THE ECONOMIC DIMENSION

OF RESEARCH AND DEVELOPMENT

THE CASE OF KUWAIT

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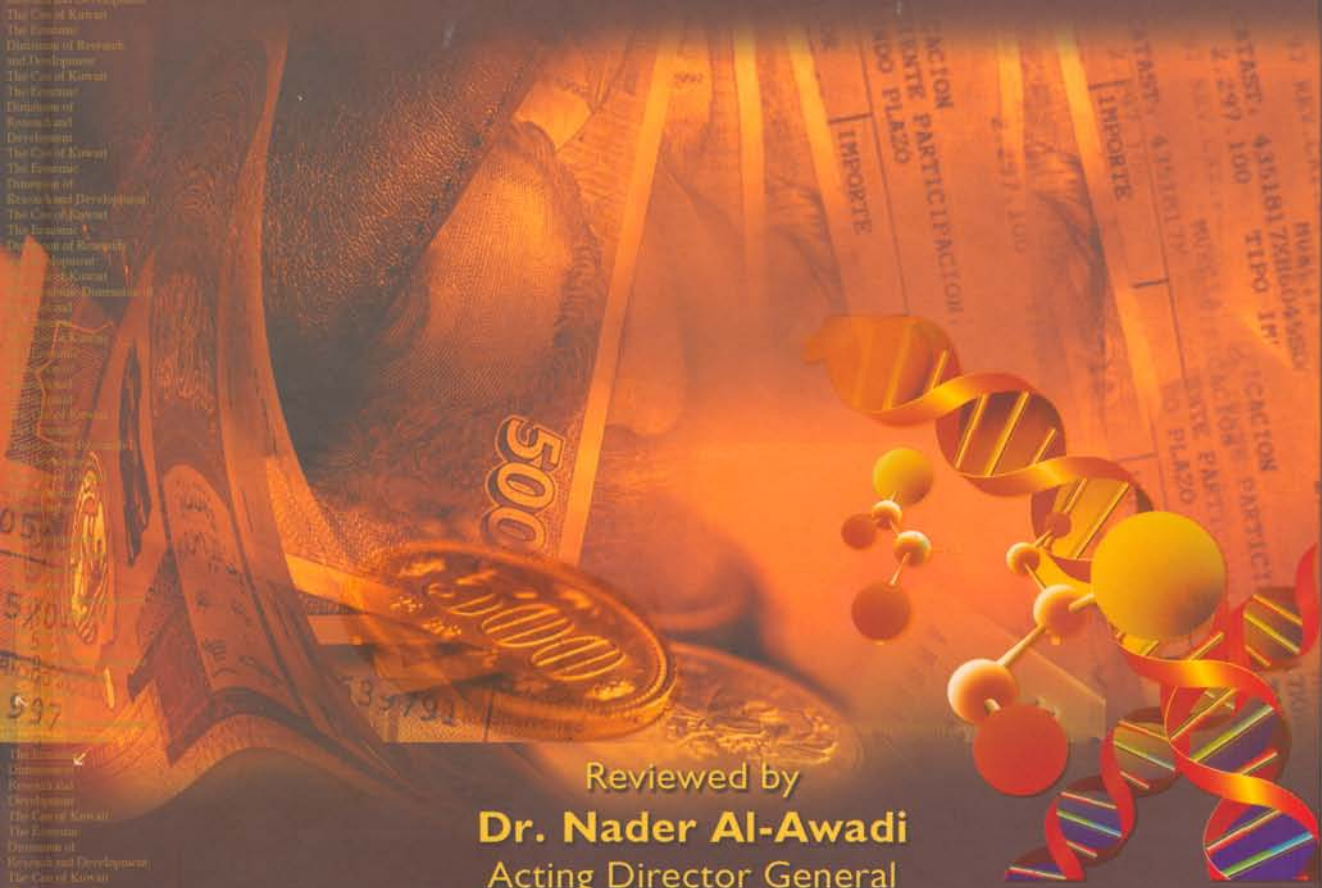

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Contents

Glossary of Abbreviated Terms

AC	Apparent Consumption
AD	Aggregate Demand
ARL	Army Research Laboratory
BEP	Break Even Point
CA	Current Assets
CBR	Cost Benefit Ratio
CGE	Computational General Equilibrium
COGS	Cost of Goods Sold
CL	Current Liabilities
CR	Current Ratio
CCF	Cumulative Cash Flow
CF	Cash Flow
CPI	Consumer Price Index
DCF	Discounted Cash Flow
DEES	Dependence and External Economic Status
DER	Debt Equity Ratio
DP	Domestic Production
DR	Debt Ratio
EI	Economic Indicator
EPA	Environment Public Authority
EPM	Evaluation Performance Measure
FC	Fixed Cost
FDI	Foreign Direct Investment
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product

GNE	Gross National Expenditure
GNP	Gross National Product
GPM	Gross Profit Margin
IRR	Internal Rate of Return
KFAS	Kuwait Foundation for the Advancement of Sciences
KISR	Kuwait Institute for Scientific Research
LR	Liquidity Ratio
MARR	Minimum Alternative Rate of Return
MENA	Middle East and North Africa
MITI	Ministry of International Trade and Industry (Japan)
MSF	Multi Stage Flash
NDC	Net Domestic Consumption
NEE	Newly Emerging Economies
NFIA	Net Factor Income from Abroad
NI	Net Income
NP	Net Profit
NPV	Net Present Value
OECD	Organization of Economic Cooperation and Development
OLS	Ordinary Least Squares
PAA	Public Authority for Agriculture
PAAET	Public Authority for Applied Education and Training
PAAC	Public Authority for Assessment of Compensation for Damages Resulting from the Iraqi Aggression
PAAFR	Public Authority for Agricultural Affairs and Fisheries Resources
PAI	Public Authority for Industry
PI	Planning Indicators
PBP	Pay Back Period
PM	Profit Margin

