UNIVERZA V LJUBLJANI
FAKULTETA ZA DRUŽBENE VEDE

Gregor Gomišček

Tehnološke politike v ZDA na prehodu v informacijsko družbo

Technology policy of the United States of America, Shaping for the information era

Magistrsko delo

Ljubljana, 2011

UNIVERZA V LJUBLJANI
FAKULTETA ZA DRUŽBENE VEDE

Gregor Gomišček

Mentor: red. prof. dr. Bogomil Ferfila
Somentor: prof. dr. Calvin Mouw

Tehnološke politike v ZDA na prehodu v informacijsko družbo

Technology policy of the United States of America, Shaping for the information era

Magistrsko delo

Ljubljana, 2011

Acknowledgement

I would like to express my gratitude to:

prof. dr. Bogomil Ferfila for putting up an interesting postgraduate study and for his unique attitude toward the students as well as for the way he motivated and supported me during the study;

prof. dr. Calvin Mouw for accepting the co-mentorship of my thesis, for his positive criticism with fruitful suggestions and for a really fast responsiveness;

parents for teaching me that knowledge is a value and for demonstrating me the importance of interdisciplinary and life-long studies;

Jana, Anja and Tjaša for the support and the patience when our family life was put aside due to my studies

and at last, but not at least, to

dr. Jože Pučnik and Janez Janša for making me believe that changes in Slovenia are possible, and thus, encouraged and later on supported my political work.

Univerza
v Ljubljani
Fakulteta
za družbene vede

Kardeljeva ploščad 5
1000 Ljubljana, Slovenija
telefon 01 58 05 122
01 58 05 120

IZJAVA O AVTORSTVU
magistrskega dela

Podpisani/-a Gregor Gomišček, z vpisno številko 15982,sem avtor/-ica magistrskega dela z naslovom:

Tehnološke politike v ZDA na prehodu v informacijsko družbo
Technology policy of the United States of America, Shaping for the information era.

S svojim podpisom zagotavljam, da:

- je predloženo magistrsko delo izključno rezultat mojega lastnega raziskovalnega dela;
- sem poskrbel/-a, da so dela in mnenja drugih avtorjev oz. avtoric, ki jih uporabljam v predloženem delu, navedena oz. citirana v skladu s fakultetnimi navodili;
- sem poskrbel/-a, da so vsa dela in mnenja drugih avtorjev oz. avtoric navedena v seznamu virov, ki je sestavni element predloženega dela in je zapisan v skladu s fakultetnimi navodili;
- sem pridobil/-a vsa dovoljenja za uporabo avtorskih del, ki so v celoti prenesena v predloženo delo in sem to tudi jasno zapisal/-a v predloženem delu;
- se zavedam, da je plagiatorstvo – predstavljanje tujih del, bodisi v obliki citata bodisi v obliki skoraj dobesednega parafraziranja bodisi v grafični obliki, s katerim so tuje misli oz. ideje predstavljene kot moje lastne – kaznivo po zakonu (Zakon o avtorski in sorodnih pravicah (UL RS, št. 16/07-UPB3, 68/08, 85/10 Skl.US: U-I-191/09-7, Up-916/09-16), prekršek pa podleže tudi ukrepom Fakultete za družbene vede v skladu z njenimi pravili;
- se zavedam posledic, ki jih dokazano plagiatorstvo lahko predstavlja za predloženo delo in za moj status na Fakulteti za družbene vede;
- je elektronska oblika identična s tiskano obliko magistrskega dela ter soglašam z objavo magistrskega dela v zbirki »Dela FDV«.

V Ljubljani, dne 25. 6. 2011

Podpis avtorja/-ice: Gregor Gomišček

Tehnološke politike v ZDA na prehodu v informacijsko družbo

POVZETEK

Tehnologija je motor gospodarske rasti v vsaki industrijsko razviti državi in poznavanje znanosti in razvoja v ZDA, ki ima svetovni primat v tehnologiji, nam pokaže smernice, po katerih se bo svet razvijal v času informacijske družbe. Zato v magistrski nalogi preučujemo ameriške tehnološke politike s posebnim poudarkom na obdobju zadnjih dveh desetletij ob prehodu stoletja. Predstavljene so: osnovne teme, ki zadevajo tehnološke politike ZDA, pretekle in sedanje ameriške politike, proces kreiranja in implementacije tehnološke politike ter nekaj izbranih dilem. V nadaljevanju razpravljamo o razvoju tehnologije v ZDA v prvem desetletju 21. stoletja in predstavimo posamezne cilje in dosežke v raziskavah in razvoju ZDA. Kvalitativni in kvantitativni parametri (razmerja med vojaškim in civilnim investiranjem, osnovnimi in aplikativnimi raziskavami, vojaškim in civilnim razvojem, skupnim državnim financiranjem itd.) kakor tudi mednarodne primerjave so uporabljene, da se potrdi štiri osnovne hipoteze na prehodu stoletja: *i)* vlaganja ZDA v vojaške raziskave in razvoj se ne bodo bistveno zmanjšala, *ii)* država bo bolj intenzivno podprla komercialne raziskave in razvoj, *iii)* ZDA bodo tudi v bodoče ohranile primat na področju razvoja in raziskav in *iv)* organizacijska struktura ministrstev in zveznih agencij se v ZDA ne bo bistveno spremenila. Vse štiri hipoteze, z izjemo druge, so se izkazale kot pravilne.

Ključne besede: tehnologija, politike, ZDA, informacijska družba

Technology policy of the United States of America, Shaping for the information era

SUMMARY

Technology is the engine of the economic growth in every major industrialized nation and the knowledge concerning the research and development in the USA, the world leader in technology, reveals the ways the world will develop in the information era. Therefore, the technology policy in the USA is studied with a special interest in the period of two decades around the change of the century. Some basic issues connected to the technology policy of the USA, the past and present technology policy of the USA, the decision making process, its implementation and some chosen dilemmas are discussed. The development of the USA technology, its state of art in the first decade of the 21st century as well as some case studies of the USA technological goals and achievements are presented. Qualitative and quantitative parameters (i.e. ratios among defense and civilian investments, basic and applied research, defense and civilian development, total federal funding, etc.) and an international comparison are used to prove four basic hypothesis: *i)* the federal funding of defense research and development will not significantly decrease, *ii)* the federal government will support the private sector more intensively*, iii)* USA will keep its leading position in technology and *iv)* the organizational structure of the USA federal agencies (departments) will remain mainly unchanged. All four hypotheses with the exception of the second one were proven.

Key words: technology, policy, USA, information era

CONTENTS

List of tables

List of figures

List of abbreviations

AAAS – American Association for the Advancement of Science

ARRA – American Recovery and Reinvestment Act (ARRA; Public Law 111-5)

ATP - Advanced Technology Program

CEO – chief executive officer

CRADA - Cooperative Research and Development Agreements

DOD – Department of Defense

DOE – Department of Energy

EPA - Environmental Protection Agency

EU – European Union

GATT – General Agreement on Tariffs and Trade

GDP – gross domestic product

GNP – gross national product

GPS - Global Positioning System

HHS - Health and Human Services (Department of Health and Human Services)

HPCC – (Federal) High Performance Computing and Communications Program

ITI - Intelligent Transportation Initiative

MEP - Manufacturing Extension Partnership

NAFTA - North American Free Trade Agreement

NASA - National Aeronautics and Space Administration

NIH - National Institute of Health

NII - National Information Infrastructure

NSF - National Science Foundation

NSTC – National Science and Technology Committee

OECD - Organization for Economic Cooperation and Development

OMB – Office of Management and Budget

OTA - Office of Technology Assessment

R&D – research and development

S&E – science and engineering

TRP - Technology Reinvestment Project

TV - television

UK – United Kingdom

U.S. – United States (of America)

USA – United States of America

1 INTRODUCTION

The end of the 20th century will be, without any doubts, characterized by the onset of a new, "information" era. The changes induced especially by the fast and previously unforeseen development of science and technology have influenced the world dramatically. Globalization with its advantages and disadvantages is surely one of the most important. In addition, the ending of the Cold war and the technological challenges posed by Europe and Japan have opened several questions and doubts concerning the technological policy of the United States. A chance which enables less effort to be put into the research & development for the military supremacy on one side and an inexperienced inferiority in some areas of technological development on the other side offer opportunities and demands for appropriate answers to the USA policy makers at the end of the industrial era.

If we consider that the nation's standard of living depends heavily on the productivity growth – a feature that is strongly coupled to the technical progress – it becomes clear that appropriate technology policies are of vital importance to the nation. Technology is the engine of the economic growth in every major industrialized nation. Thus, studying the development of the technology policies in the USA, which are emerging as the only superpower, offers a challenging insight into many questions concerning the research & development that will not only be restricted to the United States. It greatly reveals the ways the world will develop in the 21st century and accordingly, it might give some answers to several questions that will rise in other countries concerning their own technology policies.

In this thesis I intend to discuss: *i*) some basic issues connected to the technology policy of the USA (the influence of technology on the economic growth and the state of art in the USA technology at the end of the 20th century, *ii*) the past and present technology policy of the USA, *iii*) problems connected to the technology policy (the policy decision making process and its implementation) and *iv*) the development of USA technology and its state of art in the first decade of the 21st century. Case study of technological goals and achievements in the USA, as seen from the USA perspective at the end of the 20th century, and the advisory boards to the president of the USA concerning science and technology issues will be given in the appendix.

I sincerely hope that this work offers some additional information to the problems that should be open and discussed in Slovenia in order to trim our national technology policy to higher technological development and consequently, to launch our national economy on a high-growth path.

1. 1 Determination and research relevancy of the theme

The productivity growth is, according to a broad consensus among economists, the most important factor for a long-term prosperity of a nation (Borrus and Stowsky 1998). A long-term difference between 1 and 2 percent in the overall growth rate could mean a significant difference in the standard of living in a hundred-year period: in the first case merely doubling the standard is experienced compared to a five-fold increase in the latter. The comparison between the USA and Argentina offers an example of two countries with only slightly different growth rates: they had a comparable standard of living in 1860s; however, the USA followed the high-growth path while Argentina stayed on the low-growth path (Borrus and Stowsky 1998).

It has been proven that the productivity is mostly influenced by a combination of three factors: *i*) capital investment (including infrastructure), *ii*) well trained and educated people and *iii*) technological progress (including the development of new technologies and new organizational schemes). Among them the technological progress is believed to be the most important factor. It is estimated that the technological progress accounts for half of the long-term economic growth in the last 50 years in the USA (Cohen and Noll 1991; Tassey 1996). Firms that use advanced technologies are more productive and offer higher-wage jobs in the USA. Technology provides tools that enable a competitive business and increase the employment at higher rates (NSTC Committee 1996).

The technological progress is closely connected to research & development (R&D), modern technical infrastructure and competent, technically educated people. Therefore, a higher rate of economic growth cannot be imagined without a superior education, the support of scientific R&D and investments into infrastructure. And it is the role of technology policies to determine the aims and to achieve them by supporting and coordinating the individual components that are important for the technological progress. Hence, it is very important, especially in the times of change from industrial into information era, which is thought to be even more dependent on knowledge and technical development, that the technology policy of each country is well thought and that it is leading into the right direction.

To make and to perform an appropriate technology policy it is inevitable and necessary to possess a lot of knowledge as well as experiences. More precise understanding of technology policies, their dilemmas, successful solutions, and also pitfalls that were taken by other, especially developed countries, is one of the basics in the mosaic of this knowledge. This is especially true for the technology policy of the technologically most successful country in the world – the USA. The ideas and dilemmas that are shaping the USA technology policy for the information era are surely of a particular interest.

If the latest technology policy in the USA is studied, it is impossible to pass the end of the Cold war in year 1988. Although it may have primarily been seen as a political change in the world, it also influenced the technology policy in the USA (Irwin 1993). In this time, namely, a decreasing international competitiveness of the USA commercial industry was experienced, especially in the high technology (»leading-edge«) sector. On the other side, a chance to redistribute the federal funds into the commercial sector seemed to become real since huge amounts of money were not necessary to be invested in military R&D in order to gain military supremacy.

Although Bush administration previously rejected a federal role in commercial technology development, a document named "US Technology Policy" was submitted showing that the changes in the technology policy are a political necessity in the USA (Mowery and Rosenberg 1989; Ham and Mowery, 1995). When the Clinton administration came to office new and profound measures were set to ensure a global technological leadership of the USA in the next century. The changes in the USA technology policy are based on five principles (Executive Office of the President, Office of Science and Technology Policy 1990 and 1997):

- long-term commitment to research, education, and innovation;
- creation of a business environment where innovation and competitive efforts of the private sector are encouraged;
- support of development, commercialization and the use of civilian technology as well as promotion of the integration of civilian and military industrial bases;
- creation of a world-class infrastructure to support the industry and commerce;
- development of a world-class working force for a rapidly changing, knowledge- based economy.

The technology policy in the USA should, in addition, encourage and invest into certain fields of science and technology that are of primary interest for the USA (Executive Office of the President, Office of Science and Technology Policy 1997). These are the areas where a big social return to the investments in R&D is expected: national security and global stability, environment and health.

There are also several dilemmas concerning the technology policy for the 21st century that have to be resolved. Let us mention some of them (Branscomb 1998; Irwin 1993; Barke 1986):

- the relation between science and technology,
- the basis for federal funding of technology,
- the influence of globalization on technology policy and
- the creation of Department of Science and Technology.

Technology policy is a complex theme, therefore, aside of basic principles, measures and dilemmas which should help to maintain the global technological leadership of the USA and well being of American citizen in the information era, specific topics will be presented in the thesis in order to round up the technology policy in the USA.

The status of technology and its position in a country is difficult to present by only one quantitative parameter (Irwin 1993). Therefore, many qualitative and quantitative (absolute and relative) parameters will be used in this thesis. The status of the USA technology and its temporal development will also be presented in an international comparison.

Since the present decisions, steps and dilemmas in the USA technology policy are correlated with the past, a fully understanding of the changes in the technology policy undertaken at the end of the 20th century can be gained only by knowing the ways the policy was evolving in the past. Therefore, a brief history of the USA technology policy in specific time intervals starting with the year 1787 will be given.

A brief analysis of the policy making process in connection to the technology policy, its main actors and the problems connected with it will be given (Barke, 1986; Jones, 1984). The influence of six major factors in the decision making process, i.e. president and executive office, Congress, courts, federal bureaucracy, public and scientists will be revealed. The lack of sufficient knowledge on technology issues on one side and limited political power on the other side lead to an incremental model which may sometimes resemble to a “garbage can” model.

Finally, some examples of the research and development in the USA at the end of the 20th century will be presented and a list of Nobel prize winners in years 1995 and 1996 will be given in order to get an impression of the achievements in the USA research and development as a consequence of the technology policy in the USA (Executive Office of the President, Office of Science and Technology Policy 1997). The importance and the weight of the technology policy will be demonstrated by the level of the advisory boards and by the personnel choice of their members which coordinate and advice the president on science and technology issues (National science and technology council and President's Committee of Advisors on Science and Technology).

1. 2 Intention, hypothesis and aim of the thesis

In this thesis the technology policy in the United States of America will be presented. We would like to show the most important policy features of the world's technology leader and to discuss the dilemmas and problems connected with it.

The studies of the technology policy in the USA will be concentrated mainly on the time period of two decades around the change of the century, hence, on the times when the industrial society meets the information era. According to common opinion, the meaning of the knowledge and the necessity of research and development, which is tightly connected to the acquisition of new knowledge, will even increase in the information era.

Therefore, we believe that knowing the current status of the world leader in the field of research and development, its intensions and dilemmas connected with the beginning of the 21st century, is very important. We firmly believe that this knowledge is necessary to understand the role and the future in the field of research and development. It enables to keep contact with the developed countries as well as to preserve prosperity in the society.

Technology is, without any doubt, a complex field, uncertain and full of dilemmas. However, I would like to point out four basic hypotheses concerning the technology policy in the USA entering the 21st century:

1. The funding of military (defense) research and development will not, in spite of the end of the Cold war, significantly decrease. The tendency that the military (defense) and civilian (non-

defense) R&D are more interleaved will be increased, which is especially true for the "spin-off"s and the "dual-use" technology.

2. The classical attitude in the USA claiming that the federal government should not fund the private sector, even in its pre-competition phase, will change, if nothing else, due to an increased competition of other developed countries.

3. USA will keep its leading position in technology (in the field of research and development).

4. The organizational structure of the federal agencies (departments) will remain unchanged, no Department of Science and Technology will be established.

In summary, the aim of this thesis is to present the technology policy in the USA in order to show the future steps of the world leader, based on current position of its technology and also on its dilemmas and problems. These steps will have to be followed, willingly or not, by the rest of developed countries in the field of research and development. In addition, this thesis should be a small stone in a mosaic of knowledge, which is urgently needed in discussions and decisions concerning the field of research and development in Slovenia.

1. 3 Methodology and structure of the thesis

The presentation of the technology policy of the USA, which is without any doubt the world leader in science and technology, the selection of their problems and dilemmas is undertaken on the basis of my experiences over several years in scientific and research work in Slovenia and abroad as well as in accordance with several discussions with domestic and foreign scientists. My experiences in different supervisory boards and boards of governors in research institutions and industry as well as on different levels of political decision-making process were surely helpful.

The technology policy in general and some selected themes are studied by the use of relevant international publications. The majority of them are from the most direct sources – publications published by different agencies in the administration of the USA which are responsible for the development and evaluation of the research and development in the USA (i.e. Office of Science and Technology Policy, Executive Office of the President; National Science Foundation, Division of Science Resources Statistics; National Science and Technology Committee, Committee on Civilian Industrial Technology; National Science Board Committee on Industrial Support for R&D; Council on Competitiveness etc.).

The themes are presented qualitatively and quantitatively, many tables with numerical data and diagrams are included. The confirmations of the majority of hypothesis are undertaken on the basis of quantitative data and different parameters calculated from them, i.e. different ratios like applied research/basic research, development/total research, (development+applied research)/ basic research and civilian development/ total R&D.

The following themes will be discussed in the thesis:

Firstly, the basic issues connected to the technology policy will be presented: the correlation between the technology and the economic growth and the state of the USA technology at the end of the 20th century. They will be demonstrated by parameters like GDP and federal investments in research and development.

Afterwards, a short historical overview of the technology policies in the USA will be presented. The characteristic time intervals will be listed and discussed: between the years 1787 – 1941, 1941 – 1945, 1945 – 1980 in 1980 – 1988. For each time interval characteristic features will be demonstrated. Following, the basic intensions of the policymakers for the 21st century will be discussed: *i)* creating a healthy business environment, *ii)* technology development and commercialization, *iii)* world-class infrastructure and *iv)* world-class working force.

The description of national objectives of the USA will follow and thus, the aims which should be followed by the national technology policy: national security and global stability, care for the environment and the health of its citizen.

The policy making process in the USA will be presented and different policymaking players will be discussed: the president and the executive office, the congress and the federal bureaucracy, the courts and the legal system, the public and the scientists.

The thesis would not be complete unless some selected dilemmas connected to the technology policy were not addressed: *i)* the relation between science and technology, *ii)* the basis for federal funding of technology, *iii)* the influence of globalization on the technology policy and *iv)* the creation of the Department of Science and Technology.

To round the thesis up, the development of the USA technology in the last two decades is discussed and its status in the first decade of this century is studied. It will be demonstrated by different indicators: R&D expenditures and foreign direct investment, education and advanced training, science and engineering (S&E) workforce and mobility, scientific publications, collaboration, citations, patents and high-technology manufacturing and exports.

The thesis is ended with an appendix which will try to show some scientific and technological achievements and goals in the USA research and development: studying Methannococcus jannaschii, Bose-Einstein condensate, increased precision of cancer treatment, a new look at Midwest flooding and the USA Nobel Prize Winners in 1995 and in 1996. At the end, the selection of the persons which were appointed into the advisory boards to the president concerning science and technology issues (National science and technology council and President's Committee of Advisors on Science and Technology) will be presented. It should indicate the respect that these committees posses in the American society.

1. 4 Definitions of research, development and technology

Research is defined as systematic study directed toward a fuller scientific knowledge or an understanding of the subject studied. Research is classified as either basic or applied according to the objectives of the sponsoring agency (NSF, Division of Science Resources Statistics 2009).

Basic research is defined as systematic study directed toward a fuller knowledge or an understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind (NSF, Division of Science Resources Statistics 2009).

Applied research is defined as systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met (NSF, Division of Science Resources Statistics 2009).

Development is defined as systematic application of knowledge or understanding, directed toward the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements (NSF, Division of Science Resources Statistics 2009).

The word **technology** comes from Greek *technologia*: from *téchnē*, meaning "art, skill, craft", and -*logia*, meaning "study of-" (Wikipedia).

Dictionaries and scholars have offered a variety of definitions for technology. The most useful definitions of technology for our purpose are given bellow.

Technology is defined as:

1. The making, usage and knowledge of tools, techniques, crafts, systems or methods of organization in order to solve a problem or serve some purpose. The term can either be applied generally or to specific areas: examples include construction technology, medical technology, and information technology (Wikipedia).

2. The branch of knowledge that deals with the creation and use of technical means and their interrelation with life, society, and the environment, drawing upon such subjects as industrial arts, engineering, applied science, and pure science (Dictionary).

3. a. The application of science, especially to industrial or commercial objectives.
   b. The scientific method and material used to achieve a commercial or industrial objective (Farlex, Answers).

4. a. The practical application of knowledge, especially in a particular area.
   b. The capability given by the practical application of knowledge (Merriam-Webster 2007).

The distinction between science (research), engineering (development) and technology is not always clear. The exact relations between science and technology in particular have been debated by scientists, historians, and policymakers towards the end of the 20th century (Wikipedia).

In this thesis the term technology will be used in accordance to the belief that research, in particular applied research, is very closely related to development. Hence, an exact distinction between science and technology, especially when the technology policy is discussed, is very difficult and might also not be useful. Therefore, the term technology policy will be meant in a broader sense, as a policy concerning both, the research and the development as well. For more information on this topic see Chapter 4.2.1.

2 BASIC ISSUES CONNECTED TO THE TECHNOLOGY POLICY OF THE USA*

2.1 The influence of technology on the economic growth

The standard of living of a nation is the best indicator of its economic performance (Borrus and Stowsky 1998). It is determined by three most important factors: *i*) the productivity growth, *ii*) the income distribution and *iii*) the rate of unemployment. The productivity growth is defined as the rate of growth in output per unit of input, growth in output per worker is encountered in most cases.

Essentially all economists agree that productivity growth is the most important factor for the long-term prosperity. They also agree that productivity growth is mostly influenced by a combination of three factors: *i*) capital investment (including infrastructure), *ii*) people (including training and education) and *iii*) technological progress (including the development of new technologies and of new organizational schemes). Most economists believe that technological progress seems to be the most important factor – "technological progress is a vital source of economic growth and research & development (R&D) a vital source of technological progress" (Cohen and Noll 1991, 11). It is estimated that the technological progress accounts for half of the long-term economic growth in the last 50 years in the USA (NSTC Committee on Civilian Industrial Technology 1996, 12-3; Tassey 1995). The rest is due to the capital investment (24 %) and the labor force (27 %). The "New growth theory" emphasizes that the rate of economic growth depends - in a similar way - on human capital as a whole: the collection of knowledge or innovative "ideas". This approach takes these "ideas" responsible for the economic growth – they

* as seen from the perspective of the last decade of the 20^{th} century

lead to technical innovation and hence, to productivity improvement. Hence, when limiting the resources for education and scientific R&D, the rate of economic growth will be lower than it could be (Romer 1986, 1002-37; Romer 1990, 71-102).

Technology underpins the fastest growing industries and high-wage jobs in the USA and provides tools that enable a competitive business. The performance of individual companies strongly depends on their use of technology. Firms that use advanced technologies are more productive, pay higher wages and increase the employment at higher rates than the firms that do not. Between 1987 and 1991, the employment in companies that used eight or more advanced technologies grew 14.4 % faster compared to the ones without advanced technologies. Accordingly, the production workers' wages were more than 14 % higher (NSTC Committee on Civilian Industrial Technology 1996). The communications and information industries, for example, hardly existed decades ago in the form they do today and their growth rates are impressive: the employment in the cellular telephone industry has grown from 7.100 in 1987 to 53.900 in 1994; the cable television employment grew from 23.500 in 1978 to more than 112.000 in 1996. Accordingly, the number of registered E-mail users in the USA changed from 300.000 in 1985 to over 12 million in 1993 and to 27 million in 1996.

The long-term difference between 1 and 2 percent in the overall growth rate could mean, as already mentioned, a significant standard difference in a hundred-year period: the standard of living would merely double in the first case, while a five-fold increase is expected in the second case (Irwin 1993). This means a considerably different standard of living in two countries in the future which have the same standard now and only slightly different growth rates and it emphasizes the importance of high rates of economic growth. In addition, the high or low types of economic growth are likely to self-reinforce, leading to even increased differences in time (Borrus and Stowsky 1998; Arthur 1994, 111-32). History offers several examples, e.g. USA – Argentina, which had a comparable standard of living in 1860s, however, the USA followed the high-growth path while Argentina stayed on the low-growth path.

The rates of return to investments in new technology in a variety of industries show that the private rates of return vary from 20 to 30 % in firms that perform R&D, while the average rate of return to investment is approximately 10 % in the business sector. Estimated rates of return from R&D to the society as whole vary from 20 % to over 100 %, with an average around 50 %. They are due to spillovers to the consumers or other firms, the channels of the diffusion vary considerably (Borrus and Stowsky 1998; Nadiri 1993).

As a conclusion, the economists agree that a strong linkage between advances in knowledge, technical progress and long-term productivity growth exists leading to a higher gross domestic product and, hence, better standard of living. There is also a broad consensus that *i*) high rates of investment in broad-based R&D, *ii*) a modern technical infrastructure and *iii*) technically competent human resources are important for the achievement of high economy growth rates (Borrus and Stowsky 1998).

2.2 State of art in the USA technology at the end of the century

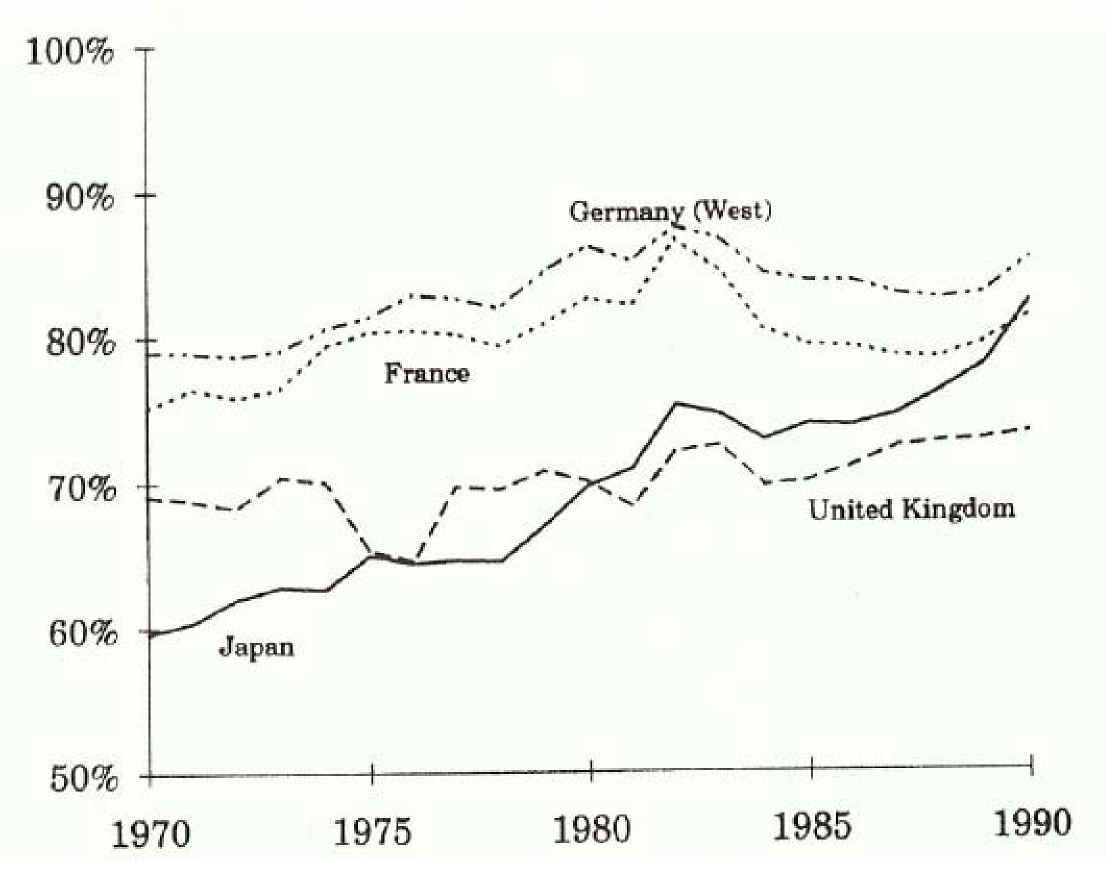
As seen in the previous section, R&D plays an important role as an engine stimulating the productivity rate and accordingly, the economy of the USA. Therefore, in order to more deeply understand the discussions about the USA technology policy, a short look at some indicators revealing the position of the USA economy and its technology at the end of the 20th century shouldn't be missing.

While there is no single indicator of the state of the USA technology and its relative economic competitiveness (Irwin 1993, 17-55), a picture will be presented by using several different indicators describing macroeconomic features (i.e. real gross domestic product, USA exports and imports as well as investments in R&D (i.e. total and civilian R&D expenditures) and comparing them to other developed countries (i.e. Japan, Germany, France, United Kingdom).

2.2.1 Indicators describing macroeconomic features

Level of gross domestic product per capita is one of the most popular measures of the nation's overall standard of living. According to this indicator, the USA is still the most productive nation in the world, however, the gap to Europe and Japan is steadily decreasing (Fig 2.1). If the period between 1972 and 1991 is considered, the gross domestic product per capita increased in real terms by 28 % in the USA. In Japan and in Italy, for comparison, its increases were 87 % and 65 %, accordingly. The average increase of the non-USA members of the G-7 group was 63 % (Council on Competitiveness 1992), which is well over its growth in the USA.

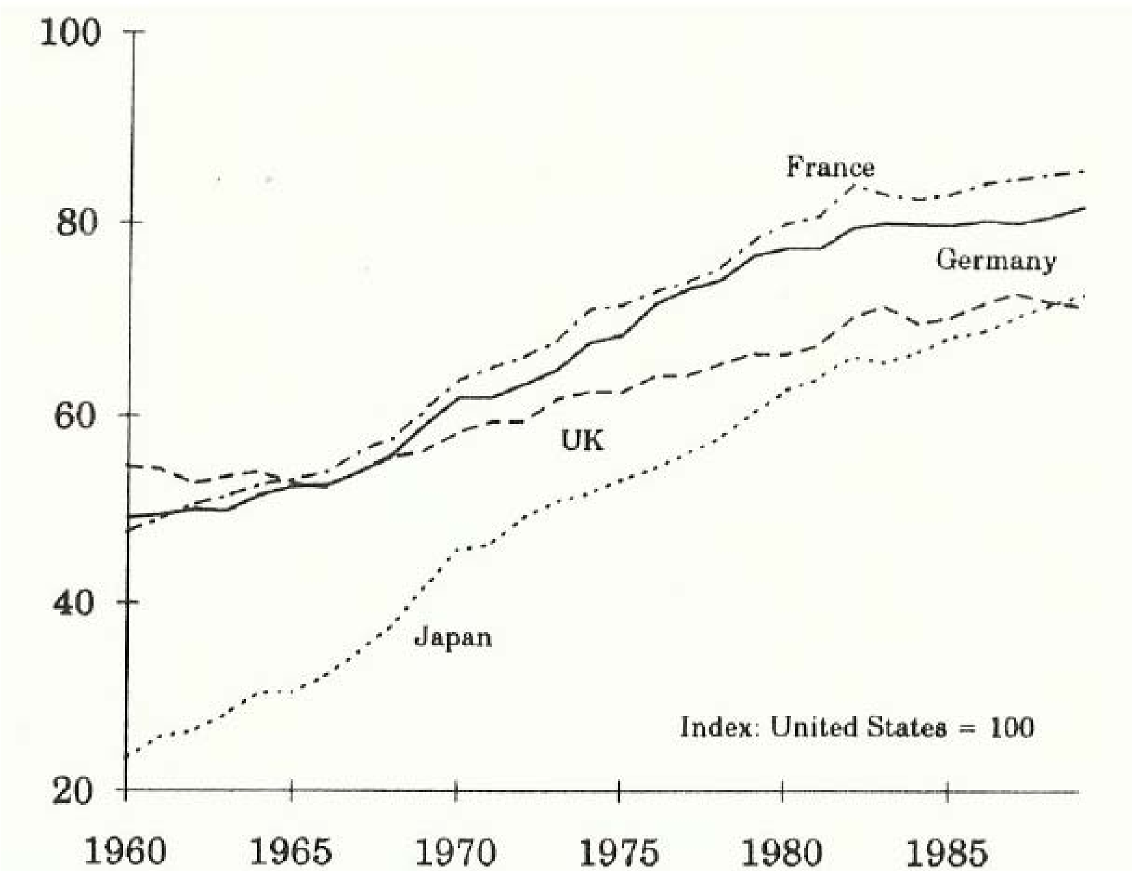
Fig. 2.1: Real gross domestic product per capita in years between 1970 and 1990. The decreasing gap between USA (USA = 100 %) and followers can clearly be seen during this period.



