Go Back

Name : Serdar M. DURGUN
Title : Industrial Engineer
Organization : ROKETSAN Missile Industry Inc.
Complete Postal Address : OYAK Sitesi 14. Giris D: 8 Cankaya
ANKARA, 06610 / TURKEY

Phone:
Mobile : (011-90) 532 455 5298
Work : (011-90) 312 447 3153
Home : (011-90) 312 439 5754

Fax : (011-90) 312 447 3914
E-mail Address : msdurgun@usa.net

TECHNOLOGY IMPROVEMENT POLICY: THE CASE OF TURKEY

2001 System Dynamics Conference

Atlanta 2001
Emory Hotel and Conference Center
Atlanta, Georgia, USA
July 23 - 27, 2001

ABSTRACT

A SYSTEM DYNAMICS APPROACH FOR TECHNOLOGY IMPROVEMENT POLICY: THE CASE OF TURKEY

Durgun, Serdar M.
B.S., Department of Industrial Engineering
M.S., Department of Science & Technology Policy Studies

Sayin, Erol
Associate Professor
Department of Industrial Engineering

Technology has been one of the most important factors of the economic and social growth and globally scaled competitiveness, although not respected as a separate factor by traditional economists until recently. It is now widely accepted that technology improvement plays a very major role on national growth.

Technology has a number of interactive and conflicting variables and parameters, which is not allowing an analysis with quantitative tools only. Complex dynamic analysis seems to be a proper tool to handle this sophistication.

This presentation is about a system dynamics model constructed for policy analysis in Turkey with respect to technology improvement and comparison of technology improvement policies.

It is part of a MS dissertation study which is still under progress, to be finalized on May 2001. This paper is based on preliminary findings of that study.

Keywords: System Dynamics, Economic Growth, Technology Improvement, Technology Policies.

1. SYSTEM DYNAMICS

System Dynamics can fundamentally improve the effectiveness of management decision making, since it was designed to model complex systems by representing the structure, processes, strategies and information flows of the system. Therefore can be used during the phase of policy making. While System Dynamics Models never substitute the practical management experience, it helps to capture and structure that experience and extend decision support throughout an organization.

The complex systems are high order. The quantity of levels/states determines the order of the system. Many economic, business, government and social systems are complex systems. Once a conceptual appreciation has been developed for the dynamics of complex systems, meaningful simulation models can be constructed to translate those mental models into simulations. Simulations allow us to shrink space and time to see the short and long term effects of our decisions.

During the identification of technology policy, a representative model of technology environment can be prepared and what if scenarios can be implemented for better and tested decisions.

By the integration of results of System Dynamics, quantitative methods and expert experience, more accurate and timely technology policy decisions can be created.

Technology Improvement Policy Evaluation will be approached at five stages; problem identification and definition, modeling, analysis of models, policy evaluation and possible future studies.

2. TECHNOLOGY & THE TECHNOLOGY IMPROVEMENT POLICY CONCEPTS

Technology should not refer only high-tech or science, engineering and mathematics. Technology covers more than machines, processes and inventions. Technology has many descriptions; some are very simple and others are very complex.

Here are some descriptions of technology:

- Technology is the means for accomplishing a task-it includes whatever is needed to convert resources into products or services.
- Technology includes the knowledge and resources that are required to achieve an objective
- Technology is the body of scientific and engineering knowledge, which can be applied in the design of products and/or processes or in the search for new knowledge.

Technology and science has directly become productive powers and this is the distinguishing characteristic of the 20^{th} century. Capability in production means capability in science and technology. Therefore science and technology has gained strategic importance in economic development and social welfare. In addition to

that fact, “science policies” of countries have become “science and technology policies” and these policies have been started to be knitted with economic and social concepts.

Technology is becoming a productive power replacing labor force and brainpower to some extent. If a country has superior technology, it dominates its position in industry and in all the other economic activities.

Industrialization, increase of the export and competitiveness were the major issues of technology policy of this period.

Technological advancement and economic growth can only be sustained by the innovative capability. Innovative capability requires extensive and massive R&D investment and high R&D Personnel ratio. Managing technology can be described as the process of integrating the business unit resources and infrastructure in the fulfillment of its defined purposes, objectives, strategies and operations.

To manage technology and improve technology, the system related with the technology should be well defined, the changes by time and the feedback gathered should be well analyzed. The policies should cover the purposes, objectives, strategies and processes of technology improvement studies. All these points make the system complex and unmanageable with the classical approaches. System Dynamics can be used both for defining policies that are tested by simulations and for better decision making support.

Technology has a number of interactive and conflicting variables and parameters. In order to have a reliable and valid model, all these variables and parameters should be identified and related with each other in an appropriate form.