QR	Quick Ratio
RAV	Real Asset Valuation
R&D	Research & Development
REMI	Regional Economic Models, Inc.
RER	Return on Equity Ratio
RO	Reverse Osmosis
ROA	Return on Assets
ROE	Return on Equity
ROI	Return on Investment
ROR	Rate of Return
RRI	Rate of Return on Investment
SOE	State Owned Enterprises
S&T	Science & Technology
SWOT	Strengths, Weaknesses, Opportunities and Threats
TA	Technology Achievement Index
TC	Total Cost
TE	Total Equity
TFP	Total Factor Productivity
TR	Total Revenue
UNCC	United Nations Compensation Commission
UNESCO	United Nations Educational, Scientific & Cultural Organization
UNDP	United Nations Development Program
UNIDO	United Nations Industrial Development Organization
UP	Unit Price
VA	Value Added
VC	Valuable Cost
VFM	Value for Money
WB	The World Bank

Preface

The economic dimension of research and development (R&D) is a broad subject that has many linkages and externalities. Therefore, exploring this subject in a purposeful and target-oriented context is the best way to give it shape and meaning. This book will look at the economic dimension of R&D from a conceptual perspective and from macro-economic (macro) and a micro-economic (micro) perspective in seven chapters, with special emphasis on the model of the State of Kuwait. Conceptually, R&D will be explored as an economic activity that has become central not only to achieving, but to sustaining the competitiveness of today's world economies. As land, capital and labor are the classical, traditional factors in production, R&D may be rightfully added as a critical and partial function of economic growth today, carrying maybe even greater weight than the other factors of production in the knowledge revolution in which we live. As did the agricultural revolution, which was followed by the industrial revolution, the knowledge revolution again, changes the primary factors of production. What is required now is not machinery, land or masses of laborers; instead, cutting-edge knowledge, creativity, planning, differentiation and distinction all components of R&D have become the central components of the knowledge revolution.

Why does a government need to invest in R&D? The private sector on its own will not commit the level of resources to R&D that is best for society or even for individual firms at the micro-level (Bond, 2000). Investments in R&D are inherently risky. The private sector makes investment expenditures and choices, including those on R&D, based on expected economic returns. However, because it is well-known in R&D

that firms will only realize a portion of the total return on an investment, investing is an undesirable choice and a poor corporate decision (Arrow, 1962). R&D is a unique input in the production process, the results of which have been the provision of entire fields of productive wealth-enhancing, job-creating economic activity. The government's role does not end with funding basic research; in fact, R&D should be viewed as a continuum, with basic research at one end.

The objective of this book is to present a holistic picture of the economics of research and development (R&D) in a nutshell. This is a multi-dimensional, inter-disciplinary subject that involves understanding what R&D is, how R&D impacts economic growth and development, and how economics impacts the performance of R&D around the world. The first chapter of the book will look at the role of R&D in economic growth by presenting a number of exemplary global and regional country cases, where the importance of scientific research in the process of economic growth and development in developed countries, and as its vital role in achieving and sustaining positive growth rates are analyzed. Scientific research has provided the economic engine for economically developed countries because economic competitiveness today is propelled by knowledge and technical prowess. Knowledge development and scientific research have become the keys to the progress of nations and main criteria for measuring a nation's value-added. Chapter 1 also addresses the very definition of scientific research, and presents its variety and requirements, as well as its most important pre-requisites, mainly being the presence and development of the human resources suitable for such giving and creativity.

Chapter 2 will focus on the intricacies of the economics of R&D, exploring issues that include the impact of R&D on gross domestic product (GDP); justification of R&D expenditures; and the impact of

R&D capital on total factor productivity (TFP) growth and R&D spillovers, social returns and economic returns. The State of Kuwait and its R&D efforts and policies will be the focus of this book, providing an exemplary case through which the concepts and practices of the economic dimension of R&D may be effectively presented.

Chapter 3 discusses the planning indicators that feed into the strategic planning process; which in turn delineates and expresses the R&D policy, and sets the requirements and objectives for it, which eventually translate into R&D budgetary appropriations and allocations. The immeasurable impact of R&D on the socio-economic fabric of Kuwait will be the subject of Chapter 4; socio-economic development is an undeniable outcome, and a viable externality and by-product of an R&D culture. Most importantly, this includes understanding the economic constraints, among other resource constraints that force decision-makers to prioritize, target or pick and choose their investments, rather than investing in everything and anything that looks good, a subject that will be discussed throughout the remaining chapters of the book.

Chapter 5 addresses the financing of scientific research and the importance of the existence of a network linking universities on one hand, and other research institutions, production and services sectors on the other, as a prerequisite for the advancement of scientific research, especially in developing countries. It also presents prevalent models that are used to evaluate scientific research output from an economic perspective.

Chapter 6 presents the utility of cost-benefit analyses in the evaluation of R&D projects and the investments required for them. Chapter 7 discusses the various sources of funding available for R&D in Kuwait, and chapter 8 proposes a set of recommendations and provides an outlook on the subject.

The case of the State of Kuwait will be used to evaluate the benefits and rewards of R&D investment over the past four decades, not only from an economic angle but also from a socio-economic perspective, since the socio-economic benefits are at times used to justify economics imperfections.

The focus of this book is rather unique and distinctive because it addresses the economic aspect of R&D from a holistic perspective in the world in general, and in Kuwait in particular. Whereas the discussion of R&D activities has been addressed in previous publications, from the perspective of evaluating output, efficacy, and efficiency, an economic focus has not been presented previously, especially with respect to Kuwait.

Investors and researchers alike have to ultimately justify and rationalize their investments of capital, time and manpower, with a return-consciousness, i.e., the question of economic feasibility of a research project or activity. While economic feasibility or lack thereof, for a research project of activity is neither sufficient grounds nor the only criterion for to justifying commencement and adoption (or not) of a project, nevertheless, the economic perspective; its determinants, its tools and methods are the focus of this book.