Source: Irwin 1993, 26 (OECD, Department for Economics and Statistics 1992)

Real gross domestic product per employed person is shown in Fig. 2.2. Again, it reveals that the rates of labor productivity growth were higher than the one experienced in the USA in the period between 1960 and 1990. In 1990, however, they still haven't reached more than 86 % of the USA labor productivity (National Science Foundation 1991). If the labor productivity per employed person is divided by the number of hours worked, the achievements in France and Germany are more impressive, with labor productivity being higher than in the USA, however, Japan's labor productivity decreases (McKinsley Global Institute 1992).

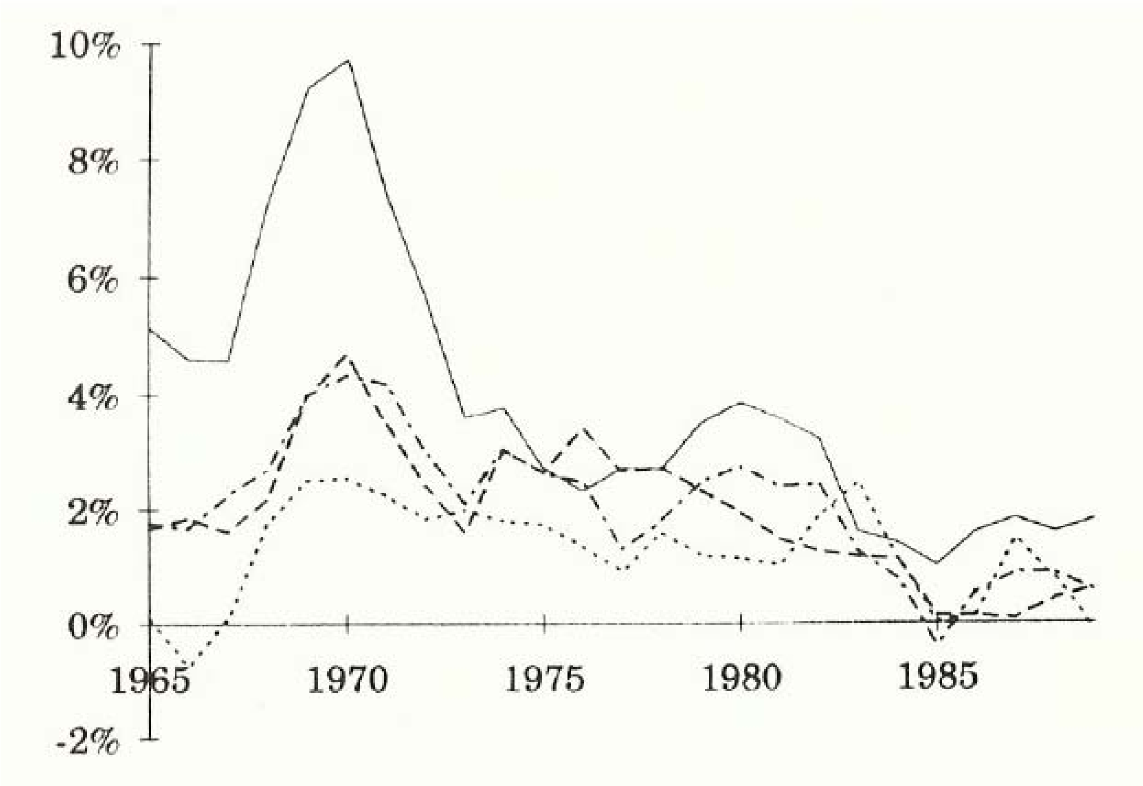
Fig. 2.2: Real gross domestic product per employed person in years between 1960 and 1989. Similarly, a decreasing gap between the USA (USA = 100 %) and followers can be seen during this period.



Source: Irwin 1993 (National Science Foundation 1991)

However, the rate at which the productivity gap between the USA and the other developed countries is decreased demonstrates a slowdown (Fig. 2.3).

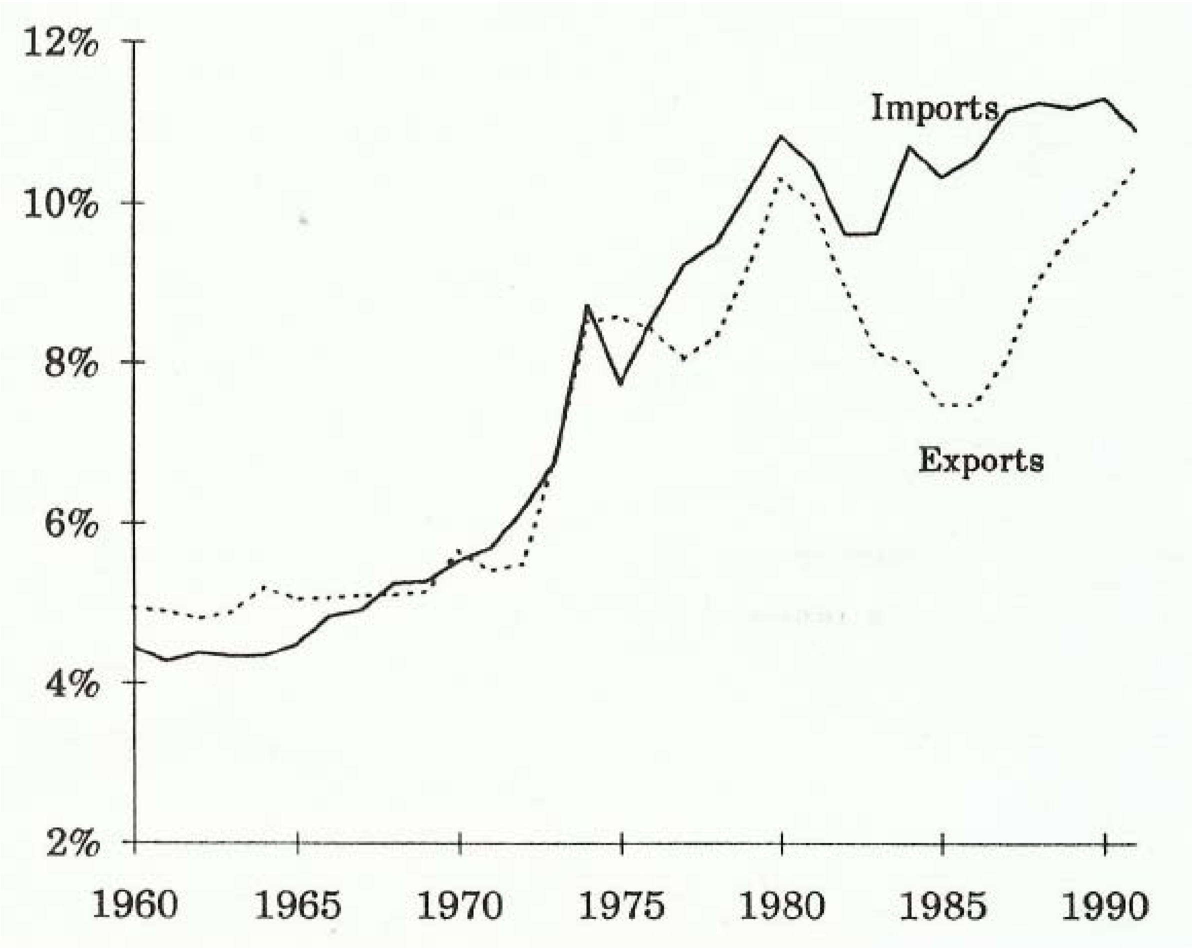
Fig. 2.3: Annual percentage gain in real gross domestic product per employed person relative to the USA. A three-year moving average is shown for the same countries as in Figs. 2.1 and 2.2.



Source: Irwin 1993, 32 (National Science Foundation 1991)

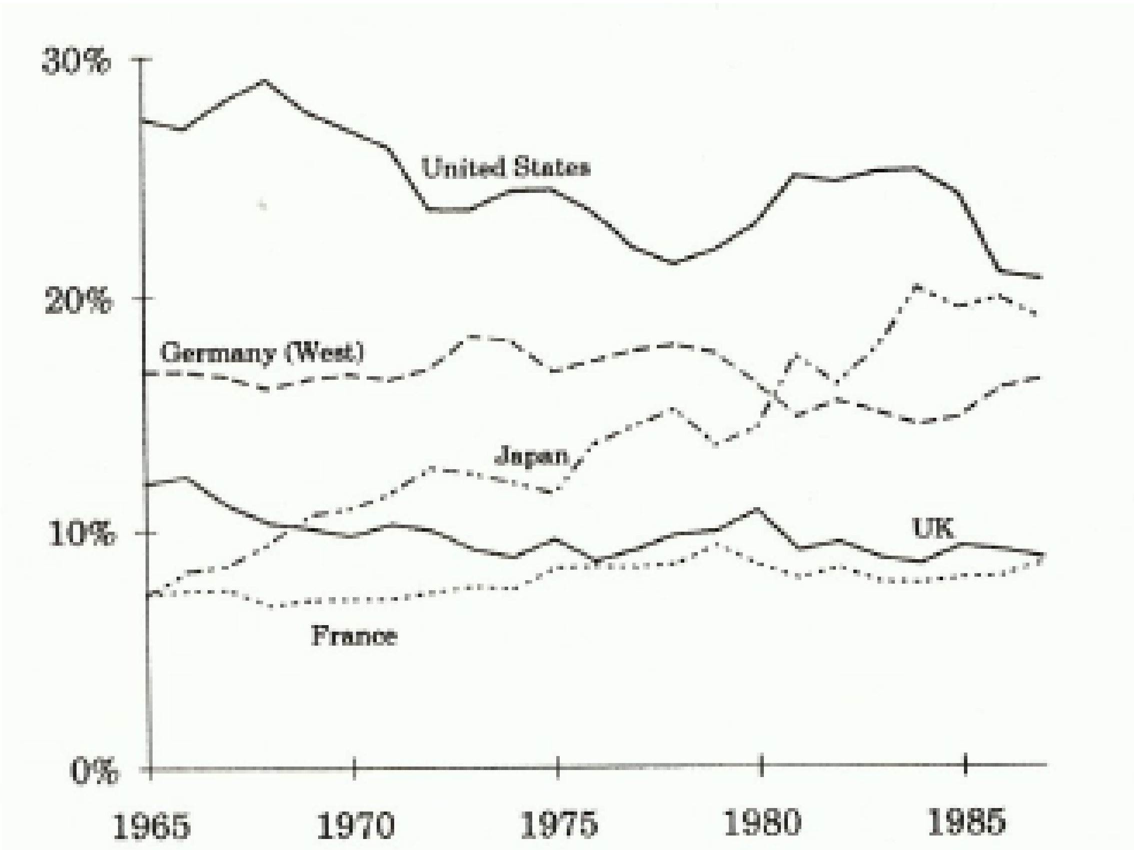
Another interesting parameter to indicate the competitiveness of the USA industry on the international market may be the USA export and import (Fig. 2.4). If the lack of exports in years 1980-1985 may be explained by macroeconomic factors such as non-stimulating US interest and exchange rates and not due to the competitiveness failures, the structure of the export, especially the falling shares in the export of the technology-intensive products could indicate some problems (Irwin 1993). While the European shares of the technology-intensive products remained constant in the period 1965-1987 and the Japanese share more than doubled as seen in Fig. 2.5, the Americans experienced a significant decrease from 28 % to 21 %. If we look at specific sectors, the same pattern of USA export is observed: computers - from 39 % share in 1980 to 24 % in 1989, telecommunications - from 11 % to 9 %, scientific instruments - from 28 % to 25 % and aerospace - from 48 % to 46 %, accordingly.

Fig. 2.4: USA export and import as a fraction of GDP.



Source: Irwin 1993, 22 (National Income Product Accounts 1992)

Fig. 2.5: Shares in the export of technology-intensive products of different countries.



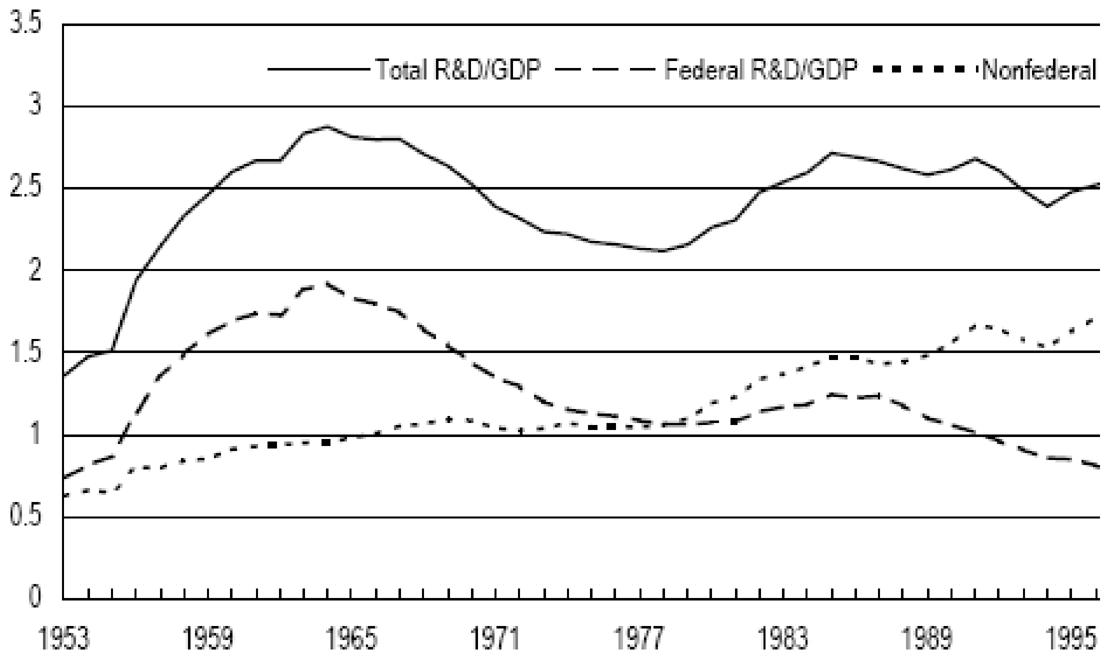
Source: Irwin 1993, 24 (National Science Foundation 1991)

indicators describing macroeconomic features (i.e. real gross domestic product, USA exports and imports as well as (i.e. total and non-defense R&D expenditures) and compare them to other developed countries (i.e. Japan, Germany, France, United Kingdom).

2.2.2 Indicators describing the investment in R&D

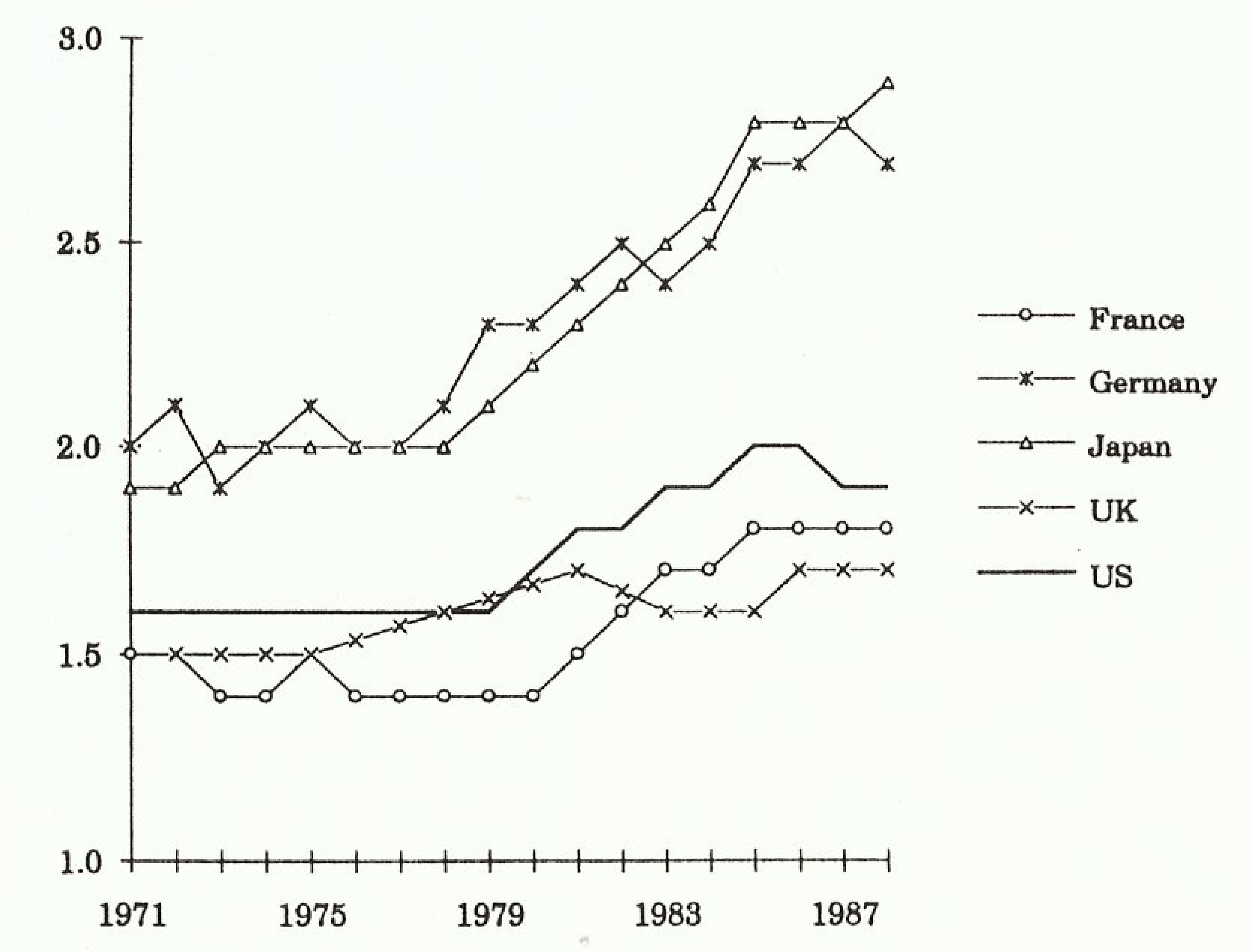
USA spent approximately $ 150 billion on research and development each year around 1990 (Irwin 1993). In 1988, for example, the USA invested more in R&D and employed more scientists and engineers than Japan, Germany, France, the United Kingdom, Sweden and Italy. In the time between 1953 and 1990 the industry and government R&D funding has grown in real terms by 475 % (National Science Foundation 1990; National Science Foundation 1991). As seen in Fig. 2.6, the USA spent 2.7 % of its GDP in year 1961, which was the highest percentage compared to any other industrialized country at that time. Most of them, including Japan, spent between 1.2 % and 1.4 % in 1961 (National Science Foundation 1991). In year 1990, however, the same percentage of GDP is encountered in the USA, while Japan already spends 3.1 % of its GDP and West Germany 2.8 %, accordingly. The changing situation is even more pronounced if we consider that the majority of the USA federal funds (approximately 60 %) flow into military R&D, while only 19 % and 9 % in Germany and in Japan, respectively. Subtracting the military R&D expenditures, another picture emerges (Fig. 2.7). The USA spent in 1990 only 1.9 % of its GDP compared to Japan with 3.0 % and West Germany with 2.7 %.

Fig. 2.6: Total R&D spending in USA as a percentage of GDP in years 1953 - 1996.



Source: Boroush 2008 (National Science Foundation, annual series)

Fig. 2.7: Total civilian (non-defense) R&D spending as a percentage of GNP in different countries.

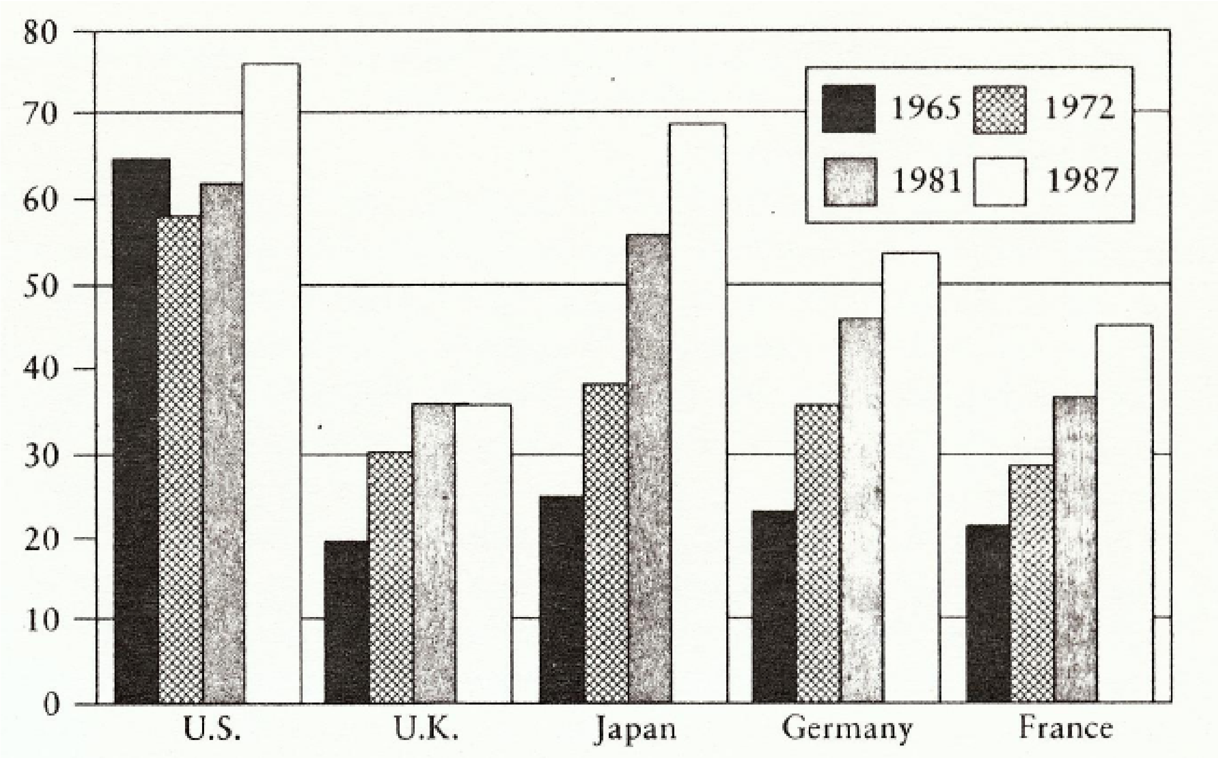


Source: Irwin 1993, 41 (National Science Foundation 1991)

Industrial R&D spending is also considered to be an important indicator for R&D investments in the USA (Fig. 2.6). Namely, in 1991 the USA industry spent around $ 76 billion in research and in addition performed $ 30 billion R&D funded by the federal government. As a consequence, industry is seen as the leading R&D performer in USA with approximately 75 % of all R&D performed. The industry R&D funding grew in real terms by 6.1 % between 1975 and 1980 and by 7.3 % between 1980 and 1985, respectively. In contrast, industry funded R&D fell down to real growth of only about 0.4 % in the years from 1985 to 1992 (Irwin 1993, 42-3; National Science Board Committee on Industrial Support for R&D 1992).

Since knowledge is the ultimate source for creating new ideas, the nation's number of technically skilled people that work and develop at the leading edge, is another important indicator of investment in R&D. As shown in Fig. 2. 8, the comparison between the industrialized countries indicates, again, a closing gap between the USA and the other countries, especially Japan.

Fig. 2.8: Scientists and engineers in R&D per 10.000 labor force.



Source: Nelson 1996 (U.S. National Science Board 1989)

If the USA could claim a technological leadership in cutting edge technologies decades ago, the situation has been changed. Several reports (Irwin 1993, 46; Council on Competitiveness 1991; US Department of Commerce 1990; Office of Science and Technology Policy 1991, 13-5), initiated in the early 1990s to determine the position of the USA, showed comparable results. It was shown (Council on Competitiveness 1991) that out of 94 important technologies that are crucial for competitiveness in the next century, the USA lost or are losing its position compared to the other countries in 15 technologies, were weak in 18 and strong or competitive in the remaining 61. Similarly, in 10 out of 13 emerging technologies Japan was gaining rapidly or has already surpassed the USA. Holding the same trend further, Japan would be better in all areas by the end of the century, in some areas even the European Union. Advanced semiconductors, sensor technologies, medical devices, high-performance computing, biotechnology and advanced materials are fields where the biggest competition problems are encountered (US Department of Commerce 1990, Office of Science and Technology Policy 1991).

In conclusion, although encouraging trends in overall productivity and economic growth rates were determined in the beginning of the 90s, the trends in R&D investment are not satisfying. The macroeconomic indicators show that the USA is still the most productive country in the world, however, the developed industrial countries, especially Japan, are closing the gap. The situation is surely not satisfying if the leading edge technologies are considered where Japan has already taken the lead in several technological areas. These indicators suggest that the technology policy of the USA should be at least reconsidered.

3 TECHNOLOGY POLICY IN THE USA*

"We live in an age of possibility. A hundred years ago, we moved from farm to factory. Now we move to an age of technology, information, and global competition. These changes have opened vast new opportunities for our people, but they have also presented them with stiff challenges."
Ex-president Bill Clinton

3.1 Principles of the technology policy in the past

If we want to fully understand the changes in the technology policy undertaken at the end of the 20th century in the USA, we must know and understand the ways it was evolving in the past.

The evolution of the technology policy could be split into five time intervals (NSTC, Committee on Civilian Industrial Technology 1996, 20-35):

- 1787 - 1941
- 1941 – 1945
- 1945 - 1980
- 1980 - 1988
- 1988 - present

* as seen from the perspective of the last decade of the 20th century

3.1.1 Time interval 1787 – 1941

It is worthwhile to mention that the first technology policy was written into the Constitution of the USA, establishing federal responsibilities to "promote the progress of science and useful arts, by securing for limited time to authors and inventors exclusive right to their respective writings and discoveries" and "fix the standard of weights and measures".

In 1862, the government offered federal land to the states in order to establish colleges for agricultural, scientific and industrial studies. In this way a federal incentive was given the support to basic and applied agricultural research (three out of five Americans worked in agriculture at that time) and to the emerging industrial sector. In 1914, the USA Agricultural Extension service was established, an institution for the advancement and spreading of the knowledge, created together with the colleges, to the farmers. For the needs of agriculture, roads, canals and railroads were built and road research laboratories were established. In 1887 the Laboratory of Hygiene, a forerunner of the National Institutes of Health was established. In 1901, the National Bureau of Standards was created in order to develop the standards for weights and measures. In 1915 the National Advisory Committee on Aeronautics was established by the Congress.

All these institutions, established and supported by federal funds, have laid pioneering work for an increase in productivity of USA agriculture and for the emerging industries in the fields of electricity, aviation, material sciences, medicine etc. They also promoted government-industry R&D, building of infrastructure as well as the education. Federal programs were centered to specific government mission requirements (Irwin 1993, 85). The research was done by scientists and engineers, employed directly by the government.

Aside from these notable exceptions, only a limited support was given by the government to the commercial industry. At the beginning of the 20th century, namely, the USA industry experienced a tremendous growth and increasing sophistication. In addition, USA industrial giants became the world's leading innovators. The government left the initiative to private inventors and "corporations" also in the field of basic sciences – an arrangement also preferred by private sector in order to prevent the interference by the state.

3.1.2 Time interval 1941 – 1945

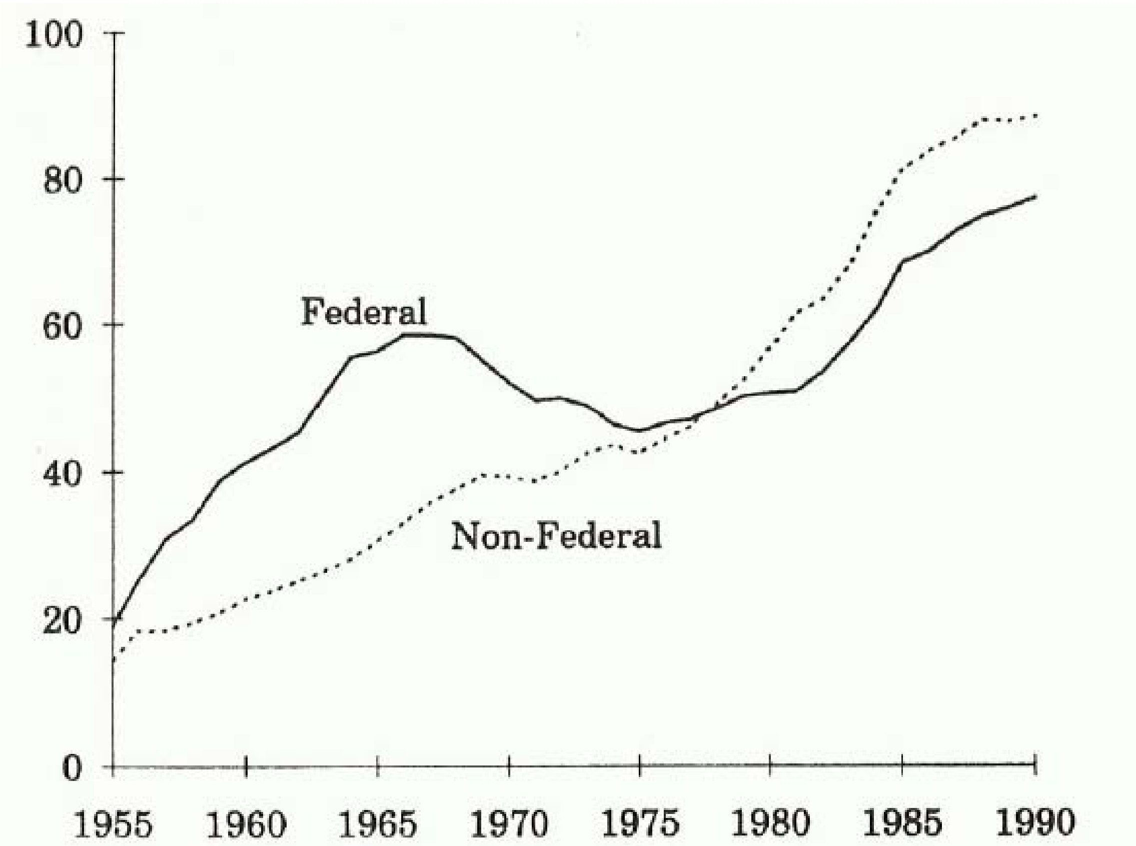
The need to be superior to the enemy and to win World War II, put a lot of pressure on R&D. As a consequence, the technical breakthroughs were enormous. Most notable, the development of the atomic bomb changed the altitude of the government's policy-makers towards the role of science and technology. They found a link between R&D and the military supremacy.

3.1.3 Time interval 1945 – 1980

The importance of R&D for the nation's defense was even underlined by the onset of the Cold War, yielding to an increased federal R&D spending for the development of the defense technology. The altitude of the government towards the basic scientific research has also changed. The federal support for the "research on the frontiers of science" has started to be seen as essential for the defense as well as national economy. Hence, a consensus has emerged that *i*) federal government has the primary responsibility for funding of basic research, performed by private universities, corporations and government laboratories, *ii*) Department of Defense invests in R&D for the development of weapons and *iii*) private sector takes responsibility for the commercial technology development (Irwin 1993, 85-7).

As a consequence, an increase in federal spending was experienced. As seen in Fig. 3.1, the annual increase between 1953 and 1961 was around 14 %, stimulated by the launch of Sputnic and the escalation of the Cold war. During the late 60s and 70s the spending decreased. The federal investments remained relatively limited to the defense sector, energy and environment, and space exploration. This research wasn't judged from the perspective of the national economy well-being. The contribution to the commercial sector was considered to be through "spin-off"s and in fact, it has yielded important commercial benefits on the fields like computer, biotechnology and commercial air craft industry.

Fig. 3.1: Federal R&D spending in billions of constant 1992 dollar.



Source: Irwin 1993, 24 (National Science Foundation 1991)

There were few exceptions to that general consensus. The federal assistance for the agriculture and health R&D continued from the prewar times. In addition, large technology demonstration projects like development of a supersonic aircraft, commercial satellite technologies, breeder reactors, new fuels and photovoltaic technologies were initiated after 1960 and funded by the federal government in order to help the commercial sector (Irwin 1993, 89).

3.1.4 Time interval 1980 – 1988

A decreased economic growth in the USA in the 70s and a penetration of foreign products on the national market characterized this time period. In spite of an increased military R&D spending in the 80s an impetus to abandon the consensus that was lasting from World War II grew increasingly. The change of the technology policy, especially the attitude of the government towards the commercial technology, seemed to be inevitable (Irwin 1993, 91).

As a result, efforts focused primary on general measures to facilitate private investment in R&D and to stimulate the transfer of federally funded technologies to the private sector. Laws enabling *i*) private sector an easier access to federally funded research, *ii*) enactment of the R&D tax credit, *iii*) loosening of antitrust laws in order to stimulate the R&D cooperation among companies, *iv*) cooperative R&D agreements of federal agencies with companies, universities and non-profit organizations and *v*) stronger worldwide protection of intellectual property rights were accepted.

