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# Analysis of Efficiency and Effectiveness of Technical-engineering Groups in Iranian Universities of Technology

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**Abstract:** In this study, the status of technical-industrial groups of Iran's state universities of technology is studied with two approaches of documental study and survey research. Based on the analysis of this research, the effectiveness and efficiency of technical-engineering groups is not mutually balanced. Efficiency of technical-engineering groups of Iran's universities is more than their effectiveness. Therefore, it is recommended that the effectiveness and efficiency of technical-engineering groups are paid attention more than ever. It must be planned in a systematic way by utilization of effective actions to improve the efficiency and effectiveness of technical-engineering groups simultaneously.

**Key words:** Efficiency, effectiveness, research, technology, Iran universities, technical-engineering groups

## INTRODUCTION

Contemporary modern societies are formed based on successful technologies, most of them have been established based on scientific discoveries (Best, 1990). Technology is considered the product of new development of human civilization, determining of essential elements in economical and political exchanges in the communities. It is expression of advancement level and empowerment and a superior parameter of a society (Webster, 1991). The main goal of research and scientific production of technical-engineering groups is creation of wealth and power through the production of knowledge of technology development (Pestre, 2000; Ashley *et al.*, 2000). As expected, knowledge resulted from technical-engineering activities is technology and its power due to the development of technology (Davari, 2000).

Developments in the last two centuries in industrialized countries are due to attention to the production and application of science and technology more than other things. Various relatively fixed ranking of the first seven science productive countries in the world during recent years in one hand and similar position of them in number of filed patents in other hand, show positive relationship between knowledge and technology production (Salamon, 2000). Technology production as infrastructure of social and economical development has important place in today's world.

Present time is era of knowledge-based societies, economies and institutions. Promotion of national development and international position of countries in the competition depends on production and application of knowledge (Delanty, 2001).

From another perspective, production of science does not have the certain and determined level. To achieve its competitive advantages and benefits, the minimum value of science, called the critical mass, is required to produce respected quality within quantity. Also, there is a narrow range of use of knowledge and empowerment. This spectrum includes two head end: (1) Production and supplementation of knowledge with the maximum possible pressure and using the mass production of knowledge for use in different areas (Science Push). (2) Knowledge production based on demand of market and different areas of social and economic (Technology-Market Pull) (Rush *et al.*, 1995; Meyer, 2000).

By considering to given level of development and participation rate in global science production in the developing communities (e.g., Iran), the combination of modes 1 and 2 has better performance (Mahdi, 2008). It is due to lack of necessary institutions for normal potential and pressure for the mass production of science and knowledge, or if so, they have not been given adequate levels of development and maturation in order to create proper potential and pressure. Hence, complete stop for to create a demand for expected scientific output or expect for creating required pressure of mass production of science, may hit the efficient institutions and science consumer and science production and also to postpone their relative development. In any case, the reality shows

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achievement of national sustainable development, a level of knowledge production is needed which is far above from the current level of scientific production in Iran. The fact is that there is somewhat different between the growth in science and technology system at the level of academic and research centres and what there is in the society level and the impact and implications of science and technology in the economy and wealth of the country. This difference and gap between science and society is a good sign for studying and analysis of science production of scientific groups, particularly technical-engineering groups. Due to this problem, major scientific revolutions, the national innovation system, industry-government-university triple helix model and systems approach and effectiveness of technical-engineering groups of the Iranian universities of technology has been analyzed based on normative model of science and technology system, such as the modes of knowledge production (Mahdi, 2008; Etzkowitz, 2001; Viale and Ghiglione, 1998). In this study, based on normative model of science and technology system, the status of technical-engineering groups is analyzed by literature review, qualitative meta-analysis of earlier studies and limited benchmarking.

## RESEARCH METHODS

Methodology of this study is a combination of documental study, qualitative meta-analysis of previous studies and limited benchmarking (Cohen and Manion, 1992; Bazargan, 2002; Yamani, 2003). In this study, the technical-engineering groups are those disciplines of research and technology that the results of their work are in the field of industrial design, engineering design, construction and manufacturing, industrial equipment and the similar (Yaghoubi *et al*., 2006). Therefore, technical-engineering groups include engineering disciplines of universities, research groups, applied-science based engineering research centres (i.e., physics, chemistry and mathematics), research firms, incubators and scientific and research parks and towns and R & D centres. So, the purpose of the technical-engineering groups is those activities and fields of scientific research and scientific activities classified in a generally in the field of engineering and technology. The main areas of technical-engineering groups including universities, technical-engineering groups and centres, units of research and firms in research parks and scientific-research town under administration of the Ministry of Science, Research and Technology (SRT) has been covered.