ꕥ Chapter One ꕥ

The Role of Scientific Research in Economic Development: International and Regional Perspectives

R&D activities "may be defined as the creation of know-how and know-why of new materials and technologies that eventually translate into commercial development". (Wheelwright-Clark, 1992a). (Two-phased: generation and transition to market, followed by diffusion, or the value that is transferred to the capital market, which is a separate process unrelated directly to the R&D channel).

Scientific research and development (R&D) is a strategic process, that is essential for development and "inseparable from scientific advance" (Hoffmann, 1992) R&D is one of the key root activities in an organization, due to its ability to build national capacity and to develop and transform a nation from being a developing exporter of basic raw materials to a developed exporter of high value-added, knowledge-intensive products and services (Westholm, 2004). R&D expenditure, as a percentage of gross domestic product (GDP), also referred to as R&D intensity, has become a central indicator in evaluating the contribution of R&D activities to economic growth and vice versa. This economic link is measurable due to the existence of a dynamic spillover effect from R&D activities that contribute to total factor productivity (TFP) growth.

R&D intensity varies from country to country. Countries like Sweden and Finland, that devote a relatively large portion of their GDP to R&D, have an R&D intensity of 3.7% (Eurostat, 2005), whereas other

countries like Malta, Cyprus and Kuwait have R&D intensities of less than 1%, and sometimes even less than 0.5%.

R&D intensities and how much a country allocates for R&D may fluctuate from year to year depending on many factors that include the economic growth rate of the country, which is a contributing factor to how much capital is dispensable toward that objective, and the designation of R&D as a priority area of investment. In general, developed countries today commit and invest in ambitious R&D programs and activities to stay competitive in an age where knowledge industries rule (Porter, 1985). R&D has become a permanent factor in movement along the value chain, and even more so, it is a strategic competitive driver, especially in the economies of more economically developed countries (MEDCs), which are more economically developed countries. R&D, quite simply, is the new integral factor required to sustain economic growth and development. It is important to note that the real impact of government-supported R&D is not in the returns to the individuals involved, but in the returns to society. Measuring such returns is a difficult task, since the results of public R&D weave their way through the economy in countless ways and directions; this is referred to as the spillover effect.

Scientific research has become a major component of today industrial advancement and social welfare in most societies, especially in developed countries, which have provided scientific research and its diverse activities with a variety of support mechanisms, particularly since the second world war. The production function has linkages with three factors: capital, land and labor. This equation is empowered today only, after adding a fourth factor, namely, technology and technological know-how, which no doubt, stem from R&D.

As the economic structures and political systems in developed countries are different from those in developing countries institutions of scientific R&D also differ. In most developed countries, these institutions are independent of the government bureaucracy, except for institutions related to defense and security activities, and most are dependent on the private sector. In developing countries, most if not all of the institutions of scientific research work in a centralized manner. They are financed, supervised and managed completely by their governments. There is no doubt, that each of these two systems has advantages and disadvantages; the development of society and the benefits that it gains from the final results and returns of scientific research depend on the balance that is forged between those advantages and disadvantages.

The success or failure of the institutions of scientific R&D is dependent on a number of factors, including financial support, manpower, political conception and appreciation, the existence of a social outlook in the development of the society, legislation of policies for scientific research, accessibility to scientific and technological information, and channeling the application of scientific research results in to the various institutions and sectors of the society.

Scientific research and its technological applications play an important role in the development and welfare of society in any country. The scientific research undertaken in countries is regarded as a measurement of their social and economic advancement and growth. Countries that know how to apply the output of scientific research have seized advanced positions in many fields, which include the manufacturing of machines and military devices, which, in turn, allows them to achieve military advantage and provide abundant cultural and scientific contributions to civilization as well as providing various services to their citizens. This advantage is also evident in their economic

growth, the construction of their industries, their high productivity levels and the effective allocation of their resources. Such countries are referred to as developed countries or industrial countries (of the north). Other countries, which are referred to as developing (of the south) countries, are seen as lacking in the ability to utilize science and scientific research.

If one of the latter (i. e., developing) group of countries chooses to utilize the applications of scientific research, it finds that its technological experience is insufficient. This stems from a shortage in national manpower that can bring experience in the field, which means that utilizing a given technology or manufacturing a given product can be quite problematic. In turn, developing countries find themselves dependent on developed countries to fulfill their needs, which overwhelms their budgets and yet again delays their growth.

Scientific research, along with its technological applications, is linked vitally and inseparably to national development. The industrially developed countries are very proficient in employing such linkages to the maximum. For example, 60 to 80% of the increase in the standard of living of the citizens of the developed north is due to scientific and technological advancement, while only 20% to 40% of that same increase is caused by the availability of capital. Their share of international exports in 1987, was estimated to be 69.9%, while the share of developing countries (more than 100 countries) was only 19.7%; the remaining 10.4% was the share of what were then referred to as the socialist countries.

Under-utilization of the results of scientific research and its technological applications in developing countries makes their relationship with industrially developed countries one that is based mostly on unilateral commercial exchanges, with the former supplying the latter with raw materials, while the latter provides the former with

manufactured supplies, causing huge disparities in prices and terms of trade, which are often manifested in price reductions for raw materials in recent years.

For example, the reduction in the prices of metals escalated from 7% to 30% during the period between 1980 and 1982. The reduction in the prices of sugar during the same period reached 71%. Inflation is another possible contributory factor for such price declines in developing countries. While absolute inflation did not exceed 10% on average in industrial countries during the 1970s, it reached 11.5% in 34 developing countries and as much as 16% in petroleum-rich countries. As for the Latin American countries, financial inflation exceeded 100%. These numbers demonstrate that industrial countries have been able to bring their inflation rates under control. No doubt, the results of scientific research have given decision makers in industrial countries the upper hand in enabling optimal decisions to be made that have, in turn, improved many economic and financial indicators.