In conclusion, the USA technology policy has experienced significant changes in the past in spite of the fact that the USA has always stressed research and development as one of its most important goals. Starting from a very passive role of the federal government in basic and applied research as well as in development, first major change in the technology policy occurred during the World War II, led by the merits of R&D to win the war. Linked together with the importance for the nation’s defense, the role of the federal government expanded and an enormous support for military R&D as well as broad basic research emerged. However, no funding of the commercial R&D was executed in order to leave the ultimate decisions to the free competition of the market. The effects of the federal support on the commercial industry were experienced through spin-offs from the federally supported military R&D and some directed projects. However, an increased competition from Japan and Europe in the 80s was forcing the USA policy-makers to develop government-industry partnerships for technology development, diffusion and commercialization in order to improve the long-term prospects of the USA economy.

Agriculture, infrastructure, energy and environment, health, education and space were the only areas of R&D that were financed all the time by the federal government, primarily due to their big social returns.

3.2 Technology policy for the 21st century

"Cutting back on research at the dawn of a new century where research is more important than it has been for even the last fifty years would be like cutting our defense budget at the height of the Cold War."

"Investing in technology is investing in America's future: a growing economy with more high-skill, high-wage jobs for American workers; a cleaner environment where energy efficiency increases profits and reduces pollution; a strong, more competitive private sector able to maintain U.S. leadership in critical world markets; an education system where every student is challenged; and an inspired scientific and technological research community focused on ensuring not just our national security, but our very quality of life."

Ex-president Bill Clinton

With the end of the Cold War in 1988 and the decay of the Soviet Union the entire political situation in the world changed. Although this was primarily a political milestone, depicting the end of the communist block, it influenced significantly the technology policy of the USA.

Therefore, studying the technology policy of the USA, the year 1988 seems an appropriate time to start with, when the current as well as the future technology policy is considered. This time was characterized, as already indicated in the last section of chapter II, by the loss of competitive advantages in the commercial industry, especially in the leading edge technologies. In addition, it seemed that there was no need to invest huge amounts of money in military R&D in order to gain military supremacy and thus, the possibility existed to redistribute the federal funds into the commercial sector.

Indeed, several reports prepared by Defense and Commerce Departments as well as by the Office of Science and Technology Policy have favored more active federal technology policy (Irwin 1993, 92). The voices from various industry organizations and private think tanks also stressed the need for a more coherent federal technology policy. The trend of the USA technology policy was turning more and more towards the commercial sector with the legislature that established the Advanced Technology Program and the Manufacturing Extension Partnership, with programs initialized to help to develop high-risk enabling technologies and to provide technical and management assistance to small and mid-size manufacturers in 1988, with the announcement of the High Performance Computer and Communications Program in 1991 and with the congressional funding of several "dual-use" technology developments within the Department of Defense.

Although Bush administration previously rejected a federal role in commercial technology development, the Executive Office of the President submitted a report to the Congress in 1990 that was prepared by the Office of Science and Technology Policy in coordination with several federal departments and agencies. Named "US Technology Policy" it outlined a wide range of federal responsibilities (Irwin 1993, 32; Executive Office of the President, Office of Science and Technology Policy 1990, 5): *i*) encouraging technology investments through monetary and fiscal policies, *ii*) providing an environment without obstacles for innovation, *iii*) eliminating regulatory barriers to integration of government and commercial production, *iv*) easing technical data rights requirement to facilitate the commercialization of government-funded technologies, *v*) providing a stable regulatory environment, *vi*) negotiating comparable regulatory guarantees with other countries, *vii*) promoting international standards and *viii*) enforcing intellectual property rights at home and abroad. For the first time it was also mentioned that the government's responsibility is also to participate with the private sector in precompetitive research on generic, enabling technologies that have a broad range of government and commercial applications. The submission of this document by the Bush government showed that the changes in the technology policy became a political necessity in the USA.

The Clinton administration came to office at a time of increasing concern about the state of U.S. technology and competitiveness. In February 1993, a vision for the technology policy which was the core element of the Administration's strategy for long-term economic growth was presented by President Clinton. In "Technology for America's Economic Growth: A New Direction to Build Economic Strength" measures were set to ensure global technological leadership of the USA into the next century. The technology policy is guided by five principles (Executive Office of the President, Office of Science and Technology Policy 1997, 41; Science and Technology Shaping the Twenty-First Century and Executive Office of the President, Office of Science and Technology Policy 1990, 37):

- the USA must retain a long-term commitment to research, education, and innovation even in the periods of budgetary constraints;

- the primary role of the federal government in technology policy is to create a business environment in which innovative and competitive efforts of private sector can flourish;

- federal government must encourage the development, commercialization and the use of civilian technology as well as promote the integration of civilian and military industrial bases;

- federal government must help to create a world-class infrastructure for the 21st century to support the industry and commerce;

- USA must develop a world-class working force for a rapidly changing, knowledge- based economy.

The government believed that these initiatives would help the USA to ensure that the technology remained the engine of the economic growth, to create high-wage jobs and to improve the standard of living and the quality of life (Executive Office of the President, Office of Science and Technology Policy, Science and Technology Shaping the Twenty-First Century 1997, 35-56).

In order to enforce a more effective management of federal portfolio a cabinet level National Science and Technology Council was established. This high-level council which started to coordinate the science and technology policies in the federal government underlines the position of the R&D in the USA. In addition, the President named the President's Committee of Advisors on Science and Technology Council. It advises the President on matters involving science and technology and assists National Science and Technology Council to secure private sector involvement (see Appendix).

3.2.1 Creating a healthy business environment

To create a healthy business environment in which innovative and competitive efforts of the private sector can flourish is according to the present technology policy of the USA the primary role of the federal government. This means that the government has to eliminate unnecessary legal, regulatory and economic barriers that impede the development and commercialization of new technologies. It should also rethink about the impact of proposed laws and regulations on the competitiveness of USA industry as well as stimulate innovation through new policies (Executive Office of the President, Office of Science and Technology Policy, Science and Technology Shaping the Twenty-First Century 1997, 38).

Fiscal policies affect the cost and the availability of the capital which is needed by the firms for the investment in technology, product development and manufacturing. Therefore, the government made great efforts to decrease the federal budget deficit and to balance it in order to make more capital free for private investments. Another measure was to permanently extend the research and experimentation credit which offers an incentive for firms to invest in new technologies.

Regulatory policy was reformed in order to take care that the goals for the environment, health and consumer protection were achieved with the lowest possible burden to the industry. Unnecessary paperwork as well as unnecessary regulatory barriers were removed. Regulations were conceptualized in a way to encourage the development of innovative technologies. For example:

- amendment to the 1984 National Cooperative Research Act in 1993 further reduced antitrust barriers for the cooperation of the firms in order to reduce costs and risks of R&D and establish production facilities;

- in 1995 the National Institute of Health dropped the “reasonable pricing”, a provision that was seen by the industry as a barrier to cooperate with this federal institution;

- passage of the Telecommunications Act of 1996 which should support new innovations, jobs in the 21th century;

- federal government worked together with industry to verify critical environmental technologies and helped to capture global markets for environmental technology.

Trade policy changed in order to ensure fair competition for the USA technology products. The export controls on key telecommunication, supercomputer and other products were changed in order to open the international markets to high-tech products from the USA. The North American Free Trade Agreement (NAFTA) provided high protection of patents and other intellectual property. The Trade Related Aspects of Intellectual Property, an accord reached under GATT, increased the protection for copyrights, trademarks, patents, industrial designs, and trade secrets. GATT protects against unfair government support in late-stage technology development, thus, ensuring free competition on international markets and government support of industrial R&D only in the pre-competitive stage of non-manufactured prototypes.

3.2.2 Technology development and commercialization

As already mentioned in the previous section, the change in the technology policy towards the private sector for commercial use has changed in the 80s. In addition to the spin-offs, gained as a consequence of the federal expenditures into military R&D, the federal government is now working with the private industry hand-in-hand to combine resources for new technological development. The federal government has to encourage the development, commercialization and the use of technology (Executive Office of the President, Office of Science and Technology Policy 1990, 49-62; Executive Office of the President, Office of Science and Technology Policy, Science and Technology Shaping the Twenty-First Century 1997). It has to invest into nascent technologies that offer large economic and social returns. Furthermore, the federal government has to take care that the findings from the federal research come to the private sector and - in partnership with state and local governments, the academic community and the private sector – has to cultivate mechanisms that encourage widespread deployment and use of technology.

The Advanced Technology Program (ATP) is sponsored by the Department of Commerce in order to share the costs of the development of the enabling and emerging technologies. Thus, broad-based economic benefits and high rates of social return are intended to be achieved through this "technology partnership". ATP forms partnerships and joint ventures with companies, the government acts as a catalyst and the industry conceives co-funds and executes the ATP projects. The industry also acts as a source for new ideas. These projects are multi-year projects for specific, well-defined technology and business goals. Through managing similar projects the government can complement them and thus, induces a synergy that is very important for the industry in the future. There are several examples of ATPs, let us mention only some of them:

- auto body consortium: formed in 1992 through ATP out of eight small and medium automobile technology suppliers and Chrysler, General Motors and two universities in a program that was aimed to develop new manufacturing technologies, practices and training techniques to fit automobile parts up to 2 mm precisely.

- tissue engineering: a Massachusetts company was awarded by ATP for developing technologies at the leading edge of tissue engineering. The integration of advances in cellular biology and textile manufacturing is necessary for the creation of "prosthetic tissue" which is manufactured like cloth for biodegradable implants.

- nanophase technologies: a small start-up company (two men) gained an ATP for development of a production process for ultra fine ceramic and metal powders. These powders with the size in a nanometer scale could be applicable in a wide range from skin-care products to high-performance engine parts.

In addition directed, large-scale "**partnering for mutual benefit**" with private industry have also been encouraged and developed, they are following a joint R&D in specific areas with their ultimate aim to promote the national economy. Let us mention some of them:

- partnership for a new generation of vehicles: to improve the competitiveness of U.S. automobile industry since one of every seven jobs in the USA is connected to the car manufacturing industries. Seven federal agencies and 20 national laboratories have joint together with the "Big Three" automobile manufacturers (Ford, Chrysler, General Motors) and more than 400 suppliers to achieve R&D goals in three areas: new manufacturing methods; better automobile efficiency, safety and emission; automobile prototype with three-fold improvement in fuel efficiency.

- Industry of the Future Program is shaped to co-fund the R&D with energy intensive industries in the USA (i.e. steel, chemicals, forest and paper, glass, petroleum, aluminum, textile) to develop new technologies in order to reduce the energy, resources consumption and pollution.

Another form of the R&D federal support is the "**federal mission research**". The federal government invests more than $ 71 billion annually to advance science and to develop new technologies. The results, developed in national laboratories jointly with the universities and private companies, have a significant impact on the commercial sector. Some of the forms of this mission research are briefly presented.

The 1986 Federal Technology Transfer Act gave the basis for the cooperation between the federal laboratories and the private sector. In 1996, private sector received even greater assurances for retaining intellectual property rights from these cooperative research and development agreements (CRADA). This cooperation was meant to enforce the enabling and emerging technologies to be developed in a competitive time frame. The private firms, namely, would be unable to do it alone (or maybe, too slow) due to high cost, high risk and late investment return in spite of the fact that these technologies are the fundamental block for the future economic growth and prosperity. The federal laboratories formed alliances with the private sector in R&D areas of mutual interest, and in addition, the technology was most efficiently transferred to the private sector as part of their functions. Between 1992 and 1994, a number of licenses of federal patents granted to the industry almost doubled, licensing royalties paid to the federal government became as high as $ 24.5 million annually (Executive Office of the President, Office of Science and Technology Policy. Science and Technology Shaping the Twenty-First Century 1997, 39). In 1997, there were 13 federal agencies engaged in 3.500 CRADAs with the private sector – an increase of 177 % compared to 1992. The National Institute of Health (NIH) started 353 CRADAs with private organizations that brought $ 31 million in industry resources. Thus, the enabling and emerging technologies are being developed with the help of the federal government.

Partnerships in aeronautics are another example of federal mission research. They are developed to meet the challenges of a $ 15 billion USA industry, for example problems posed by air traffic growth (security, delays), environmental constraints, an aging aircraft fleet and the foreign competition. This field of technology has been supported by the federal government for a long time, however, a National Aeronautics and Space Administration's (NASA) Aeronautics Enterprise identifies, manages the R&D for high pay-off aeronautics technologies together with the U.S. industry and universities as well as Department of Defense and Federal Aviation Administration. These technologies are developed to the level that the customers (industry) can clearly meet the decision about their further application. In addition, NASA has established over 3500 partnerships with industry.

The National Institute of Health (NIH) has identified five R&D areas of interest. Their R&D will enlarge knowledge which will be of interest to industry and will experience social profit in form of an improved health and quality of life as well. Between 1985 and 1996, NIH was awarded 667 patents and executed 896 licenses to develop commercial applications based on these patents. Accumulated sales of products based on these licenses were around $ 2 billion and brought $ 122 million in royalty income.

There is another public-private R&D cooperative research program in construction and building, an industry with 3.5 millions of workers and 8 % of U.S. GDP.

Similar projects are running in the field of biotechnology, an area which will create thousands of new jobs, promote economic growth and hopefully, help to solve agricultural, environmental and health problems. 13 Federal agencies are involved in this R&D, in 1997 already 40 approved biotechnology drugs and more than 700 biotechnology derived medical devices were on the market.

Small Business Innovation Research Program is designed to encourage small business to participate in federal mission related R&D and to take commercially promising new technologies to the market.

Several programs were expanded in order to speed up the dissemination of technical information. Namely, the knowledge of the promising government research, more competitive manufacturing techniques or management practices can lead to the advantage of private sector on the market. Some examples are presented bellow.

The establishment of The Manufacturing Extension Partnership (MEP) in 1988 has given a push to found a nationwide network of extension centers. Established in all 50 states and Puerto Rico till 1996, they gave assistance to 381.000 small and medium-sized manufacturers an advice how to modernize their production capability in more than 300 sites nationwide. More than 2.800

manufacturing engineering and business experts are giving the advice about the implementation of new technologies and approaches, upgrades of their equipment and thus, help to strengthen the business performance of small and medium-sized manufacturers. These firms form a backbone of the U.S. industrial base representing about 95 % of the manufacturing plants. The MEP is led by Commerce Department's National Institute of Standards and Technology and works with non-profit state and local partners. For example, two achievements should be shown: the economic impact of New York centers' was estimated to be as high as $ 175 million in 1995 and with their help, a Chicago firm increased the sales by 30 % increase and grew the employment by 20 %.

The National Technical Information Service is providing a vast amount of scientific and technical information of potential value to the private sector. It maintains around 3 million documents and adds 100.000 each year.

Malcolm Baldrige National Quality Award has been developed to improve the adoption of management innovations and it recognizes the firms with the highest level of quality management.

To promote **the integration of civilian and military industrial bases** administration's initiatives in dual-use and acquisition reforms are necessary. They will remove the barriers between the military and commercial industrial bases like special defense requirements and business practices. In this way, many leading-edge technologies that have been developed for commercial purposes will be used for military purposes at much lower cost. Two basic principles are accepted: the dual-use technologies and defense acquisition reform.

The dual-use strategy is based on three pillars: *i*) dual-use R&D to find the potential of advanced commercial technologies for military use, *ii*) integration of military and commercial production and *iii*) insertion of commercial products, processes and technologies into defense systems. The Technology Reinvestment Project (TRP) awarded nearly $ 1 billion for "dual-use" R&D in a competitive funding over 1993 - 1995. The federal government only matched the projects with co-funding less than half of the expenses. The TRPs were awarded for the development of composite aircraft structures, detection of chemical and biological agents, low-cost night vision, high-density data storage devices and battlefield casualty treatment. A Dual-use Applications Program will increase involvement of dual-use technology by the military to speed up its insertion into weapon systems as well as to promote its acceptance.

The defense acquisition reform will enable that the Department of Defense and other federal agencies could easier buy commercial components, products and services. It will also streamline contracts for smaller purchases as well as authorize the Department of Defense to test the approaches to buy commercially derived aircraft engines and other items. This procedure was extended to cover the entire facilities and to further simplify the contracting procedures for less than $ 5 million purchases. The specifications for military items were also simplified in order to adopt the commercial or performance-based standards.

International cooperation is another important aspect of the technology policy at the end of the 20^{th} century. As a consequence of the increased globalization the U.S. multinational corporations move their R&D to other countries as well as other companies bring their R&D to the USA. In addition, more R&D takes place also as cooperation between USA and foreign companies. The USA companies benefit from this cooperation since they get new technologies, markets and a reduced cost for technology development. However, the barriers exist for the international R&D and agreements will be necessary to overcome the problems. An initiative was led by the USA in the Organization for Economic Cooperation and Development (OECD) to develop the rules for governments as well as companies. The "Principles for Facilitating International Technology Cooperation Involving Enterprises", signed in 1995, call upon governments to protect intellectual property, apply international standards and encourage small and medium-seized enterprises in cooperative projects (Executive Office of the President, Office of Science and Technology Policy. Science and Technology Shaping the Twenty-First Century 1997, 51). This agreement recognizes the primary role of private firms to develop a competitive technology base in order to use it for commercial purposes. However, the national governments have an important role in creating an environment that will encourage industry to long-term investments in technological innovation.

3.2.3 World-class infrastructure

The role of the government to invest into the infrastructure is the same as it was more than a century ago when the investments in canals, railroad transportation, aviation and the national highway system were undertaken. A good infrastructure remains the basis for the nation's future, especially for the development of nation's industry and commerce. In addition to an efficient high-performance transportation infrastructure, national standards research as well as test and measurement capability applicable to new technologies, knowledge-based economy demands the application of new information technologies.

In 1993 the National Information Infrastructure (NII) was articulated. Its guiding principles were: *i*) promote private sector investment, *ii*) extend the "universal service" concept to ensure that information resources are available to all at reasonable prices, *iii*) promote technological innovation and new application, *iv*) promote seamless, interactive, user-driven operation of NII, *v*) coordinate with other levels of government and other nations and *vi*) provide access to government information and improve government procurement.

The USA is building up the basis for the NII which will link different places (i.e. institutions, firms, homes) and enable a huge amount of knowledge sharing. It is led by private firms, however, the role of the government is to complement and enhance the efforts of the private sector to provide the information infrastructure to all citizens at reasonable prices. Thus, the Telecommunications Information Infrastructure Assistance Program supervised by the Department of Commerce awards competitive matching grants to school districts, libraries, state and local governments, health care institutions, universities and other non-profit organizations in order to connect into the existing network. In 1994, a global network system was proposed by the American government, which would be built on the ideas and experiences of the national information infrastructure.

The Federal High Performance Computing and Communications Program (HPCC) was launched in 1991. It has conducted long term R&D in advancing computers, communications and information technologies with its aim to advance information technologies across the government and throughout the economy. Its primary areas were: high end computing and computation, large scale networking, high confidence systems, human centered systems as well as education and training. This federal R&D has already created an array of accomplishments and, thus, contributed to the U.S. leadership in the Information Age.

The Intelligent Transportation Initiative (ITI) was established by the federal government in order to develop a basis for an intelligent information transportation system in 75 largest metropolitan areas. In the USA, the business loss is estimated to be around $ 40 billion due to traffic congestion each year. Developed in cooperation with the state and local governments as well as with the private sector, the system will consist of traffic control centers that will provide real-time traffic information of all major streets and respond rapidly in case of car accidents or breakdowns. Through this intelligent system a 15 % saving in travel time is expected. The alternative would be to enlarge the highway system capacity by one third. That would cost $ 150 billion only in 50 largest cities in the USA. A development of this intelligent transport system which would increase the capacity by two-thirds, is estimated to cost $ 10 billion. The pilot experiments in Seattle show, for example, a 50 % travel time shortening due to an advanced freeway management system. An extension of this ITI to the sea and in the air is planned in the future.

The Global Positioning System (GPS) will also enormously change the transportation. Being developed originally for military purposes, it represents a case of dual use navigation technology. It has been promoted as the backbone of the new Global Navigation Satellite System. It will improve the safety in the air and on the ground. It will also serve as a tool for the automatic vehicle control including mass transit, intelligent vehicles as well as railroads.

National Institute of Standards and Technology is, as in the past, engaged in the development of measurement methods, standards, data evaluation and test methods. This goal will be achieved through the cooperation with the USA industry and other national and international standard-setting organizations. The USA Patent and Trademark Office has been promoting technological process and innovations by issuing patents to inventors. Today, it examines the existing legal regimes and adapts them to meet the challenges of the 21st century. In addition, USA Patent and Trademark Office are trying to improve the legal regimes in foreign countries.

3.2.4 World-class working force

"Education has been at the heart of America's progress for over 200 years. Let us pledge to give our children the best education in the world, and the support they need to build strong futures, higher standards in our schools, more choices, and the opportunity for all Americans to go on to college."

Ex-president Bill Clinton

The knowledge and the ability to use information and technology are becoming increasingly important for the countries as well as the individual citizens in a knowledge-based economy (all: Executive Office of the President, Office of Science and Technology Policy 1990, 75-9). New form of work organization in the USA firms requires conceptual, interpersonal, communication and self-management skills. Many USA citizens are not prepared well enough for the workplace challenges in the 21st century. It is estimated that only 22 % of workers today posses the skills that will be needed in 60 % of jobs in year 2010 (Executive Office of the President, Office of Science and Technology Policy 1990, 75). The disparities that are in a direct correlation with the education are increasing – namely, a full-time male worker with at least bachelor's degree earned 49 % more than one with only high school diploma in 1979, this difference almost doubled to 89 % by the year 1993. Several steps are planned by the federal government to meet these challenges.

The "Goals 2000" set the goals in the elementary and secondary education. The Educate America Act of 1994 is aimed to promote USA student's knowledge in mathematics and sciences, adult literacy and life-long learning. Both, teaching and learning has to be improved through a set of well-defined standards. Goals 2000 establishes a very ambitious goal, namely, that the USA students will be worldwide the first in science and mathematics. This poses a great challenge to the educators as well as students, since according to international comparison the USA students rank below the average of the other developed countries (Tables 3.1 and 3.2). The federal government will invest to improve mathematics and science education with the focus in teacher skills, improvement of science and mathematics curricula and promotion of systemic reforms.

The School to Work Opportunities Act of 1994 provides assistance to states and localities in partnership with business, educators and labor organizations to prepare young people for the first job.

Table 3.1: Nation’s average performance in mathematics in international comparison.

Nations with average scores significantly higher than the USA:

country	**average performance**
Singapore	643
Korea	607
Japan	605
Hong Kong	588
Belgium-Flemish	565
Czech Republic	564
Slovak Republic	547
Switzerland	545
Netherlands	541
Slovenia	541
Bulgaria	522
Austria	539
France	538
Hungary	537
Russian Federation	535
Australia	530
Ireland	527
Canada	527
Belgium-French	526
Sweden	519

Nations with average scores not significantly different from the USA:

country	average performance
Thailand	522
Israel	522
Germany	509
New Zealand	508
England	506
Norway	503
Denmark	502
United States	**500**
Scotland	498
Latvia	493
Spain	487
Iceland	487
Greece	484
Romania	482

Nations with average scores significantly lower than the USA:

country	average performance
Lithuania	477
Cyprus	474
Portugal	454
Iran	428
Kuwait	392
Columbia	385
South Africa	354

Source: Executive Office of the President, Office of Science and Technology Policy. Science and Technology Shaping the Twenty-First Century 1997, 119

Table 3.2: Nation's average performance in science in an international comparison.

Nations with average scores significantly higher than the USA:

country	average performance
Singapore	607
Czech Republic	574
Japan	571
Korea	565
Bulgaria	565
Netherlands	560
Slovenia	560
Austria	558
Hungary	554

Nations with average scores not significantly different from the USA:

country	average performance
England	552
Belgium-Flemish	550
Australia	545
Slovak Republic	544
Russian Federation	538
Ireland	538
Sweden	535
United States	**534**
Germany	531
Canada	531
Norway	527
New Zealand	525
Thailand	525
Israel	524
Hong Kong	522
Switzerland	522
Scotland	517

Nations with average scores significantly lower than the USA:

country	average performance
Spain	517
France	498
Greece	497
Iceland	494
Romania	486
Latvia	485
Portugal	480
Denmark	478
Lithuania	476
Belgium-French	471
Iran	470
Cyprus	463
Kuwait	430
Columbia	411
South Africa	326

Source: Executive Office of the President, Office of Science and Technology Policy. Science and Technology Shaping the Twenty-First Century 1997, 119

The cost of higher education is often a barrier which prevents many USA citizens to go to college. A new Federal Direct Loan Program allows individuals to borrow money directly from the federal government for the higher education. The repayments can be tailored according to individual needs.

In addition, business has been allowed a tax deduction for the costs of employee education. A tax deduction of up to $ 10.000, proposed in 1994, would provide individual Americans an incentive for further education and training.

Undergraduate and graduate education is considered to be the key to obtain a pool of well educated and trained scientists and engineers. They are increasingly important for the USA society which is more and more dependent on advanced scientific and technological achievements. USA universities and colleges offer one of the best opportunities for advanced education accompanied by leading-edge research. In spite of that, the interest in science, mathematics, technology and engineering is decreasing with a higher level of education. Therefore, the federal government is working as a catalyst to change the way of education in these areas including curriculum improvement programs, organizational reform and faculty enhancement.

Federal government also supports students by fellowships and traineeships in pre- and postdoctoral programs. They provide grants for assistantships as well. The share of Ph.D.-level scientists at academic institutions has been steadily declining for more than the last two decades. Therefore, the university-private sector cooperation through the industry-university research will offer the students a chance to gain the insights into the leading-edge technologies and awareness of opportunities and needs of the private sector.

In a fast changing, technology and market dependant society the industry has to adapt quickly to the changes and the same is true also for the working force. As a consequence, many jobs and companies are eliminated. In the period between 1973 - 1988 9.1 % jobs were created in manufacturing sector per year and 10.3 % were destroyed. These changes required at least 11.7 % of workers in the manufacturing industry to change their jobs. Hence, the federal government tries to change the unemployment system into a reemployment system that will offer a smooth change from one job to another. It is based on one-stop career centers that will offer job counseling and information on training programs, job openings etc. The system of training programs will be reorganized in order to unify a complicated system of many separate programs with different restrictions and rules into a single choice-based program. The program will be supported by skill grants.

The Goals 2000: Educate American Act established a board to develop a national system of occupational skill standards. This will strengthen the connection between the skills needed at the workplace and the ones, gained by the education and training and, thus, smoothen the transition between different jobs as well as enforce the wish to educate.

Despite drastic changes in the information and communication technologies the U.S. schools remain in an unchanged “chalk and talk” way of education. The National Information Infrastructure initiative is established to promote the use of new information technologies for the education and training needed in the 21st century for the knowledge-based economy. Initiatives to connect every classroom to information superhighway and to adopt new telecommunication technologies in schools, libraries and universities are being set. “Tech Corps” recruits, places and supports volunteers from private sector to help the schools in integrating the new technologies into the classroom. “21st Century Teachers” will help other teachers to improve teaching with the new technology. They will be matching grants offered by the federal government and private sector for these purposes. The Technology Learning Challenge grant program, run by the Department of Education, supports partnerships of schools, colleges, and the private sector to develop and demonstrate the educational technology. The initial challenge grant competition for elementary and secondary education attracted more than 500 proposals and resulted in 19 grants in the worth of $ 10 million. In addition, a Technology Literacy Challenge Fund in the worth of $ 2 billion has been proposed by the President to develop statewide strategies to expand efforts that were initiated under Goals 2000 technology planning grants.

3.3 National objectives

There are certain fields of science and technology that are of primary interest for the USA. These are the areas where a big social return to the investments in R&D is expected and hence, they have always been an issue of the federal government. Therefore, a separate section is dedicated to the three areas which are the most important: national security and global stability, environment and health.

3.3.1 National security and global stability

"Our nation's security derives from a combination of diplomatic leadership, economic vitality and military might. Advances in science and technology underlie our strengths, promoting stability through engagement, giving rise to new industries, and ensuring that our Armed Forces remain the best trained, best equipped, and best prepared in the world."
Ex-president Bill Clinton

The dissolution of the biggest military threat has opened the USA new opportunities for broader peaceful alliances, however, an environment where the threats are more dispersed and increasingly varied has emerged (Executive Office of the President, Office of Science and Technology Policy. Science and Technology Shaping the Twenty-First Century 1997, 57-75). The accelerated diffusion of information, people, capital and technology has led to an increased risk of proliferation of advanced weapons, including the weapons of mass destruction. The strategic effort in R&D efforts may result to strengthen the ability of the USA to protect the nation.

In 1995, the National Security Science and Technology Strategy was developed, reflecting an important role of military R&D for the national security. For decades, the possession of superior technology has been one of the basic issues in our military strategy. The technological supremacy enables success as well as decreases the number of casualties in military operations. In addition, it enables a swift mobilization and coordination of troops and deters potential adversaries from taking hostile steps. New technologies are being developed in order to be protected against proliferation and terrorism and to be able to enforce peacekeeping and care of the nuclear weapons stockpile. New technologies have enhanced the ability of the USA, for both, to be prepared and to conduct military operations.

The military R&D program is designed to support the Joint Vision 2010 strategy of the USA. It includes issues like: *i*) dominant maneuver, *ii*) precision engagement, *iii*) full dimensional protection and *iv*) focused logistics. Full spectrum dominance will be the key characteristic of the U.S. Armed Forces for the 21st century. In accordance with The National Security Science and

Technology Strategy a plan for technologically superior war-fighting equipment needed today and for the preservation and the development of the technological base for future combat capability is established.

The military short- and long-term R&D programs involve multidisciplinary studies in areas like biomimetics, nanoscience, smart structures for modeling, predicting and optimizing dynamic response, broad band communications, intelligent systems and compact power sources.

The changes in the ways of doing business aimed to increase the performance and to reduce cost are acquisition reform, dual-use technologies and advanced technology demonstrations. While the first two have already been described in previous section, the intention of advanced technology demonstrations is to move the innovations and new technology from the laboratory to the filed faster and at lower cost.

There are several problems in the world that have to be taken care of and are also the subject of the technology policy. Let us mention some of them. In order to stop the mass proliferation of weapons new technologies for detection, monitoring and verification are needed. The threat of terrorism has to be minimized by developing suitable new technologies, for example efficient explosive detection, means for detection and management of the consequences of chemical or biological agents, means against threats of infrastructure including computer attacks. New technologies for the removal of landmines have to be developed as well. The stockpile of nuclear weapons produced during the Cold War has also to be secured and safely dismantled.

In addition, international cooperation will be developed in order to prevent the potential threats in the world. The communications between the scientists and engineers from different countries are sometimes the only means left for the communication and accordingly, decrease of the tensions.

3.3.2 Environment

"I would like to state in the strongest possible terms that the Clinton Administration is committed to moving our nation forward on the path towards sustainable development. We are especially proud of the progress our country has made in the past generation in cleaning up our natural environment. We strongly support long-term environmental research, energy research and development, reducing emissions of greenhouse gases, ecosystem management, and pollution prevention, to name just a few important areas."
Ex vice president Al Gore

The investments in environmental R&D have a tremendous potential for the world. They offer a healthier environment; create jobs and prosperity as well as greater quality of life (Executive Office of the President, Office of Science and Technology Policy, Science and Technology Shaping the Twenty-First Century 1997, 77-93). In a general sense, a strong fundamental environmental research is needed in order to effectively conduct environmental assessments.

One of the most significant achievements in environmental R&D is the new generation of models, reaching from climate and weather modeling to underground pollutant streams. Modeling allows the enhancement of public safety improves the environment, makes human activities more suitable to the environment and in a more economic way – through the use of computers and not by building expensive, physical models that are sometimes accompanied by harmful experiments. Let us see some examples:

- Models of Pacific Ocean basin allow the prediction of El Nino and the climate changes, connected to it. It helps farmers to adjust their planting schedule and crops to maximize harvests, water managers to adjust releases and thus, save many millions of dollar.

- Bering Sea Fisheries Oceanography Coordinated Investigations Program enables to predict pollock stocks three years in advance and thus, a decrease in over-fished stocks from 45 % in 1992 to 33 % in 1995.

- Vegetation/Ecosystem Modeling and Analysis Project is studying the influence of the climatic changes, especially due to the elevated carbon dioxide levels, on the vegetation. Thus, predictions of the tree growth that could be important to timber industry and wildlife studies can be undertaken.

A national integral framework for monitoring and research network is being developed by the federal government. It will allow an evaluation of environmental resources and ecological systems in the USA. It will tighten different specific monitoring programs in a linkage that will allow parallel monitoring from more than 15.000 monitoring sites and, hence, enable a better understanding of the causes and effects of environmental changes. It will permit to make more suitable decisions on local as well as on global environmental topics.

A new generation of technologies which can produce goods and services with less energy, less material and less environmental damage is needed. To facilitate the development and the use of more cost-effective environmental technologies, the regulatory system has to reward the innovation and to encourage more integrated approaches. The "Pollution Prevention Pays" program, for example, developed by $ 3 million, has cut the emissions by more than 500.000 kg and saved $ 500 million; the technology roadmap, developed with the pulp and paper industry is expected to cut the environmental costs from 411 billion to $ 3 - 4 billion by the year 2020. An analysis undertaken by the Department of Energy in 1993 has pointed out that a 10-20 % reduction in waste in the USA industry would cumulatively increase the GDP for almost $ 2 trillion by year 2010 and in addition, generate nearly two million new jobs.