Technology has a cycle to be called as ‘Technology Flow Process’, steps of which are Technology Awareness, Technology Acquisition, Technology Adaptation, Technology Advancement and Technology Abandonment. All the interactive and conflicting variables and parameters should follow this cycle to achieve a remarkable technology improvement.

Technology has effects on economic, social, political, ecological, technical, educational, psychological, safety related, ethical, and institutional factors. On the long run, technology affects all the factors of life. Therefore technology is very important and should be managed in a well-defined manner.

Policies of technology management for the technology improvement should resemble the real system. As the system is dynamic and changes over time, System Dynamics appears as a major tool to determine the technology improvement policies.

3. TECHNOLOGY IMPROVEMENT POLICIES IN TURKEY

National policy studies in science and technology started with the planned economy period in Turkey. As the result of the First Five-Year Development Plan (1961-1966), establishment of TUBITAK (Scientific and Technical Research Council) in 1963 was the first step for the Science & Technology institutionalization in Turkey. TUBITAK is responsible for coordination and promotion of research in basic and applied sciences.

Turkey has to cope with many problems. The most vital one is to catch up with technological changes. As Ottoman Empire missed the evolutionary process towards an industrial society during the Industrial Revolution, Turkey could not surpass the industrialization threshold. Currently, Turkey has to face the problem of overcoming this historical gap as well as keeping up with the changes in the high-tech and post-industrialization age while the industrial societies are evolving into a new era called as Information Society. The ability of Turkey to solve these problems will determine her future. Improving the scientific and technological ability of Turkey and creating a dominance of science and technology is a proposed strategic choice, which may be entitled as National Science & Technology Policy.

At the beginning of 1980's, "Turkish Science Policy: 1983-2003" was prepared with the contribution of 300 scientists and experts. This was the first time that a detailed science and technology policy document had been prepared. However it

could not be implemented and "The Supreme Council for Science & Technology" that had been established in 1983 could make its first meeting on 9 October 1989.

When R&D expenditures are analyzed and statistics compared, it can be observed that during the period *1980s*, the R&D expenditure of Turkey was very insufficient. On the average R&D expenditure was 0.15 % of GNP which was far behind of other developing countries. In addition to that fact, Turkey was one of the countries with lowest R&D Personnel ratio, namely 3.5 among 10,000.

There was very few R&D and innovative effort related to new industrial technologies.

Research Priority Areas during 1980s were:

- Low Cost Industrial Automation
- Advanced Materials
- Macro-optimization of Agricultural and Forestry Production
- Optimization of Coal Utilization
- Local Production of Organic and Inorganic Chemical Materials
- Recycle of Agricultural and Industrial Wastes

During 1980s, the major technological advancements were in defense industry and telecommunication sector.

The Supreme Council has put forward some goals for the 1990s:

a) increasing the number of R&D personnel to 15 per 10,000 labor force (7.5 in 1992);
b) increasing Gross Expenditure on R&D (GERD) to 1 % of the GDP (0.5 % in 1992);
c) increasing the business enterprise's share of R&D expenditure to 30% of the GERD (24 % in 1992);
d) raising the Turkey's rank (38 in 1992) in journals covered by the Science Citation Index.

During this period for the first time numerical targets related to science and technology were identified and stated in the plans.

Taking Turkey's capabilities and world scientific and technological trends and forecasts into account, the following generic technologies, in general, have been accepted as priority areas of activity:

informatics,
advanced materials,
gene engineering
biotechnology,
defense technology,
[aero]space technology.

In brief, the main proposition was that Turkey has to establish her "National Innovation System" with all the necessary building blocks of it in order to enhance

her ability in science and technology, and to get the capability of transforming science and technology to economic and social benefit.

Today; R&D expenditures and # of R&D personnel are still very low when compared with the statistics of developed countries (0.5 % GNP and 7.5 out of 10,000 respectively). In 1990s the business enterprise's share of R&D expenditure was planned to be 30 % of the GERD however it is still around 20 %. It can be said that a balanced technological advancement could not be reached. But there are faster developments in defense technologies (National Defense Information Network, Attack Helicopter and Main Battle Tank Projects).

In order to finance more advanced technological industrialization Turkey can cooperate with countries at similar development levels and sell her technology by the way of technology transfer or licensing. Simultaneously, Turkey should cooperate with technologically advanced countries to obtain developed technologies and know-how in these fields.

4. MODELING

Current and past technology improvement policies that Turkey has followed have been demonstrated in previous sections. Our purpose is to employ System Dynamics approach to develop a model for technology improvement at national scale, which may serve as a support tool for strategic S&T policy makers.

Following an extensive literature search and interviews and discussions with experts, a representative model has been shaped. Current version of the model is given in the Annex. The model is based upon opinions of us, experts and findings gathered from the literature search.

