in the report.

The base scenario has a number of assumptions, including: that the government will not have any special policy with regards to BT; no incentives will be given to BT producers; no regulations will be proposed; and the use of BT in agriculture will not be approved as is the case in the EU. According to our estimate, the market for biotechnology-based products in 1996 was 760 million USD. Our study data shows that in the three years from 1996-99, this market reached 950 million USD. In other words, the market growth per year corresponds to 5.74%. This market growth can be explained by the natural dynamics of the market itself, since there were no specific policies for BT. Applying this natural development

trend to the future, we calculated that the market growth would be 85% in 11 years for the period 1999-2010.

Table 1. Turkish Scenarios: Biotechnology User Products (Million US$)

Sector	1999	2010 Base Scenario (85 %)*	2010 Successful Imitator Scenario	2010 Dragging Imitator Scenario
Health	350	648	1575 (350%)	567 (62%)
Agriculture	0	0	560 (85%)- 4 800 (1,500%)	0
Food	450	833	1350 (200%)	158 (-65%)
Chemical	30	56	40 (33%)	17 (-44%)
Environment	100	185	750 (650%)	0 (-100%)
Others	0	28	75 18	
Total	**950**	**1750**	**4 350-8 590**	**760**

* The values in 2010 correspond to 85% growth from the values in 1999.

The positive scenario, or successful imitator scenario, assumes a policy shift where incentives will be given for the growth of BT, R&D expenditures in the BT discipline will increase, universities will graduate more experts in molecular biology, and the relationship between firms and research organisations will significantly develop. But the crucial assumption in this scenario concerns the diffusion of BT in agriculture. The Turkish agriculture market in 1999 was 30 million USD and the immediate potential use of BT in some products such as genetically modified corn seeds could be a total of 300 million USD. We can assume that Turkey can follow the same positive development as in Europe, which is expected to have a 1500% growth rate during the period 1995-2005. Under these circumstances, the market for BT-based agricultural products might reach a size of 4.8 billion USD in 2010. However, if the growth rate of Europe is not realised, but rather a slow, natural development takes place as in the case of the base scenario, the market size could be 560 million USD. Depending on the developments in BT applications in agriculture, the positive scenario foresees a market for BT-based products that ranges between 4.3 and 8.5 billion USD.

The negative scenario, or dragging imitator scenario, expects negative developments in various BT-related sectors. This scenario assumes that even the natural growth of the industries will not be realised. This scenario could be possible in the future, if Turkey continues to ignore its investments in R&D, only create limited opportunities for training skilled labour, lose its markets to multinational firms, use licensed technologies, and fail in the efficient use of imported technologies. Turkey should take action to prevent being left outside the technological developments in the world.

Although Turkey might not develop advanced and state-of-the-art technologies in BT, it can develop competencies that will allow firms to understand and use BT for their immediate needs. The success of the positive scenario to a large extent depends on the realisation of this capability to incorporate BT. In other words, it is necessary to transfer the existing body of knowledge in BT from advanced countries into Turkey, to learn the transferred knowledge in detail, and to diffuse it across sectors where it has application potential. If this imitation phase can be used in an efficient way, it could lead to BT capability that might in future be the base for technology development in Turkey.

Turkey needs to develop a strategy that might be called "global strategic learning and collaboration". In order to realise this strategy, it is necessary to build a strong scientific background, to strengthen national and international relations among firms and research organisations, and to create a supportive and motivating environment for entrepreneurs and researchers, in addition to establishing a strong regulatory framework.

This broad strategy can be transferred to detailed sector-based strategies as summarised in the following sections.

4.2.1. Pharmaceuticals and Health

The largest sub-sector within the health industry is pharmaceuticals. The Turkish pharmaceutical market is expected to reach 4 billion USD in 2000. Around 5% of this market consists of imported BT products. National pharmaceutical firms are small and in general based on production under foreign licences. Turkey has a number of large multinational pharmaceutical firms; while some of them have production sites focused on local demand, others prefer to have local producers as

their production partners. As the majority of Turkish pharmaceutical producers produce for a local market, exports in the industry account for less than a 1% share in the total exports of manufacturing industries.