The government is trying, in cooperation with 5.000 partners, to decrease the growth rate of carbon dioxide emissions by different means like signing voluntary agreements with the utility industry, cooperation with manufacturers to produce more energy efficient computers, buildings and lighting systems as well as developing new technologies in forestry, transportation etc.

The USA are very dependent on energy, however, the vast majority is being produced from fossil fuels that produce carbon dioxide. Therefore, a basis for an improved energy system has been introduced by strongly supporting energy efficiency, renewable energy, fusion power and pollution prevention R&D. Strong industry-government R&D partnerships were developed to reduce emissions and to create different energy sources. For example:

- Partnership for a New Generation Vehicle,
- Biomass energy R&D for power projects in rural areas,
- Building Initiative for building more efficient housing.

The environmental R&D must be applied for assessing, anticipating and avoiding environmental problems. The knowledge of basic biogeochemical processes will help to address problems created in the past due to illegal or ill-informed toxic chemical wastes. The R&D should be carried on in a multidisciplinary manner with a better coordination of federal agencies. The environmental influence of the Endocrine Disrupting Chemicals, for example, is being studied by a cooperation of 14 federal agencies.

A commitment to reduce losses due to natural disasters is pursued by R&D on following topics:

- improvement of the understanding of the nature of hazards and their impacts on the human health and the ecological system,
- development of new environmental technologies to reduce their effect,
- improvement of data management and assessment of risk.

In addition to the USA Global Change Research Program, the regional implications are being studied that are necessary for the design of effective mitigation and adaptation measures. Three basic approaches are being incorporated into the global program:

- regionally resolved timing and magnitude of climate change,
- regional analyses of the consequences of climate change alone and in context with other pressures on the ecosystem,
- integrated assessment methods.

3.3.3 Health

"Our strategy for continuing to improve America's health, safety, and food emphasizes investing in the fundamental research necessary to assure our future well-being, promoting prevention in the areas of both health care and environmental protection, and educating Americans so they can improve their own health and safety decisions."
Ex president Bill Clinton

Improving the health has been a major goal of the federal government since 1862 when the financial support for the Land Grant institutions was offered (Executive Office of the President, Office of Science and Technology Policy, Science and Technology Shaping the Twenty-First Century 1997, 95-116). The federal support for biomedical and agricultural R&D has resulted among others in a 60 % longer life expectancy of 76 years compared to 47 years a century ago. In addition, the production of food and fiber is the largest U.S. industry - its share in GDP is 15 % and it employs 16 % civilian jobs. The exports contribute over $ 100 billion with positive balance of about $ 20 billion. Health care and related activities account for 1 trillion dollars in expenditures per year and employ above 7 % of worker.

The economic, scientific and social situation has changed enormously in the last decade; hence, the federal funding must be reassessed. In the health care, changes are occurring in the age distribution: in 1990 12.5 % of USA citizen were 65 years old or older, however, more than 20 % are estimated to be in 2030. This will increase the diseases connected with the elderly. In order to keep the costs of long-term health care, more attention is being given to preventive medicine. In agriculture, the growing environmental and health problems as well as new trade agreements force government to reconsider its R&D funding and increase its cooperation with the states and private sector.

The administration has increased the biomedical research investments. The National Institute of Health got $ 2.4 billion more funding in years 1993 – 1997 which represents an increase of 23 % in an era of constrained budget. Since the agenda in biomedical R&D is broad, we will discuss only the most important goals.

The new approaches to understand disease processes, especially acquired immunodeficiency syndrome (AIDS/HIV) and Alzheimer's disease are one of the primary goals. The first is the leading cause for the death of USA citizens between 25 and 44 years old (more than 500.000 AIDS cases were reported in the USA in 1995), the latter affects 4 million people in the USA.

New preventive strategies against disease and disability are being developed and applied. They involve biomedical as well as behavioral research. New preventive strategies involve the investigations of emerging infections as well as the prevention and the treatment of drug and alcohol abuse. Vaccines against cancer and infectious diseases such as AIDS as well as the control of the transmission of infectious diseases are being studied. For example, the vaccine against otitis media is being developed, a vaccine that would help millions of American children and save $ 3.5 billion spent annually due to their visits to doctors. New ways, including the determination of risk factors to prevent the disability among older people are studied.

Genetic medicine seems to be a promising tool for the diagnosis, treatment and prevention of disease. Among others, R&D in cancer genetics as well as in obesity is performed. Another field of R&D is the biology of brain disorders, encompassing studies of the basic biology, chemistry, anatomy as well as physiology of the neuron.

A high priority has also the development of science-based healthier eating habits in the USA. However, expanded human nutrition knowledge, especially the understanding of nutrient-gene interactions, is needed in order to prevent many nutrition-related diseases. The enhancement of a R&D program in food safety issues is expected to further ensure the public health. Scientists are studying new ways to reduce the microbial contamination of food products.

Much effort in R&D strategies is also given in order to maintain and to enhance grow rates of food and fiber production in a more friendly way for the environment and health. This will be one of the greatest challenges for the agricultural and natural resource scientists in the 21st century. Projects concerning the integrated management of farms, lands, forests and coastal waters are taking place in order to keep the long-term, sustainable use for production as well as to preserve the other vital functions like wildlife and water quality. In addition, the results of R&D in precision farming and biotechnology-derived crops are offering to be used to increase the food productivity at decreasing environmental damage in the near future.

A very important goal is also R&D which increases animal and plant health. Recent developments in Europe, especially in Great Britain underline this topic. The integrated pest management which will reduce synthetic pesticides is also the area of R&D in agriculture.

Another important issue is the biodiversity of the genetic pool which needs future work in germplasm preservation and maintenance. Therefore, the work on animal and plant gene mapping must be continued and improved. An access to existing worldwide collection should be improved and the gaps that exist in these collections should be identified.

The training of agricultural scientists from other countries, especially from the developing countries, is also a very important mission of the USA Land Grant universities in the fight against the world hunger.

3.4 Federal R&D funding

Any policy, goals or good will, if not matched and supported with appropriate funding and investments, have little effect. Therefore, in order to see the technology policy of the USA more clearly, it is important to look at the financial support of R&D and its distribution to different areas of interest. The federal R&D investments are given in tables 3.3 to 3.6.

Table 3.3: Federal R&D investments in years 1993, 1997 and 1998 in millions of dollar. The investments are split by agency (area) (* proposed, therefore showing the intensions of the government).

agency (area)	**year**		
	1993	**1997**	**1998***
defense	38.898	37.461	36.780
HHS[1]	10.472	12.933	13.478
NASA[2]	8.873	9.314	9.603
energy	6.896	6.186	7.312
NSF[3]	2.012	2.458	2.553
agriculture	1.467	1.545	1.485
commerce	793	1.050	1.115
interior	649	581	605
transportation	613	639	754
EPA[4]	511	504	555
other	1.308	1.229	1.229
total	72.492	73.821	75.469

[1]Health and Human Services, [2]National Aeronautics and Space Administration, [3]National Science Foundation, [4]Environmental Protection Agency

Source: Executive Office of the President, Office of Science and Technology Policy, Science and Technology Shaping the Twenty-First Century 1997, 7 (Office of Management and Budget)

Table 3.4: Federal R&D investments in years 1993, 1997 and 1998 in millions of dollar. The investments are split by R&D theme (* proposed, therefore showing the intensions of the government).

R&D theme	**year**		
	1993	**1997**	**1998***
basic research	13.362	14.885	15.303
applied research	13.608	14.529	15.159
development	42.795	42.153	41.636
equipment	-	937	960
facilities	2.727	1.317	2.411
total	72.492	73.821	75.469

Source for both tables: Executive Office of the President, Office of Science and Technology Policy, Science and Technology Shaping the Twenty-First Century 1997, 7 (OMB)

Table 3.5: Federal R&D investments in years 1993, 1997 and 1998 in millions of dollar. The investments are split by civilian/military theme (* proposed, therefore showing the intensions of the government).

civilian/military theme	**year**		
civilian	**1993**	**1997**	**1998***
basic research	11.915	13.747	14.112
applied research	9.130	10.469	11.125
development	7.269	7.860	8.117
equipment	-	492	506
facilities	1.979	984	1.128
subtotal	30.329	33.552	34.988
military			
basic research	1.411	1.138	1.191
applied research	4.478	4.060	4.034
development	35.526	34.293	33.519
equipment	-	445	454
facilities	748	333	1.283
subtotal	42.163	40.269	40.481
total	**72.492**	**73.821**	**75.469**

Table 3.6: Federal R&D investments in years 1993, 1997 and 1998 in millions of dollar. The investments are split by R&D share (* proposed, therefore showing the intensions of the government).

R&D share	**year**		
	1993	**1997**	**1998***
military	42.163	40.269	40.481
civilian	30.329	33.552	34.988
total	72.492	73.821	75.469
percent civilian	42 %	45 %	46 %

Source: Executive Office of the President, Office of Science and Technology Policy, Science and Technology Shaping the Twenty-First Century 1997, 7 (Office of Management and Budget)

4 ISSUES CONNECTED TO THE TECHNOLOGY POLICY

4.1 Technology policy making process

Studying the technology policy of the USA it is worthwhile to look at the policy making process, its main actors and the problems connected to it.

A policymaking process (in the USA), including the technology policy, is divided into five stages (Barke 1986, 9; Jones; 1984): *i*) a problem must be recognized and defined, usually by citizens, interest groups or policy makers, *ii*) formulation and debates about the solutions in Congress or executive branch, *iii*) adaptation of the solutions as law, an executive decision or regulation, *iv*) implementation of the policy by bureaucrats, connected by the uncertainties about the true intent of the Congress, by bureaucratic interpretations and political pressure and finally *v*) evaluation of the program. Several models describe the policymaking process, let us mention three of them: *i*) rational model with objectivity, neutrality and use of quantitative measures, comparable to scientific method, *ii*) model with incremental changes that take the present model as starting point (Lindblom 1959), and *iii*) garbage can model with the government characterized as "organized anarchy" (Kingdon 1984; Cohen, March and Olsen 1972).

Technology policy making is a complex process, however, four major constraints that policymakers in the USA must deal with, can be pointed out (Barke 1986, 14-5): law, knowledge, coordination and politics. The constraints by the law prohibit some policy actions or encourage them, for example, law determining the hazardous waste concentrations or experiments on human and animals. Knowledge is an important factor when deciding about the technology policy, especially what is known and what is uncertain, for example, is saccharin really carcinogenic?. A good coordination among institutions that influence and/or implement certain technology policies is a crucial point, especially in the USA, where a lot of overlapping between several agencies that are in charge of similar areas, exists. A technology policy can be in accordance with all legal and scientific considerations, but it still does not pass if it is opposed by the political opinion. These four constraints are not independent and there is no hierarchy among them (Barke 1986).

Six main actors, playing different roles at different stages can be defined in the policy making process in the USA:

1. President and the executive office
2. Congress
3. federal bureaucracy
4. courts and the legal system
5. public
6. scientists

4.1.1 President and the executive office

The president of the USA has always been an important figure in technology policy making (Barke 1986, 43-60). He has the most information from the foreign policy as well as domestic policy bureaucracy and thus, an overview to shape the political process. In the majority of cases, the Congress is waiting for the president to make the first move.

The executive powers included in the Constitution are the basis for the active role in technology policy making. The Congress, the bureaucracy and the courts can impede the President; however, he may find ways to override them. Even more, a great share of federal R&D funding for military purposes (around $ 40 billion) is secret and thus, not discussed in public and mostly not even in the Congress. He has a potential to recommend legislation to the Congress and a choice to sign the bills into law or veto to them. There were cases in the past when the president used his veto to reshape the technology policy. In addition, he appoints or nominates the top officials of most federal offices as well as carries into the execution the laws passed by Congress – or not. The president may also control the technology policy through the executive orders that need not to pass the Congress.

The question arises, how are the presidents of the USA able to know anything, or better enough, to shape the technology policy. In common, they know about their political goals and know about the importance of science and technology to achieve them. Hence, technology is used more like a tool for other policies. However, every executive department except Treasury includes an office for R&D. These offices put their demands along with pressures from industry, academic community, scientific and public associations as well as the Congress. To manage all those demands certain information filters are needed in the White house. Therefore, science advisors to the president as well as different advisory boards have been established like the President's Advisory Committee and Office of Science and Technology.

The coordination of the technology policy in the executive branch is left to different councils, one of the most important is the Office of Management and Budget.

If we are considering the everlasting conflict science – politics, we must find out that the president determines the technology policy according to two major factors: according to his own political program and according to the political pressures from outside. It is possible that the political aims of the president prevail in the technology policy making. Off-the-record is told that president Reagan consulted with only a few scientists before he announced the Strategic Defense Initiative (SDI), the largest weapon-development program in the history. His top experts found out about it only a couple of days before the TV speech: the White House science advisor five days before, the secretary of state and the Joint Chiefs of Staff two days before, and the chief Pentagon scientist nine hours before. This case demonstrates a common concern about technology policy making in the executive branch.

4.1.2 Congress

Congress is a complex organization, with its members responding to a wide range of tasks to promote the public interest (Barke 1986, 21-42).

To influence the technology policy the Congress uses mostly its most powerful tool – the passage of laws. Laws are, however, sometimes very vague and in other cases extremely specific and hence, posing many problems for their implementation. In common, the Congress often encounters problems with the enforcement of its will. A statutory policy change must pass tests in legislative process and thus could be influenced or quenched. In addition, the congressional committees investigate policy issues, and thus mobilizing voters for a change in policy. One of the most effective tools of the Congress to affect the technology policy is its power to influence the budget. The role in confirmation of the heads of executive departments and agencies is also another possibility of the Congress, although seldom used, to influence the policy.

Only few members of the Congress have adequate knowledge in science or technology. The technology policies are analyzed in most cases by hired, well-trained congressional staff or outside experts. In addition, several scientific associations appoint a professional scientist as a Congressional Science Fellow. Several support agencies were established in the Congress, the most known is the Office of Technology Assessment (OTA).

The work in Congress is very fragmented due to many committees and accordingly, problems in coordination occur. The Senate Commerce, Science and Transportation Committee and the House Science and Technology Committee are the dominant committees for technology policy.

Lobbying over scientific and technological projects is intensively met in Congress. Congressional decisions can be based on both, the ignorance or the expertise. In several issues on technology policy, a coalition is built that does not depend on party membership, but on the balancing of interests.

4.1.3 Federal bureaucracy

Federal bureaucracy has no constitutional status like the President or the Congress, hence, they posses little maneuvering space when pressured by the executive, the legislative branch or by courts (Barke 1986, 61-94).

Commonly the implementation of one federal policy is pursued by one dominant agency, however, discussing the technology policy of the USA one must be aware that at least a dozen federal agencies are in charge of its implementation. In fact 98 % of R&D financed by federal government is performed by ten agencies.

Each of the executive departments except Treasury has at least one research office (table 4.1). For example, the Department of Health and Human Services includes among others the National Institute of Health, the Department for Commerce the National Bureau of Standards etc. Most of the federal spending is given to the Department of Defense, for example, during Reagan's first 6 years of presidency its share grew from 56 % to 72 %. In addition, there are several executive agencies that deal with narrower issues than the departments. One of the most known is the National Aeronautics and Space Administration (NASA). Independent Regulatory Commissions are another form of federal bureaucracy, established by the Congress to issue regulations and resolve disputes. There are about 380 federal laboratories in the USA with a combined budget of approximately 25 % of all federal R&D funds and employ about one-sixth of all researchers in the USA (i.e. National Institute of Health, Marshall Space Flight Center). There are about 35 Federally Funded Research and Development Centers among them, being operated by the universities or private firms for the government agencies (Table 4.2).
In addition, two other institutions, the National Science Foundation which allocates typically 30 % of federal research funds to the universities, and the National Academy of Sciences play a significant role in managing the federal R&D.

Table 4.1: Major federal science and technology offices and their budget in 1986 (in millions $).

Department / agency	budget outlay
Department of Agriculture:	
Agricultural Research Service	544.7
Cooperative State Research Service	255.9
Economic Research Service	44.3
Forest Service	105.5
Human Nutrition Information Service	10.8
Other	15.7
Total	976.9
Department of Commerce:	
National Bureau of Standards	98.5
National Oceanic and Atmospheric Administration	183.6
Bureau of the Census	4.9
National Telecommunications and Information Administration	9.4
Other	0.5
Total	296.9
Department of Defense:	
Department of the Army	5,028.4
Department of the Navy	10,306.2
Department of the Air Force	14,816.3
Defense Agencies	3,926.3
Director of Test and Evaluation	69.3
Total	34,146.4
Department of Education	122.0
Department of Energy	5,520.9
Department of Health and Human Services:	
Alcohol, Drug Abuse, and Mental Health Administration	353.1
Centers for Disease Control	46.1
Food and Drug Administration	93.2
Health Care Financing Administration	22.0
National Institute of Health	4,679.2
Other	69.2
Total	5,262.8
Department of Housing and Urban Development	18.6

Department of the Interior:	
Bureau of Land Management	3.2
Bureau of Mines	63.3
Bureau of Reclamation	9.9
Geological Survey	213.4
National Park Service	15.5
Fish and Wildlife Service	61.6
Other	6.3
Total	373.2
Department of Justice	25.9
Department of Labor	14.5
Department of State	1.6
Department of Transportation:	
Coast Guard	23.0
Federal Aviation Administration	212.4
Federal Highway Administration	43.9
Federal Railroad Administration	17.9
Maritime Administration	12.4
National Highway Traffic Safety Administration	45.0
Urban Mass Transportation Administration	25.4
Other	8.2
Total	388.2
Department of Treasury	26.1
Other agencies:	
Agency for International Development	267.3
Consumer Product Safety Commission	0.3
Environmental Protection Agency	317.2
Federal Communications Commission	0.9
Federal Emergency Management Agency	4.0
Federal Home Loan Bank Board	2.7
Federal Trade Commission	1.8
General Services Administration	0.9
International Trade Commission	6.3
Library of Congress	8.4
National Aeronautics and Space Administration	3,804.9
National Science Foundation	1,472.0
Nuclear Regulatory Commission	143.1

Smithsonian Institution	65.0
Tennessee Valley Authority	67.9
Veterans Administration	210.1
Other	3.8
Total, all agencies	**53,550.6**

Source: Barke 1986, 64-5

These agencies and offices are implementing the technology policy according to law and procedural requirements. The vague laws and the uncertainty in the data and scientific understanding enable agencies certain area for the interpretation. However, the judicial and legislative oversight, on the other side, poses the limits.

These agencies often deal with "trans-scientific" questions that mean scientific decisions with no scientific consensus. They must often decide over the issues that extend over their capabilities when dealing with technology policy, for example, estimating the influence of radiation on human beings from animal experiments. The agencies must determine the risk-benefit (to health and safety) as well as the cost-benefit of R&D. However, there is a very good potential of scientific and technologically educated people in the bureaucracy. In addition, the advisory committees are established for certain purposes, the other ones by law. Expert advisory panels and peer reviews are used to rank the importance of research programs.

Coordination is a difficult task when all the different agencies are considered. Fragmentation and duplication occur.

The interpretations of the bureaucrats must be in accord with the president, the Congress as well as the public. The bureaucrats are not isolated from political influences. Two general ways of the behavior were observed within the science and technology bureaucracy (Barke 1986; Lambright 1976): a "society-oriented administration" selects problems to be researched and responds to the politicians, while a "science-oriented administration" delegates program choices to scientists and downplays the political influence.

Table 4.2: Federally funded research and development centers and their R&D budget in thousands of dollar in fiscal year 1984. Abbreviations: DOE – Department of Energy, DOD - Department of Defense, HHS - Department of Health and Human Services, NASA – National Aeronautics and Space Administration, NSF - National Science Foundation

Name and Type of Administering Organization	Principal Sponsoring Agency	R&D budget
Administered by industrial firms:		
Bettis Atomic Power Laboratory	DOE, DOD	275,088
Energy Technology Engineering Center	DOE	215,944
Frederic Cancer Research Center	HHS	32,008
Hanford Engineering Development Laboratory	DOE	141,450
Idaho National Engineering Laboratory	DOE	117,408
Knolls Atomic Power Laboratory	DOD, DOE	63,519
Oak Ridge National Laboratory	DOE	297,274
Sandia National Laboratories	DOE	604,368
Savannah River Laboratory	DOE	57,956
Administered by universities and colleges:		
Ames Laboratory	DOE	17,790
Argonne National Laboratory	DOE	221,239
Brookhaven National Laboratory	DOE	179,632
Lawrence Berkeley Laboratory	DOE	150,876
Lawrence Livermore Laboratory	DOE	651,537
Fermi National Accelerator Laboratory	DOE	181,683
Jet Propulsion Laboratory	NASA	261,494
Lincoln Laboratory	DOD	160,406
Los Alamos National Laboratory	DOE	513,301
National Astronomy and Ionosphere Center	NSF	6,111
National Center for Atmospheric Research	NSF	40,383
National Optical Astronomy Observatory	NSF	23,160
National Radio Astronomy Observatory	NSF	20,260
Oak Ridge Associated Universities	DOE	11,529
Princeton Plasma Physics Laboratory	DOE	130,934
Stanford Linear Accelerator Center	DOE	117,770
Administered by other nonprofit institutions:		
Aerospace Corporation	DOD	203,740

Center for Naval Analyses	DOD	19,306
Institute for Defense Analyses	DOD	21,720
Mitre Corporation, C 3 Division	DOD	215,640
Pacific Northwest Laboratory	DOE	69,683
Rand Project Air Force	DOD	17,806
Solar Energy Research Institute	DOE	53,399
Total		**5.094,414**

Source: Barke 1986, 71 (National Science Foundation)

4.1.4 Courts and the legal system

Beside the constitutional and common law the courts also enforce the statutory and administrative laws which affect and are affected by the science and technology (Barke 1986, 95-112). The environment of the legal system that is based on constant or slowly evolving legislature must adapt to dramatic changes in the fast evolving field of science and technology.

The most important task of the judiciary system in the USA in the policy process is to review the steps taken by the president, the Congress, the agencies or the state and local governments. Courts may also review the substance of the agency's decision concerning the science and technology policy.

Very few judges have the knowledge in technical matters, accordingly, they are dependent on additional knowledge. External experts are used, however, new ideas like science clerks as well as science court are considered.

There are coordination problems among the courts in the USA leading to different decisions. The political influence has always been tried to be kept away from the court in the USA, however, the appointments of federal judges by the president might lead to a political influence on technology policy, especially in areas such as health, safety and environment.

4.1.5 The public

In the history of the USA there has never been a widespread opposition against the science and technology (Barke 1986, 113-31). However, this common benevolent opinion does not prevent the public to influence the technology policy.

The legal system in the USA encourages public participation, however, legal limitations posed on this participation in changing the technology policy are: an interest in standing matter must be proved, availability of information and the financial costs.

The “public” in the arena of technology policy could be described by a pyramid (Barke 1986; Almond 1950; Miller 1958): at the top are few decision makers interacting with several second-level policy leaders (i.e. university professors, publishers). The third level is the attentive public, the last, fourth level are people who don’t care about the technology policy and are not interested about science. The knowledge that is important for the policy role of the public is limited: a study in 1979 found that 7 % of the adult public can be “scientifically” literate (Miller; 1958). If we consider that only one third of the USA high schools require graduates to take more than one year of science or mathematics, the question about the satisfactory knowledge is relevant.

The coordination of public in order to change the technology policy is very scarce. This is probably due to the fact that rational, self-interested individuals seldom try to achieve their group interests (Barke 1986; Olson 1965). However, there are some non-scientists and non-engineers environmental groups in the USA (i.e. Natural Resources Defense Council, National Wildlife) as well as some organizations (i.e. L-5 Society, Viking Found). The relative poor coordination of public activity has the consequence that the public has little effect on the technology policy in the USA. However, the recent events demonstrate that this coordination improves and, hence, the public influence will surely increase. The second reason for getting little influence on the policy is a disagreement of public opinion of different groups.

Nevertheless, the public should have a voice in the policy making procedure, if nothing else, to underline the democratic way of decision making (Barke 1986).

4.1.6 Scientists

There are more than three million scientists and engineers in the USA (Barke 1986, 133-53). Most of them participate in the political system like voters. Very few of them are acting in some other way, if they do, than as a well-educated and more competent extension of the civil service (Barke 1986, 135; Brooks 1984). A direct role in political life is very unusual also for those, who could be identified as policy leaders (Barke 1986; Miller 1985). The majority of them (53 %) prefer direct personal contact to influence federal policies, group response (23 %) or formal communication (11 %). However, even the highest scientific awards do not guarantee a comparable political influence.

There is no particular law that enables a political influence of scientists and technologists in the policy making process. It is simply their knowledge that makes them appropriate for this role. In addition to self-imposed regulations, it is the law that puts some limitations on the scientific work concerning the protection of experimental subjects and national security limitations. It is also the legal protection that guarantees the scientific community the freedom of inquiry, claims for the patents and the protection for “whistle blowers”.

The knowledge possessed by most scientists is a very profound, but a narrow one - without an ability to adjust to the political norms. This might be a problem when addressing a policy making process.

The coordination among scientists is usually performed through the scientific associations which are in most cases forbidden by their own rules to take stands on political issues. In addition, the conflicts among scientists are not rare resulting in a confusion of nonscientists and jeopardize the application of scientific knowledge by the policy makers.

The problems in the interaction between the science and the politics seem to be inevitable. The system is namely conceived in a way that the personnel with a scientific knowledge like congressional staff, regulatory commissions and advisory groups are used to prepare the technology policy and the politicians that don't have an appropriate knowledge or time to get to know the issues, have the authority to legalize it. Thus, politicians do not have the ability to supervise the issues and they do not know who really has the principal role in this process.

Henry Kissinger made the following observation (Kissinger 1974): Intellectuals are now divided into essentially three groups: those that reject the government totally; those that work on pure, abstract intellectual models which are impossible to make relevant; and a third group that's too close to power and that sees its service to the government as residing primarily in day-to-day tactics. No outsider can be very helpful on the day-to-day business because he doesn't know enough of the current situation to really make a contribution.

As a conclusion, the technology policy making process in the USA is influenced by six major factors: by the president and executive office, by the Congress, by courts, by federal bureaucracy, by public and by scientists. While the first three institutions may be assumed to lack a sufficient knowledge for these issues, the political power of the federal bureaucracy and scientists with a sufficient technical knowledge is limited. The public, in general, doesn't have enough knowledge as well as political power. Thus, the technology policy process can be described as an incremental model with resemblance to the "garbage can" model.

4.2 Major dilemmas connected to U.S. technology policy

4.2.1 Relation between science and technology

The use of the phrase "research and development" is so common that someone might think that it has become almost one word (Branscomb 1998, 112-24). However, we should keep in mind that it represents two distinct kinds of activities. Word research, meaning scientific as well as technological research, denotes intensive intellectual activities that create new knowledge. It is an activity with an uncertain outcome and full of risks. The majority of it is being performed in laboratories with a lot of freedom and desire to move to new frontiers of the knowledge. Development is, on the other hand, a focused activity to produce a specified objective like a design or a process. The outcome is more or less certain and it can be realized in a defined time within a predetermined amount of resources.

The next division of the term "research and development" (R&D) is applied when the federal funds are being allocated. It is split into three categories according to the purpose and the nature of the work: "basic research", "applied research" and "development". Basic research should denote scientific investigations in an university or an independent laboratory, while development should be performed by engineers, usually in industrial laboratories. Basic research is primary supported by public funding and the development by the market, private or public. The applied research lies somewhere in the middle between new scientific theories on one side and the well predictable application of known theories on the other. Since it is not clear enough what the category "applied" means, especially when connected with the technology policy and its federal support for the applied research, let us discuss a little more about this issue.

Scientific research, in common, is undertaken to highlight the workings of nature regardless of the motivation of the scientists or the investor. All "basic" (also called "fundamental ") research falls into this category, however, much of the "applied" research can be counted into this category as well. "Research" does not apply to development, testing, design and product simulation. Although some of the basic research is highly abstract, far from any practical application, there is no need for the research to be useless in order to be classified as basic. There are several cases for basic research to have value in short time, for example, in helping to technological choices. Or, for example, basic research in superconducting materials may influence scientific as well as technological progress.

Most often, scientific and technological advancement happen concurrently. Sometimes, like the development of radio-isotopes or stable-isotope tracers, the technological advancement induces the progress in scientific knowledge, in other cases science drives the technology. The term “basic technological research” denotes the work that creates new capabilities and new understanding. Thus, the “basic technological research”, that creates new technical opportunities, and the “basic scientific research”, that creates new understanding of nature, form two arms of intellectual investment that are highly interdependent and overlapping into a vital capability of human society (Branscomb 1998). Sometimes they are even indistinguishable. Thus, the criteria for federal investment of basic research should be comparable to the criteria for basic scientific research. The term “applied research” should be, thus, used for narrow research with a defined goal - to solve a specific problem for an identified customer with limited time and costs. A synonym would be a “problem-solving research”.

This interdependence of science and technology suggests that the science and technology policy are coupled and that the discussion of technology policy incorporates the scientific policy as well. Even better, both should be addressed in a common “research policy” in order to promote the technical knowledge and in an “innovation policy” in order to cover the incentives for innovation (Branscomb 1998).

4.2.2 Basis for federal funding of technology

As discussed in the first chapter, technological progress has been the key to a better economical situation in the USA. The real power of the technology policy, as a tool to promote the technological innovation, is its influence on the budgetary spending. Accordingly, one of the permanent sources of political discussions in the recent decades has been the appropriateness of federal support for R&D in the private sector.

Since World War II it has been a general agreement that basic research should be supported by the government, however, the commercial technology development and thus, spending in commercial R&D has been seen as a matter of private firms. The private sector would be supported by a good infrastructure of scientific institutions and eventual spin-offs from military technologies (Irwin 1993, 87). The commercial R&D should be set by market mechanisms which are the best way to determine the goals and to prevent the "pork-barrel" spending of federal money. This has been a general altitude of the Republicans, while the Democrats, in contrary, have been more willing to support the private sector, claiming that it would increase the declining competition of the USA industry and thus, strengthen the USA economic situation.

The main problems of private industry in the USA are manifold (Irwin 1993, 56). The inability of the American managers to plan in long-term R&D is one of the most important. This is mainly due to the tendency that the managers and investors in the USA are not willing to spend the money for the promising technologies due to a small near-term investment return. In contrast, the Japanese or European industry is willing to spend long-term investments in refining and commercializing technologies. For example, the videocassette recorder was developed by AMPEX, an American company, but the Japanese firms succeeded in the market with its commercialization. The reasons for this short-term behavior of the U.S. firms are complex, among them a high cost of capital. U.S. firms are also not able to commercialize the product fast enough, partially due to a separation between the developers (product designers) and manufacturing engineers. Furthermore, they do not invest in process technology; only one-third of firms' R&D expenditures are devoted in improved process technology compared to two-thirds that are spent for new products. Even when the new production ways are already on the market, the private sector, especially small manufacturers, are very slow to incorporate the improved process technology into their operation. The cooperation between the firms and their suppliers is limited, in contrast to Japan. There are also several other shortcomings of the American private industry in comparison to the other developed countries like the shortage of non-technical management as well as technically competent workers.

All previously mentioned shortages of the U.S. private industry are unlikely to be improved in a short time by the private sector itself. In addition, the increased competition from other countries that enjoy a greater federal support of their industry, made the opposition to the U.S. federal support for private sector to rethink. However, the decision for the federal funding should be based on the expected beneficiaries of the work and should not be based on the level of abstractness nor the application of research or on the motives of the investigator (Branscomb 1998). In general, when the public is expected to be the primary beneficiary, the government should support the R&D. However, it is important that the work is undertaken under highly competitive conditions including an appropriate evaluation of the projects as well as a wide diffusion of the results. If the primary beneficiary is not the public, the private sector should pay. If the firms under-invest due to the fact that the market will not return the investment in R&D and the public has its interest, which is surely the case in, for example environmental and medical R&D as well as in pre-competitive R&D, the funding should be shared according to an expected benefit.