Statistical samples are selected with scientific principles of sampling by cluster, stratified, randomized, comparison methods and determination of sample size criteria, 95% confidence and 10% of the maximum permissible error. Based on sample size calculation formula for qualitative variables ($n = z^2.p.q/d^2$), the final sample size is 90 (Cohen and Manion, 1992; Sarmad *et al*., 2001). N is the population of statistical society, n is sample size, z is standard normal distribution variable (with 95% confidence interval), d is maximum tolerated error, p is the probability of incorrectness of the population opinion about the status of research system ($q + p = 1$).

In this study, based on normative model of science and technology system, the status of technical-engineering groups is analyzed according to the knowledge production modes, great scientific revolutions, national innovation system and the triple helix model of government-university-industry. First, the status of technical-engineering groups are reviewed and analyzed separately based on their potential, efficiency and effectiveness by literature review, qualitative meta-analysis of previous studies and limited benchmarking. Then, the status of technical-engineering group has been analyzed quantitatively based on the research statistical data collection and sampling analysis. Evaluation of view of statistical samples has been done based on Likert questionnaires in three scale range (weak equivalent to 1, moderate equivalent to 2 and good equivalent to 3). Questions and statements of preliminary questionnaire have been developed based on results of studies documents, theoretical principles of previous studies and meta-analysis and design. In the study, theoretical basis of the research is analyzed based on documental studies.

## THEORETICAL FUNDAMENTALS

The theoretical basis of the research is analyzed based on documental studies. The knowledge production modes are discussed as following:

**Knowledge production modes:** Knowledge production has four major transformation stages and modes:

- **Mode 0:** In this mode, knowledge production in general had been done by philosophers and physicians. Today, because of created rules and the frequency demand and need for scientific knowledge, knowledge production to this mode, due to the impossibility to meet needs and its partial viewing and simultaneously interdisciplinary of scientific research, contribute a little in the knowledge production

- **Mode 1:** The sociology of science has been two distinct views, in terms of concepts and interpretation of scientific practices in the 20th century. Before the publication of Gibbons thought (Gibbons, 1994), Merton's view (Merton, 1973) had been main stream of sociology of science. Merton style knows the science as independent activity and science institutions as independent from other social institutions. Normative structure of science institutions is status of independent activities of scientists and is behaviour criteria in this institution. Whenever this structure has adapted with the normative structure of society and political and economic institutions, scientific activities grow by suitable conditions and if the inconsistency, the scientific development falls on the risk. In this mode, knowledge is produced within individual disciplines in universities and other academic institutions. Important promotion of first style is curiosity and the search for new knowledge because of knowledge nature
- **Mode 2:** Mode 2 (Gibbons' mode) emphasizes on the scientific activities associated with the economic and political institutions. This mode knows that Merton pattern (mode 1) belongs to academic science which instead with post-academic science now (Gibbons 1994). This style knows scientific activities undergo to a fundamental transformation. So, on science is open for social institution influence and with growing information society more open form of knowledge is visible. Gibbons named this style of knowledge production style in front of known traditional style of science production (Ghaneirad, 2004). In style two, methods of research and knowledge production is produced mainly in areas in various industry organizations, universities and etc under the direct influence of the economic and social needs
- **Mode 3:** This mode of knowledge production has been proposed by Etzkowitz and Leydesdorff (2000) within the framework of University-industry government triple helix model. In this mode, university has third function and mission to supply the needs of knowledge-based society (Etzkowitz, 2003). This mission is technological innovation and economic development. Academic system pays to knowledge-based entrepreneurship and economic activity by knowledge production (Sije *et al*., 2005)

**Great scientific revolutions:** During last two centuries, two major scientific revolutions have occurred with significant impact on the educational institutions. (Etzkowitz, 2001). The first revolution occurred in the late 19th century that universities accepted the mission of research addition to its educational mission. The second revolution occurred in the late of 20th century which during it universities in addition to educational and research missions accepted the technological innovation and scientific entrepreneurship mission. Morin (2009) believes that nowadays science is established in the heart of society and science while expanding its influence on society, accepts the bureaucratic and technical determination of work industrial organization. Therefore it is very difficult to understand the reactions and interactions between science and society (Morin, 2009).