Few Turkish pharmaceutical firms use BT methods. The main bulk of production capacity is concentrated on antibiotics and related products, not on products such as vitamins, hormones, and biomaterials that require BT. The research and development (R&D) capacities of firms are low, due to two reasons. First, as prices in the pharmaceutical sector is regulated by the government, the profit margins are low, thereby reducing the resources available for long term research activities. Second, the production volumes are much lower than if they were economies of scale, and therefore research costs cannot be recouped. The R&D activities of firms are in general either oriented on license-related research or production problems. As this sub-sector has a low level of R&D activities, investments in BT are almost non-existent.

Another difficulty of the sub-sector is the new patent law enacted in 2000. Accordingly, many small pharmaceutical producers that have not paid license fees or have imitated foreign technologies without buying licenses will be forced to pay license fees. The industry expects some bankruptcies because of this new law. In such an environment, it might not be realistic to see pharmaceutical firms investing in BT.

In the diagnostics sub-sector of the health industry, the future of BT looks much better compared to pharmaceutical producers. After the 1993 health reform, many new private hospitals and medical schools were established. The individuals we interviewed indicated that the increased demand for diagnostic products has created a diagnostic market of 400 million USD. One fourth of this market consists of BT-based diagnostic products.

Another sub-sector is vaccines. The majority of human and animal vaccines are imported. The Ministry of Agriculture has eight animal research institutes and seven of them produce vaccines for local consumption. In 1989, the government issued a law that allowed private firms to produce vaccines. Since then, a few private vaccine producers have started to operate in Turkey and they also export their products. The Turkish vaccine market reached 50 million USD in 1999.

The biomaterials sector is another sub-sector of the health industry. Biomaterials are composites made of polymers, metal, special ceramics, and carbons. They are used in many medical products as well as in artificial organs. Only a few biomaterials such as lenses and tooth fillings are produced in Turkey, while the rest is imported. Some of these biomaterials producers are highly technical; in fact, one of them received a technology medal in a national technology competition.

As the health industry has a number of distinct sub-sectors, the strategies of each sub-sector will be different to the others.

In pharmaceuticals, the dependence on foreign technologies is significant but this sub-sector has a long history of production that has developed a set of competencies. As restructuring is expected within the pharmaceutical firms due to the new patent law, local producers might consider focusing on specific core competence areas and build competitive advantages in some niche markets in the coming years.

The weak R&D infrastructure of pharmaceutical firms might be a problem in producing BT-based products. However, one of the firms interviewed has shown great success in developing a BT product together with a university research team. This pharmaceutical firm plans to start production of its invention in two years' time. In addition, the same pharmaceutical firm will start production of a BT product that is licensed from one of its foreign partners. This company can be an illuminating example for other pharmaceutical firms in that pharmaceutical firms:

- Can cooperate with their foreign partners to build competence for BT research.
- Can undertake joint ventures with foreign pharmaceutical firms in the production of BT products.
- Can start to produce products (such as insulin) whose patent protection periods are finished.

Even though BT applications have big potential for pharmaceutical products as observed in advanced countries, the Turkish pharmaceutical sector seems to have limited application possibilities due to its industrial structure. The sector can follow

possible routes as suggested above. It is important, however, to bear in mind that BT investments are long term and firms need to be careful with regards to the strict regulatory environment. If firms take up the challenge, the government needs to take some action such as supplying both a strong incentive infrastructure as well as regulations comparable to international standards.