In developed countries, employment in the industrial sector dropped from 38% to 34% during the period from 1970 to 1981, in spite of enormous increases in production. Concurrently in the agricultural, sector, the high productivity rates relative to human resource capital employed, dropped from 38% to 10% during the period from 1950 to 1981, in spite of an immense increase in agricultural production. The increased utilization of scientific methods and mechanization are both the final product of scientific research. The same pattern is present in developing countries, where there is a relative decline in labor employed, in both, the industrial and the agricultural sector, but without any corresponding tangible decrease in production. Correspondingly, the service sector has grown globally, claiming a sizeable and overwhelming percentage of the GDPs of most countries today.

In light of what has been presented above, the developed countries commit to and invest in change and reforms only after reaching a level of scientific conviction that has allowed them to become economically and scientifically stable. In other words, scientific research constitutes an integral part of their national development. This type of logic is part of their decision-making process; in fact it is a decision-making support tool. In contrast, most developing countries fail to address the problems facing them as they can only experiment with solutions that are far from being scientific or objective (Al-Sultan, 1994).

One of the challenges hindering the progress of scientific research for development purposes in developing countries stems from the fact that development, as well as the very concept of development itself, is still immature. Additionally, development is still being conducted in random and arbitrary ways that try to blindly and wrongly-simulate models from industrial developing countries. Hence, the activities of scientific research in these developing societies relapses and reverses. In addition, the absence of proper planning results in efforts that fail to effectively relate to, stem from or comply with the specific needs of the society. Such distance between scientific research and development in developing countries has been explained by researchers, including Mounir, et al. (1996), who basically suggest that researchers in developing countries produce research merely for the purpose of publishing in international periodicals, with the aim being academic promotion or a formal presence in the international scientific arena, which in and of itself is an important value-added; however, what it lacks is coordination and contextual meaningfulness.

The dependence of countries on quantitative inputs and indicators of economic growth does not necessarily lead to or show collective advancement. As an example, the GDP of the six Gulf Cooperation

Council (GCC) countries is US $ 151 billion; however, collectively, it is less than the GDP of a single industrial country, like Austria (US $ 157 billion) or Sweden (US $ 228 billion). The countries of the GCC are mainly dependent on their crude oil exports for revenue. In fact, petroleum exports constitute on average approximately half of their GDPs. Hence, the rate of GDP growth and its fluctuations are inherently not a reflection of productivity, but rather of oil sales, a non-sustainable natural resource. In contrast, developed countries like Japan, Austria and Sweden depend on science and technological know-how and outputs to generate economic growth.

Definition of Scientific Research

Modern times are predominantly characterized by the scientific and technological advancements that the world has achieved throughout the previous century, landmarked by the industrial revolution and the more recent knowledge revolution, along with the direct and the indirect metamorphoses that these revolutions and advancements have had on the accomplishments of economic and social development plans and programs. Thus, the basis and development of scientific research constitute the backbone of the competencies of countries to invent, innovate and develop technologies and utilize them in different sectors of their economies. What the world has gained in knowledge and technology is accumulated through continuous learning and experiences that were previously attained by humanity in past ages.

From this perspective, the development of military strength and the social welfare is a function of what the state has in human and institutional resources, that are capable of thinking, inventing and discovering, and in effect, conducting systematic scientific research.

The term “scientific research” consists of two words, scientific and research. From a linguistic point of view, the word “scientific” can be defined in many ways, that include the following:

- Asking and inspection (Mostafa et al., 1960).
- Questioning, investigating and inquiry (Mostafa et al., 1960).
- Attaining new knowledge or facts or principles. (Webster's Dictionary, 1961).
- Patience, persistence and determination.
- The endeavor to know facts and fundamentals (Cabinet Dictionary).
- Conscience and carefulness (Fowler, 1959).
- Discovering new facts by way of scientific study of a certain subject (Fowler, 1959).

Additionally, from a linguistic point of view, the word “research” can be defined in equally numerous ways, including:

- The meaning of knowledge and study (Ellias, 1980).
- The recognition of a thing as it truly is and knowing the facts related to it (Endicott, 1948).
- Distinctive kind of knowledge that seeks general laws linking a group of distinctive facts, on the basis of what they make possible as the image of human society, along with the profound adjustments in the economic organizations and functions of states.
- The involvement of the human race in an organized endeavor to discover the series of processes and placing them under control through objective study of recognized incidents and collecting the resulting knowledge in a methodical way, that gives the human race a better opportunity to understand the incidents that occur in nature and society, and then utilizing them to their benefit (UNESCO, issue# 41).

- The reconstruction of existence in a later time through the process of intellectual imagination (Khulosi, 1969).

From the above, the following definitions of "scientific research" can be formulated:

- The profound and real study of a problem facing society in any field, whether in the natural or technological sciences, and in any type of human knowledge through systematic and scientific ways (Hassan, 1966).
- A more systematic investigation that aims to add knowledge and verify its accuracy (Egren, 1957).
- An activity that aims to discover and verify facts and general principles (Hiteney, 1946).
- The systematic utilization of human intellect to treat specific problems with no available solutions (Hertz, 1950).
- Any structure wherein the primary use is the administration and conducting of investigation, examination, experimentation or training aimed at the discovery and interpretation of facts and/or the practical application of the above to produce products or processes.
- The systematic, controlled, empirical and critical investigation of hypothetical propositions about the presumed relationships amongst natural phenomena. The objective inquiry into natural phenomena using currently accepted investigation procedures, the immediate product of which is evidence, with the objective of discovering how that aspect of the physical world works.
- The scientific method or process is considered fundamental to the scientific investigation and acquisition of new knowledge based upon physical evidence Scientists use observations, hypotheses and

deductions to propose explanations for natural phenomena in the form of theories. Predictions from these theories are tested by experiment. If a prediction turns out to be correct, the theory survives. Any theory which is cogent enough to make predictions can then be tested reproducibly in this way.

- The thorough critical endeavor to reach solutions for problems that face humanity (Leopold, 1977).

Differentiating Types of Scientific Research

With the aim of achieving numerous objectives, scientific research comes in different forms, depending on the objectives, the quantity and quality of spending allocated, and the aims to be fulfilled. The following is a classification of the main types of scientific research.