**National innovation systems and triple helix model of government-university-industry:** According to the national innovation system theory, universities, industry and government have certain specified boundaries. Technological innovation is specific function of industry, while science development and education is specific function of universities. Policy-making and motivation of innovation is also specific function of governments (Nelson, 1993). Innovation was emerged due to interactions between industry and university in R & D market (Entezari, 2005). Incidence of new developments in knowledge production and the emergence of style 2 (Gibbons, 1994) and the second academic revolution (Etzkowitz, 2001) and the emergence of knowledge-based economy and society have been disrupted the boundaries between university, industry and government. Due to overlapping of university, industry and government missions, the new multi-ethnic organizations were born (Etzkowitz and Leydesdorff, 2000) or must come to live. Main mission of these organizations is facilitating relations of university, industry and government in the framework of the university-industry-government triple helix model (Etzkowitz and Leydesdorff, 2000), excellence national system of innovation and national economic development.

Today, university, industry and government retaining their independence in the domains of development of technology expand their area of activities resulting in overlap of the missions between them. Industry and research are so intertwined that does not seen one day that have not been conflicts between the interests of researchers and commercial interests. Many researchers or research groups are controlled by industrial companies that follow the benefit through patent (Bourdieu, 2007).

**Systems approach to knowledge production:** A system is set of components and elements including input, process

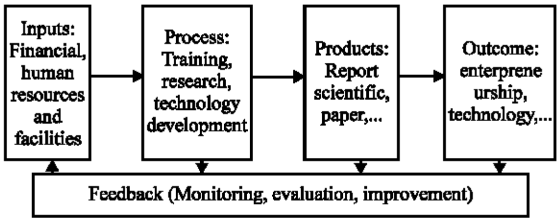


Fig. 1: Components of science and technology system

and output set up to achieve a certain goal (Senn James, 1989; Bazargan, 2002). System elements must be in contact and exposure to external environment wherein after a process of changes on inputs and performing the necessary transforms, will lead to the desired output. Derived from patterns provided by the Bazargan (Bazargan, 2002), system of science and technology can be clarified in form of Fig. 1.

Science and technology system can be defined as a sub-system of the cultural, economic and social and innovation and etc. Or it may be spite to a variety of other sub-systems such as technical-engineering groups system, services system, scientific research and science production system and etc. What is important that the science and technology systems must have efficient input and processes, useful and appropriate and effective and reliable products and outputs in order to continue desirable life (Dias, 1998).

**Cybernetics model of science and technology system:** Based on cybernetics model system, science and technology system (UNESCO, 1990) should be managed in three areas of ability, efficiency and effectiveness of fully proportional and concurrent planning, control and protection. Elements of science and technology of cybernetics model cited from UNESCO (1990) is shown in Fig. 2.

In developed countries, the ability to scientific promotion and research ability of institutions in the form of policies, financial resources, human resources, infrastructures, facilities and equipments, lead to increase strength and ability of the scientific-technical outputs. This situation is not governed in developing countries (Krishna *et al*., 1998).

Therefore, it is important to determine the scientific system efficiency and measuring its effectiveness. Based on the theory of national innovation systems, in addition to increasing potential and power of scientific systems, the information flow intensity of science system (efficiency) and its innovation flow intensity (effectiveness) must be upgraded. Also, determination of efficiency and the effectiveness of the scientific system

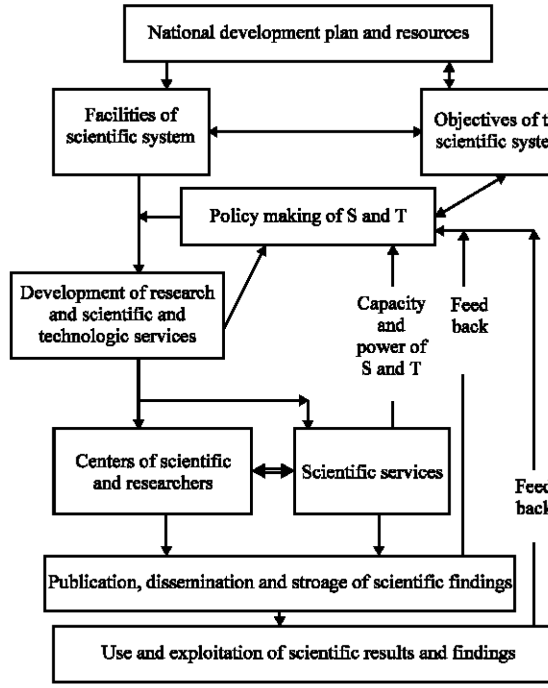


Fig. 2: Cybernetics model of science and technology system

are fully adapted with differentiation functions and system integration. Differentiation and integration functions determine the limit of freedom, independence and ethics and social responsibility of the scientific system (Ghaneirad, 2004).