The diagnostic sub-sector could be an investment area within the health industry that could bring in revenue in the short term. Diagnostic equipment and test kits can be used not only for human but also animal illnesses. Hospitals, clinics, universities, laboratories, and individual households constitute a large demand market for diagnostic products (such as pregnancy test kits). The integration with the European Union markets will spur the demand for test kits in the food sector. There is also a potential export market for many test kits. Technologically successful diagnostic kit producers in our study supported the assertion that Turkish producers might have a good competitive edge in diagnostic market. In other words:

- Diagnostic firms can invest in animal and human diagnostic products, including BT-based diagnostics in order to produce for local and export markets.

Vaccine production could be a profitable investment area where investments could be recovered in the short term. Turkey has both strong research and production experience in this area. Many imported vaccines can be produced at low cost, leading into savings. But more importantly, Turkish vaccine production has potential for export since some of the animal illnesses in Turkey and the Middle East are similar, and the vaccines developed to fight these illnesses can be easily exported. One private vaccine producer has already succeeded in exporting a large number of vaccines to the Middle East. Thus:

- Vaccine producers can invest in the production of many imported vaccines and aim to export to neighboring countries.

Biomaterials is an interesting BT application area in which Turkey has strong research competence but a weak production capability. As the success of a few private biomaterial producers has shown, if private companies invest in

this sub-sector they can start to produce many imported products locally. That is why:

- There should be a transfer mechanism that will transfer scientific and technological knowledge from universities and research institutes into new start-up companies.

4.2.2. Agriculture and Food

Agriculture is one of the most important industries in Turkey. The number of workers in agriculture constitutes 42% of all workers in Turkey. It is one of the rare industries where exports exceed imports. Agriculture's contribution to the gross domestic product has dropped from 40% in 1960 to 16% in 1999 (approximately 30 billion USD), but its export share is still significant. Even though the export of pure agriculture and forestry products is 10% of the total export (2.4 billion USD in 1999), manufactured agricultural products such as food products and textile products accounted for 40% of the total exports. In manufacturing industry, 15% of value added and export comes from the food industry whose contribution to the total economy was 5.5 billion USD in 1999.

When BT applications lead to improved plant types, increased quality features, and higher resistance to various environment conditions (i.e. drought) and illnesses, the Turkish agriculture will benefit greatly from these improvements. However, there are no BT applications in Turkey yet. Neither are genetically modified products developed on Turkish soils nor are imported products used. Until now, the Ministry of Agriculture has allowed only a few test crops of genetically modified seeds of cotton, corn and potatoes. When the regulations allow wide application of genetically modified seeds in Turkey, the Turkish Seed Association and International Seed Trade Federation expect to find a large BT market, since the total market for these seeds in 1999 was 170 million USD.

Similar to agriculture, there is no BT application in the Turkish food industry. However, there are many opportunities, such as increasing the vitamin content of food or adding different features to food products such as increasing their shelf life. The Turkish food producers are not yet interested in BT. Although many food producers are operating in local markets, the majority of them are small-scale firms and are not capable of investing in new technologies. Large-scale firms prefer to

import BT-based ingredients such as starter cultures rather than to produce in-house. The strategy to develop BT among food firms could be:

- To invest in R&D to develop or at least to utilize advanced technologies developed in advanced countries in order to increase both the quality of their products and their competitiveness.

Typical BT applications in Turkey cover classical fermentation methods; in other words classical BT, which is used in the production of beer, wine, yeast, yoghourt, and cheese. Our interviews in the industry indicate that the total market size of the BT-based products in the food industry is 450 million USD, the yeast market alone worth 300 million USD. If the potential of the overall food industry, the value of which is 5.5 billion USD, is considered, the application of BT is highly significant for the Turkish food industry. In fact, Turkey has an advantageous position with respect to food and agriculture, since it has many food and agriculture engineering departments across the universities and many state-owned research institutions in this area. So:

- The research capability and knowledge from the research units into commercial business could be transferred if a mechanism can be developed with the purpose of establishing this link.
- Food producers might consider producing some of the imported ingredients in-house and to export their products in the long term.
- Many large food producers that have foreign partners might motivate/ attract their partners to invest in R&D activities in Turkey.
- Food producers can improve their existing production processes by collaborating with universities or research institutions.