As System Dynamics software "iThink" is selected. The reasons of this selection are the ease of use of the software, user-friendly and familiarity as I have used this software before.

When the developed Influence Diagram is studied some concentration zones can be identified in the chart. These clusters are:

4.1. Free Technology Zone,

4.2. Fusion-Diffusion and Transfer of Technology,

4.3. Academia-Government,

4.4. R&D Expenditure,

4.5. Technological Capability of Turkey,

4.6. National Innovation System (NIS),

4.7. Product-Process Development,

4.8. Technology Improvement

4.1. Free Technology Zone:

This cluster is one of the main clusters in the system. There is remarkable number of outward and inward bounds with several other clusters and individual entities.

4.2. Fusion-Diffusion and Transfer of Technology:

This cluster is one of the main clusters in the system. There is remarkable number of outward and inward bounds with several other clusters like Free Technology Zone, Technology Improvement and individual entities.

4.3. Academia-Government:

Within this cluster there is a strong relationship between funds and labs. Funds and labs are positively supporting university-industry research centers. This cluster also has strong bounds with the other clusters such as NIS, Product-Process Development and R&D Expenditure.

4.4. R&D Expenditure:

Within this cluster there is a strong relationship between funds and R&D expenditure. R&D Expenditures are directly related with Invention, Innovation and Product Development.

4.5. Technological Capability of Turkey:

Within this cluster there is strong relationship with Industrial Growth and Technological Capability of Firms.

4.6. National Innovation System (NIS):

University-Industry Research Centers, Funds, Labs are the main sources of NIS and NIS has bounds with to main cluster such as, Technological Capability of Turkey and Technology Improvement.

4.7. Product-Process Development:

Product-Process Development has direct links with Invention, Innovation, Labs, Technological Capability of the Firms and Upgrading Technological Capability. This cluster has also strong relationship with cluster Academia-Government.

4.8. Technology Improvement:

This cluster is the core of this study. NIS, Technological Capability of Turkey, Fusion-Diffusion of Technology and Industrial Growth are the direct resources of Technology Improvement.

Numerical data is missing at the current status of our research. With the import of numerical data into the model it is possible that the presented clusterization may accordingly be modified. The non-quantifiable parts of the model (system) may be ignored for more solid and self-standing structure. Different future scenarios will be demonstrated at the end of our research as outcomes of different policy selections.

5. CONCLUSION

The aim of this study was to show that system dynamics methodology is a proper and valid tool for technology improvement policy analysis. The case of Turkey is used and the research process is still continuing. The results obtained up-to now are positive. The model seems to be applicable to real life when the study is completely finalized.

As there are plenty of social, economical and technical parameters related with technology improvement activities, the abstractions made/will be made during the construction of the model may result in some inconsistencies. They can be corrected by more extensive analysis, adjustment of parameters and employing other research techniques.

System Dynamics methodology is proven to be a competent technique for technology improvement policy analysis and after more precise adjustments of the parameters, system model representing technology improvement can be used by policymakers.

REFERENCES

1) Assoc. Prof. Dr. Kemal Güleç, At the 75th Anniversary of Republic, The Affect of Science, Technology and Research Policies on Industrialization, KOSGEB, October 1998, Ankara.
2) Prof. Dr. Metin Durgut, Prof. Dr. Metin Ger, Prof. Dr. Nevzat Özgüven, Prof. Dr. Erol Taymaz, Dr. Baha Kuban, Aykut Göker, Draft Science and Technology Report of Scientific and Technical Research Council (For the 8th Five-Year Plan Preparation Studies), TUBITAK, 06.01.2000, Ankara.
3) Prof. Dr. Orhan Güvenen, Medium and Long Term Strategic Goals of Turkey, State Planning Organization, 1999, Ankara.
4) TUBITAK, Turkey's Science & Technology Policy (Summary), TUBITAK STP, January 1999, Ankara.
5) TUBITAK, 25th Years Book of Marmara Research Center, TUBITAK Marmara Research Center, 1997, Istanbul.
6) Richard W. Stevenson & Prof. Eric F. Wolstenholme, Modeling for Competitive Advantage (3-day Workshop Presentation), St. George Swallow Hotel, June 1993, Harrogate USA.
7) Louis Edward Alfeld, The System Dynamics Modeling Methodology, Decision Dynamics, 1994, USA.
8) Science Policy Department, General View of Turkish R&D, TUBITAK, 1983, Ankara.
9) Local Content & Industrial Integration Directorate of SSM, 1997-1998 Turkish Defence Industry Products Catalogue, Undersecretariat for Defense Industries, 1997, Ankara.

MODEL OF TECHNOLOGY IMPROVEMENT POLICY - THE CASE OF TURKEY