For analyzing situation of technical-engineering groups of Iranian uiversities of technology, cybernetics model of science and technology system has been used (Mahdi, 2008).

## STATUS OF TECHNICAL-ENGINEERING GROUPS BASED ON DOCUMENTS

In this study, the status of the technical-engineering groups based on documents and proposed analyzing of the situation of technical-engineering groups, is studied. ognitive of status of technical-engineering groups in Iranian governmental universities of technology is evaluated as well as holistic analyzing of the efficiency and effectiveness. The efficiency is defined as overall production and outcomes of scientific system while effectiveness is the consequences of the scientific system on the society. Based on theoretical principles and the cybernetics model of science and technology systems, status of technical-engineering groups has been studied and analyzed in three areas of potential, efficiency and effectiveness.

Table 1: Status of human resources of technical-engineering groups

| | Year | | | |
|---|---|---|---|---|
| Index | 1998 | 2000 | 2002 | 2007 |
| No. of researchers of technical-engineering groups | 4558 | 6285 | 3485 | 11071 |
| Percent of researchers of technical-engineering groups | 36 | 42 | 28 | 32 |
| No. of Ph.D. Graduates in Engineering groups per a million population | 0.92 | 1 | 1.3 | 4.5 |

Table 2: Status of financial resources for research in Iran

| | Year | | | |
|---|---|---|---|---|
| Index | 1998 | 2000 | 2002 | 2003-2009 |
| Ratio of research budget to GDP | 0.3 | 0.29 | 0.29 | 0.5 |

**Potential status:** One aspect of analysis of the science production system is to determine the potential and ability of the system. In this type of assessment resources and inputs of science production system are only studied. With this type of assessment is not able to analyze and measure the efficiency and effectiveness of science production system. According to the UNESCO Science Report (add reference), major indexes to determine the position of science production system, include indicators of production system resources such as research, credit and costs of research and etc. representation of power and system capacity to produce knowledge in the technical-engineering groups is showed in Table 1 for years 1998-2007 in human resources disciplines (Iranian Statistic Center, 2006; IRPHE, 2007).

Representation of power and capacity of knowledge production system with an emphasis on technical-engineering groups in funding sector during 1998-2007 is reported at Table 2.

During years 2003-2009, although the exact amount of official information has not been published in research funds but, at best situation, the average ratio of credit to GDP is about 0.5%. But the average ratio in developed countries (European Union, the United States, Japan) is about 2.5%. Situation of research funding in Iran is low. Also, the participation of private and business sector in providing research funds is negligible. However, in developed countries, non-public sector partnership in research funding is three times more than the government.

Also, according to the country's higher education national information (IRPHE, 2007) scientific and professional associations in the technical-engineering groups (32% of total non-medical scientific associations in Iran) are active. In more than 51 scientific journal (22% of all Iran's non-medical journals) belong to technical-engineering groups. Technical-Engineering groups have 39 scientific cores (36% of the total non-medical scientific cores in Iran). In this group,

Table 3: Status of students in technical-engineering groups

| Description | Amount | Ratio to whole Iranian cientific groups (%) |
|---|---|---|
| Admitted to Universities | 223000 | 29 |
| Universities students | 771600 | 27 |
| Universities graduates | 150300 | 33 |
| Educational approved Fund (Million $) | 946 | 3.60 |
| Full-time researchers | 11071 | 27 |
| Full-time public Faculty | 5013 | 18 |
| Ph.D. graduates | - | 5 |

Table 4: Facilities of research system in Iran (2007-2008)

| Description | Amount |
|---|---|
| No. of Scientists and engineers in a million population | 1411.00 |
| Share of research and technology fund to GDP | 0.56 |
| No. of public research units | 271.00 |
| No. of private sector research centres | 114.00 |
| No. of incubators of S and T | 56.00 |
| No. of S and T parks | 20.00 |
| No. of technologic firms located in incubators and S and T parks | 1395.00 |

more than 36 permits for the establishment of non-governmental higher education institutions (37% of the total permits issued for the establishment of non-governmental organizations in Iran) have been issued. Also, technical-engineering groups have third rank (after the chemistry and medical sciences) in number of articles published in scientific-research journals, indexed by ISI. Some aspects of technical-engineering groups in years 2006-2007 are discusses in Table 3.

Also, the number of scientists and engineers, share of research and technology funds, the number of research unit, the number of growth centres and science and technology parks at years 2007-2008 is shown in Table 4 (IRPHE, 2007).

