Türkiye Bilimsel ve Teknik Arastirma Kurumu (TÜBITAK)
Scientific and Technical Research Council of Turkey

Productivity

Science and Technology Management Systems

and

Innovation Opportunities

H. Aykut Göker

NATO ARW
Globalization of Science and Technology:
A Way for CIS Countries to New Markets
Conference Hall
47, Khorezmskaya Street
Tashkent, Uzbekistan
September 23 -25, 1996

Productivity
Science and Technology Management Systems
and
Innovation Opportunities

H. Aykut Göker

Summary

This presentation has dealt with the science and technology management systems of several countries, and has attempted to point out the remarkable common points among them. The need for a science and technology management system at national level as the main component of the national innovation management system has been the starting point of the presentation. In respect of this point, the need for a national innovation system has been studied as well.

Improving Productivity for National Prosperity: Technological Innovation for Improving Productivity

Michael E. Porter of the Harvard Business School says in his monumental work, **The Competitive Advantage of Nations [1991]**: "The principal economic goal of a nation is to produce a high and rising standard of living for its citizens. [And] the ability to do so depends on the **productivity**(*) with which a nation's resources (labour and capital) are employed." And he emphasizes, "Productivity is the prime determinant in the long run of a nation's standard of living, for it is the root cause of national per capita income. The productivity of human resources determines their wages, while the productivity with which capital is employed determines the return it earns for its holders."

Adding to these arguments, Porter points out, "The only meaningful concept of competitiveness at the national level is national productivity." According to him, "a nation's firms must relentlessly improve productivity in existing industries by raising product quality, adding desirable features, improving product technology, or boosting production efficiency... A nation's firms must also develop the capabilities required to compete in more and more sophisticated industry segments, where productivity is generally higher. At the same time, an upgrading economy is one, which has the capability of competing successfully in entirely new and sophisticated industries. Doing so absorbs human resources freed up in the process of improving productivity in existing fields."

In this context, Porter calls attention to the fact that **revolutionary new technologies** (namely, information systems, bio-engineering, new materials, super fast microchips, and others) provide the opportunity for an era of innovation and improving productivity in virtually all industries that may well be unprecedented in industrial history.

Annemieke J.M. Roobeek of the Economic Geographical Institute at the University of Amsterdam underlines the critical role of productivity from a different theoretical view in her work entitled

(*) "Productivity is the value of the output produced by a unit of labour or capital. It depends on both the quality and features of products (which determine the prices they can command) and the efficiency with which they are produced."[Porter, 1991]

Beyond the Technology Race: An Analysis of Technology Policy in Seven Industrial Countries [1990]. According to her, "since the late 1960s and early 1970s, practically all Western industrial countries have been confronted to a greater or lesser degree with the problems arising from the post-war growth model itself." She argues that post-war growth model has some limitations that are incorporated in the dynamism of the model itself. These limitations are inherent control problems of Fordism and it was these control problems that slowed down economic growth. She says that the rise of wages without a parallel rise in **productivity** can be seen as the first control problem. Furthermore, the declining productivity growth is another important control problem.

In this context, Roobeek also calls attention to the **new generic technologies** (namely, microelectronics, biotechnology and the new materials) in solving these control problems.

As Christopher Freeman points out, "virtually all economists, neo-classical, Keynesian, Marxist, Schumpeterian or whatever, accept the point that **productivity growth** depends very heavily on the introduction and efficient diffusion of new and improved processes and products in the economic system." [C. Freeman, 1989] According to Freeman, we experience now some radical changes in 'techno-economic paradigm' and new generic technologies, but in particular the new information and telecommunication technologies, which create this deep-going transformation, enable us to change the technology base of labour process in order to enhance the productivity.

In brief, **productivity** is the prime determinant in the competitive advantage and the national prosperity. As for that productivity, **technological innovation** is the key factor, and in Carlota Perez's words, radical changes in techno-economic paradigm make possible a 'quantum leap' in potential productivity [C. Perez, 1988].

Technological Innovation as a Socio-Economic and Political Process

Those are all true, but the question is how we can bring our production systems, and the labour process as a whole, into harmony with the new generic technologies, and how we can manage the technological innovation.

For the first, we should keep in mind the technological innovation is not only a technical process, it is also a socio-economic and a political process. Many different social and political actors have taken part in this process. As a policy report of OECD, proposing 'a socio-economic strategy based on new technologies for 1990s, put it; "new generic technologies cannot be imposed on our societies, they have to be introduced through institutional adaptation and a process which mediates between differences of interest." [OECD, 1988.]