(1) Basic and Academic Research

Academic research is aimed to increase human knowledge, discover facts and develop theories without concern for the degree of market utility or applicability of the results (science for the sake of science). This includes social, economic and human research. Here, scientific research stems from the researcher's desire to understand a phenomenon in a scientific way, fathom its secrets, increase the science of specialized research with all that it entails in terms of publishing in scientific journals and lecturing in scientific conferences.

Basic and academic research is usually undertaken in academic institutions, universities, and institutes. These centers of learning, and knowledge acquisition and dissemination are not interested in the technical, economic on market pertinence of their work, but rather, their attainment is measured by the quantity of research published in scientific

periodicals and specialized scientific journals relative to the demographics of the population. While basic research is not constrained or controlled by economic feasibility or marketability measures, it is constrained by capital resource restrictions. Its intrinsic value may be appreciated in light of its long-term prospects, and its direct and indirect contributions to applied research. Applied research is a sequential, long-term benefit, utilizing the true outputs of basic research as its raw knowledge.

One of the important factors in the planning of basic and academic research stems from the evaluation of projects or research proposals. It is through the process of evaluating projects and research proposals that the institutions responsible for research determine which researchers have merit and talent, and who are usually the sources of great ideas and generate diverse research concepts that can propel the advancement and improvement of their societies. The motives of such researchers are usually deeply rooted in the nature of their societies with their traditions, customs, concerns, problems, and means of education and learning, at scientific and cultural levels (Badawi, 1997).

(2) Applied Research

Applied research includes the exploration of new fields of science with practical, applied output planned from the outset. This kind of R&D is usually born and bred in applied research institutes and centers. Methods of applied research have usually been tried and pre-determined, beforehand. The options are analyzed from different aspects, after which the best scientific method for conducting the specific research is selected, with an assigned time schedule for manpower. Applied research is ultimately geared toward product and market-applications development. Hence, from the outset, companies and corporations from the private

sector fund and work with research centers to develop market solutions cooperatively. This is one of the most important factors differentiating lied research from basic research. The partnership in funding and the clearly defined ultimate market target keep applied research teams focused on their research objectives.

New products are developed and conventional ones are renovated as a result of applied research. Innovation, and market preparation and development are critical. Economic feasibility is an important consideration in applied research. The results of applied research may thus be of decisive value for a given field, with outputs proving positive or negative, or leading to an accumulation of technological know-how.

(3) Developmental Research

This form of research is specifically conducted to improve existing products and materials by increasing their efficiency and effectiveness. Primarily developmental research is funded to attain new and innovative products and materials. Developmental research is usually conducted in laboratories in industrial countries, where large multi national corporations, industrial companies and institutions possess the sufficient sources, not only capital but also human, and the required expertise required to conduct this kind of work, which ultimately benefits its founders and suppliers, and hence, reaffirms the special purposes of those industrial companies and institutions. The objectives of such research centers are to develop and improve existing and potential products and materials with the objective of achieving higher marketing buzz and higher profits.

(4) Consultation and Study

This type of research depends on selecting the best scientific solution or suggestion from a selection of those available in the scientific arena. Hence, this type of research involves reviewing and selecting from what is already available, i.e., matching application with need.

Requirements and Prerequisites of Scientific Research

The requirements and prerequisites of scientific research, in terms of human, resources funding and institutional organization and support, are fairly common to all countries (even when the priorities of scientific research differ). Such requirements constitute the cornerstones of scientific research activities and include the following:

(1) Attracting, Fostering and Retaining Talented Human Resources

Human resources make the difference between development and under-development in this contemporary age. Today's development process is not dependent on land, capital or labor, in a conventional sense, but rather, on knowledge and innovation. Scientific and technological progress is not attainable without the right quantity and quality of human resources. Thus, investment should be directed toward developing the right quality of trained human capital that is specialized and inventive.

The main problem facing developing countries, where university graduates provide the larger pool of researchers and public opinion leaders, can be summed up in the novelty of higher academic education, and the fact that it is still under-developed. This also applies to, students in universities in the Arab World, where educational policies are analogous to those in public education, where pupils, the admission systems and the progress from grade to grade are based solely on the their

abilities to memorize, and not on their abilities to innovate. This problem worsens when students struggle with this style of education, which fails to captivate potential innovators and creative thinkers. In spite of their competency and ability, some graduates prefer not to devote themselves to working in a field of scientific research due to the lack of financial support available at home, compared with their colleagues in developed countries. All of this demonstrates the pressing needs in developing countries for the revision of the educational systems and the provision of more progressive educational, and for university educators developing countries to formulate new policies for student admission and selection, that aim to ensure the selection of the best students who can rightfully contribute to the augmentation and amelioration of scientific research. Such talent should be recognized and encouraged.

Educational methods used in universities in developing countries, coupled with evaluation systems that reward complacency should be reformed and replaced with systems that lead to the identification of those pupils most able to conduct scientific research, the enhancement of their research potentials, and support for their quest for innovation, by pursuing means to transform the educational process from that of a merely passive learning experience (in which the student accepts what is given to him or her) in to an active learning experience (in which the student participates actively in the learning process).

Illiteracy has now been established to be a critical determinant and a primary contributor to under-development. Modern states cannot flourish with high illiteracy rates dominating their populations, or while there is an incapability to include all their citizens in the education process, which is sadly still the case in many developing countries.

Promoting human resources that are qualified to conduct scientific research is essential to the development process. However, the

developing world suffers from many short-comings and inefficiencies in identifying and building this caliber of human resources; if found, they are often not matched effectively to research careers in which they can be best utilized and developed. Similarly, many of those undertaking academic careers do not conduct scientific research or are overcome by the retarded conditions in their societies, eventually giving up without exerting any real effort to change such conditions.