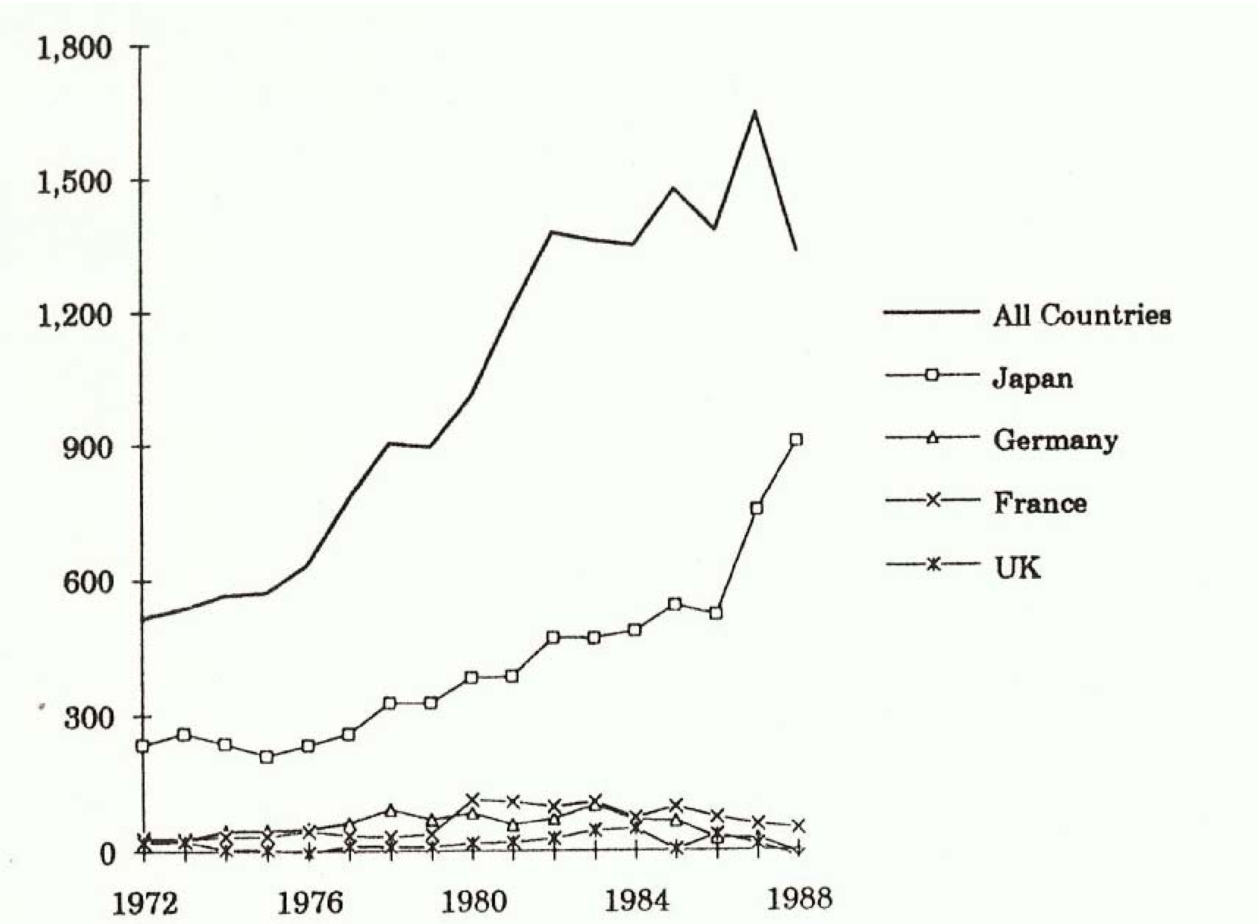
4.2.3 Influence of globalization on technology policy

When the federal support for private industry R&D is discussed in the USA, the main reason for it is the advancement of new technologies, leading to more international competitiveness of the U.S. firms and thus, more prosperity for the citizens of the USA. (Irwin 1993, 66-78). All this reasoning assumes that the U.S. technology base exists, distinct from foreign industries. However, the globalization of the technology is the dominant process in today's world. The globalization makes a national technology policy somehow questionable. It is difficult to imagine that the federal support is given to the U.S. private industry in order to increase the national well-being and to find that the benefits do not flow to the American society owing to the international character of the company.

The development in the past two decades has shown that the flow of technology has become more bi-directional, with the USA using the cutting-edge technologies from Japan and Europe. The largest USA-based corporations conduct business on the global scale. As a result it has become very difficult to contain the technology within the nation's frontiers. The USA has become, in addition to the largest producer of technical know-how, also the largest consumer of foreign know-how. Technology is traded in many different forms like incorporated in products and in services, through the sale and licensing of patents, technical knowledge and other forms of intellectual property (Fig. 4.1). The majority of the trade is between the U.S. corporations and their affiliated corporations (in which U.S. companies share at least 10 %) or subsidiaries abroad, accounting for more than 90 % of all USA technology trade in 1988. These numbers show that the American firms make a significant portion of their R&D abroad. Firms invest directly abroad in order to leapfrog protectionist barriers and improve market access, to track the foreign competitors and to acquire foreign technologies and technical talents. The foreign firms do the same in the USA, the statistics shows that the foreign companies invest into R&D in their USA subsidiaries a comparable amount of resources as do the American companies. They cooperate with U.S. universities and research institutions, foreign students form a significant portion of the USA student population. Thus, the university projects supported and research centers established by subsidiaries of foreign firms as well as the talented foreign students contribute to an innovative climate in the USA. In addition, strategic alliances were developed among US and foreign companies in order to solve a range of tasks from marketing agreements to expensive and risky developments. There is also no distinction between the USA work-force employed in an American or foreign owned company.

Fig. 4.1: USA net trade of intellectual property to other developed countries in terms of royalties received and US payments for the foreign technology.

.



Source: Irwin 1993, 70 (National Science Foundation)

Hence, the US technology policy must adapt to the challenges of the globalization like fast technology diffusion, rising foreign competition and the transnational cooperation and connection. In contrast to the past, the company's owners, its employees and its suppliers do not necessary share the same nationality, as a consequence, the idea of American companies or American product has become blurred. The interests of the USA-based corporations do not have to be identical to the national interests and accordingly, to assist the USA owned company may not have to do much with the economic growth of the USA. In contrast, the discriminatory measures and restrictions towards foreign-owned companies may hurt American workers.

Thus, a question should be raised of the wisdom to federally support the research and development of the private industry if there is no guarantee that the USA economy will profit. However, on the other side, any effort to be able to host the enabling and emerging leading-edge technologies in the USA should be supported, independent from the country of origin.

4.2.4 Creation of the Department of Science and Technology

The coordination of the bureaucrats that are supposed to promote the technology policy is difficult in the USA. This is primarily due to many different federal agencies that are supervising similar issues, for example, fifty-four federal entities have responsibilities for research on ocean pollution. It is no wonder that overlapping as well as duplication are not unusual (Barke 1986, 87-90), leading to a technology policy that appears sometimes to be illogical and inconsistent.

There are several possibilities to improve this coordination; one of them is to unify the federal science and technology activities in a Department of Science and Technology. This idea has been first brought up in 1880 and revived several times till now. Repeatedly the main reason that opposed this cabinet-level department was the fear that this may cause an over-centralization of science and technology leading to a rigid peacetime R&D in the USA.

The idea of the president Reagan's Commission on Industrial Competitiveness in 1985 was to combine the research activities of NASA, the National Institute of Health, the National Science Foundation and other federal agencies into the Department of Science and Technology. In this way not only would the coordination have been improved, but also there would be a chance to improve the commercial R&D. In addition, there are several other reasons to establish this department. A representative of scientists and engineers would be a part of the cabinet which would give more status as well as more influence to this community. The Congress could also have more influence because the bureaucracy would be centralized in one executive department.

The tasks concerning the technology policy would be more efficiently performed with a known hierarchy.

However, there are also some drawbacks that impede the creation of this department. Some of them are of political nature. The existing agencies would not be pleased to release their programs, including the mission-oriented programs that would surely remain in the Departments for Defense, Agriculture and Health and Human Services. There would also be a chance that the National Science Foundation could be forced not to focus so much on basic research. Therefore, the Congress also hesitates to transfer the authority of independent agencies to the president. In addition, there is a basic assumption that fragmentation, duplication and conflict are not only the drawbacks - they namely also assure pluralism and unplanned opportunities as well as the participation of citizens which are very important for the research and innovation to flourish.

5 STATE OF ART IN THE USA TECHNOLOGY AT THE BEGINNING OF THE 21ST CENTURY *

5. 1 Federal R&D funding

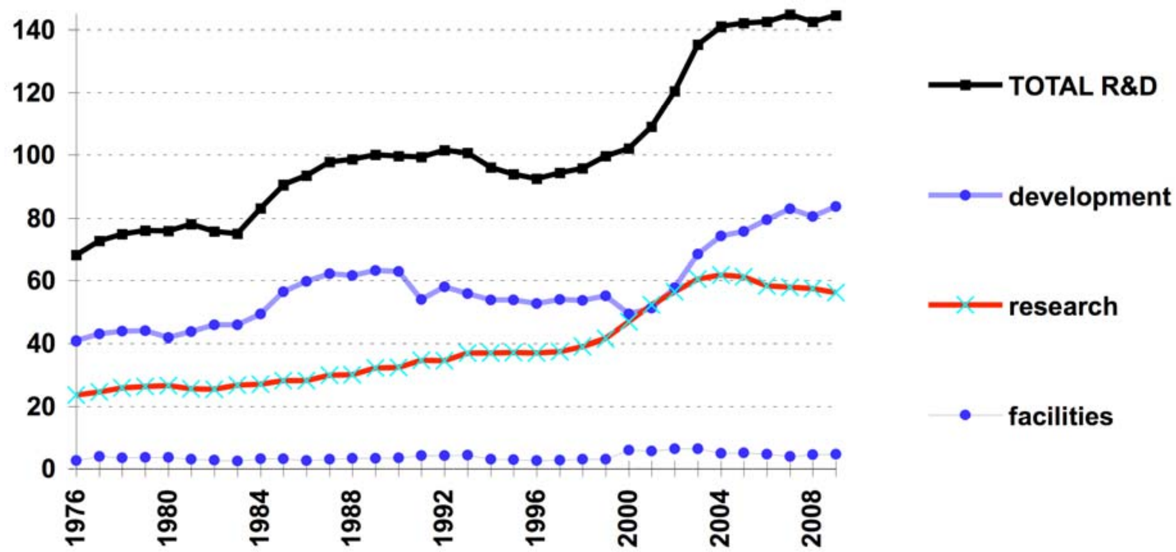
As we have already discussed in Chapter 3, any policy, goals or good will, that are not supported with appropriate funding, have little effect. Thus, the changes in federal funding of R&D in the last two decades will be discussed as one of the most important means to support and guide the technology policy of the USA and vice versa, to see if the intensions of the government at the end of the 20th century were supported by the funding of the R&D in the following years.

The federal R&D funding will be studied in two ways: as a more qualitative presentation of temporal development over the last two decades and as a more quantitative comparison of federal funding in fiscal years 1993, 1997 and 1998 to fiscal years 2008, 2009 2010 and 2011.

* as seen from the perspective at the end of the first decade of the 21st century

5.1.1 Tendency of federal R&D funding in the last two decades

Fig.5.1: Federal R&D investments in years 1967 – 2009. Investments are in billions of constant 2008 dollar.

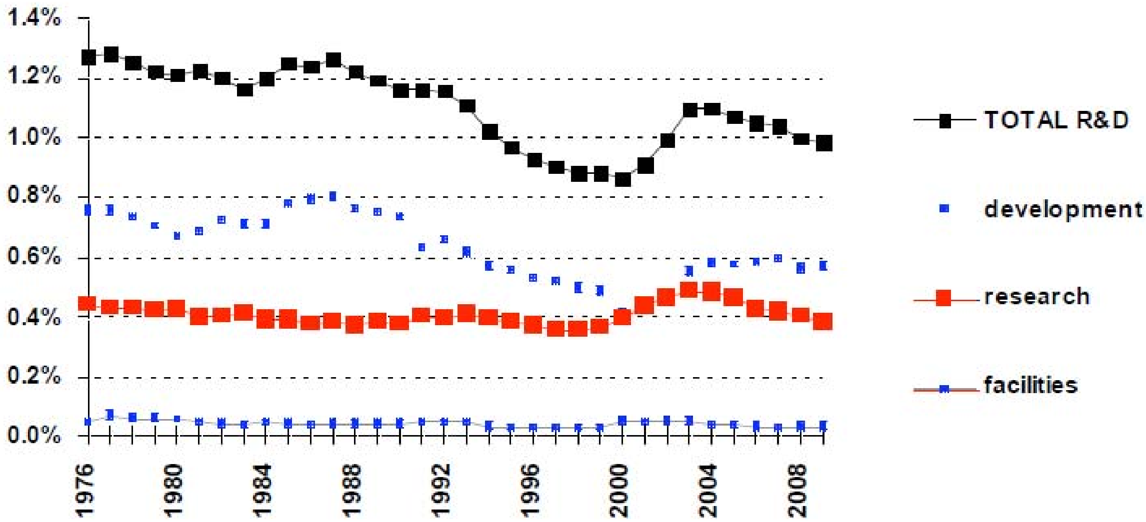


Source: Koizumi 2008 (AAAS Analyses of R&D in AAAS annual R&D reports)

The changes in federal R&D investments are given in Figs. 5.1 and 5.2. It can be clearly seen that a period of an almost constant total R&D funding (1988-1992) was followed by a period of its decrease in years 1993-1996. However, a significant total R&D investment increase from approximately $ 90 million up to $ 140 million can be observed in years 1996 – 2004. Afterwards, the increase of total funding slowed down, nevertheless, the funding experienced a still increasing tendency. If the temporal funding patterns of development and research are observed, significant investments increase in the time period 2000 – 20003 can be observed for both. Before the year 2000, the funding of research experienced a long and slow, but stable growing period, while development funding was more volatile, but having a decreasing tendency. After the year 2003, the federal investments in research and development are at levels around 60 and 80 billions of constant 2008 dollar.

The situation looks differently if the funding is not taken into account absolutely, but compared to the GDP (Fig. 5.2). Starting from the year 1987, a period of increasing funding can be observed solely in the years between 2000 and 2003. The rest of the time the funding experiences a predominantly falling tendency. Fairly stable funding is seen only for research in the time period before the year 2000 and for the development after the year 2003, respectively.

Fig.5.2: Total federal R&D investments as a % of GDP in years 1976 – 2009.



Source: Koizumi 2008 (AAAS Analyses of R&D in AAAS annual R&D reports)

We may conclude that the promise given by the policy makers that "federal R&D funding must be stable and growing during the times of the onset of information era" was fulfilled. However, it is true only if the funding is considered absolutely and not relatively, compared to the GDP.

5.1.2 Federal R&D funding in fiscal years 2008 to 2011

A more quantitative description of federal funding in the beginning of the 21st century will be given based on the R&D investments in fiscal years from 2008 to 2011. The investments in these years seem to best characterize the relatively stable funding situation after its sharp increase in the previous years (Fig. 5.1). The investments will be given split by agency (area), by R&D theme (basic and applied research, development) and by purpose/character (military, civilian).

The investments for the year 2009 are listed in two ways (columns): as it was accepted in the budget for the year 2009 and together with the investments that are in accordance with the American Recovery and Reinvestment Act (ARRA; Public Law 111-5). Namely, the acceptance of this Act in year 2009 enabled some additional investments into research and development in key science agencies.

The distribution of federal R&D investments to different agencies is shown in table 5.1. It can also be seen as a rough estimation of the funding of areas of interest. We may see that the

Table 5.1: Federal R&D investments in years 2008, 2009 (2009+ARRA), 2010 and 2011* in millions of dollar. The investments are split by agency (area) (* proposed, therefore showing the intensions of the government; ** investments due to American Recovery and Reinvestment Act).

agency (area)	**year**					
	2008	**2009**	**ARRA****	**2009+ARRA**	**2010**	**2011***
defense	80.278	80.821	300	81.121	81.090	77.548
HHS[1]	29.265	30.595	11.063	41.658	31.177	32.156
NASA[2]	11.182	10.887	790	11.677	9.286	10.986
energy	9.807	10.301	2.967	13.268	10.693	11.219
NSF[3]	4.580	5.379	2.197	7.576	5.092	5.571
agriculture	2.336	2.437	176	2.613	2.591	2.448
commerce	1.160	1.393	576	1.969	1.516	1.727
interior	683	701	74	775	755	772
transportation	875	976	0	976	1.012	1.018
EPA[4]	551	559	0	559	622	651
other	3.029	3.269	10	3.279	3.519	3.600
total	143.746	147.318	18.153	165.471	147.353	147.696

[1]Health and Human Services, [2] National Aeronautics and Space Administration, [3]National Science Foundation, [4] Environmental Protection Agency

Source: Office of Science and Technology Policy 2009 and 2010 majority of the investments (90 %) is divided between three or four agencies (areas): defense, health and human services, NASA and energy. The federal funding is also relatively stable in this time period, however, the ARRA might indicate the intension of the new government to make some changes in the funding of certain agencies (areas). Health and human services, energy, National science foundation and commerce are gaining most of the ARRA investments, especially if the relative numbers are considered. A similar intension is seen also in the proposed budget for the year 2011.

The federal R&D funding, split according to the R&D theme, is shown in table 5.2. A relatively stable situation is observed in the period 2008 - 2011, however, the basic research is gaining more funding compared to the applied one, and especially to the development. But it has to be noted that if ARRA is considered, the funding increase was significant in year 2009.

Table 5.2: Federal R&D investments in years 2008, 2009 (2009+ARRA), 2010 and 2011* in millions of dollar. The investments are split by R&D theme (* proposed, therefore showing the intensions of the government, ** investments due to American Recovery and Reinvestment Act).

R&D theme	**year**					
	2008*	**2009**	**ARRA****	**2009+ARRA**	**2010**	**2011***
basic research	28.613	29.583	7.794	37.377	30.002	31.341
applied research	27.413	29.054	5.385	34.439	28.327	30.276
total research	56.026	58.637	13.179	71.816	58.329	61.617
development	83.254	83.866	1.482	85.348	84.373	81.455
equipment & facilities	4.466	4.815	3.492	8.307	4.651	4.624
total	143.746	147.318	18.153	165.471	147.353	147.696

Source: Office of Science and Technology Policy 2009 and 2010

If the federal funding is split by its purpose (character) into military (defense) and civilian (non-defense) it is visible that the shares of civilian investments are between 41 % and 43 % in this time period (Table 5.3). The intensions of the government seem to be in favour of higher spending for civilian purposes, which is indicated by ARRA and the proposed budget 2011 with the shares of 49 % and 45 %, respectively.

Table 5.3: Federal R&D investments in years 2008, 2009 (2009+ARRA), 2010 and 2011* in millions of dollar. The investments are split by R&D share (* proposed, therefore showing the intensions of the government, ** investments due to American Recovery and Reinvestment Act).

R&D share	**year**					
	2008*	**2009**	**ARRA****	**2009+ARRA**	**2010**	**2011***
military	84.337	84.646	300	84.946	85.038	81.695
civilian	59.409	62.672	17.853	80.525	62.315	66.001
total	143.746	147.318	18.153	165.471	147.353	147.696
percent civilian	**41 %**	**43 %**	**-**	**49 %**	**42 %**	**45 %**

Source: Office of Science and Technology Policy 2009 and 2010

5.1.3 Quantitative comparison of the federal R&D funding in the last two decades

In this chapter, a more quantitative comparison of the federal R&D funding in the years before and after the change of the century will be given. The funding in fiscal years 1993, 1997 and 1998 will be compared to the one in fiscal years 2008 – 2011. These years can represent two separate periods of relatively stable federal R&D funding before and after the period of an intense funding increases around the year 2000. Therefore, they are suitable to study the changes in federal R&D investments in the last two decades.

In order to compare the funding strategy and its changes the funding is investigated in respect to the total federal R&D investment in relevant years (Table 5.4). In addition, the changes in the real dollar value can be omitted in this way. Furthermore, the average values for the years representing the two periods before and after the year 2000 are calculated and listed in table 5.5. These values are the basis for the comparison of both periods. The values for the year 2009 as well as for the averages are given with and without the investments due to ARRA (for more detail, see 5.1.2).

Table 5.4: Shares of federal R&D investments in years 1993, 1997 and 1998* as well as those in years 2008, 2009 (2009+ARRA), 2010 and 2011*. The shares are in % and split by agency (area). They are normalized to the total R&D investment in the same years (* proposed, therefore showing the intensions of the government).

share by agency (area)	**year**							
	1993	**1997**	**1998***	**2008**	**2009**	**2009+ ARRA**	**2010**	**2011***
defense	53.7	51	49	56	55	49	55	53
HHS[1]	14.5	18	19	20	21	25	21	21.8
NASA[2]	12.2	12.6	12.7	7.8	7.4	7.1	6.3	7.4
energy	9.5	8.4	10	6.8	7.0	8.0	7.3	7.6
NSF[3]	2.8	3.3	3.4	3.2	3.7	4.6	3.5	3.8
agriculture	2.0	2.1	2.0	1.6	1.7	1.6	1.8	1.7
commerce	1.1	1.4	1.5	0.8	1.0	1.2	1.0	1.2
interior	0.9	0.8	0.8	0.5	0.5	0.5	0.5	0.5
transportation	0.85	0.87	1.0	0.6	0.7	0.6	0.7	0.7
EPA[4]	0.7	0.7	0.7	0.4	0.4	0.3	0.4	0.4
other	1.8	1.7	1.6	2.1	2.2	2.0	2.4	2.4

[1]Health and Human Services, [2]National Aeronautics and Space Administration, [3]National Science Foundation, [4]Environmental Protection Agency

Table 5.5: Average shares of federal R&D investments in years 1993, 1997 and 1998* as well as in years 2008, 2009 (2009+ARRA), 2010 and 2011*. The shares are in % and split by agency (area) (* proposed, therefore showing the intensions of the government).

share by agency (area)	average in years 1993, 1996 and 1998*	average in years 2008, 2009, 2010 and 2011*	average in years 2008, 2009+ARRA, 2010 and 2011*
defense	51.2	55	53
HHS[1]	19	21	22
NASA[2]	12.5	7.2	7.2
energy	9.3	7.2	7.4
NSF[3]	3.2	3.6	3.8
agriculture	2.0	1.7	1.7
commerce	1.3	1.0	1.1
interior	0.8	0.5	0.5
transportation	0.9	0.7	0.7
EPA[4]	0.7	0.4	0.4

[1]Health and Human Services, [2] National Aeronautics and Space Administration, [3]National Science Foundation, [4] Environmental Protection Agency

As seen in Table 5. 6, the biggest absolute changes after the year 2000 occurred in defense, health and human services, NASA and energy. The first two gained + 3.8 % (+ 1.8 % and +4.8 % with ARRA) each, while the NASA and energy lost 5.3 % and 2.1 % (5.3 % and 1.9 %), respectively. A different picture is obtained, when the relative changes are considered. Health and human services and National science foundation gained 22 % and 12.5 % (28 % and 19 % with ARRA) more funding, while NASA (- 74 %), environmental protection agency (- 43 %) and interior (- 38 %) lost the most. The funding of defense remained relatively constant with + 7 % (+ 3.5 % with ARRA), all the other agencies that were not mentioned above, lost their shares.

In general, the tables 5.4 - 5.6 demonstrate that the basic organizational scheme used to deal with the federal R&D spending and supervise its effects did not change significantly after the year 2000. Namely, the most important agencies (departments) remained the same and only 8.6 % of the total federal R&D funding (around 13.000 million dollars) was allocated to another agency if the average R&D budget in years 2008 - 2011 is compared to that in years 1993, 1996 and 1998. No additional "Department of Science and Technology" was established in order to centralize the federal R&D funding and to make the process potentially more efficient. However, an additional funding was given to the National Science Foundation which could be seen as an increase of its power.

Table 5.6: Changes in average shares of federal R&D investments in years 2008, 2009 (2009+ARRA), 2010 and 2011* and average shares in years 1993, 1997 and 1998*. The shares are split by agency (area) (* proposed, therefore showing the intensions of the government).

share by agency (area)	**absolute difference average (2008, 2009, 2010 and 2011*) – average (1993, 1996 and 1998*)**	**absolute difference average (2008, 2009+ARRA, 2010 and 2011*) - average (1993, 1996 and 1998*)**	**relative difference average (2008, 2009, 2010 and 2011*) - average (1993, 1996 and 1998*)**	**relative difference average (2008, 2009+ARRA, 2010 and 2011*) - average (1993, 1996 and 1998*)**
defense	+ 3.8	+ 1.8	+ 7 %	+ 3.5 %
HHS[1]	+ 3.8	+ 4.8	+ 22 %	+ 28 %
NASA[2]	- 5.3	- 5.3	- 74 %	- 74 %
energy	- 2.1	- 1.9	- 23 %	- 20 %
NSF[3]	+ 0.4	+ 0.6	+ 12.5 %	+ 19 %
agriculture	- 0.3	- 0.3	- 15 %	- 15 %
commerce	- 0.3	- 0.2	- 30 %	- 18 %
interior	- 0.3	- 0.3	- 38 %	- 38 %
transportation	- 0.2	- 0.2	- 22 %	- 22 %
EPA[4]	- 0.3	- 0.3	- 43 %	- 43 %
other	+ 0.6	+ 0.5	+ 35 %	+ 29 %

[1]Health and Human Services, [2]National Aeronautics and Space Administration, [3]National Science Foundation, [4]Environmental Protection Agency

5.2 Comparison of military and civilian federal R&D funding in the last two decades

The end of the competition in military power with the end of the Cold war in the eighties of the last century seemed to offer a chance to allocate more funds into the civilian programs. This was also one of the intensions of the policy makers and ex-president Clinton (see Chapter 3.2). Did he succeed? Were there some changes in the policy due to the events on September 11th ?

The hypothesis in this thesis was that the federal military (defense) R&D funding will not be significantly altered in the beginning of this century in spite of the end of the Cold war. However, I strongly believed that the traditional attitude in the USA that the state should not support the private sector and interfere the free market in this way will change. The second hypothesis was that the private non-defense sector will get more federal R&D funding in order to strengthen its competitiveness in the world.

5.2.1 Military (defense) versus civilian (non-defense) R&D funding

Let us check our first hypothesis. The changes in the federal military (defense) R&D funding in comparison to the non-defense civilian sector will be quantitatively investigated by the changes in the share of federal military R&D investments (to the total federal R&D funding in each year) in years 2008 – 2011 and in years 1993, 1997 and 1998. The share values in these years are between 54 % and 59 %, with ARRA between 51 % and 59 % (Table 5.7). No tendency over the years can be observed, the values are scattered equally. If we calculate two average values for the years after and before the year 2000 (2008 – 2011 vs. 1993, 1997 and 1998), an increase from 55.7 % to 57.2 % can be observed (Table 5.8). If the additional funding in accordance with ARRA is considered, the share of military funding remains unchanged (55.7 %).

Table 5.7: Shares of military (defense) and civilian (non-defense) federal R&D investments in years 1993, 1997 and 1998* as well as those in years 2008, 2009 (2009+ARRA), 2010 and

2011*. The shares are normalized to the total R&D investment in the same years (* proposed, therefore showing the intensions of the government).

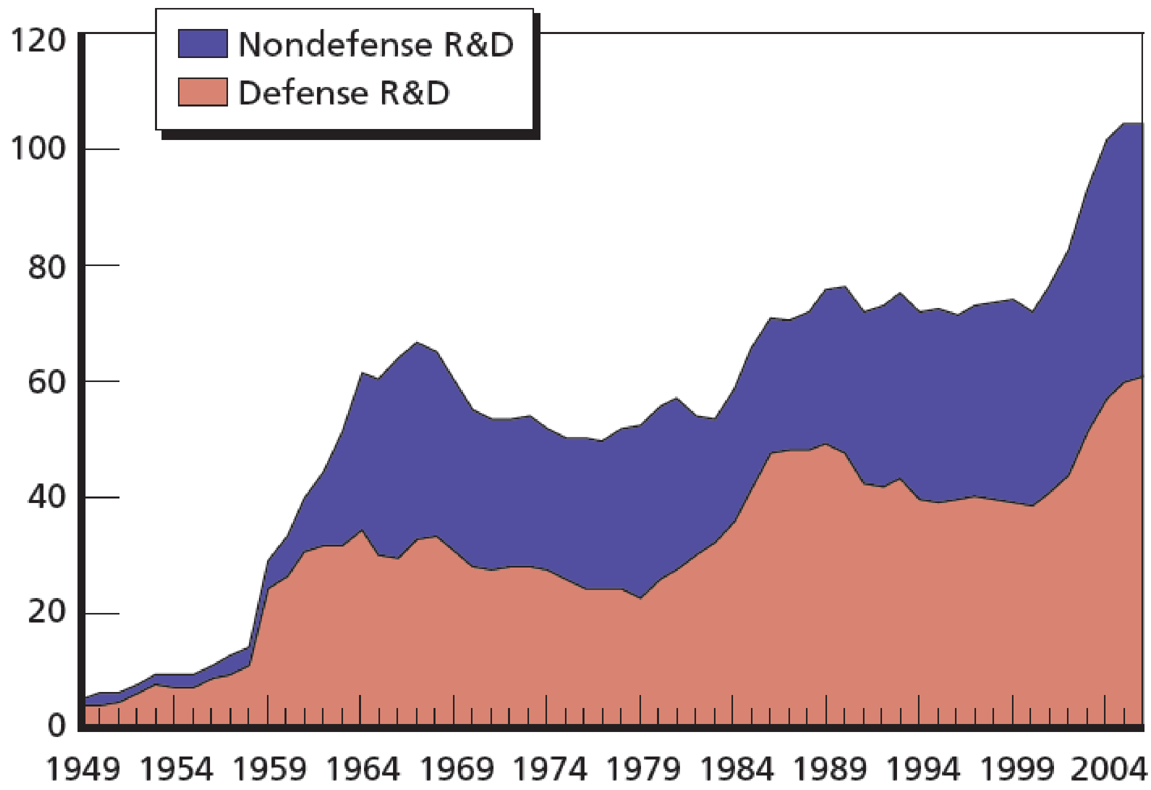
R&D share	**year**							
civilian / total	**1993**	**1997**	**1998***	**2008**	**2009**	**2009+ ARRA**	**2010**	**2011***
percent military	58 %	55 %	54 %	59 %	57 %	51 %	58 %	55 %
percent civilian	42 %	45 %	46 %	41 %	43 %	49 %	42 %	45 %

Table 5.8: Average shares of military (defense) and civilian (non-defense) federal R&D investments in years 1993, 1997 and 1998* as well as those in years 2008, 2009 (2009+ARRA), 2010 and 2011*. The shares are normalized to the total R&D investment in the same years (* proposed, therefore showing the intensions of the government).

R&D share	**average in years 1993, 1996 and 1998***	**average in years 2008, 2009, 2010 and 2011***	**average in years 2008, 2009+ARRA, 2010 and 2011***
percent military	55.7 %	57.2 %	55.7 %
percent civilian	44.3 %	42.8 %	44.3 %

A more quantitative picture of the changes in federal military (defense) and civilian (non-defense) funding in the last two decades can be seen in Fig. 5.3. A significant decrease of military federal funding, which was more pronounced until the year 1994, can be observed in the years between 1990 and 2000. On the contrary, a fairly stable total federal R&D funding was experienced in these years. However, a steep increase of both, the military and the civilian federal R&D funding followed after the year 2001.

Fig.5.3: Federal R&D funding for military (defense) and civilian (non-defense) purposes in years 1949 – 2006. They are given in billions of constant 2000 dollar.



Source: Galama and Hosek 2008 (American Association for the Advancement of Science, Trends in Federal R&D by Function 2007)

We may conclude that the share of the military federal R&D funding did not change significantly in the beginning of this century in spite of the end of the Cold war. This confirms our hypothesis. We may speculate that the events on September 11th did not pass the technology policy in the USA without any influence.

5.2.2 Civilian (non-defense) R&D funding of applied research and development

In this section our second hypothesis is discussed. It states that the strong traditional attitude in the USA technology policy which is against the federal government funding of the private industry, even in the pre-competition phase, will be changed. Since the beginning of the federal funding it has namely been believed that the free market, and accordingly, the competition among the producers which is very important, will be influenced or even destroyed if the federal funding is offered to the private sector (Mowery and Rosenberg 1989; Ham and Mowery 1995). Our second hypothesis was based on the assumption that more federal R&D support was needed urgently by the private non-defense sector in order to sustain its position in the world. Especially, because there is an opinion that other states are supporting their own industries as well.

The results in section 5.2.1 show that the share of the federal military (defense) R&D funding increased by 1.7 % or, if ARRA is taken into account, did not change in years 2008 – 2011 compared to the years 1993, 1997 and 1998. Accordingly, no significant changes in the non-defense civilian sector are to be expected. In fact, the civilian (non-defense) federal R&D share experienced a small decrease from 44.3 % to 42.8 % (tables 5.7 and 5.8) and it is only due to ARRA, that the share of civilian funding remained unchanged (44.3 %) in this decade.

The unchanged share of civilian funding in this decade means that a significant change of federal R&D funding in favor of private sector did not happen. However, there might still be a chance that a change of the funding distribution inside the civilian federal funding share occurred in favor of the support of the pre-competition phase in the private sector. In this case a more intensive funding of applied research and development is to be expected in the last decade. Therefore, the distribution of federal R&D funding inside the civilian share should be analyzed (Table 5.9).

Table 5.9: Parameters, showing the federal R&D investments in years 1993, 1997 and 1998* as well as those in years 2008, 2009 (2009+ARRA), 2010 and 2011* into research (applied and basic), development and applied research and development (military and civilian). In addition, the federal investments in civilian (nondefense) development are shown. They are all in millions of dollar (* proposed, therefore showing the intensions of the government).

parameter	**year**							
	1993	**1997**	**1998***	**2008**	**2009**	**2009+ ARRA**	**2010**	**2011***
research (applied +basic)	26.970	29.414	30.462	56.026	58.637	71.816	58.329	61.617
development	42.795	42.153	41.636	83.254	83.866	85.348	84.373	81.455
development+ applied	56.403	56.682	56.795	110.667	112.920	119.787	112.700	111.731
civilian development - equipment & facilities[1]	6.521	7.082	6.380	5.371	5.928	7.195	5.665	6.237
civilian development+ equipment & facilities[2]	9.248	9.336	9.751	9.837	10.731	15.502	10.316	10.861
R&D total	72.492	73.821	75.469	143.746	147.318	165.471	147.353	147.696

[1] military equipment & facilities, [2] civilian equipment & facilities

Source: Office of Science and Technology Policy 2009 and 2010 (Office of Management and Budget)

For a quantitative assessment of a possible change in civilian R&D funding, three parameters were calculated for the years of interest: applied / basic research, development / research and (development + applied) / basic research. All these ratios depict the share of applied research and/or development compared to the basic research in different ways. In addition, the share of civilian development compared to the total R&D federal funding is estimated.