In addition to, "as living standards have improved, concern has grown about the quality of products and services, the quality of work, about environmental conservation and improvement, and the quality of life more generally. These issues require systematic consideration and public debate preferably in the form of technology assessment." [OECD, 1988.]

Furthermore, "a climate of confidence for the successful introduction of new technologies requires what may be described as '**the comprehensive innovation process**'. The spectrum includes not only the enterprise and the market, but also the rules of the game as **set by society through its various organs**. Hence, entrepreneurship, management, work organisation, financing, the opening up of markets, worker and employer organisations, labour market, educational and regional authorities, etc., are all involved. The more radical the nature of technological change, the more profound and complex the social interaction it generates, and the more innovative institutional changes it necessitates." [OECD, 1988.]

Another policy report of OECD, issued this year, confirming the previous arguments once more, puts the matter clearly. In terms of this report;

"**Technology and productivity growth** are central to the current employment problem in OECD countries. In the long run, knowledge, particularly technological knowledge, is the main source of economic growth and improved quality of life. But the process of **technical change**, best described as one of "creative destruction", is not smooth. It requires adapting economic structures, behaviour and resource allocation among sectors, firms, and occupations.

"**The key policy challenge is to boost productivity and growth through increased knowledge-intensive economic activities while maintaining social cohesion**." [OECD, 1996.]

For this 'policy challenge' the report points to the need for a new coherent policy framework. As the report puts it;

"Providing the conditions that allow market forces to deliver their best results remains a primary role of governments. This includes: policies to ensure well functioning financial and labour markets; competition and trade policies to promote efficiency in product markets, international diffusion of technology, and development of knowledge-intensive activities; and sound macroeconomic and budgetary policies that facilitate firms investment decisions (a conducive tax environment, price and exchange rate stability, lower interest rates).

"In addition to these framework conditions, five specific areas for policy action are suggested:

- Enhancing productivity through improved creation, access and diffusion of knowledge.
- Promoting organisational change to achieve more effective knowledge management.
- Coordinating technological and human resource development. This involves both improved human resource accounting and a focus on adult skill training and on early education.
- Stimulating new demand by fostering emerging markets particularly in information and communication technologies-based services. Regulatory reform will often be a precondition for the emergence of these markets.
- Realising the innovative and job-creating potential of SMEs. [OECD, 1996]

Technological innovation is also vital for the European Union. The **Green Paper on Innovation** prepared by European Commission puts the fundamental objectives to pursue as follows [European Commission, 1995.]:

- Better direct research efforts towards innovation.
- Reinforce human resources for innovation.
- Improve the conditions for the financing of innovation.
- Foster a legal and regulatory environment favourable to innovation.
- Adapt the role and the modalities of public action regarding innovation.

These objectives also point out the socio-economic and political extent of the innovation process.

The Need for Innovation Management System at National Level

In respect of all these arguments, it is easily seen that we need an **innovation management system at national level** to be able

- to control, in general, such a complex process not only depending on the technological factors, but also the socio-economic and political ones, and particularly, to cope with the social difficulties to be emerged,
- to get the coherency among the many different actors that take part in the process and to get the internal integration of the process, and
- to motivate all the related actors of the innovation process for the attainment of national economic and social goals.

And the Need for Science and Technology Management System

Taking into consideration the need for a national innovation management system and all its aspects, it can be easily seen that the need for a science and technology management system(*) at national level, too.

After this summary of the theoretical and practical framework that my presentation has depended on, I will attempt to deal with the science and technology management system as the main component of the innovation management.

What kind of a science and technology management system do we need, and what should be the descriptive characteristics of such a system?

At the beginning of this year, I and a colleague of mine, N. Dizdaroglu, studied the science and technology management systems (**STMSs**) of several countries including USA, Germany, France, Sweden, Italy, Finland, Netherlands, Spain, Japan, South Korea, Taiwan, Malaysia and Thailand. We have found out some remarkable common points in these systems. I wish to share with you these findings:

(i) Participation of the Political Power as a Sine Qua Non Partner

At first, it can be explicitly said that all of the STMSs have reflected the determinant role of science and technology in respect of national economy and international competitive advantage, and they have been formed on this concrete base. Ability in science and technology has been taken as a very powerful tool in surviving the vividness of national economy, in sustaining economic growth and upgrading the living standards. In this context, in order to attain national goals in economy, governments have taken regulatory measures in the field of science and technology.

These measures are generally associated with the rational using of public resources and with the pursuing an integrated strategy for

---

(*) **Science management** and technology management should be considered as a whole, because science and technology are integral parts weaving and enhancing each other.