The process of building and developing a body for assistants of scientific researchers is as important as the process of grooming the body of scientific researchers itself. Assistants are required for the success of the researchers. Scientific research is an extensive undertaking in both effort and time, since it requires constant follow-up, step-by-step monitoring of results, and screening of research results to enable timely analysis and interpretation, in order to obtain valid results and formulate accurate theories. All of this requires the existence of research assistants with qualities of scientific integrity, trustworthiness and efficiency. The establishment of scientific institutes with high levels of internal efficiency thus becomes inevitable. Coordination between universities can be utilized to establish centralized, institutes where research assistants could be trained for all universities and other institutions involved in research.

(2) Providing an Innovative Environment

Scientific research is not a process of routine, but one of creativity and invention that calls for an environment that is conducive to innovation. The availability of finances and a capable support team is not sufficient for scientists to produce appropriate scientific research. An atmosphere of freedom, managerial stability and serenity is required for researchers to be able to produce without constraint. This undoubtedly includes the need for dignified living conditions, including decent

housing, sufficient income, reasonable social atmosphere, and easy means for an everyday life, and facilitating of political and bureaucratic maizes. Moreover, scientists should be motivated to network with colleagues through scientific seminars and conferences, and by exchanging ideas across borders, internally and externally, in order to enrich research outputs.

Unfortunately, scientific research in universities and institutions in the developing world, particularly in Arab universities, lacks the characteristics of a flexible, dynamic structure. There is no integral linkage between institutions of scientific research and centers of production, services, or industry, and the market. This prevents researchers from understating the real problems that face the various production and industry units. Thus, the market does not benefit from research developments that pertain to it, because it is not connected to the local research units through funding or any other means. As a result, academic researchers cannot contribute to solving actual existing problems and cannot work to improve production, increase productivity or decrease production costs. On the other hand, people in the production and service sectors are disconnected from what is being developed in research institutions. Thus most results and outputs from the scientific research are not accessible to people in the production and services sectors, and hence, provide no benefit, especially in the field of applied research. Thus, the outputs do not become disseminated properly, and their ability to boost market profits is hindered right from the start.

(3) Financing Scientific Research

Adequate and timely financing of R&D is an important factor in enabling scientific research to fulfill its mission. Nevertheless, prioritizing research expenditure may be considered as a constraint, since

it pushes decision makers to strategize the researchers mission. Nevertheless, maintaining a balance between these two factors creates a situation of optimum allocation of the investment injected into scientific research. The idea that scientific research sectors should only provide services for other sectors is becoming unacceptable. From an economic perspective, scientific research sectors should legitimately and rightly be considered production and investment sectors. Supplying them with the required finance through integration is a necessity, in the form of sufficient financial resources for expenses and manpower; and building and maintaining the facilities, laboratories, tools, and public services and support services required to conduct scientific studies. The need for and value of such support become evident when one considers the sizeable allocations spent on scientific research in advanced countries, compared with developing countries, as shown in Table 1.1.

Being aware of the importance of R&D as a critical factor in increasing and sustaining the competitiveness of industry and markets, in developed countries, a portion that is no less then 2% of GDP is allocated annually to research. However, in developing countries, the scenario is quite different; miniscule allocations are dedicated to R&D; in most cases less than 1% even among the wealthier developing countries where GDP growth rates have been rising recently.

(4) Providing Scientific and Technical Services and Information for R&D

Developing a competent scientific researcher is not the end of the road. In fact, it is only the beginning. A researcher cannot conduct research unless he or she is able to utilize facts and results previously attained by scientists in the same field. Hence, facilitating library services

between research centers and universities is a vital resource that provides researchers with many valuable documents and references that are needed to attain the objectives of research (Yousuf Al-Sulatn, 1993). Advanced technology, fore-fronted by the Internet, has made knowledge more accessible. This factor alone has contributed immensely to disseminating knowledge, connecting scientists and educating people.

Table (1.1): Expenditure on R&D Activities Across the World

Region	Expenditure (million US$)			Expenditure as a Percentage of GDP			Scientists and Engineers Working in R&D Per Million Population		
	1970	1975	1980	1970	1975	1980	1970	1975	1980
World total	62101	113815	207801	2.04	1.87	1.78	790	803	847
Developed countries	60677	109330	195377	2.36	2.25	2.24	2290	2696	2954
Developing countries	1424	4485	12424	0.30	0.36	0.43	81	101	125
Arab countries	115	334	1027	0.31	0.23	0.27	123	165	207
Africa (excluding Arab countries)	105	300	698	0.33	0.35	36	29	43	52
Asia (excluding Arab countries)	4540	12304	30661	1.02	1.08	1.18	225	270	284
Europe	15739	36455	70649	1.70	1.78	1.79	1253	1552	1743
Latin America	498	1686	3745	0.30	0.44	0.49	136	181	253
North America	27620	38382	66646	2.59	2.26	2.23	2521	2369	2677
Soviet republics	12987	23794	32421	4.04	4.79	4.67	3882	4809	5172

Source: Al-Sultan and Al-Heeti, (1990).

(5) Encouraging Scientific Publication

Scientific publication is one of the main scientific outputs of scientific research. Specialized scientific journals are still lacking in developing countries, with most capable researchers preferring to publish

their work in well-known international journals, keeping the less prestigious scientific magazines in most third world countries reserved for less advantageous and less rigorous scientific research, due to the modest quantities they distribute and the mediocre reputation they enjoy.

(6) Application of Scientific Research Outputs

Although, some developing countries have improved in the field of scientific research and have determined frameworks for the planning of their scientific research activities in light of strategies that complement their plans for national development, the degree of applicability of such scientific research is still lacking.

The phenomenon of passing the buck, which is rife at many ministries, institutions, establishments and private and mixed-sector corporations in their R&D departments and regarding the registration of inventions developed by national parties, only fosters withdrawal and indecisiveness for most scientists, in spite of the importance of their role in the process of development. For example, during the meeting of the Arab Ministers responsible for the utilization of science and technology (S&T) in the development process, it become clear that they were not really utilizing S&T in the development process and that R&D is viewed as a self-contained sector where spillovers do not occur; hence, opportunities are missed, which is another reason why expenditure on scientific research is not seen as a feasible investment. There is a wide gap separating the process of conducting and publishing scientific research from the process of applying and utilizing the results of such research.