By carefully attention to position of resources of knowledge production system in the research and technology, it can be judged that the system capacity and power to produce knowledge in technical-engineering groups, is talented and somewhat is powerful.

During the 1994-2004, only about 5% of the country's researchers had participated in the about 80% of scientific production (Supreme Council for Cultural Revolution in Iran, 2005). In other words, researchers participate in scientific production, is negligible.

Currently, another failure of country scientific system is pressure of educational system in the quantitative and qualitative dimensions, to other areas of this system in universities. If this pressure is not managed logically, meaningful and balanced development of principles and priorities of the national innovation system will be ambiguous as well as the future power and capacity of the scientific production, technology and research system.

Also, in recent years, in the ability field, a good investment have been done in important science and

Table 5: Status of science production in technical-engineering groups based on ESI

| State (Scientific groups) | Global ranking in referring to the any scientific documents | Global rank in the no. of scientific documents | No. of indexed scientific documents |
|---|---|---|---|
| Iran (engineering groups) | 79 | 28 | 5074 |
| Iran (whole scientific groups) | 136 | 40 | 32050 |
| Turkey engineering groups) | 50 | 18 | 10219 |
| Turkey (whole scientific groups) | 127 | 23 | 101843 |
| Egypt (engineering groups) | 69 | 32 | 4219 |
| Egypt (whole scientific groups) | 125 | 41 | 29138 |
| Pakistan (engineering groups) | 74 | 61 | 741 |
| Pakistan (whole scientific groups) | 130 | 57 | 9606 |
| Saudi Arabia (engineering groups) | 70 | 38 | 2719 |
| Saudi Arabia (Whole scientific groups) | 126 | 50 | 15799 |
| South Korea (engineering groups) | 58 | 9 | 26867 |
| South Korea (Whole scientific groups) | 96 | 14 | 203637 |

technology infrastructure such as development of more than 76 towns, parks and science and technology development centre, creating university entrepreneurial offices, establishment of National Elites Foundation (NEF), focused Ministry of Science, Research and Technology (SRT) and Supreme Council of Science, Research and Technology (ATF) on the technology topic, creating six non-governmental research and technology fund, which they can be assessed tangible results in the coming years as expected.

**Efficiency status:** Efficiency of technical-engineering groups system is evaluated based on scientific publication, activities and products. The purpose of system performance is outputs rate and the final products of knowledge production system. Research projects and scientific papers are considered as the most important products of science production system. For evaluation of scientific system performance, ratio of scientific knowledge production output to the amount of system inputs must be determined. Output of scientific system includes books, articles, reports of research projects, scientific and new theory etc. According to UNESCO Science Report, purpose of performance of knowledge production system is the index of publication of scientific and research. Representation of system efficiency of knowledge production system in the technical-engineering groups is shown in Table 5 (Noroozi *et al*., 2008).

By considering Table 5 the science production status in technical-engineering groups based on statistics of ESI (Essential Science Indicator) Institute of Scientific Information database during 2007-1997 show that country's global rank of science production in the technical-engineering groups during the past 10 years is 28 that it is the lower than rank of South Korea (rank 9) and higher than other studied countries. This comparison revealed the appropriate status of science production in technical-engineering groups compared to other studied countries. Also, in technical-engineering groups, rank of referring to any of scientific production which kindly showed quality of volubility of scientific output is 79 that it is that lower than Turkey (rank 50), Egypt (rank 69), Pakistan (rank 74) Saudi Arabia (rank 70) and S. Korea (rank 58). The low rank of citing to country's scientific output is not a good indicator for these products. Country's scientific output in the technical-engineering groups is over 2.8 times lower than the number of global scientific output. This indicates that at least, from the perspective of comparing the number of production and citation rate, quantity has been dominant over quality. According to Table 5 this situation in the total scientific output of country has extra intensity. So, that the global rank of scientific production in Iran is 40, while rank of citing of any scientific production was 136 which has three times differences over the global rank of number of scientific production.

Table 6: Growth of science production in engineering groups based on WOS and SCIE

| State | Growth percent of SCIE | Growth percent of WOS (%) |
|---|---|---|
| Iran | 34 | 34 |
| Turkey | 10 | 10 |
| Egypt | 10 | 11 |
| Pakistan | 30 | 28 |
| Saudi Arabia | 13 | 13 |
| S. Korea | 2 | 2 |
| Average | 16.5 | 16.3 |

According to Table 6, the growth rate of scientific production in technical-engineering groups (based on statistics databases of WOS and SCIE Institute of Scientific Information during 2006-2007) shows approximately 34% growth in scientific output of Iran which is significantly higher than the growth rate of scientific output of studied and regional countries. Also, based on information of regional information centre of Science and Technology, the country's scientific output in 2008, still has more than 30% growth.