- enhancing the intellectual capacity (in other words, intellectual or intangible capital) of the country,
- upgrading the R and D ability and capability of the country,
- focusing this ability in the fields of economic priority,
- encouraging the activities aiming at the transformation of scientific and technological findings into economic and/or social benefit immediately,
- accelerating the diffusion of new generic technologies in all the fields of economic activity,
- financing the technology-intensive mega projects that will raise the technological ability of the country and create vividness in economy.

These regulatory measures have found expression in the national science and technology policies, and the STMSs in fact, serve to make such a national policy at the strategic planning level and to realise it. Structural and functional features of the STMSs are all in harmony with this national mission. The striking indication of such a systemic formation as a strategic planning and policy realization tool is the participation of the politic power into the STMSs as an integrated but generally a sine qua non agent.

In all the countries, the representatives of the politic power take place in the policy making and realisation process so as to achieve the orchestration.

In some countries, all of the executive bodies of the government take place in that process and undertake an efficient role as it is seen in the USA. Furthermore, the legislative bodies may participate the process and play a very active role as it occurs in the USA and Italy.

There are some countries, like Sweden, that have reinforced the role of the prime minister in the process, but generally we have seen that one or more ministries take place in the process and play a central role in general. For example, in Germany, the Federal Ministry for Research and Technology, and the Federal Ministry of Education and Science; in France, the Ministry of National Education, Higher Education and Research; in Italy, the Ministry of Universities, and Scientific and Technological Research with the Ministry of Industry; in Netherlands, the Ministry of Education and Science with the Ministry of Economy; in Japan, the Ministry of International Trade and Industry; and in S. Korea, the Ministry of Science and Technology have got an efficient role in the science and technology management system. However, it must be noticed that while some countries have got dedicated ministries for the fields of science and technology, and research, others have given these missions or responsibilities related to these fields to the ministries of industry, economy and trade.

(ii) Interactive Policy Making Process

The second remarkable common point is that all the actors of the science and technology system take part in framing science and technology policy, in terms of national plans and programs. This participation has been made possible by means of the governmental and/or nongovernmental bodies like that advisory councils to government, interministrial or intersectoral coordination committees at macro level, multidisciplinary science and technology societies, evaluation or assessment committees, and task forces at sectoral level. The representatives of the government bodies, regional authorities, universities, research institutes, industry and other productive sectors come together, for the policymaking and assessment process, under the roof of these bodies at the national and/or regional level.

The President's Committee of Advisers on Science and Technology (PACTS), and the task forces like that the Task Force on Information Infrastructure and the Clean Car Task Force in the USA; the Science Council in Germany; the Supreme Council of Research and Technology, and the Strategic Steering Committee in France; The Advisory Council for Science and Technology in Spain; National Science and Technology Council, and Presidential Council on Science and Technology in S. Korea are the well known examples of such bodies.

It must be noticed that the representatives of funding bodies supporting research activities have also taken part at the decision making process.

Another fact is that some scientific societies or research institutes have got dual purpose and they act, for example, both an advisory body to government and a research institute.

In brief, it can be said that there has been an interactive policy making environment covering all the actors of the science and technology system rather than a solid management hierarchy. This is a characteristic feature of the science and technology systems.

(iii) Powerful Funding Mechanism as an Efficient Stimulation and Steering Tool

The existence of an improved and powerful funding mechanism serving as an efficient tool in the realisation of national science and technology policy is the third point. The funding bodies, although they usually depend on the public resources, show a great variation in structure. For example, in some countries only the related ministries or governmental bodies support the academic research, in the other ones, some independent or autonomous bodies also support the academic research. As an example, in France, the Ministry of National Education, Higher Education and Research acts as a funding agency for the research activities achieved by the university, but in Germany, autonomous German Research Society beside the Federal Ministry for Research and Technology supports the university. In the USA, an independent foundation, namely National Science Foundation, also supports the academic research a great deal.

Of course, not only the academic and basic research has been supported on the base of public resources, but also the all R and D activities of the private sector have been supported depending on the public funds through same or similar funding mechanisms.

(iv) Public Research Institutes in the Strategic Fields of R and D

The conspicuous mission of the public research institutes in national science and technology systems and the decisive role of them in the raising the scientific and technological ability and performance of the country at some specific and strategic fields of R and D is the fourth point that I wish to point out.

As it is known, almost in all countries, nonmission-oriented basic research usually takes place at the university, and the activities such as experimental development, process innovation and product innovation are achieved by the industry, but mission-oriented basic research which cannot be performed by university, and applied research which cannot be performed by industry itself because it is long-term application-oriented, economically risky and requires relatively large-sized interdisciplinary research teams, particularly expensive facilities and equipment, and large funds are generally realised by the public or national research centres or institutes. [Cunningham, P., B. Barker, 1992].