Obstacles to Scientific Research

Both scientific research and technological development, like any scientific activity that requires allocation of resources and the exertion of effort, face many problems and obstacles that can hinder their development and prevent them from reaching the objectives set. These obstacles differ between developed and developing countries, and they may even differ from one country to another. The following are examples of some of the obstacles that can pose problems in developed or developing countries (Al-Sultan et al., 1997):

- Deficiencies in developing the research programs needed for development requirements, manifested mainly in the following:
- Absence of coordination between national planning units and agencies, and research institutes and programs.
- Lack of awareness of the real problems or needs of the economic sector.
- Absence of standardized methods of R&D in the State making it difficult to determine the ways or means of meeting development requirements.
- Problems in training, motivating and developing the skills of talented human resources.
- Absence of coordination between institutes and universities.

- Absence of synergy between universities and scientific institutes:
- Discouraging researchers from utilizing research facilities and resources, including laboratory facilities.

- Absences of networking among universities to provide facilities for R&D institutions.

- Absence of cooperation between the industrial sector and research institutes:
- Fields of research that are incompatible with the industrial sector's interests.
- Lack of trust by the industrial sector in the research institutes be capabilities to provide suitable solutions for its problems within a reasonable time France and at competitive costs.

- Absence of coordination and internal orchestration between research institutes, in their effort to avoid gaps, as follows:
- Lack of facilities.
- Shortages of technicians and training to improve their skills.
- Absence of opportunities for training in research employees.
- Lack of marketing skills and unsuitability of sources of information.

- Absence of motivation for interested research scientists:
- Absence of a motivational environment.
- Insufficient salaries.
- Unsatisfactory working conditions.
- Unclear assignments.
- Lack of a proper mechanism for allocating financial resources for scientific research; most resources are randomly and haphazardly allocated.

- Favorable political atmosphere:
- The existence of a favorable political atmosphere that encourages R&D is dependent on several factors, most importantly, distinguished leadership, elected decision makers with superior educational caliber, the type of government, and the social, cultural and political settings available.
- Lack of awareness in and participation of scientific researchers in formulating national development plans.
- Reliance on social and political factors to appoint authorities who are responsible for research institutes, without employing sensible consideration to their academic achievements, degree of expertise or specialization, leading to the general deterioration of research institutions and in the quality of what they produce.
- Absence of a declared policy for scientific research, leaving the identity and activity of scientific research susceptible to influence by those responsible for managerial posts in the institutions.
- Lack of regard given to the major needs and resources of the society in choosing researchers and research teams, with the research requiring a longer time periods lagers budgets, and tools and devices, that cannot be timely supplied. Researchers often fall into the trap, and relapse and duplicate previous research, adding only minor modifications to numbers, statements and means, and hence, diluting its meaningfulness.
- Lack of social support for research institutes in many societies, specially developing societies, research institutes do not enjoy enough social support. The majority of society may view their national research institutes as being inferior, comparing their work with that of their counterparts in the developed countries. Any

endeavor to improve and encourage the work of national research institutes must rely on support stemming from a positive social attitude towards national research institutes and their employees.

- Organizational instability, and successive disruptive managerial changes, and lack of networking with other institutions. Organizational instability may lead to a lack of opportunities for research programs, which produces an atmosphere of occupational insecurity among employees.

Priorities of Scientific Research

Scientific research is considered to be a costly activity both money-wise and resource wise. It requires long years of faithful, intense efforts to obtain positive returns for society and the economy. From this perspective, formulating a methodology and a policy for scientific research to couple with a strategy to attain desired objectives is not a simple task. It requires perception and a comprehensive, long-term vision, in addition to penetrating intelligence and an understanding of the nature of the society and the needs of each of its different sectors. It is no wonder then, that such policies and methodologies are lacking or absent in most third world countries.

Setting priorities for scientific research is an extremely trying challenge in most developing countries, especially in the field of applied research. This is because of the absence of practical and technical policies for determining research programs. In such cases, research institutes acquire their priorities from their own key players, which may not be an optimal solution, for research institutions are meant to play a role in conducting research, but not in setting research agendas and priorities. It is also expected that the key players in the research institutions set priorities according to their own fields of speciality, interests, expertise and research

capabilities, which all changes with and changes to those key players or turnovers in the managerial staff of the research institutions (Daghistany, 1989).

Formulating a policy for scientific research, and the rationalization of scientific and research resources according to the needs society, the objectives of economic, social and industrial development plans and with regard to available assets is a necessary pre-requisite that should be achieved by policy and decision makers, particularly in developing countries.

A strategy, in its more comprehensive conceptualization, is a drive from the present situation towards a better future, making changes with the aim of achieving specific objectives in accordance with the available resources and the comprehensive development plans in place. Such a drive is dependent upon factors that include the following (Mohsen and Culor, 1986):

- The societal need for change and development along with the will required to bring about such change.
- The current state of affairs and the experience through which the society has passed, along with the gains of inventions it develops.
- Obtainable resources that can be supplied to achieve the objectives of improvement.
- A clear methodology in which the paths and directions of work converge to achieve the desired objectives.
- A strategy that is characterized by flexibility, integrity and reality sufficient to face all future probabilities and changes.
- A strategy that is bound by the political conscience of society along with the directions and philosophy of the state, from which the general objectives and vision required are derived.

- The objectivity and clarity of the main and the secondary aims, especially those related to building the capability of, along with programming and supporting the scientific research activities in the state.

It should be emphasized that the priorities of scientific research stem from the views of decision makers and political leaders seeking to fulfill needs, and respond to take aspirations and ambitions of the state. That is why they differ broadly from country to country, as the prevailing conditions and the influencing factors, economic, social or political, differ.