According to Table 7, it shows the growth rate of scientific production in the technical-engineering groups based on WOS statistics during 1993-2007. It

Table 7: Growth of scientific production in the technical-engineering groups based on WOS

| State | Percent of growth between 1993 -2007 | Percent of growth between 1993-2002 (%) |
|---|---|---|
| Iran | 276 | 20.0 |
| Turkey | 134 | 125.0 |
| Egypt | 33 | 20.0 |
| Pakistan | 102 | 19.0 |
| Saudi Arabia | 5 | 5.0 |
| S. Korea | 86 | 142.0 |
| Average | 106 | 55.2 |

demonstrates that the growth of scientific production in this period was approximately 276% that there is very large difference (about 14 times) with 20 Percentage of growth rate in period 1993-2002. Meanwhile, in the same period, none of the studied and region countries have not such mutation in the number of scientific output. Obviously, this mutation must be managed and guided in coordinate that aligned with the goals and needs of national development.

Comparison of scientific production in Iran and South Korea during 1981-2001 in Engineering Sciences (Table 8) has a representation lessons. In 1981 the published scientific articles (Engineering Production) in Korea are approximately 37% more than knowledge production in Iran. But this difference in 2001 (after 20 years) is about 12 times (Yaghoubi *et al.*, 2006).

There is an obvious difference in scientific production between S. Korea and Iran in the economical, technological and industrial fields with more intensity and strengths. However, based on Table 6 and 7, Iran's first place in the global growth rate of scientific production, signs of performance of scientific system in technical-engineering groups are manifested and created.

**Effectiveness status:** In the effectiveness field, the effectiveness of knowledge production system is assessed with regard to the consequences and effects of technological, innovative, economical, social, cultural, political and scientific-research activities. Based on the theory and the concept of national innovation system, only the country's scientific production is not a sign of achievement to economic goals and social development of the country. In the Knowledge production system, efficiency and effectiveness must be examined simultaneously. Effectiveness as the consequence of the science production system has relation with its effect on other systems such as economical, social, cultural, political, technical, industrial, educational systems and etc. According to the UNESCO report, index of innovation patents is a symbol of the effectiveness of the system to produce knowledge. Picture of the effectiveness of scientific system in technical-engineering groups during 1963-2004 is clarified in Table 9 (Yaghoubi *et al.*, 2006).

Table 8: Comparison of the number of paper publication S. Korea and Iran

| | Year | | | | | |
|---|---|---|---|---|---|---|
| State | 1981 | 1983 | 1989 | 1993 | 1995 | 2000 |
| Iran | 35 | 1500 | 25 | 78 | 113 | 336 |
| S. Korea | 48 | 9200 | 342 | 878 | 1517 | 3392 |

Table 9: No. of patents in Iran and S. Korea

| | Year | | | | |
|---|---|---|---|---|---|
| State | 1963-1980 | 1981 | 2000 | 2004 | Sum |
| Iran | 48 | 2 | 0 | 0 | 67 |
| S. Korea | 85 | 17 | 3314 | 4428 | 33865 |

Table 10: No. of patents applications in the WIPO

| | Year | | | | |
|---|---|---|---|---|---|
| State | 2002 | 2003 | 2004 | 2005 | Sum |
| Iran | 0 | 2 | 0 | 2 | 4 |
| Turkey | 85 | 111 | 115 | 174 | 485 |
| Malaysia | 18 | 31 | 45 | 37 | 131 |

In Table 9, the number of Iran and South Korea patents during 1963-2004 is compared. Table 9 shows that the number of patents in Korea and South Korea during 1963-80 is comparable (South Korea's patent number was 1.7 times more than patent number of Iran). After about 25 years (a quarter century) comparison of the patent in South Korea and Iran is meaningless. Because in this period the number of patent in Korea has been increased to more than 500 times of Iran's patents. It is Important that in recent years, Iran's scientific products (engineering articles) have grown substantially, but diminishing in innovation is continuing. While in South Korea at 2004 per 24,825 scientific papers, the 4428 inventions are patented (for each 5.6 paper one patent), in exchange Iran has not recorded any patent for 3851 articles. If Iran acts according to the Korea pattern, about 687 patents (Yaghobi *et al.*, 2006) must be recorded. Number of patent applications in the WIPO is reported in Table 10 (Supreme Council for Cultural Revolution in Iran 2006).