Regarding the Turkish animal husbandry sector, the main BT applications are focused on tests and vaccines. Having a large animal stock, BT might have a great impact in the industry. Diagnostic kit producers are not yet oriented on this sector but a few BT firms are planning to enter into this area. In the case of vaccines, there are a number of experienced vaccine producers and private companies are starting to operate in the industry. All these firms:

- Can focus on specific animal problems and develop vaccines.

- Can be supported by government incentives to export to countries having similar animal illnesses.

As a reminder, it is important to note that the rate of return on investments made in the agriculture and food industries is to a large extent much less than the rate of return in the health industry. In addition to this, as Turkey wants to be a member of the EU and directly sell its food and agricultural products in the European countries, Turkey must be comply with the regulations of the EU which is highly sensible to the public. This means that until the EU finalises its overall regulations relating to the use of BT, Turkey cannot by itself apply BT. That is why BT investments in these sectors are not going to bring any revenue in the short term. However:

- If Turkey cannot prepare its food and agriculture industries by building up competencies in BT, it could lose its competitiveness by the time Europe is ready for BT.
- Even though much of the potential of BT is long term, surely there are possible applications that are profitable short-term projects. For example, BT can be used to reduce production costs of food ingredients.

During the establishment of the Turkish Republic, a strong research and development infrastructure was developed due to the role of agriculture in the economy. This infrastructure has created a network of researchers who can be transferred and utilized in BT applications.

4.2.3. Environment and Energy

BT is used in the energy sector to reduce costs through the use of new renewable resources and organic waste. Turkey is not yet utilizing this opportunity except for a few firms that are involved in biomass applications. Even though the short term investment plans in the energy sector do not include these new technologies, it might be an excellent solution to the energy shortage in Turkey.

Regarding environment BT, many small environment firms in Turkey import BT systems and implement them rather than developing these technologies themselves. An interview from an environment firm indicated that there are no R&D activities in any of the firms in this sector. Firms purchase technologies and together

with university professors who help to design projects, they construct biological treatment systems for their customers.

The development of the environment sector started in 1992 when pollution regulations began to be enforced systematically after the establishment of the Ministry of Environment. According to the Ministry of Environment data, 70-80% of Turkish industry has some sort of waste treatment and cleaning system, though they are not fully integrated into all functions of these firms. Biological treatment is the main technology used in these environment systems. Not only production firms but also some municipalities (almost 18% of all municipalities in Turkey) have waste treatment systems. The demand for waste treatment systems is expected to increase in the coming years in parallel to pollution controls.

The size of the Turkish environment sector was considered to be 150-200 million USD in 2000; the biological waste treatment market accounted for half of this. Around 40% of the biological input used in the processes of biological waste treatment are imported.

The strategies for the development of BT in the environment sector can be summarized as follows:

- Firms need to recognize the potential benefits of BT applications in waste treatment and energy production in their plants.
- Environment departments of many universities have developed competence in R&D that can be highly useful for production firms. The development of the relationship between university and industry can lead to the diffusion of the waste treatment and biogas production technologies to firms.
- If the government can enforce its pollution standards and regulations, it can increase demand for waste treatment and cleaning systems.
- Working together, universities and firms might produce some of the imported machinery and equipment used in waste treatment systems. Moreover, the ingredients of biological processes can be produced locally as a few firms have managed to do.
- Some incentives can be supplied to support the transformation of both solid and water waste of many producer firms into energy. In this respect,

municipalities might set incentives and establish some central mechanisms that will give the infrastructure support to firms having organic waste content, particularly food firms.