Table 5.10: Ratios between applied and basic research, development and research as well as the ratio between applied research + development and basic research. In addition, the ratio between the investments in civilian (nondefense) development and R&D investments is shown. The ratios are shown for federal R&D investments in years 1993, 1997 and 1998* as well as those in years 2008, 2009 (2009+ARRA), 2010 and 2011* (* proposed, therefore showing the intensions of the government).

parameter	**year**							
	1993	**1997**	**1998***	**2008**	**2009**	**2009+ ARRA**	**2010**	**2011***
applied / basic	1.02	0.98	0.99	0.96	0.98	0.92	0.94	0.97
development / research	1.59	1.43	1.37	1.49	1.43	1.19	1.45	1.32
development + applied / basic	4.22	3.81	3.71	3.87	3.82	3.20	3.76	3.57
civilian development[1] / R&D total	9.0	9.6	8.5	3.7	4.0	4.4	3.8	4.2
civilian development[2] / R&D total	12.8	12.6	12.9	6.8	7.0	8.1	7	7.4
average	10.9	11.1	10.7	5.3	5.7	6.9	5.4	5.8

[1] military equipment & facilities, [2] civilian equipment & facilities

It can be seen in Table 5.10 that the three basic parameters show overlapping values in the periods before and after the year 2000. However, there is a tendency to lower values in the years between 2008 and 2011, especially if the funding with ARRA is considered. This tendency is best observed when the average values of these parameters before and after the year 2000 are listed (Table 5.11). A direct comparison of these data reveals (Table 5.12) that the redistribution of federal civilian funding did not occur in favor of applied research and development, but in favor of basic research. Namely, the calculated ratios show decreased values of applied / basic research for 4 % (with ARRA 5 %), development / research for 2.7 % (with ARRA 6.9 %), and (development + applied) / basic research for 3.8 % (with ARRA 7.9 %), respectively.

Table 5.11: Average ratios between applied and basic research, development and research as well as the ratio between applied research + development and basic research. In addition, the average ratios between investments in civilian (nondefense) development and R&D investments are shown. The averages are calculated for years 1993, 1997 and 1998* as well as for years 2008, 2009 (2009+ARRA), 2010 and 2011* (* proposed, therefore showing the intensions of the government).

parameter	average in years 1993, 1996 and 1998*	average in years 2008, 2009, 2010 and 2011*	average in years 2008, 2009+ARRA, 2010 and 2011*
applied / basic	1.0	0.96	0.95
development / research	1.46	1.42	1.36
development + applied / basic	3.91	3.76	3.60
civilian development / R&D total	10.9	5.6	5.9

A more significant decline of the federal civilian R&D funding of the private industry is noticed when the investments into the civilian development and their share to the total R&D federal funding are studied (Tables 5.9 and 5.10). It has to be noted that only the estimated values for the civilian development are used. They were calculated using the data for total development, military R&D and military research on one side and civilian R&D and total and military research on the other. The average value of both estimations for each year offers an approximation which leads to a reasonably good agreement with the real values, especially when the military and the civilian equipment & facilities are comparable.

Tables 5.11 and 5.12 show that the ratio between the federal funding of civilian development and total federal R&D funding, experienced a significant decrease from 10.9 to 5.6 (with ARRA 5.9). This means a relative decrease in federal funding of civilian development for 50 % (with ARRA

46 %) after the year 2000 if the average value in years 1993, 1997 and 1998 is compared to the average in years between 2008 and 2011 (Table 5.12).

Table 5.12: Changes in average ratios between applied and basic research, development and research as well as the ratio between applied research + development and basic research. In addition, the change of average ratio between investments in civilian (nondefense) development and R&D investments is shown. The relative differences are calculated between federal R&D investments in years 2008, 2009 (2009+ARRA), 2010 and 2011* and in years 1993, 1997 and 1998* (* proposed, therefore showing the intensions of the government).

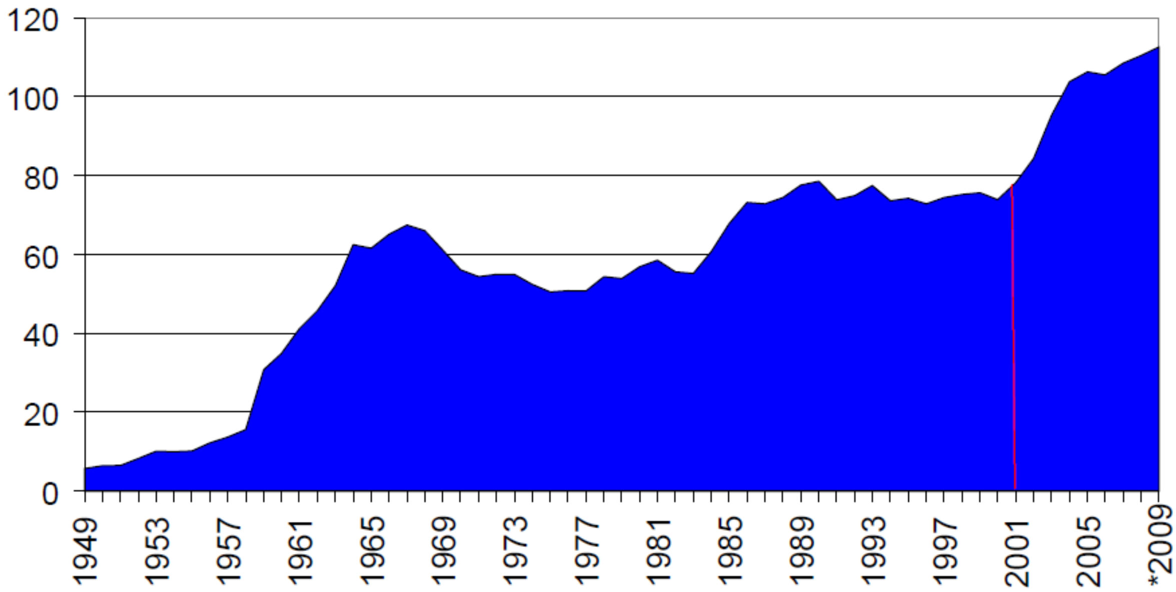
parameter	**relative difference average (2008, 2009, 2010 and 2011*) - average (1993, 1996 and 1998*)**	**relative difference average (2008, 2009+ARRA, 2010 and 2011*) - average (1993, 1996 and 1998*)**
applied / basic	- 4 %	- 5 %
development / research	- 2.7 %	- 6.9 %
development + applied / basic	- 3.8 %	- 7.9 %
civilian development / R&D total	- 50 %	- 46 %

In figures 5.4 and 5.5, a significant increase of civilian federal R&D funding at a nearly stable total R&D federal funding can be observed in the time period between 1990 and 2000. The increase was more pronounced before the year 1994. However, a steep increase of both, the total and the civilian federal R&D funding followed after the year 2001.

A similar picture, showing a decline of federal R&D funding of the private sector in comparison to the total R&D funding, is gained when the cumulative data for the last two decades (years

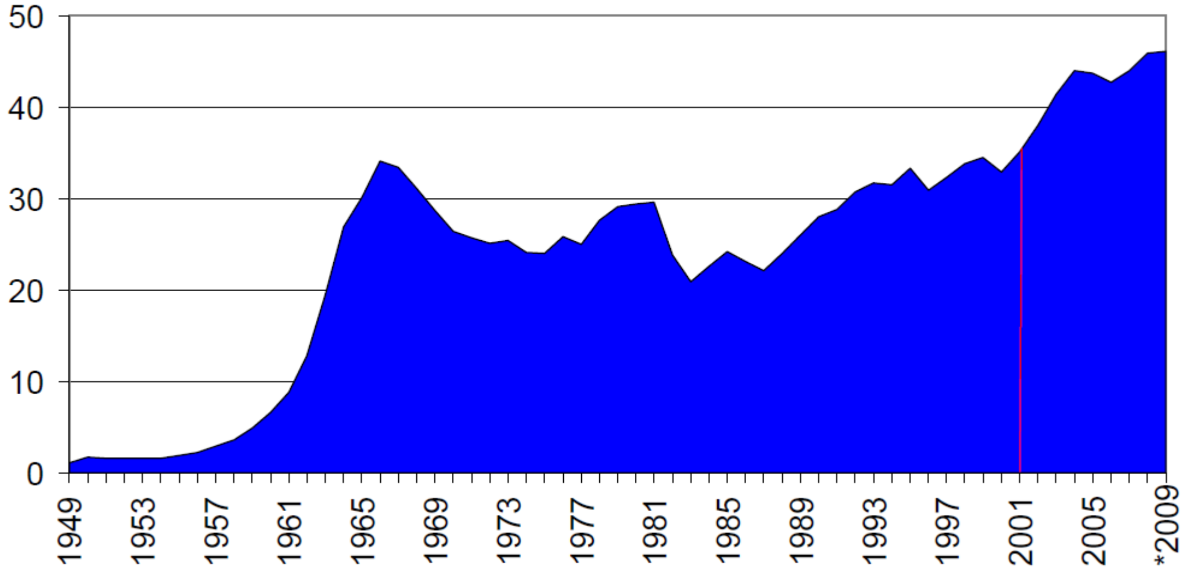
1994 – 2001 and 2002 – 2009) are considered (Figs. 5.4 and 5.5). Federal R&D was 617 billion dollar

Fig. 5.4: Changes in federal R&D spending in time period 1949 – 2009, given in billions of constant 2000 dollar.



Source: Office of Science and Technology Policy 2008

Fig. 5.5: Changes in federal civilian (non-defense R&D) spending in time period 1949 – 2009, given in billions of constant 2000 dollar.



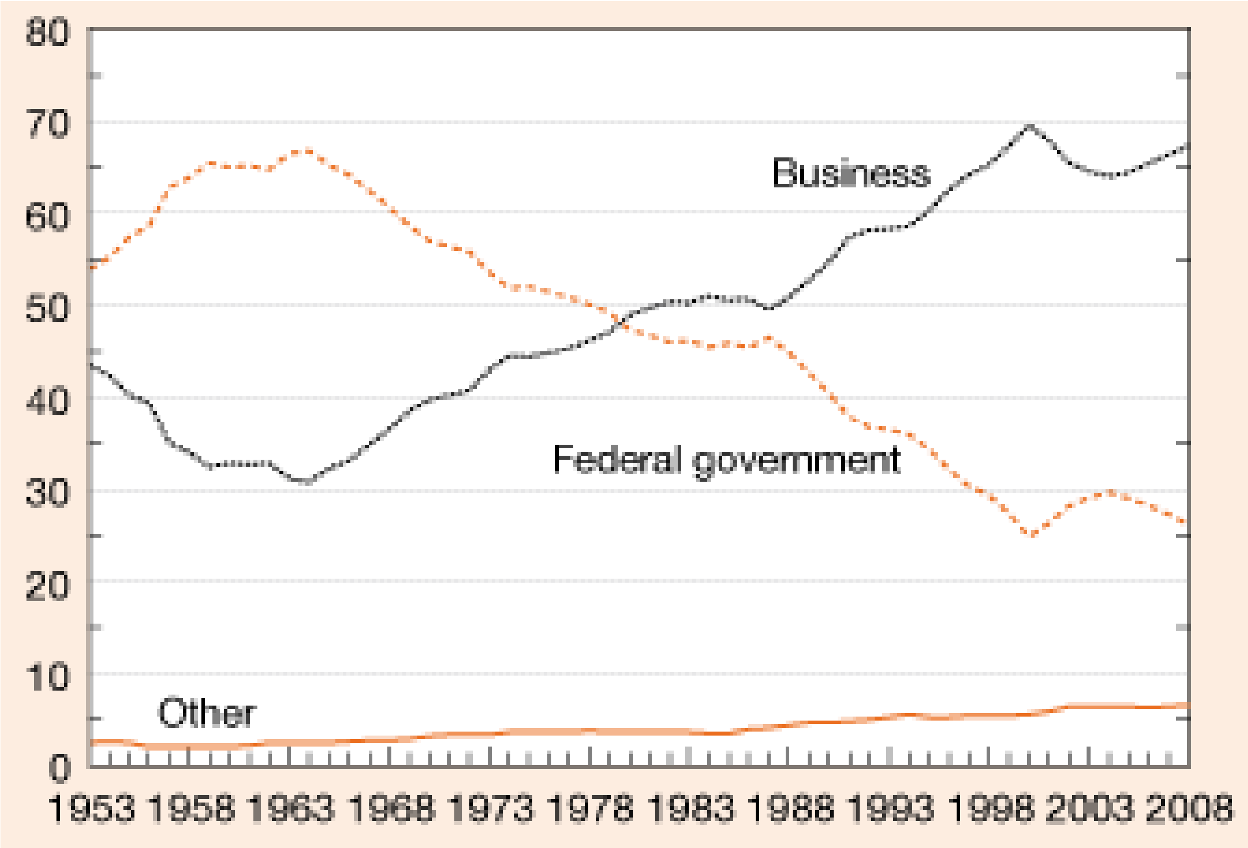
Source: Office of Science and Technology Policy 2008

(578 billion constant 1994 dollar) in the years between 1994 and 2001 and 1.039 billion dollar (819 billion constant 1994 dollar) in the years between 2002 and 2009, meaning a 42 % real increase. Accordingly, civilian R&D was in the years between 1994 and 2001 291 billion dollar (272 billion constant 1994 dollar) and in the years between 2002 and 2009 452 billion dollar (357 billion constant 1994 dollar), meaning a 31 % of real increase (Office of Science and Technology Policy; 2008). In the basic research 129 billion dollar (120 billion constant 1994 dollar) were invested in the years from 1994 to 2001 and 216 billion dollar (171 billion constant 1994 dollar) in the years from 2002 to 2009, meaning a 42 % real increase. Considering that the majority of the basic research belongs to the civilian R&D spending, it can be concluded that the share of civilian R&D spending in civilian applied research and development increased even less than civilian R&D spending (31 %). A rough estimation, where a realistic share between 10 % and 20% of total basic research was accounted to the basic military research, would give an increase between 20% and 25% in civilian applied research and development. This increase is only half of the real increase in total R&D in this period (42 %), which is in accordance with the results in Table 5.12.

Thus, based on the comparison on average values of two time periods of interest (1993, 1997 and 1998 vs. 2008 – 2011) and cumulative data of two 8 year consecutive periods (1994 – 2001 vs.

2002 – 2009), it can be seen that the federal investments into civilian applied research and development did not get the attention which could be comparable to military spending or basic research. The decline of federal R&D support of the private sector for approximately 50 % does not prove our second hypothesis. On the contrary, it gives sufficient evidence that the attitude in the USA that the federal government should not fund the private sector, even in its pre-competition phase, seems to remain unchanged even in this century. Furthermore, we may speculate in accordance to figure 5.6, that the private sector found enough strength to compensate the "missing" federal R&D support by itself.

Fig. 5.6: Share of total national R&D expenditures by funding source in years 1953 to 2008.



Source: Science and Engineering Indicators 2010 (National Science Foundation, Division of Science Resources Statistics, National Patterns of R&D Resources (annual series))

5.3 International comparison of the current status of the USA technology and its development in the last two decades

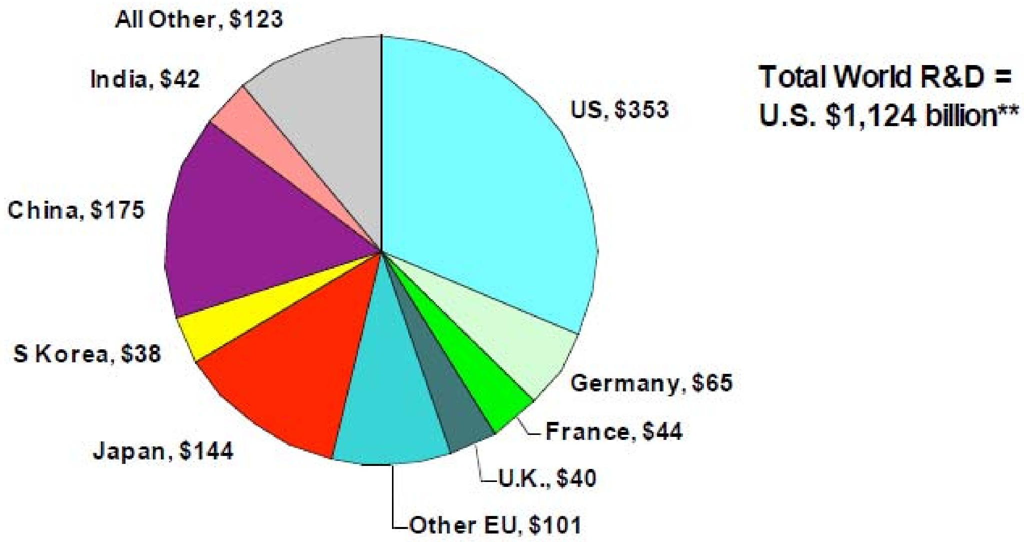
The third hypothesis that the USA did remain the world's leader in technology still has to be proven. The indicators which are most often used to compare the status of national R&D and its competitiveness are (National Science Foundation, Division of Science Resources Statistics 2007):

- R&D expenditures and foreign direct investment
- Education and advanced training
- Science and engineering (S&E) workforce and mobility
- Scientific publications, collaboration, and citations
- Patents
- High-technology manufacturing and exports, services, and trade in technical know-how.

Therefore, let us show some of the above listed indicators to compare the development of the USA technology in the last two decades and its status in the 21st century.

5.3.1 R&D expenditures

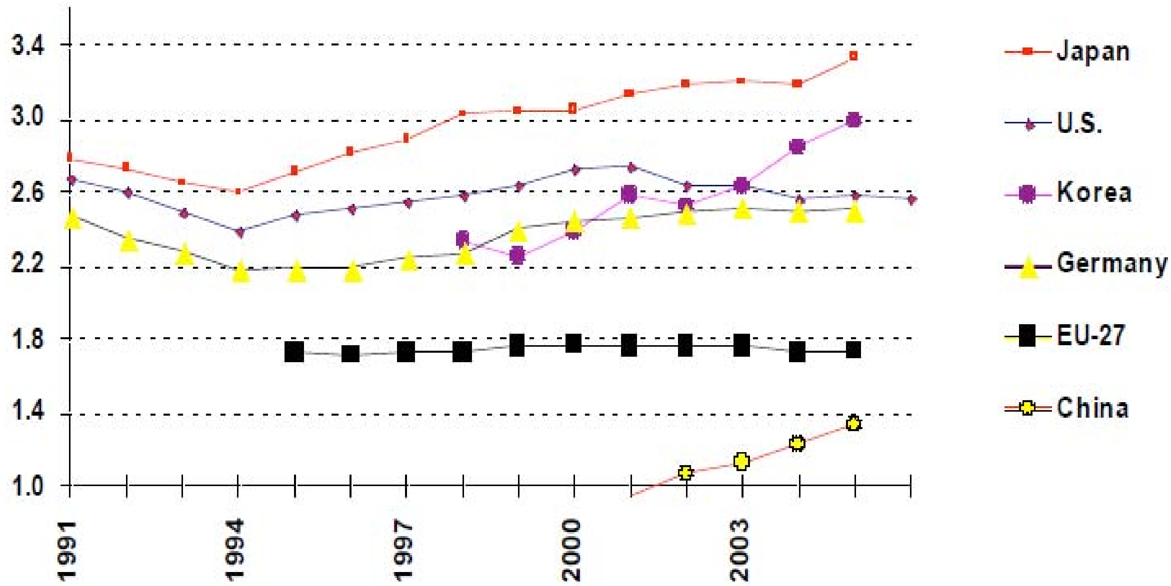
Fig. 5.7: World shares of the total R&D investments in the year 2007. Investments are given in millions of dollar.



Source: Koizumi 2008 (Battelle. Global R&D Report. 2007, from Battelle, OECD, and R&D Magazine data)

The predominant role of the USA in the share of the total world R&D spending is shown in figure 5.7. The USA is with its $ 353 billion of total national R&D investments and its 31 % world share far before the EU with its $ 250 billion (22 %), China ($175 billion, 16 %) and Japan ($ 144 billion, 13 %), respectively. When the total national R&D investments as % of GDP are compared in the years between 1991 and 2006 (Fig. 5.8), the USA also remains with a fairly constant 2.6 % (of GDP) in the leading group. According to this comparison, Japan has the leading role with a value around 3.4 % and a constantly increasing tendency in this time interval, Europe remains behind the USA with a fairly constant value just below 1.8 %.

Fig. 5.8: Total national R&D investments as % of GDP in years 1991 – 2006.

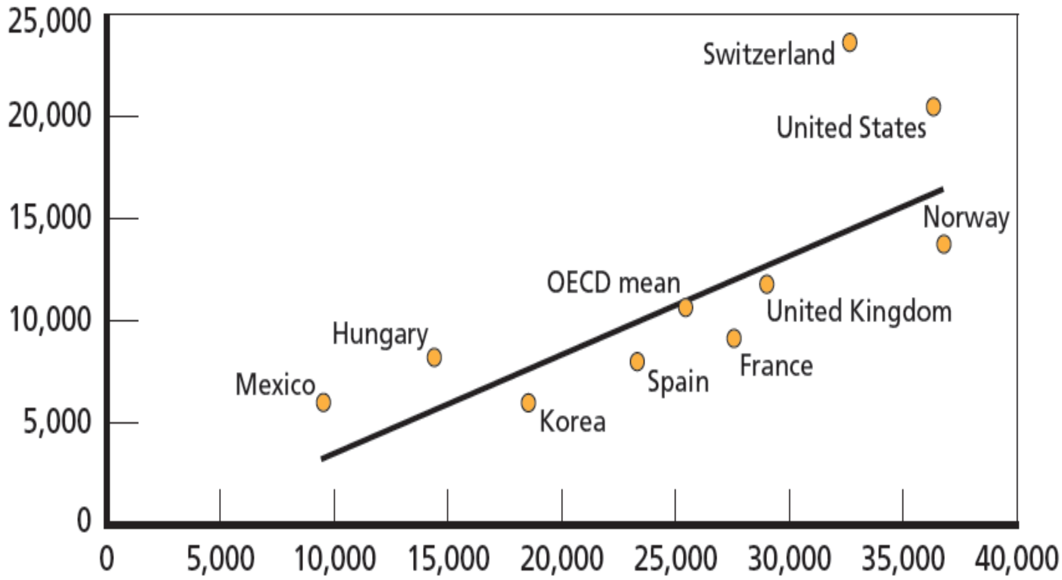


Source: Koizumi 2008 (National Science Foundation, National Patterns of R&D Resources in OECD, Main Science and Technology Indicators)

5.3.2 Education and advanced training

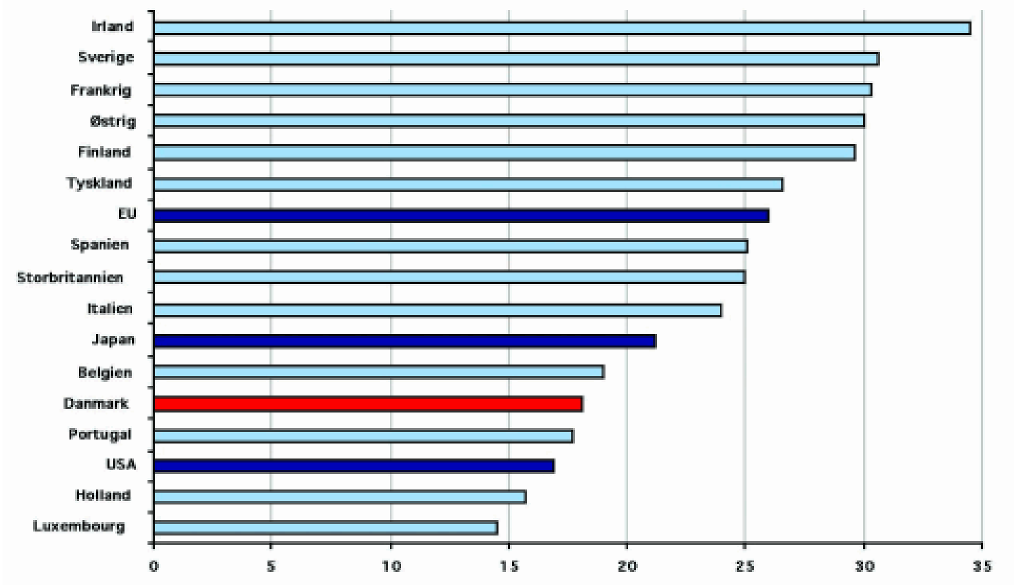
The annual expenditures at the postsecondary level show that the USA, together with Switzerland, invests the highest amounts of money per student (Fig. 5.9). A similar picture is also observed on the primary and secondary level (Galama and Hosek; 2008). The shares of candidates in natural science and technology in different countries which can be seen in Fig. 5.10, depict a worse picture of the USA position: the USA lies with a 17 % share behind Europe (27 %) and Japan (22 %). The numbers of awarded doctoral degrees in science and engineering place the USA (26.891; 22 %) on the second position, leaving it behind Europe (40.776; 33%), but far in front of Russia (10.409; 8 %), China (8.153; 7 %) and Japan (7.581; 6 %) (Table 5.13).

Fig. 5.9: Annual expenditures at postsecondary level per student in dependence of GDP per capita. The data are given in dollars for year 2002.



Source: Galama and Hosek 2008 (NCES 2006)

Fig. 5.10: Share of candidates in natural science and technology in different countries.



Source: Levy 2004 (EU Commission, Third European Report on S&T Indicators, 2003)

Table 5.13: Awarded doctoral degrees in science and engineering in different countries. They are given in absolute and relative units for year 2002 (or closest to it).

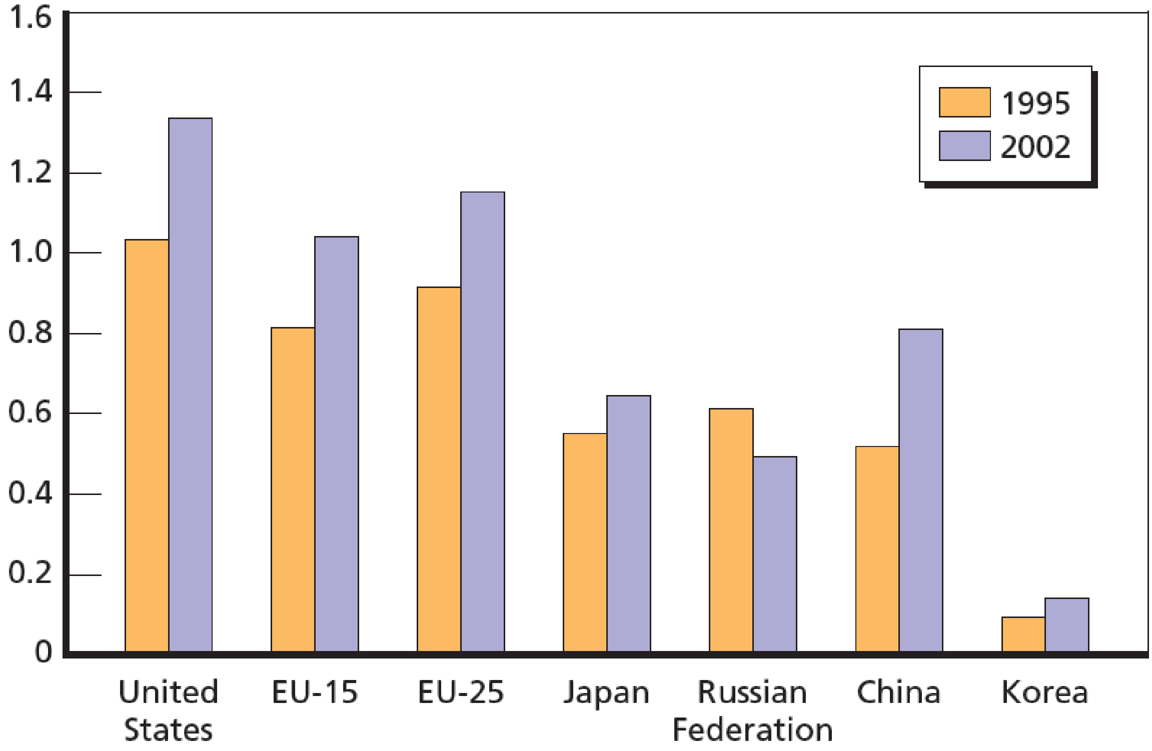
nation/region	**awarded doctoral degrees in S&E**	
	number	**percentage**
EU-15	40.776	33
United States	26.891	22
Russia	10.409	8
China	8.153	7
Japan	7.581	6
India	5.527	4
Romania	4.544	4
South Korea	3.225	3
Canada	2.475	2
Brazil	2.176	2
Australia	2,154	2
All Other	11.100	9
All Recipients	**125.011**	**100**

Source: Galama and Hosek 2008 (National Science Board 2006a)

5.3.3 Science and engineering workforce and mobility

The international comparison of the number of full-time equivalent researchers shows the leading role of the USA (Fig. 5.11). With around one million researchers in year 1995 and almost 1.4 million in year 2002 it has the biggest science and engineering workforce in the world. The increase of their number in the period between 1995 and 2002 is higher in the USA (40 %) than in Europe (approx. 30 %) and Japan (20 %), but lower than in China (60 %). Russia is the only country involved in the comparison experiencing the decrease of full-time equivalent researchers in this period. The USA is also counted to the countries with the biggest international mobility of the educated people, the two countries, where the majority of the high educated people comes from, are China and India (Galama and Hosek 2008).

Fig. 5.11: Increase of the number of full-time equivalent researchers in different countries between the years 1995 and 2002, given in millions.

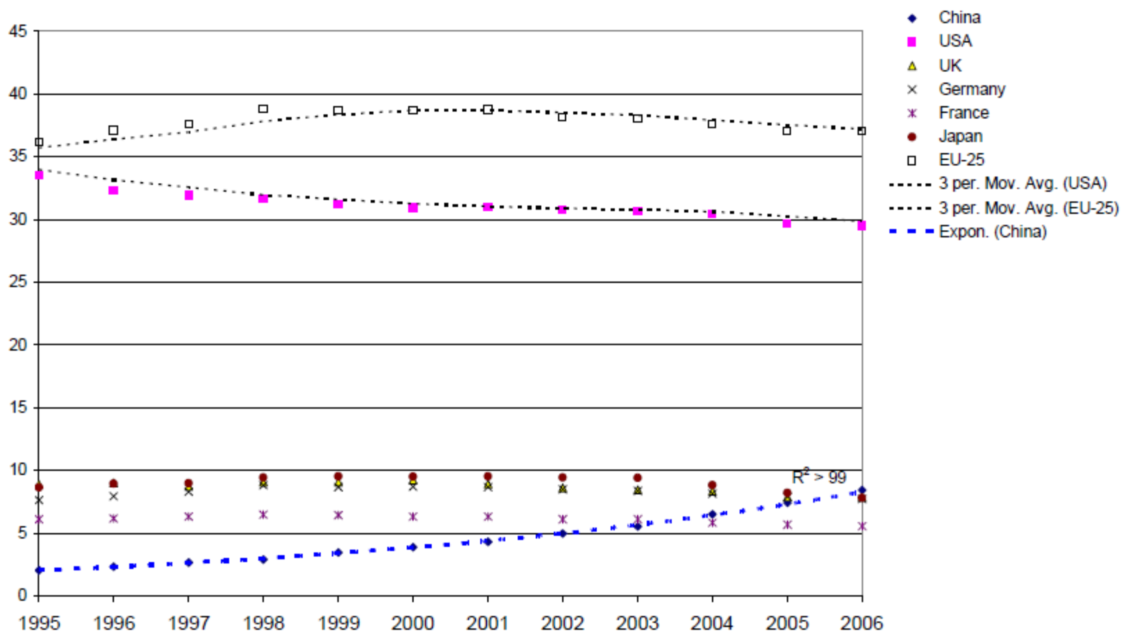


Source: Galama and Hosek 2008 (OECD 2006b, 2006c, 2006d)

5.3.4 Scientific publications and citations

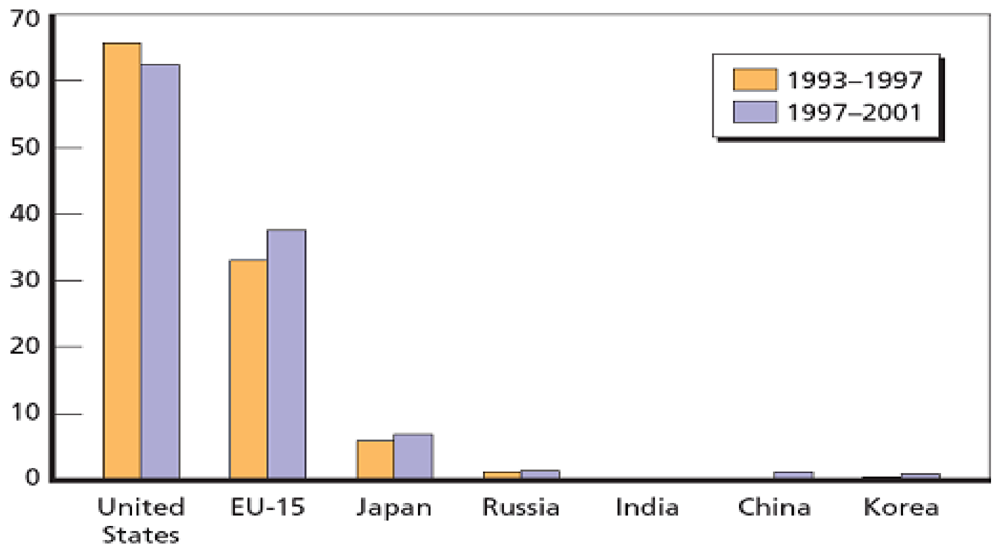
In terms of citations, the papers from the USA and the EU are on average becoming more equal with the world shares around 35% (Fig. 5.12). Europe seems to have a small advantage compared to the USA in overall citations, however, these two (with distance the most important world players) are far apart in the category of the top 1% most highly cited papers, with values around 65 % and 35 %, respectively (Fig. 5.13). The USA is also more successful than the EU in its research efforts in strategic priority areas like nanotechnology. As it can be seen in figure 5.14, the USA leads with a 35 % world share of citations in the top ten “nano” journals, before Europe (28 %), China (9 %) and Japan (9 %).