Comparison of patent status in developed countries and developing countries shows that the developed countries contribute a very high share of global patents while share of less developed countries such as Iran, in this area is negligible. According to statistics of important centres of the global patent (US, Japan and European Union Patent Office) during the 2004-2008, Iran has held a ranking 75 in foreign patents and scientific discoveries. The country has improved two steps in comparison to before of it on 2004. During these years, Japan, Switzerland, Turkey, Algeria and Malaysia has 1st, 2nd, 52th, 31th and 76th ranking, respectively. While According to Table 5, Iran has 40th global ranking of knowledge production.

As a case study of the situation of patents in nanotechnology technologies field, as an important

Table 11: Patent application of companies in WIPO (2004)

| No. of demand | State | Company | No. of demand | State | Company |
|---|---|---|---|---|---|
| 1711 | Japan | Matsushita | 2362 | Netherlands | Philips |
| 805 | Finland | Nokia | 1296 | Germany | Siemens |
| 578 | America | Motorola | 710 | Germany | Bosh |
| 475 | Germany | Bayer | 572 | Japan | Sony |
| 595 | America | 3M | 412 | America | Honey will |

technology of world, Iran has been evaluated being having short distance in terms of onset and amount of support. According to information provided by especially headquarters of the nanotechnology development, Iran has no inventions in the field of nanotechnology in the USPTO and JPO up to now (2009). In 2007, Iran recorded four patents of nanotechnology in EPO and had the ranking 22 in patent office between the patent owner countries in this field, jointly with Finland, Brazil and Norway. The US, Japan, Germany, South Korea and France are in the first to fifth ranks respectively. From regional countries only Turkey has been recorded one nanotechnology invention at 2007 in the Europe. Including all patents registration in all patent offices of the world, the number of Iran's patents in nanotechnology at 2007 is 5 and is placed in position 42 of the world ranking. The US, China and South Korea are the first three countries and Turkey with 14 and Malaysia with six inventions, have 30 and 41 scores, respectively.

Also, based on the Information Special Agency of the Nanotechnology Development, the number of nanotechnology patents prior to 2007 is only 2 cases which have been recorded in the WIPO by cooperation of Iranian scholars and foreign institutions. So, novelty of nanotechnology technology and position of Iran on patents in this field shows that the effectiveness of science production is low in Iran.

Review of data suggests that most patents in the world are developed mainly by private enterprises (Table 11). From this perspective, the development of knowledge production and its relationship with national interests in Iran are far from developed countries. The fact is that enterprises need to protect their innovations by recording. There are a long way between invention and commercialization that enterprises are able to handle it.

Lack of proper university-industry communication infrastructure and lack of commercialization of research results, which is highlighted by all the experts and scholars and innovation monitoring centres, is the symptoms of low effectiveness of the knowledge production of technical-engineering groups. Despite of the several years efforts, yet there does not exist satisfying communication between universities and industry in the country. Due to negligible participation of the private sector and industry in research activities, technical and engineering universities are in a major role in research and technology. The Country depends on foreign technology in various aspects of the industry. Therefore despite the establishment of research centres in different governmental departments and affiliated organizations, growth in research and technology of industry has been low. More research activities in universities are founded on basics and not applied research and less has been developed into applications and development field (Shafiei, 2003). In Iran, the potential and actual technical and industrial researches have been accumulated traditionally in the industrial colleges and universities. Even active and high level members of public and private research centres are academics members that make the different forms of cooperation with research centres.

In recent years, access to advanced technologies such as processing cycles and nuclear fuel production, heavy water production, satellites missile production, satellite launch and manufacturing, construction technology, carbon fibber technology, zirconium sponge production, gaining the top ranks in competitions and global festivals and growth of patents are signs effectiveness of knowledge production in technical-engineering groups. Important point which should be noted as importance of synchronization and proportion between the scientific, technical, economical, industrial achievements and development and prosperity for the people that must be created. This proportion is not established yet. According to World Bank report in 2005, license sales of research results conducted to zero and contribution of high-tech products exporting is about 2.6% of total industrial exports of the country.

**Final status of technical-engineering groups based on documental study:** Based on the study of documents, it is determined that ability, efficiency and effectiveness of technical-engineering groups was not balanced and based on the expectation, efficiency and effectiveness is lower than ability bound. Also, the effectiveness of groups is lower than their performance. Therefore, in the policiy-making and management of scientific system of technical-engineering groups, appropriate and simultaneous promotion of developing, ability, efficiency and effectiveness with national and global criteria must be considered.