4.2.4. Industrial Biotechnology

Industrial enzymes are used as catalysts in many industries, including textiles, pharmaceuticals, leather, detergents, and food. The wide application of BT as production input is seen in the food industry but this BT-based input is classical BT products; in other words, fermentation products. In the food industry, the majority of firms, which do not have industrial R&D activities, import starter cultures. In the textile and leather sectors, there is only one local producer that produces specific enzymes such as amilase while the majority of the enzymes used in these sectors are imported from multinationals having large scale production and cheap products. The total size of the industrial enzyme market in Turkey was 32 million USD in 1999.

As the research capacity in industrial enzymes is weak, firms need to develop technologies themselves. In order to become a major player in industrial BT, Turkey might follow a few strategies:

- To focus on niche markets where multinational firms do not exist and create a competitive advantage with specific products.
- To support start-up firms that are technology-based and have a large potential market until they can become competitive with respect to multinational firms.

5. SUGGESTIONS: DIVISION OF LABOUR

This report has analysed BT in Turkey relative to some countries which have had success in this area so that we can identify some alternative courses of action that will lead the way to developing BT in Turkey. Due to the systemic perspective of the report, we have identified the strengths and weaknesses of the Turkish BT system and put forward some suggestions for all actors taking part in this system. These suggestions can be considered as a division of labour among important actors of the BT system, and they can be summarised under four headings:

5.1. Tasks of Firms

- Investment in R&D.
- Efficient use of BT.
- Increased cooperation with national and international firms and research organisations.
- Attracting foreign direct investments that will bring their R&D departments to Turkey.
- Integrating BT with other technologies used in production.

5.2. Tasks of Organizations

- Building a sound research base (creating a skilled labor force educated in molecular biology, research, publications and patents).
- Giving the patent rights to researchers working in research organisations and universities to motivate them to innovate.
- Increasing job opportunities for young researchers to work as researchers.
- Establishing state-owned research organisations that will specialize in BT, or restructuring existing organisations.
- Supporting the formation of venture capital firms that will supply capital to new start-up technology-based firms.
- Forming an alternative stock exchange for technology firms similar to NASDAQ in addition to the existing stock exchange.
- Establishing or supporting the formation of professional or civil society organisations that will function as a link between firms and research organisations.

5.3. Tasks Regarding Networks

- Increasing cooperation between national firms.
- Increasing cooperation between national and foreign firms.

- Increasing cooperation between national firms and research organisations.
- Increasing cooperation between national and international research organisations.
- Utilizing foreign R&D activities.

5.4. Tasks Regarding Institutions

- Sustaining economic and political stability.
- Formulating regulations related to BT issues.
- Providing specific incentives for BT development.
- Designing the technology roadmap of Turkey for the long term so that priorities will be established and technology policies will be structured accordingly.
- Supporting entrepreneurship.
- Solving all ethical and security issues related to BT with the consensus of society at large.
- Increasing the awareness of society with respect to BT through education.

6. CONCLUDING REMARKS

The potential advantages of BT applications in Turkey can only be realised if all the actors of the BT system (firms and organizations) can come together and work with a long term strategy perspective. If a healthy and efficient system is established, Turkey can increase its competitiveness. The system view also emphasises that Turkey needs to be competent in (1) BT, (2) complementary technologies, and (3) production technologies used in industries where BT is applied.

Although BT has many potential advantages, it is important to note that for national economic growth, it is not sufficient to be successful in BT alone. As Turkey is a developing country with limited resources, it needs to identify the best use of these resources. To do this, Turkey needs to determine its long term strategy by designing its technology roadmap where the priority areas are identified. Based

on long term strategies, a national technology policy might allocate resources among potential technologies that will carry Türkey to economic growth.

In short, Turkey faces a challenge in the dawn of the knowledge and technology era of the 21st century. On the one hand, Turkey can build a new economy based on technology and skilled labor; on the other hand, it can continue to try and compete in global markets with its traditional economy based on low value-added products. The choice of economic growth path will determine the future strategies of industry and technology policies.