Fig. 5.12: World shares (in percent) of scientific publications in years 1995 - 2006. Data for USA, EU-25 and China are interpolated by dotted lines.



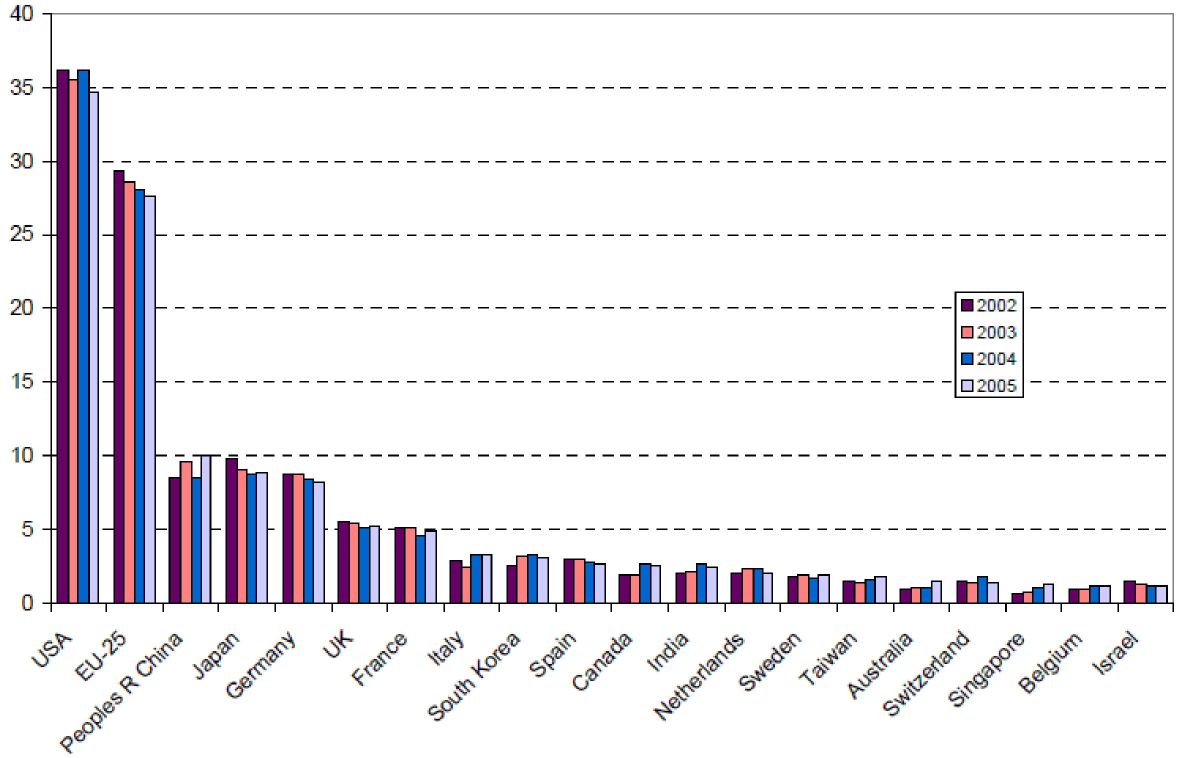
Source: Leydesdorff and Wagner 2009

Fig. 5.13: World share (in percent) of the most cited S&T publications (top 1 %) per country.



Source: Galama and Hosek 2008

Fig. 5.14: World share (in percent) of citations in the top ten "nano" journals per country in years 2002 - 2005.

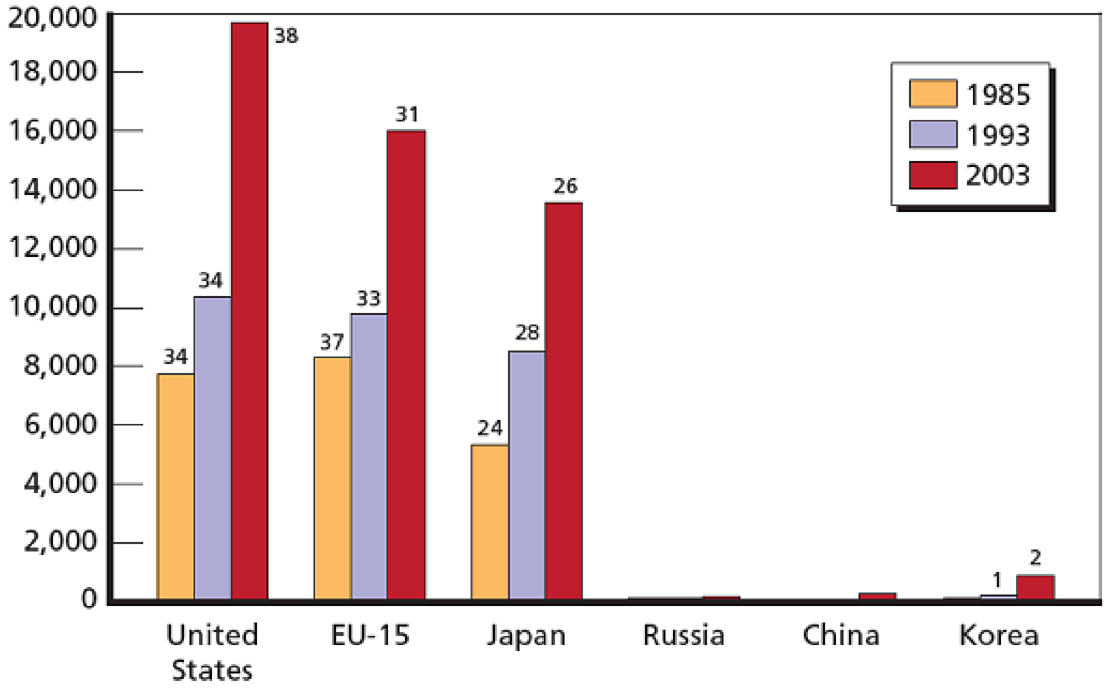


Source: Leydesdorff and Wagner 2009

5.3.5 Patents

Two kinds of parameters are used to compare the international position of the USA technology: the number of triadic patents and the share of patent citations. In year 2003, the USA built up its leading role with around 20.000 triadic patents and a 38 % world share, followed by Europe (16.000 patents and 31 % share) and Japan (14.000 patents and 26 % share) (Fig. 5.15). The comparison in years 1985, 1993 and 2003 shows that the USA increased its world share in triadic patents by 4 %, while Japan remained pretty stable with the share around 26 % and Europe lost 6 % of its share. Furthermore, the primate of the USA technology is untouched if the world share in patent citations (patents cited by scientific literature as well as scientific literature cited in patents) is considered (Table 5.14). However, note a significant decrease of its share in the year 2001 compared to the year 1991.

Fig. 5.15: International comparison of the number of triadic patents in years 1985, 1993 and 2003. The number above the bar denotes the percentage of all OECD triadic patents.



Source: Galama and Hosek 2008 (OECD 2006b and 2006c)

5.3.6 High-technology manufacturing and exports

The leading position of the USA before Europe, China and Japan is depicted by international comparison of world market shares for exports in high-technology (Fig. 5.16), however, the advantage of the USA technology decreased significantly during the years from 1999 to 2005. When the absolute numbers of world exports in high-tech per capita are compared during the same period (Fig. 5.17), Japan leads closely before the USA. The changes of value added in high-technology manufacturing industry between the years 1990 and 2003 are shown in figure 5.18. In contrast to the time dependencies exhibited in Figures 5.16 and 5.17, an increased performance of the USA high-technology can be observed after the year 1996 according to this parameter.

Table 5.14: Ten leading countries according to patent citations given by country shares in world total (* patents cited by scientific literature, ** scientific literature cited in patents).

rank	Patent references*				Patent citations **			
	1991		2001		1991		2001	
	country	share	country	share	country	share	country	share
1	USA	30.6%	USA	26.3%	USA	53.3%	USA	46.0%
2	DEU	9.3%	DEU	9.2%	JPN	10.2%	JPN	12.0%
3	JPN	7.6%	CHN	7.9%	GBR	8.3%	DEU	10.0%
4	FRA	7.1%	FRA	6.8%	DEU	6.8%	GBR	9.1%
5	GBR	6.5%	JPN	6.8%	FRA	5.2%	FRA	5.8%
6	CAN	3.6%	GBR	6.3%	CAN	4.6%	CAN	4.3%
7	ITA	3.2%	RUS	6.1%	ITA	2.4%	ITA	3.4%
8	IND	2.2%	IND	3.8%	NLD	2.3%	CHE	8%
9	CHE	1.8%	ITA	3.8%	CHE	2.1%	NLD	2.7%
10	NLD	1.7%	KOR	3.4%	SWE	2.0%	SWE	2.7%

Source: Glänzel, Debackere and Meyer 2006

Fig. 5.16: World market shares for exports in high-tech in years 1999 – 2005.

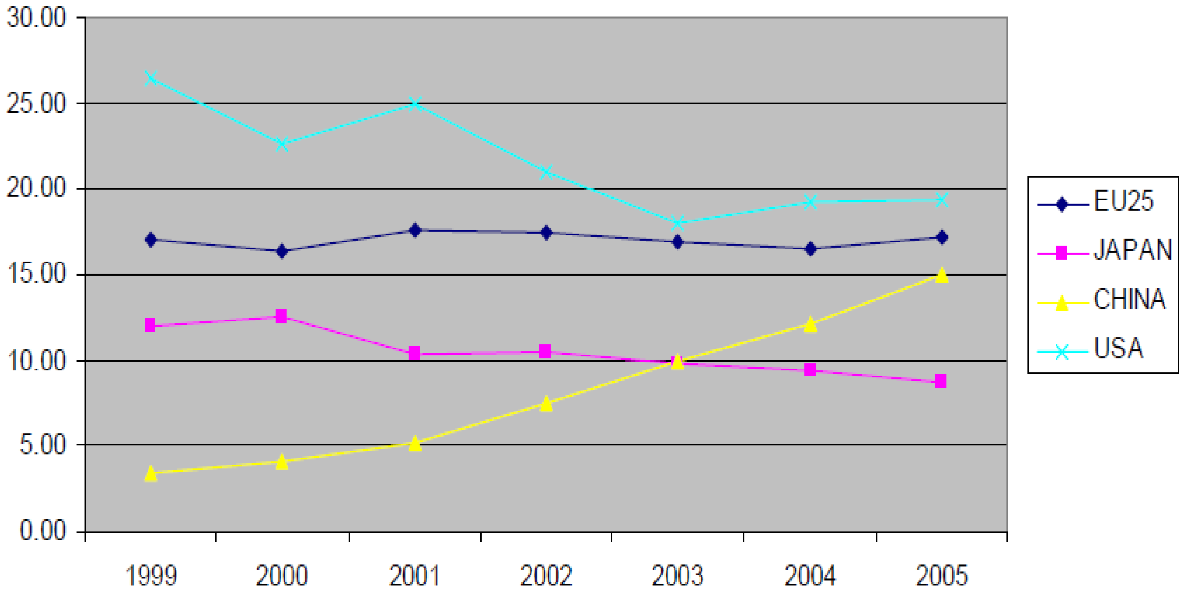
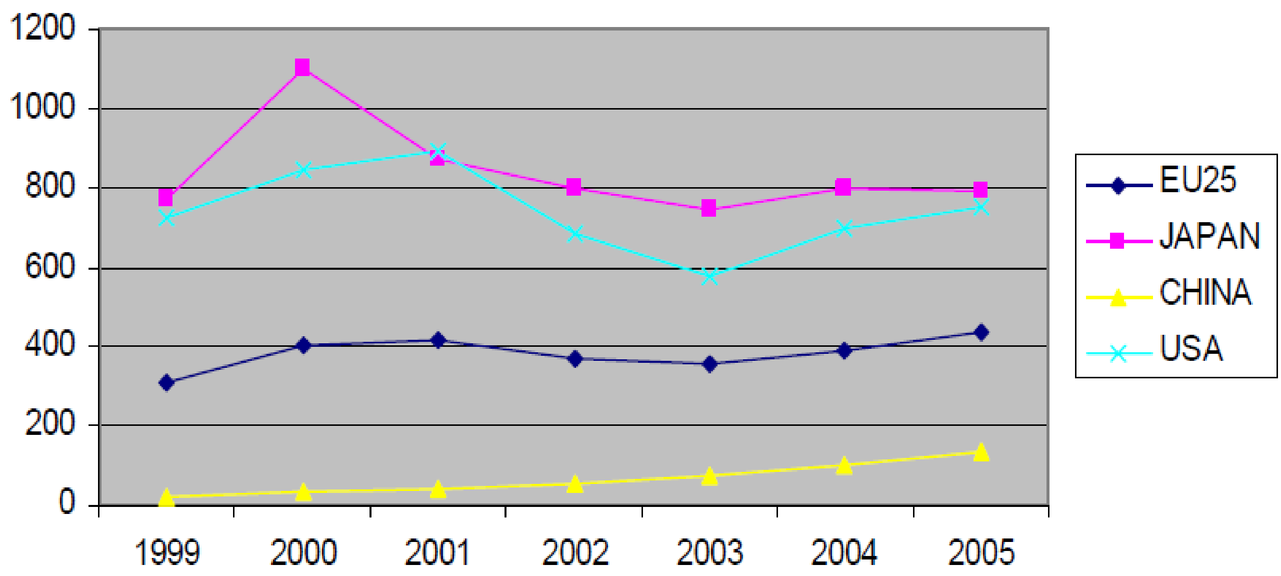
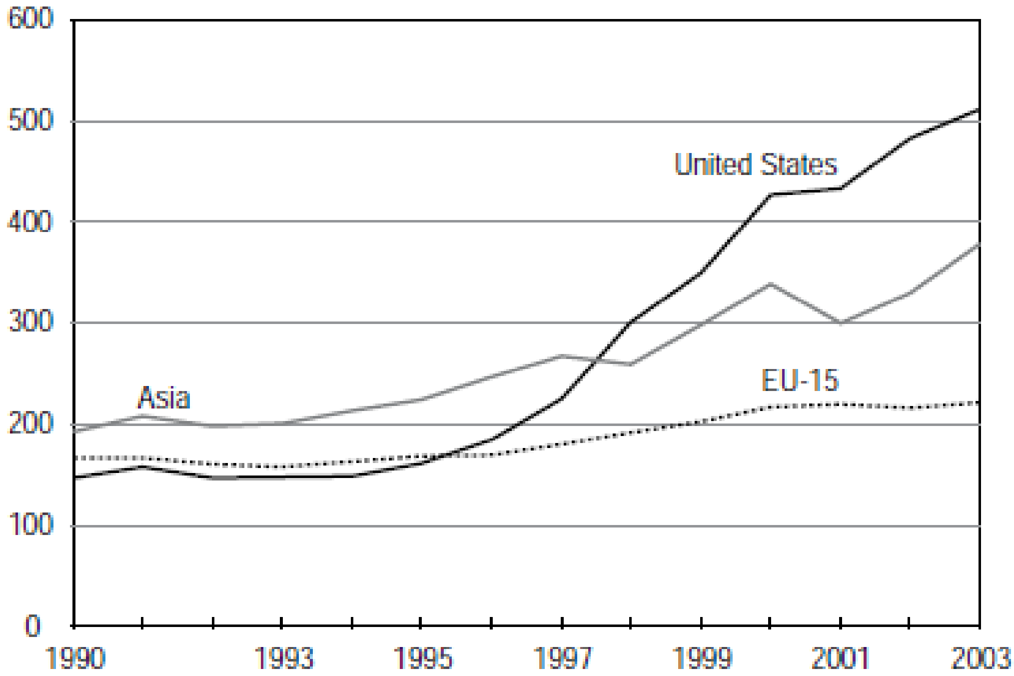


Fig. 5.17: World exports in high-tech per capita in years 1999 – 2005. They are given in euro.



Source: Gatelli and Tarantola 2007

Fig. 5.18: Changes of added value in high-technology manufacturing industry in years 1990 – 2003.



Source: National Science Foundation, Division of Science Resources Statistics 2007 (Global Insights Inc., World Industry Service database 2005, special tabulators)

As an aggregate, we should also look at the results in Table 5.15. They show that the gap from the time distance perspective in R&D is the largest between Europe and the USA (Sicherl 2004). The dimension of the time distances in this domain is alarming. Namely, the share of 1.9 percent of R&D investment per GDP, for example, achieved in Europe-15 countries in 1998, was achieved in the USA in the year 1956 and in Japan in the year 1979. This time distance factor shows that Europe-15 is around 40 years behind the USA and 19 years behind Japan.

As a conclusion of section 5.3, we might say that since the 1950s the top science and technology goal of the USA government has been "to maintain the world leadership in science, mathematics, and engineering". There seems to be a wide acceptance in the world that the USA is ahead and no single nation rivals the USA for the lead (Table 5.15). This can also be confirmed by the data presented in this section. However, if the USA may currently lead the world in science and technology in some aggregated sense, some parameters suggest that the USA does not lead the world in many important parameters (European Union Comission 2004).

Table 5.15: USA and Japan compared to Europe-15: gap in time distance in year 1999 and the years when the values for Europe-15 were attained by USA and Japan.

Indicator ranked by the time distance	**US (years)**	**Japan (years)**	**EU 15 (year)**	**US (year)**	**Japan (year)**
R&D in industry per capita	- 40	- 14	1998	1956	1982
R&D investment per GDP	- 40	- 19	1998	1956	1979
S&E engaged in R&D per 1.000	- 21	- 18	1997	1976	1979

Source: Sicherl 2004

6 CONCLUSION

In this thesis the technology policy in the United States of America was studied. The times around the change of the century were of particular interest, since they represent the ending of the industrial era and the beginning of the information one, times where the knowledge, technology and innovations will play an even more important role. The topic of the thesis was chosen with the intention that the basic thinking, current problems and dilemmas as well as the intended steps of the world technology leader become more present, since they can be considered as the future directions in the technology which will have to be followed by the rest of the developed countries.

Therefore, the basic features of the USA technology policy were discussed in the first part of the thesis:

i) some issues connected to the status of the USA technology,
ii) past and future technology policy of the USA,
iii) policy making process, problems and dilemmas of the USA technology policy.

In the appendix, some case studies of the USA technological goals and achievements as well as the high level advisory boards on science and technology issues were given.

In the second part of the thesis the development of USA technology and its status in the first decade of the 21st century was studied. Using quantitative parameters based on different statistical data (i.e. on the federal funding of basic and applied research and development, on the federal funding of military and civilian R&D, on the investments in education, on world citations, on patents etc.) four basic hypotheses were investigated:

1. The funding of military (defense) research and development will not, in spite of the end of the Cold war, significantly decrease. The tendency that the military (defense) and civilian (non-

defense) R&D are more interleaved will be increased, which is especially true for the "spin-off"s and "dual-use" technology.

2. The classical attitude in the USA claiming that the federal government should not fund the private sector, even in its pre-competition phase, will change, if nothing else, due to an increased competition of other developed countries.
3. The USA will keep its leading position in technology (in the field of research and development).
4. The organizational structure of federal agencies (departments) will remain unchanged, no Department of Science and Technology will be established.

.

We may conclude that the share of the military federal R&D funding did not change significantly in the beginning of this century, in spite of the end of the Cold war, which confirms our first hypothesis.

Namely, if the average share values of the federal funding for military purposes in the years after and before the year 2000 are calculated, even an increase in the share of military funding from 55.7 % to 57.2 % (compared to civilian funding) can be observed. Only if the additional funding in accordance with the American Recovery and Reinvestment Act is considered, does the share of military funding remain unchanged (55.7 %). The share values in these years are between 54 % to 59 % (with ARRA between 51 % and 59 %) and no tendency over the years can be observed, the values are scattered equally. We may speculate that the events on September 11th did not pass the technology policy in the USA without any influence.

A decline of federal R&D support of the private sector for approximately 50 % does not confirm our second hypothesis.

Based on the comparison of the federal R&D investments before and after the year 2000 (years 1993, 1997 and 1998 vs. 2008 – 2011) and on the comparison of the cumulative data of two 8 year consecutive periods (1994 – 2001 vs. 2002 – 2009), it can be seen that the federal funding of civilian applied research and development did not get the attention comparable to military spending or basic research. On the contrary, the calculations give sufficient evidence that the attitude against the federal funding of private sector, even in its pre-competition phase, seems to remain unchanged in the USA.

There is a wide acceptance in the world that the USA is ahead in technology and that no single nation rivals it for the lead, which confirms our third hypothesis.

This can also be confirmed by the data presented in the thesis. However, if the USA may currently lead the world in science and technology in some aggregated sense, some parameters suggest that the USA does not lead the world in many important parameters.

The basic organizational structure of the federal agencies (departments) did not change significantly after the year 2000 and the "Department of Science and Technology" was not established which proves our last hypothesis.

Namely, all the most important agencies (departments) remained the same and only 8.6 % of the total federal R&D funding (around 13.000 out of 150.000 million dollar) were allocated to another agency. A result, which was obtained when the average R&D funding, split by agency in years before and after the year 2000, was compared. No additional "Department of Science and Technology" was established, however, additional funding was given to the National Science Foundation (a 12.5 % and a 19 % with ARRA share increases) which could be seen as an increase of its power.

I sincerely hope that this work offers some additional information to the problems that should urgently be discussed in Slovenia in order to trim our national technology policy to higher technological development. This is, namely, one of the basic keys to launch our national economy on a high-growth path and consequently, to increase the prosperity of the nation.

7 LITERATURE

1. Almond, Gabriel. 1950. *The American People and Foreign Policy*. New York: Harcourt, Brace and Co.

2. Answers.com. Accessible at: http://www.answers.com/topic/technology (5th May 2011).

3. Arthur, Brian. 1994. *Increasing Returns and Path Dependence in the Economy*. University of Michigan Press.

4. Barke, Richard. 1986. *Science, Technology, and Public Policy*. Washington: Congressional Quarterly Inc.

5. Boroush, Mark. 2008. *New Estimates of National Research and Development Expenditures show 5,8 % Growth in 2007*, National Science Foundation (NSF 08-317).

6. Borrus, Michael.and Jay Stowsky. 1998. Technology Policy and Economic Growth. V: *Investing in Innovation: Creating a Research and Innovation Policy That Works*. Branscomb, Lewis.M.; Keller, James.H. (editor), Cambridge, Massachusetts and London, England: MIT Press.

7. Branscomb, Lewis.M. 1998. From Science Policy to Research Policy V: *Investing in Innovation: Creating a Research and Innovation Policy That Works*. Branscomb, Lewis.M.; Keller, James.H. (editor), Cambridge, Massachusetts and London, England: MIT Press.

8. Brooks, Harvey. 1984. The Resolution of Technically Intensive Public Policy Disputes. *Science, Tech. and Human Values*, 9 (Winter): 39-50.

9. Cohen, Michael, James March and Johan Olsen. 1972. A Garbage Can Model of Organizational Choice. *Administrative Science Quarterly*, 17 (March): 1-25.

10. Cohen, Linda R. and Roger G Noll. 1991. *The Technology Pork Barrel*. Washington D.C.: Brookings.

11. Communication from the commission. *Science and technology, the key to Europe's future* - Guidelines for future European Union policy to support research.

12. Council on Competitiveness. 1991. *Gaining New Ground: Technology Priorities for America's Future*. Washington, D.C.: Council on Competitiveness.

13. Council on Competitiveness. 1992. *Competitiveness Index*,1. Washington, D.C.: Council on Competitiveness.

14. Dictionary.com. Accessible at: http://dictionary.reference.com/browse/technology (5th May 2011).

15. Eaton, Jonathan and Samuel Kortum. 2008. *National Security in a knowledge based global Economy*. In Galama Titus and Hosek James, eds.: Perspectives on U.S. Competitiveness in Science and Technology«, Santa Monika, RAND Corporation.

16. European Union Commission (Press release). April 2004. *Europe needs more scientists*: EU blueprint for action.

17. Executive Office of the President, Office of Science and Technology Policy. 1990. *US Technology Policy*. Washington, D.C.: Office of Science and Technology Policy.

18. Executive Office of the President, Office of Science and Technology Policy. 1997. *A Report to the Congress*. Washington, D.C.: Office of Science and Technology Policy.

19. Executive Office of the President, Office of Science and Technology Policy. 1997. *Science and Technology Shaping the Twenty-First Century*, Washington D.C.: Office of Science and Technology Policy.

20. Galama, Titus and James Hosek. 2008. *U.S. Competitiveness in Science and Technology*. National Defense Research Institute, RAND Corporation, Santa Monica, California, USA.

21. Gatelli, Debora and Stefano Tarantola. 2007. *High-tech trade Indicators 2006: EU-25 vs. USA, China and Japan*. Institute for the Protection and the Security of the Citizen, Econometric and Statistical Support for Antifraud, Joint Research Center, European Commission.

22. Glänzel, Wolfgang, Koenraad Debackere and Martin Meyer. 2006. 'Triad' or 'Tetrad'? On Global Changes in a Dynamic World; *9th International Conference on Science and Technology Indicators*, Leuven (Belgium).

23. Ham, Rose Marie and David C Mowery. 1995. Enduring Dilemmas in U.S. Technology Policy, *California Management Review* 37 (IV): 89–107.

24. Irwin, Steven M. 1993. *Technology Policy and America's Future*. New York: St. Martin's Press.

25. James, Andrew D. 2004. *U.S. Defense R&D Spending: An Analysis of the Impacts*; Rapporteur's report for the EURAB Working Group ERA Scope and Vision.

26. Jones, Charles O. 1984. *An introduction to the Study of the Public Policy*. 3rd ed. Nord Stituate, Mass.: Duxbury Press.

27. Kingdon, John W. 1984. *Agendas, Alternative, and Public Policies*. Boston: Little Brown.

28. Kissinger, Henry. 1974. Kissinger on Intellectuals. *Point of View* 186 (November): 617.

29. Koizumi, Kei. 2008. *The U.S. Federal Budget in Science and Technology*. International Seminar on Policies of Science, Technology and Innovation.

30. Lambright, W. Henry. 1976. *Governing Science and Technology*. New York: Oxford University Press.

31. Levy, Anna-Marie. 2004. Action now - no more talk! *Europhysics News*, Vol. 35 No. 4.

32. Leydesdorff, Loet and Caroline Wagner. 2009. Is the United States losing ground in science? A global perspective on the world science system. *Scientometrics* 78, no 1; 23-36.

33. Lindblom, Charles E. 1959. The Science of »Muddling Through«, *Public Administration Review* 19, No. 2.; 79-88.

34. McKinsley Global Institute. 1992. *Service Sector Productivity*. Washington, D.C.: McKinsley & Company.

35. Merriam-Webster. Accessible at: http://www.meriam-webster.com/dictionary/technology; retrieved 2007-02-16 M (6th May 2011).

36. Miller, Jon D. 1985. The Politics of Emerging Issues: An Analysis of the Attitudes of Leaders and Larger Publics Toward Biotechnology. *Ann. Meeting American Pol. Sci. Ass.*, New Orleans.

37. Miller, Jon D. 1983. *Scientific Literacy: A Conceptual and Empirical Review*. Daedalus 112 (Spring): 29–48.

38. Mowery, David C. and Nathan Rosenberg. 1989. New Developments in U.S. Technology Policy: Implications for Competitiveness and International Trade Policy, *California Management Review*.107-124.

39. Nadiri, Ishaq. 1993. *Innovations and Technological Spillovers*, National Bureau of Economic Research, Working Paper No. 4423 (Aug.).

40. National Income Product Accounts, *Aggregate Data*. Revised February 1992 (6).

41. National Science Board Committee on Industrial Support for R&D. 1992. *The Competitive Strength of US Industrial Science and Technology*: Strategic Issues NSB-92-138. Washington D.C.: National Science Foundation.

42. National Science Board Committee on Science and Engineering Indicators. 2010. Science and Engineering Indicators. National Science Foundation.

43. National Science Foundation, Division of Science Resources Statistics. 2007. *Asia's Rising Science and Technology Strength: Comparative Indicators for Asia, the European Union, and the United States*. NSF 07-319. Arlington, VA.

44. National Science Foundation, Division of Science Resources Statistics. 2009. Survey of Federal Funds for Research and Development. *Federal Funds for Research and Development: Fiscal Years 2006-08*, Detailed Statistical Tables | Definitions.

45. National Science Foundation. 1990. *National Patterns in R&D Resources: 1990* (NSF 90-316). Washington, D.C. National Science Foundation.

46. National Science Foundation. 1991. *International Science and Technology Data Update*, 113: 1991 NSF 91-309. Washington, D.C. National Science Foundation.

47. National Science and Technology Committee (NSTC), Committee on Civilian Industrial Technology 1996. *Technology in the National Interest*. Washington, D.C.

48. Nelson, Richard R. 1996. *The Sources of Economic Growth*, Howard University Press, Cambridge, Massechussets.

49. Office of Science and Technology Policy, Executive Office of the President. 2008. *FY 2009 Federal Research and Development Budget*.

50. Office of Science and Technology Policy, Executive Office of the President. 2009. *A Renewed Commitment to Science and Technology*. Federal R&D, Technology, and STEM Education in the 2010 Budget.

51. Office of Science and Technology Policy, Executive Office of the President. 2010. *Investing in the Building Blocks of American Innovation*. Federal R&D, Technology, and STEM Education in the 2010 Budget.

52. Office of Science and Technology Policy. 1991. *Report of the National Critical Technologies Panel*. Washington, D.C.: Office of Science and Technology Policy.

53. Olson, Mancur jr. 1965. *The Logic of Collective Action: Public Goods and the Theory of Groups*. Cambridge: Harvard University Press.

54. Organization for Economic Cooperation and Development, Department for Economics and Statistics. 1992. Paris: OECD: National Accounts: Main Aggregates, vol. 1.

55. Romer, Paul M. 1986. Increasing Returns and Long-Run Growth. *J.Phys.Econ.* 94, 4: 1002-37.

56. Romer, Paul M. 1990. Endogenous Technological Change. *J.Phys.Econ*. 98, 5 (Oct.): 71-102.

57. Shelton, Robert D. and Geoffrey M Holdridge. 2004. The US-EU Race for Leadership of Science and Technology: Qualitative and Quantitative Indicators. *Scientometrics* 60, 3: 353-63.

58. Shelton, Robert D., J. B. Jr. Mooney and Geoffrey M Holdridge. 2000. *American Leadership of Science and Technology: Reality or Myth ?*, Introduction: U.S. Goals for "Maintaining" World Leadership.

59. Sicherl, Pavle. 2004. *Leads and Lags between US and the EU*, e-WISDOM 2a (19th March 2011).

60. Tassey, Gregory. 1995. *Technology and Economic Growth: Implications for Federal Policy*. Washington, DC: U.S. Department of Commerce, Technology Administration.

61. Team of renowned German economic research institutes, German Federal Ministry of Education and Research. 2005. *Report on Germany's Technological Performance. Main statements from the federal government's point of view*.

62. The free dictionary by Farlex. Accessible at: http://www.thefreedictionary.com/technology (4th May 2011).

63. US Department of Commerce. 1990. *Emerging Technologies: A Survey of Technical and Economical Opportunities*. Washington, D.C.: Department of Commerce.

64. U.S. National Science Board. 1989, 1991, app. Table 3-19.

65. U.S. National Science Board. 1991, app. Table 3-19.

66. Wikipedia, The Free Encyclopedia. Accessible at: http://en.wikipedia.org/wiki/Technology (17th April 2011).

APPENDIX A: CASE STUDIES OF TECHNOLOGICAL ACHIEVEMENTS AND GOALS IN THE USA*

To previous somewhat theoretical discussions of the technology policy in the USA it is worthwhile to add a short section on the concrete examples of its R&D. Four case studies of technological achievements will be discussed: studies of Methannococcus jannaschii and Bose-Einstein condensate as examples of the basic R&D that has a potential for the applications in different areas of industry and two applied studies with a big social return for the citizens of the USA: an increased precision of cancer treatment and a new look at the Midwest flooding.