**Status of technical-engineering groups based on survey research:** Based on research methodology, the status of technical-engineering groups of public universities of technology is summarized and analyzed in three areas of the capability, efficiency and effectiveness based on the

Table 12: Status of technical-engineering groups (test value equal to 2)

| Field | ID | Significance level | t-value | SD | Average | Test results |
|---|---|---|---|---|---|---|
| Efficiency | EFFIC | 11 | 1.62 | 0.71 | 2.12 | No significant difference with the t-value |
| Effectiveness | EFFEC | 0 | -5.78 | 0.56 | 1.66 | Significant difference with the t-value |

views of statistic population using single-sample t-test with test value equal to 2 (moderate) and the significance level 0.050 in Table 12. Eight faculty members in technical-engineering groups, three researcher in technical-engineering groups, five chief officers of science and technology development centres and five graduated student participated for standardization and providing validity of research questions and statements (preliminary questionnaire). To test reliability of the questionnaire, 10 test samples by 10 members of the study population have been assessed and completed. Assessment of questionnaire by using Cronbach's alpha in SPSS software shows high degree of reliability of 0.80. Thus, in general, the validity and reliability of questionnaire diagnosed good and reliable standard and assessed as valid tool for obtaining the views of statistical population.

To analyze the data, single sample t-test with 95% confidence ($\alpha$ = 0.05) and the second test value (average score of options) are used. For data analysis, the average statistical community perspectives (m) have been compared with an average Likert scale questionnaire ($\mu$) using t-test with 95% confidence. In fact equality of perspectives mean of statistical with average Likert scale questionnaire is examined (Cohen and Manion, 1992).

**Efficiency analysis of technical-engineering groups:** Average views about the Efficiency of technical-engineering groups for research and production of knowledge, hasn't significant difference with test worth (EFFIC = 2.12 = 2). In Another word, statistical population believes with 95% confidence that efficiency of technical-engineering groups is a moderate.

**Effectiveness analysis of technical-engineering groups:** Average views about the effectiveness of technical-engineering groups for research and production of knowledge, has significant difference with the test value (EFFEC = 1.66 <2). Another words, statistical population believes with 95% confidence that the effectiveness of technical-engineering groups is lower than average.

**Summary of status analysis of technical-engineering groups based on survey research:** According to t-test with 95% confidence, from the views of statistical population, it concluded that the potential of technical-engineering groups is higher than moderate (t-value), efficiency of groups is equal with moderate (t-value) and effectiveness of groups is lower than moderate. Thus, it is assessed that potential of the technical-engineering groups is higher than their efficiency and their potential and efficiency is higher than the effectiveness of these groups.

## CONCLUSION

Technical-engineering groups of Iranian universities have prominent and crucial role in the national system of innovation. Its purposeful and powerful research and knowledge production can be cause to develop the national technology and innovation. In this study, based on the requirements of two major scientific revolutions, modes of knowledge production, National Innovation System (NIS), triple helix model of government-university-industry and systems approach, efficiency and effectiveness of the Iranian technical-engineering groups of public universities have been and analyzed by two methods of documental study and survey research. Based on this analysis, the efficiency and effectiveness of technical-engineering groups of universities of technology is not balanced and proportionate with each other. So, the efficiency of technical-engineering groups is higher than their effectiveness. Therefore, the effectiveness and efficiency of technical-engineering groups must be studied and improved more than before. In addition, policy making, guidelines, planning and resource allocation and management of the scientific system of technical -engineering groups must be done with simultaneous consideration to local and global criteria for efficiency and effectiveness of science and technology system.

According to documents, fourth Iranian development plan and Iran's 20-year vision, there are proper strategies to generate knowledge in technical - engineering groups. But implementation and execution of these strategies are not well prepared. Here consideration to implementation of their strategies with more efforts and accretions is recommended. Also, the combination of share of private sector, industry and government shows that private sectors and firms have negligible share in comparison with global trends in research and science production. It is recommended that management of scientific system perform further efforts to motivate the contribution of private sector and business firms in research and knowledge production.

Considering the weak relationship between industry and university and the position of the technical-engineering groups in technology development, it is proposed that serious mechanisms and initiative must be planed and executed according to domestic engineering-technical capabilities for export of processed materials to provide the research and technology development opportunities for the technical-engineering group. By considering to goals of knowledge production and technology development in the technical-engineering groups, it is recommended to perform special support of exportation of the production with high technical knowledge and technologies and consecutively firms are encouraged to using of high technology and research opportunities. Due to inappropriate and low levels of effectiveness of knowledge production in technical-engineering groups, it is recommended to double support the commercialization of research and technologies results.

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