In addition to those, the research activities related to the fields such as defence, nuclear power, aerospace, ecology systems, global climate changes, and health, because of their nature and/or national-strategic importance, are also achieved widely by the public research institutes.

The public research institutes, with their activities in the fields mentioned before, have got exceptional abilities in the very specific fields of research and a notable accumulation of knowledge and experience. In this context it is obvious that they can serve, as a tool, to enhance the total scientific and technological ability and capacity of the country. The ability, and the knowledge and experience accumulation of them can be transferred into the fields of economic activity by means of improved transfer mechanisms such as contract based research achieved by these institutes for industry, precompetitive research performed with the participation of them. Circulation of the researchers between public institutes and industry, know-how transfers or giving licence on the base of royalty are the other efficient transfer mechanisms.

It should be also pointed out that, by means of these mechanisms, the public research institutes serve to realise the national goals and priorities, and they can be used as a driving force for the productive sectors towards these priorities.

(v) Technology Management as an Integral Part of Innovation Management

As a last, important common point, we have seen that, in all the countries, which we have studied, their STMSs are the integral parts of their innovation management systems.

Science and technology system is the backbone of the national innovation system, but the innovation system, in regard to the social and institutional structure and labour process, is much more extensive and complex. Furthermore, unless the national innovation system has come to existence as a whole, the benefit created by the science and technology system will never be sufficient for any meaningful economic or social progress. National innovation system includes not only the basic or applied research institutes, and industrial research and development units, but it also includes technology demonstration and extension centres, design units, engineering and consulting establishments, technology transfer mechanisms, technology assessment and research evaluation agencies, information centres, academic network and national information network, national standardisation, accreditation, certification and notification system, national patent office, legislation related to intellectual property rights, funding mechanisms dedicated to R and D activities, venture capital enterprises and other facilities supporting creative, young entrepreneurs, and of course, a total innovation management system. In this context, the science and technology system at national level has been naturally considered as an integral part of the innovation system.

Conclusion

Now, I wish to turn my starting-point to draw a conclusion. At the beginning of my presentation, referring to Porter, I pointed out the necessity of improving productivity for national prosperity. It was also a necessity, in terms of Annemieke Roobeek, to solve the vital control problems of market economies. After that, referring to same authors and also to Freeman, I underlined that the need for technological innovation to improve the productivity.

Then, I tried to show the nature of the technological innovation, depending on the reports of OECD and European Commission, and I emphasized that it was not only a technical process, but also it was a socio-economic and political process. Depending on this argument, we could have drawn explicitly that **the need for a total innovation management system at national level in order to control such a complex process, and to cope with the difficulties to be emerged. It was obvious that the need for a science and technology management system at national level, too.**

And finally, I attempted what kind of a science and technology management system we needed, and what the descriptive characteristics of the system should be. For this purpose, I tried to summarise our findings on the science and technology management systems of several countries. There can be no doubt that every country has got a system depending on distinguished characteristics of its own historic development; but, as it is shown, there have also been some considerable points shared by all. The most remarkable and important point is the integrity between the technology management and the national innovation management.

If we take our own science and technology management and national innovation management systems in this integrity, I believe that we can find many innovation opportunities that will enable us 'a quantum leap' in national productivity and, as a result, in international competitive advantage.

References

- Cunningham, Paul and Brendan Barker (editors.), 1992, **World Technology Policies**, Longman Ind. and Public Service Management, Essex, U.K.

- European Commission, 1995, **Green Paper On Innovation**, Draft, December.

- FREEMAN, Christopher, 1989, "New Technology and Catching Up", **The European Journal of Development Research**, June 1989.

- Göker, Aykut, and Nurdogan Dizdaroglu, 1996, **Bilim ve Teknoloji Yönetim Sistemleri: Ülke Örnekleri ve Türkiye** [*Science and Technology Management Systems: Some Examples for Turkey*], TÜBÝTAK BTP 96/01, May, Ankara.

- OECD, 1988, **New Technologies in the 1990s: A Socio-economic Strategy**.

- OECD, 1996, **The OECD Jobs Strategy: Technology, Productivity and Job Creation**, Vol.1 (Highlights) and Vol.2 (Analytical Report).

- Perez, Carlota, 1988, "New Technologies and Development", (in) C. Freeman and B-A. Lundvall (editors.), **Small Countries Facing the Technological Revolution**, 1988, London.

- Porter, Michael E., 1990, **The Competitive Advantage of Nations**, The MacMillan Press Ltd. London and Basingstoke.

- Roobeek, Annemieke J.M., 1990, **Beyond The Technology Race: An Analysis of Technology Policy in Seven Industrial Countries**, Elsevier Science Publishers, Amsterdam, New York, Oxford, Tokyo.