In addition, a list of Nobel prize winners in years 1995 and 1996 will be given in order to get an impression of the achievements of R&D in USA that are the consequence of technology policy in the USA as well (Executive Office of the President, Office of Science and Technology Policy, Science and Technology Shaping the Twenty-First Century 1997, 13-5).

Appendix A.1: Studying Methannococcus jannaschii

Methannococcus jannaschii is a microbe that was found in a thermal vent around 2700 m below the surface of the Pacific Ocean (Executive Office of the President, Office of Science and Technology Policy, Science and Technology Shaping the Twenty-First Century 1997, 20-1). Its natural environment is the sea with the water that has temperatures just below the boiling point and pressures higher than 500 atmospheres. It belongs to organisms named Archaea, besides Prokarya and the Eukarya the third major branch of life on earth. Prokarya are cell-like bacteria without a nucleus, while Eukarya are plants and animals with nucleated cells.

* as seen from the perspective of the last decade of the 20^{th} century

Scientists have mapped the genetic sequences of bacteria, eukaryote and those of archaea. The genetic structure of archaea is totally different than that of bacteria, however, they structurally resemble the eukaryotic system. This points out that the archaea might be the missing link to the eukaryotes and previous forms of life.

However, these studies are not being limited to this basic topic only. Since M. jannaschii does not need any oxygen, sunlight or external organic materials for growth and it produces methane, it is interesting as a renewable source of energy. Furthermore, its way of life in very hard conditions might allow the clues to develop heat resistant products. Its production of metal-binding proteins which transport the toxic substances out of the cell might also have a potential for the cleaning up of heavy metals and other toxic substances.

Appendix A.2: Bose-Einstein condensate

The hypothesis of this condensate was proposed more than 70 years ago by Albert Einstein. His theory was based on the work done by Indian physicist Satyendra Bose (Executive Office of the President, Office of Science and Technology Policy, Science and Technology Shaping the Twenty-First Century 1997, 28-9). It states that at the temperature close to the absolute zero, atoms will behave like a condensate with zero velocity.

The recent advances in low temperature technology made it possible to achieve the temperature of about 170 billionths of a degree above the absolute zero. A group of scientists from the University of Colorado and a research group from the National Institute of Standards and Technology succeeded in a joint effort to perform an experiment which enabled to prove the Bose-Einstein condensate for the first time.

At such a low temperature the atoms start to behave as a single entity, they move comparable to photons in a laser beam. This experiment will enable to study the application of the laws of quantum mechanics at small distances between the atoms. They give promise to enable a better understanding of the superconductivity and the superfluidity as well as the distribution of the matter in the early stages of the universe. The development of the “atom laser” based on the Bose-Einstein condensate is on the way. Hence, a new era in condensed matter physics as well as in atomic physics is emerging.

Appendix A.3: Increased precision of cancer treatment

Around 300.000 patients who have cancer in the USA are cured by radiation therapy (Executive Office of the President, Office of Science and Technology Policy, Science and Technology Shaping the Twenty-First Century 1997, 104-5). However, one third of them die, presumably due to the fact that the radiation failed to kill the tumor’s cells. Doctors have had no accurate tools to determine the effective radiation therapy, i.e. the right dosage and its volume. As a consequence, different parts of the tumor might have been missed while some normal tissue was damaged due to an overdose.

In order to offer better means to overcome this problem a program called Peregrine was developed in the Lawrence Livermore National Laboratory. The scientists working together with medical physicists and radiology oncologists used the advancement of computer hardware and computational techniques in order to speed up the calculations of the dosage distribution. The program, first developed for the military purposes, uses the Monte Carlo method to calculate the interaction of the X-rays with the tissue molecules. The exact location, composition and the density of the tumor is provided by the three-dimensional imaging techniques like CT-scanner. The information about the passage of the radiation through different parts of the body is given in databases. The result is a three-dimensional model that determines the path of the X-rays and thus, the shape and the dosage of the radiation therapy.

In this way, a more effective therapy is being offered at a level of desktop computers in an office environment through the network connections, allowing a more effective treatment of the radiation.

Appendix A.4: A new look at Midwest flooding

The Great Midwest Flood of 1993 initiated a different approach to the high-water problem in the Midwest (Executive Office of the President, Office of Science and Technology Policy, Science and Technology Shaping the Twenty-First Century 1997, 84-5).

A multi-agency and multidisciplinary team of scientists recommended a new approach where the Mississippi river was studied as a whole system and not, as usually, as a set of different parts. An intensive set of information from different scientific areas like hydrology, geology, ecology, topology and hydraulics was collected. In addition, the information about insurance payments, hazardous waste deposits and wastewater plans were studied as well as satellite pictures before and after the flood were acquired.

This information is used for the computerized regional geographic information system of the entire Mississippi River area. The system uses the scientific and technology advances to improve the management of the basin in order to prevent damage and loss of life in a potential flood. The conclusions or further studies will show: *i*) which areas will be converted back to wetlands that retain water during floods, *ii*) the first integrated hydraulic model of the Mississippi river will determine the positions of the levees through the whole course of the river and *iii*) the experiences gained with this study will be applied to the Missouri River.

Appendix A.5: USA Nobel Prize Winners in 1995 and in 1996

In year 1995:

<u>Nobel Prize in Physics:</u>

Awarded jointly for pioneering experimental contributions to lepton physics with one-half to:
Martin L. Perl, Stanford University, Stanford, CA,
for the discovery of tau lepton

and one-half to:
Frederick Reines, University of California-Irvine, Irvine, CA,
for the detection of neutrino.

Nobel Prize in Chemistry:
Awarded jointly to:
Paul J. Krutzen (Netherlands), Max Planck Institute for Chemistry, Mainz, Germany,
Mario J. Molina, Massachusetts Institute of Technology, Cambridge, MA, and
Sherwood F. Rowland, University of California-Irvine, Irvine, CA,
for the work in atmospheric chemistry, particularly in the formation and decomposition of ozone.

Nobel Prize in Physiology and Medicine:
Awarded jointly to:
Edward B. Lewis, California Institute of Technology, Pasadena, CA
Christianne Nuesslein-Volhard, Max Planck Institut fuer Entwicklungsbiologie, Germany, and
Eric F. Wieschaus, Princeton University, Princeton, NJ,
for the discoveries concerning the genetic control of early embryonic development.

Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel:
Awarded to:
Robert E. Lucas, Jr., University of Chicago, Chicago, IL,
for the development and the application of the hypothesis of rational expectations.

In year 1996:

Nobel Prize in Physics:
Awarded jointly to:
David M. Lee, Cornell University, Ithaca, NY
Robert C. Richardson, Cornell University, Ithaca, NY and
Doughlas D. Osheroff, Stanford University, Stanford, CA,

for the discovery of superfluidity in helium-3.

Nobel Prize in Chemistry:

Awarded jointly to:

Robert F. Curl, Jr., Rice University, Dallas, TX,

Richard E. Smally, Rice University, Dallas, TX, and

Sir Harold W. Kroto, University of Sussex, Brighton, U.K.,

for the discovery of fullerenes.

Nobel Prize in Physiology and Medicine:

Awarded jointly to:

Peter C. Doherty (Australia), St. Jude's Hospital Memphis, TN, and

Rolf M. Zinkernagel, University of Zuerich, Switzerland,

for the discoveries concerning the specificity of the cell mediated immune system.

Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel:

Awarded to:

James A. Mirrlees, University of Cambridge, U.K., and

William Vickrey, Columbia University, New York, NY,

for the basic contributions to the economic theory of incentives under asymmetric information.

APPENDIX B: ADVISORY BOARDS TO THE PRESIDENT ON SCIENCE AND TECHNOLOGY ISSUES

The importance and weight of a particular policy is also demonstrated by the level of boards and the personnel choice of their members which supervise or perform a particular policy and consequently, bear the responsibility. Therefore, a quick look will be taken to two committees that are responsible for the technology policy in the USA.

Appendix B.1: National science and technology council

The National science and technology council was established in November 1993 by president Clinton to coordinate science, space and technology policies across the Federal government. In addition, the Council prepares R&D strategies and determines national goals for Federal science and technology investments to improve transportation systems and to strengthen fundamental research (Executive Office of the President, Office of Science and Technology Policy, Science and Technology Shaping the Twenty-First Century 1997).

Membership (2nd term Clinton administration):

1. President of the USA (chair)
2. Vice President
3. Secretary of State
4. Secretary of Defense
5. Secretary of Interior
6. Secretary of Agriculture
1. Secretary of Commerce
2. Secretary of Labor
3. Secretary of Health and Human Services

4. Secretary of Transportation
5. Secretary of Energy
6. Secretary of Education
7. Director, Office of Management and Budget
8. Director, Central Intelligence Agency
9. Chair, Council of Economic Advisors
10. Administrator, Environmental Protection Agency
11. Administrator, NASA
12. Director, National Science Foundation
13. Assistant to the President for National Security Affairs
14. Assistant to the President for Science and Technology
15. Assistant to the President for Economic Policy
16. Assistant to the President for Domestic Policy
17. Director, National Institute of Health
18. Director, Arms Control and Disarmament Agency

To achieve the goals nine goal-oriented committees, chaired by a senior official from a federal agency or department are appointed:

1. Committee on Health, Safety and Food
2. Committee on Fundamental Sciences
3. Committee on Computing, Information, and Communications
4. Committee on Environment and Natural Resources
5. Committee on Technical Innovation
6. Committee on Education and Training
7. Committee on Transportation
8. Committee on National Security
9. Committee on International Science, Engineering and Technology

Appendix B.2: President's Committee of Advisors on Science and Technology

This committee was established in addition to the National Science and Technology Council with the aim to advise to the president on science and technology issues, especially to secure the private sector involvement.

Membership (2nd term Clinton administration):

1. Norman Augustine, Chairman of the Board and CEO, Lockheed Martin Corporation
2. Francisco Ayala, Professor, University of California, Irvine
3. Murray Gell-Mann, Professor, Santa Fe Institute and California Institute of Technology
4. David Hamburg, President, Carnegie Corporation of New York
5. John Holdren, Professor, Harvard University
6. Diana MacArthur, Chair and CEO, Dynamac Corporation
7. Shirley Malcom, Directorate Head, American Association for the Advancement of Science
8. Mario Molina, Professor, Massachusetts Institute of Technology
9. Peter Raven, Director, Missouri Botanical Garden
10. Sally Ride, Director, California Space Institute, and Professor, University of California, San Diego
11. Judith Rodin, President, University of Pennsylvania
12. Charles A. Sanders, Former Chairman and CEO, Glaxo-Wellcome, Inc.
13. Phillip Sharp, Professor, Massachusetts Institute of Technology
14. David Shaw, CEO, D.E. Shaw and Co.
15. Charles Vest, President, Massachusetts Institute of Technology
16. Virginia Weldon, Senior Vice President, Monsanto Company
17. Lilian Shiao-Yen Wu, Research Staff, Thomas J. Watson Research Center, IBM

8 RAZŠIRJENI POVZETEK V SLOVENŠČINI

1 UVOD

Namen magistrske naloge je prikazati tehnološko politiko ZDA, tehnološko najmočneje razvite države na svetu, s poudarkom na čas ob prehodu iz dvajsetega v enaindvajseto stoletje, torej pri prehodu iz industrijske v informacijsko družbo.

Tehnologija je motor gospodarske rasti v vsaki industrijsko razviti državi in poznavanje znanosti in razvoja v ZDA nam pokaže smernice, po katerih se bo svet razvijal v času informacijske družbe. Pomen znanja in s tem povezanih raziskav in razvoja bo po vsesplošnem prepričanju v informacijski družbi še pridobil na pomembnosti.

Predstavljene so: osnovne teme, ki zadevajo tehnološke politike ZDA, pretekle in sedanje ameriške politike, proces oblikovanja (kreiranja) in uresničevanja (implementacije) tehnološke politike ter posamezne izbrane teme. V nadaljevanju avtor razpravlja o stanju ameriške tehnologije v ZDA v prvem desetletju 21. stoletja in predstavi posamezne cilje in dosežke v raziskavah in razvoju ZDA.

Magistrska naloga skuša pokazati smernice, ki jim bodo morale, hote ali nehote slediti druge razvite države na področju raziskav in razvoja, tudi Slovenija. Poznavanje le-teh pa je nujno potrebno tako za ohranjanje stika z razvitimi državami kakor tudi za ohranjanje oziroma izboljševanje blagostanja v državi.

1.1 OPREDELITEV PREDLAGANE TEME IN NJENA RAZISKOVALNA RELEVANTNOST

V ekonomiji velja prepričanje, da je rast produktivnosti tisti faktor, ki je najpomembnejši za dolgoročno življenjsko raven nekega naroda (Borrus in Stowsky, 1998). Dokazano je, da na rast produktivnosti najbolj vplivajo trije dejavniki: kapital z infrastrukturo, kvalitetna delovna sila in tehnološki napredek. Najpomembnejši med njimi je prav tehnološki faktor. Ocenjuje se, da je tehnološki napredek povzročil polovico dolgoročne ekonomske rasti v ZDA v zadnjih petdesetih letih prejšnjega stoletja (Cohen in Noll, 1991; Tassey, 1996).

Tehnološkega napredka si ne moremo zamisliti brez ustreznega investiranja v raziskave in razvoj (R&R), moderne tehnične infrastrukture in strokovno usposobljenih, tehnično vzgojenih ljudi. Prav tehnološke politike imajo nalogo, da na ravni posameznih držav usmerjajo in povezujejo posamezne komponente, ki so pomembne za tehnološki razvoj, v celoto. Zato je izrednega pomena, še posebno v času prehoda iz industrijske v informacijsko družbo, ki bo še bolj temeljila na znanju in razvoju, da so tehnološke politike neke države pretehtane in usmerjene v pravo smer.

Pri določanju in vodenju ustrezne tehnološke politike posamezne države je nujno potrebno veliko znanja in izkušenj. Podrobnejše poznavanje tehnoloških politik, njihovih dilem, uspešnih rešitev, pa tudi stranpoti, ki so jih ubirale druge, zlasti razvite države, je eden izmed temeljev v mozaiku tega znanja. Še posebej velja to za tehnološke politike tiste, ki je najuspešnejša med njimi – ZDA. Še zlasti pa so zanimive smernice, ki so jih v ZDA v zvezi z njihovimi tehnološkimi politikami nameravali narediti na prehodu v informacijsko družbo.

1.2 NAMEN, HIPOTEZE IN CILJ

Tehnološka politika je kompleksno področje, nepredvidljivo in polno dilem. Zato je čim bolj celovita predstavitev tehnoloških politik v ZDA na prehodu v informacijsko družbo že sama po sebi zelo pomembna, saj nam poznavanje stanja vodečega v svetovnem merilu na področju raziskav in razvoja, njegovih korakov v bodočnosti in njegovih dilem pomaga razumeti vlogo in prihodnost na področju raziskav in razvoja.

V nalogi so postavljene štiri osnovne hipoteze, ki zadevajo tehnološke politike v ZDA na prehodu stoletja:

1. Vlaganja ZDA v vojaške raziskave in razvoj se kljub končanju hladne vojne v osemdesetih letih 20. stoletja ne bodo drastično zmanjšala.
2. Klasično gledanje v ZDA, da v komercialne raziskave in razvoj država ne posega, se bo zaradi vedno hujše konkurence drugih razvitih držav nujno spremenilo.
3. ZDA bodo tudi v bodoče ohranile prvenstvo na področju razvoja in raziskav.
4. Organizacijska struktura ministrstev in zveznih agencij se v ZDA ne bo bistveno spremenila.

Cilj dela je čim bolj celovito predstaviti tehnološke politike ZDA in raziskati uresničevanje osnovnih potez, ki so bile napovedane konec 20. stoletja. Hkrati pa je to dodaten kamenček v mozaiku znanja, ki je nujno potreben pri razpravah in odločitvah na področju raziskav in razvoja v Sloveniji.

1.3 METODOLOGIJA IN STRUKTURA NALOGE

Naloga je časovno sestavljena iz dveh delov: v prvem delu avtor opiše ameriške tehnološke politike s stališča ZDA v devetdesetih letih prejšnjega stoletja, v drugem delu pa s pomočjo spremljanja karakterističnih kazalcev analizira razvoj in stanje ameriške tehnologije v prvem desetletju tega stoletja.

Predstavitev tehnološke politike ZDA, selekcija njenih najpomembnejših potez, pa tudi njenih problemov in dilem, je bila opravljena temelječ na dolgoletnih avtorjevih osebnih izkušnjah na znanstveno-raziskovalnem področju, njegovem delovanju v različnih upravnih in nadzornih odborih ter na različnih ravneh političnega odločanja.

Tematika je predstavljena in obdelana ter hipoteze potrjene ali zavržene predvsem na podlagi kvantitativnih podatkov in različnih, iz njih izračunanih parametrov: iz različnih razmerij med financiranjem osnovnih in aplikativnih raziskav ter razvoja, kakor tudi iz razmerja med deleži sredstev za civilne in vojaške namene ter iz razmerja državnih sredstev za razvoj privatne industrije in skupnim državnim financiranjem. Dokazi so podkrepljeni tudi s pomočjo številnih mednarodnih primerjav in povprečij v različnih časovnih obdobjih.

V nalogi so obdelane naslednje teme:

i) Osnovni pojmi, ki so povezani s tehnološko politiko ZDA. Pokazana sta povezava med tehnologijo in gospodarsko rastjo ter stanje tehnologije v ZDA ob koncu 20. stoletja. To stanje je ponazorjeno s kazalci, ki opisujejo makroekonomsko stanje in investicije v R&R.

ii) Pregled karakterističnih obdobij tehnološke politike ZDA Razdeljena je na časovne intervale, ki smiselno zaokrožujejo karakteristična obdobja.

iii) Značilnosti tehnološke politike ZDA za 21. stoletje: *v*zpostavitev "zdravega" poslovnega okolja, *t*ehnološki razvoj in komercializacija, prvovrstna infrastruktura in prvovrstna delovna sila.

iv) Opis nacionalnih interesov: nacionalna varnost in globalna stabilnost, sledijo pa skrb *za* okolje in zdravje državljanov.

v) Analiza procesa ustvarjanja tehnološke politike

vi) Glavne dileme, ki so povezane s tehnološko politiko ZDA (odnos med znanostjo in tehnologijo, osnova za zvezno podporo tehnologije, vpliv globalizacije na tehnološko politiko in ustanovitev ministrstva za znanost in tehnologijo).

vii) Stanje tehnologije v ZDA v prvem desetletju 21. stoletja. Ponazorjeno je s kazalci makroekonomskega stanja in kazalci, ki ponazarjajo investicije v R&R.

viii) Magistrsko delo je zaključeno z dodatki, ki bolj nazorno pokažejo na posamezne primere tehnoloških dosežkov in ciljev v ZDA ter na odnos do tehnoloških politik, ki se kaže tudi skozi izbiro oseb in inštitucij, ki jih te osebe zastopajo v posvetovalnih telesih na državni ravni.

1.4 DEFINICIJE RAZISKAV IN RAZVOJA (R&R) IN TEHNOLOGIJE

Definicije so podane v skladu z definicijami iz različnih slovarjev. Poudariti pa je potrebno, da razlike med znanostjo (research), razvojem (development, engineering) in tehnologijo (technology) niso vedno jasne (Wikipedia).

V magistrski nalogi je pojem tehnologija mišljen v najširšem pomenu – v veri, da je znanost, predvsem aplikativna znanost, zelo povezana z razvojem. Zato bodo pod pojmom tehnološke politike mišljene politike, ki zadevajo oboje, tako znanost kakor tudi razvoj.

2 OSNOVNI POJMI, POVEZANI S TEHNOLOŠKIMI POLITIKAMI ZDA

Kot prvo so predstavljene osnovne teme, ki zadevajo tehnološke politike ZDA: pokaže povezavo med tehnologijo ter gospodarsko rastjo ter opiše stanje tehnologije v ZDA ob koncu 20. stoletja.

2.1 VPLIV TEHNOLOGIJE NA GOSPODARSKO RAST

Rast produktivnosti je najpomembnejši faktor, ki vpliva na standard nekega naroda. Dokazano je, da na rast produktivnosti najbolj vplivajo trije dejavniki: kapital z infrastrukturo, kvalitetna delovna sila in tehnološki napredek. Ocenjuje se, da je tehnološki napredek povzročil polovico dolgoročne ekonomske rasti v ZDA v zadnjih petdesetih letih prejšnjega stoletja (Cohen in Noll, 1991; Tassey, 1996). Podjetja, ki uporabljajo napredne tehnologije so bolj produktivna, izplačujejo višje prejemke in povečujejo zaposlenost hitreje kot tista, ki jih ne. Med letoma 1987 in 1991 so zaposlenost in prejemki delavcev v podjetjih, ki so uporabljala osem ali več naprednih tehnologij, narasla za 14% hitreje kot v tistih brez te tehnologije. Rast podjetij, ki se ukvarjajo s komunikacijsko in informacijsko tehnologijo, je impresivna: rast zaposlenosti v mobilni telefoniji je zrasla s 7.100 v letu 1987 na 53.900 v letu 1994, pri kabelski televiziji pa z 23.500 v letu 1978 na 112.000 v letu 1996. Tehnološkega napredka si ne moremo zamisliti brez vlaganja v raziskave in razvoj (R&R), moderne tehnične infrastrukture in strokovno usposobljenih, tehnično vzgojenih ljudi.

2.2 STANJE TEHNOLOGIJE V ZDA OB KONCU STOLETJA

2.2.1 Kazalci makroekonomskega stanja
2.2.2 Kazalci investicij v R&R

Stanje tehnologije se ne more ponazoriti z enim samim kazalnikom, zato je opisano s kazalniki makroekonomskega stanja v ZDA, ki temeljijo na realnem domačem bruto produktu ter izvozu in uvozu ZDA. Avtor prikaže tudi kazalnike vseh investicij v R&R in tistih, ki so uporabljene v civilne namene. Ti kazalniki so podani za obdobja več let in so hkrati uporabljeni tudi za primerjavo z drugimi razvitimi državami.

3 TEHNOLOŠKE POLITIKE ZDA

Avtor nadaljuje s kratkim pregledom pretekle in sedanje tehnološke politike v ZDA. Z namenom, da bi bolje razumeli korake, ki so jih ZDA nameravale storiti na prehodu v informacijsko družbo, saj so le-ti v veliki meri odvisni od njenih tehnoloških politik, njenih izkušenj in pogledov v preteklosti.

Zato so podane značilne poteze njenih tehnoloških politik v posameznih obdobjih od leta 1787 naprej. Razdeljena so na časovne intervale, ki smiselno zaokrožujejo karakteristična obdobja: na obdobje med leti 1787 – 1941, na obdobje med leti 1941 – 1945, na obdobje med leti 1945 – 1980 in na obdobje med leti 1980 – 1988. Za vsako obdobje so navedene njihove značilnosti.

3.1 NAČELA TEHNOLOŠKE POLITIKE V PRETEKLOSTI

3.1.1 Časovni interval 1787 – 1941

3.1.2 Časovni interval 1941 – 1945

3.1.3 Časovni interval 1945 – 1980

3.1.4 Časovni interval 1980 – 1988

Pri študiju novejših tehnoloških politik ZDA ne moremo mimo leta 1988, ko je prenehala hladna vojna. Čeprav se to zdi primarno le politični preobrat v svetu, pa je pomenil tudi velike spremembe v tehnoloških politikah ZDA (Irwin, 1993). V tem obdobju zaznamo zmanjševanje konkurenčne prednosti v privatni, komercialni industriji, še posebno na področju visoke (»leading-edge«) tehnologije. Hkrati pa se odpira možnost, da država nameni več sredstev iz zveznega proračuna v privatni sektor, saj se zdi, da ni več nikakršne potrebe, da bi država še vedno namenjala visoke vsote za razvoj vojaške industrije. Tako je že Busheva administracija pričela s posameznimi spremembami tehnoloških politik.

3.2 TEHNOLOŠKE POLITIKE ZA 21. STOLETJE

3.2.1 Vzpostavitev "zdravega" poslovnega okolja

3.2.2 Tehnološki razvoj in komercializacija

3.2.3 Prvovrstna ("world-class") infrastruktura

3.2.4 Prvovrstna ("world-class") delovna sila

V tem podpoglavju se avtor osredotoči na poteze, ki naj bi predstavljale osnovo tehnoloških politik v ZDA v 21. stoletju. V obdobju predsednika Clintona namreč beležimo nove, korenite poteze v tehnoloških politikah z namenom, da se ZDA zagotovi globalno tehnološko vodstvo v prihajajočem stoletju (Executive Office of the President, Office of Science and Technology Policy, 1990 in 1997):

- zavezo k dolgoročnemu raziskovanju, izobraževanju in inovacijam

- primarno vlogo vlade pri ustvarjanju poslovnega okolja, v katerem bodo nagrajeni inovativni in konkurenčni
- vlada mora vzpodbujati razvoj civilne tehnologije in njeno integracijo z vojaškimi dosežki
- vlada mora poskrbeti za prvovrstno infrastrukturo in razviti prvovrstno delovno silo.

Med te ukrepe štejemo:

i) *v*zpostavitev "zdravega" poslovnega okolja
ii) *t*ehnološki razvoj in komercializacija
iii) *p*rvovrstna infrastruktura
iv) prvovrstna delovna sila.

3.3 NACIONALNI INTERESI

3.3.1 Nacionalna varnost in globalna stabilnost
3.3.2 Okolje
3.3.3 Zdravje

Tehnološke politike v ZDA naj bi tudi spodbujale tista področja, kjer se pričakuje velik izkupiček vloženih sredstev v raziskave in razvoj za dobrobit prebivalstva (Executive Office of the President, Office of Science and Technology Policy, 1997). Ta področja so za ZDA predvsem nacionalna varnost z globalno stabilnostjo, okolje in zdravje.

3.4 ZVEZNA (FEDERALNA) R&R PODPORA

V tabelah so navedeni izdatki za R&R v letih 19992, 1993 in 1997, saj je ravno finančna podpora v državnem proračunu eden izmed najresnejših pokazateljev o resnosti in kredibilnosti političnih izjav o pomembnosti nekega področja.

4 POJMI, POVEZANI S TEHNOLOŠKIMI POLITIKAMI

4.1 PROCES USTVARJANJA TEHNOLOŠKIH POLITIK

4.1.1 Predsednik in izvršna oblast

4.1.2 Kongres

4.1.3 Zvezna birokracija

4.1.4 Sodišča in pravosodni sistem

4.1.5 Javnost

4.1.6 Znanstveniki

Avtor analizira sam proces oblikovanja (kreiranja) tehnoloških politik, od centrov moči pri odločanju do izvajalcev teh politik. Opiše glavne akterje tega procesa: predsednika in izvršno oblast, kongres, zvezno birokracijo, sodišča in pravosodni sistem, javnost in ne nazadnje znanstvenike. Na kratko povzame njihovo moč in značilnosti njihovega vpliva (Barke, 1986; Jones, 1984).

4.2 GLAVNE DILEME POVEZANE S TEHNOLOŠKIMI POLITIKAMI ZDA

4.2.1 Odnos med znanostjo in tehnologijo

4.2.2 Osnova za zvezno podporo tehnologije

4.2.3 Vpliv globalizacije na tehnološke politike

4.2.4 Ustanovitev ministrstva za znanost in tehnologijo

Tehnološke politike so večplastna zadeva, zato se v ameriških tehnoloških politikah v tem »občutljivem« času porajajo tudi dileme - v želji, da bi se zagotovila tehnološka prevlada v dobrobit prebivalstva ZDA v informacijski družbi. V magistrski nalogi so obravnavane naslednje izbrane dileme (Branscomb, 1998; Irwin, 1993; Barke, 1986):

- odnos med znanostjo in tehnologijo
- osnova za državno financiranje R&R v privatnem sektorju

- vpliv globalizacije na tehnološke politike ZDA
- vzpostavitev Ministrstva za znanost in tehnologijo.

5 STANJE TEHNOLOGIJE V ZDA V ZAČETKU 21. STOLETJA

Delo se zaokroži s kratkoročnimi (srednjeročnimi) posledicami opisane tehnološke politike ZDA: z analizo stanja tehnologije v ZDA v prvem desetletju 21. stoletja in s primerjavo tega stanja z drugimi tehnološko najrazvitejšimi državami v svetu.

Kot že omenjeno, je stanje tehnološkega razvoja in njegovega pomena v posamezni državi težko predstaviti s samo enim kvantitativnim podatkom (Irwin, 1993). Zato je to stanje ponazorjeno z več parametri, tako absolutno kakor tudi relativno - kot primerjava med posameznimi državami. Stanje je ponazorjeno predvsem s kazalniki, ki ponazarjajo državne investicije v R&R in ostalimi kazalniki, ki so značilni za opis raziskav in razvoja po svetu (npr. število raziskovalcev, število publikacij in njihova citiranost, število patentov, izvoz/uvoz visokotehnoloških izdelkov).

5.1 ZVEZNA (FEDERALNA) R&R PODPORA

5.1.1 Težnja zvezne R&R podpore v zadnjih dveh desetletjih
5.1.2 Zvezna R&R podpora v fiskalnih letih od 2008 do 2011
5.1.3 Kvantitativna primerjava zvezne R&R podpore v zadnjih dveh desetletjih

5.2 PRIMERJAVA ZVEZNE R&R PODPORE V ZADNJIH DVEH DESETLETJIH V VOJAŠKE IN CIVILNE NAMENE

5.2.1 Primerjava R&R podpore v vojaške in civilne namene
5.2.2 R&R podpora aplikativnih raziskav in razvoja v civilne namene

5.3 MEDNARODNA PRIMERJAVA TRENUTNEGA STANJA V TEHNOLOGIJI ZDA IN NJENEGA RAZVOJA V ZADNJIH DVEH DESETLETJIH

5.3.1 Investicije v R&R

5.3.2 Izobraževanje in nadaljnje urjenje

5.3.3 Znanstveniki in inženirji ter njihova mobilnost

5.3.4 Znanstvene publikacije in njihova citiranost

5.3.5 Patenti

5.3.6 Proizvodnja in izvoz visoke tehnologije

6 ZAKLJUČKI

Poleg tega pa je avtor s pomočjo karakterističnih kvantitativnih rezultatov, ki se nanašajo na prvo desetletje tega stoletja, potrdil tri in ovrgel eno hipotezo, ki zadevajo osnovne poteze tehnoloških politik ZDA v 21. stoletju:

1. Vlaganja ZDA v vojaške raziskave in razvoj se kljub končanju hladne vojne v osemdesetih letih 20. stoletja niso drastično zmanjšala;
2. ZDA so tudi v začetku 21. stoletja ohranile svetovni prvenstvo na področju razvoja in raziskav;
3. Organizacijska struktura ministrstev in zveznih agencij se v ZDA ni bistveno spremenila.

Četrto hipotezo: »da se bo klasično, desetletja trajajoče mišljenje v ZDA, da v komercialne raziskave in razvoj država ne posega, ne nazadnje tudi zaradi vedno hujše konkurence drugih razvitih držav, nujno spremenilo«, pa je avtor ovrgel.

Magistrsko delo je zaključeno z dodatki, kjer naj bi s posameznimi primeri bolj nazorno pokazali tehnološke dosežke in cilje v ZDA ter odnos do tehnoloških politik, ki se kaže tudi z izbiro oseb in inštitucij, ki jih te osebe zastopajo v posvetovalnih telesih na državni ravni (Nacionalni svet za znanost in tehnologijo in Odbor predsednika za znanost in tehnologijo).

DODATEK A: PRIMERI TEHNOLOŠKIH DOSEŽKOV IN CILJEV V ZDA

Dodatek A.1: Raziskave Methannococcus jannaschii
Dodatek A.2: Študij Bose-Einstein-ove kondenzacijske teorije
Dodatek A.3: Povečana natančnost pri obsevanju raka
Dodatek A.4: Nov pogled na poplave na srednjem zahodu ZDA
Dodatek A.5: Dobitniki Nobelove nagrade v letih 1995 in 1996 iz ZDA

Pregled tehnoloških politik ZDA se na koncu še ustavi pri posameznih primerih dosežkov v raziskavah in razvoju ZDA, z vidika ZDA v devetdesetih letih prejšnjega stoletja ter pri Nobelovih nagrajencih v letih 1995 in 1996, ki so kakorkoli povezani z ZDA (Executive Office of the President, Office of Science and Technology Policy, 1997

DODATEK B: POSVETOVALNI TELESI PREDSEDNIKA ZDA O ZNANOSTI IN TEHNOLOGIJI

Dodatek B.1: Nacionalni svet za znanost in tehnologijo
Dodatek B..2: Posvetovalni odbor predsednika ZDA za znanost in tehnologijo

Pomen, ki ga ZDA dajejo tehnologiji nasploh, se kaže tudi s številom odborov, ki se ukvarjajo s tem področjem in nenazadnje tudi v ljudeh, ki so kot posamezniki ali pa kot predstavniki posameznih inštitucij v dveh najprestižnejših odborih za tehnologijo, ustanovljenih z namenom, da svetujeta predsedniku ZDA (Nacionalni svet za znanost in tehnologijo in Odbor predsednika za znanost in tehnologijo).