Priorities of Scientific Research in Arab Countries

The aims of S&T policies in the Arab World stem from the civilization and history of the Arab nations along with the ideals and the threats and dangers that surround it. They also spring from Arab treaties and strategies that have focused, in a specific way, on liberation, the uniqueness of Arab civilization, Arab unity and comprehensive development. The general aims of scientific research and scientific policy are briefly:

- Achieving and reinforcing comprehensive security.
- Achieving comprehensive economic and social development.
- Contributing to international civilization.

Achieving these three aims requires developing the Arabian personality, both of the collective and of the individual, into a capable, self-confident identify, equipped with scientific intellect capable of innovation, generosity and vitally tied to the originality, history and

future of the Arab Nation. From all these ideals, springs a group of objectives that complements them by providing the basic material and psychological requisites for the Arab World to seek Arab coordination and integration in all fields, and formulate a solid basis to build an Arab scientific identify, rationalize the allocation of resources, and realize justice in income and the social distribution of services.

The springboard of S&T policy and scientific research is the useful science and skillful work, the focal aim of which is to contribute to the achievement of the major ideals of the Arab Nation by way of development through S&T on territorial, regional and national levels that can be utilized as guidelines for the formulation of strategic Arab targets for the development of sciences, technology and scientific research, as follows.

(1) Linking S&T to Societal Issues and Challenges

Seeking knowledge and practicing scientific research in ways that benefit societal challenges, address the work required, and promote the master such work, is but part of the heritage and a central trait of Arab and Islamic civilizations. All scientific, research and technological policies have unanimously agreed to consider a direction worthy of pursuing as an aim. The National Arab Charter (Mithaq Al-Amal Al-Quawmi) emphasized that Arab fortunes and their benefits play a leading role in achieving the goals of the Arab nation regarding liberation, security and scientific and technological awakening. The Arab Nation enjoys numerous important natural resources that science should assist in discovering and in improving their exploitation along with preserving those that are exhaustible. All this is included in linking scientific research to societal issues.

(2) Dissemination of S&T and Encouragement of Scientific Research and Human Resources Development

One of the priorities of the Joint Arab Economic Charter (*Mithaq Al-Amal Al-Iqtisadi Al-Arabi Al-Mushtarak*), approved at the 11th Summit, was to develop, improve and maintain human resources and labor in Arab nations, and expand dependence on Arab human resources, with the objective of diminishing dependence on foreign labor. This can be achieved through the dissemination of science and motivation to practice scientific research, which require the following:

- Arabization of S&T, spreading the utilization of the Arabic language in such activities along with support of Arab linguistic studies, directing them toward achieving such tasks, in an effort similar to that accomplished during the time of prosperity of the Arabian Islamic civilization, during the initial three centuries after the *Hegrah*.
- Dissemination of the scientific, or empirical, method in thought and culture.
- Improvement of the dissemination of the sciences, employment and investment of the mechanisms in the various activities of society and the economy through the building of an Arabic system for science, scientific research and technology that is harmonious and able to perform coherently, and capable and outputs that evenly distribute the fruits of scientific, technological development on the regional and national levels, in ways that foster the awareness of the importance of technology in the social base and the surrounding environment, reinforcing synergy between all these factors, leading to the rapid accumulation required to generate the desired leap.

(3) Combating Scientific, Research and Technological Dependence, and Achieving Arab Self-Sufficiency to Generate a Leap in Civilization

A leap in civilization is not an end in itself, but a means to improving the future of the Arab individual economically, socially and in terms of security. It requires the following:

- Having ambitions that go beyond the present conditions with their limited horizons, and the opportunity to restore the vitality of the Arab Nation and liberate its creative energy.
- Building and supporting Arab scientific and technological capabilities.
- Seeking to end scientific, research and technological dependence, and, instead, deepening Arab self-reliance.
- Supporting joint Arab efforts, and constructing the types of scientific and technological networks between Arab countries to consolidate such support.

(4) Effective Contribution to International Scientific Research

Effective contribution to international scientific research should be considered neither a stand-alone objective separated from other objectives, nor a luxury that the Arab countries can do without. To the contrary, making an effective contribution to international scientific research is essential to the accomplishment of the objectives of the Arab Nation. The opportunity to perform such contributions should not be overlooked, whether in the medium or the long term. The fact that Arab countries are currently unable to make use of such opportunities should not be a deterring factor in the near future.

An effective contribution to international scientific research is not easy to achieve in light of the current struggles in the international market regarding the deepening and consecrating state of unfairness in trade terms and the international division of labor, to the advantage of industrial countries. It requires the existence of scientific research capabilities and the technological potentials in the Arab Nation, that permit it to access and deal with the international scientific society to develop and achieve national security (United Arab Studies Center, 1989).

Priorities of Scientific Research in Select Foreign Countries

In spite of the certainty that scientific research (with all its priorities, policies, objectives, and concerns, as well as its mechanisms and strategies) springs from the environment that surrounds it, scientific research is a product of humans who are dominated by cultures, and ruled by social, political and economic factors that differ from one society to another, and even from one time to another in the same society.

Yet by observing the experiences of others, we can enrich our own experiences and avoid numerous mistakes. Based on a set of economic and social indicators, eight European, Western and Asian countries were en selected to represent models of international experience:

- Sweden.
- Germany.
- The United States of America (USA).
- Japan.
- The United Kingdom (UK).
- Belgium.
- Switzerland.

- The Netherlands (Holland).

(1) Priorities of Scientific Research in Sweden

In spite of granting R&D for social issues increasing concern, they are yet not a priority in Sweden. The Swedish Institute reports that in spite of granting social issues increasing concern on the sectorial level, the efforts exerted on technical research are still clearly prevailing and dominant. Research directly relevant to industry is gaining ever-increasing concern.

Sweden is especially dynamic with regard to energy research. In cooperation with Swedish multi-national corporations, the government is currently undertaking an endeavor to develop reactors to generate nuclear power independent from external parties. Like most countries, Sweden has recently turned its focus towards energy research, with the aim of finding other sources of energy, in addition to restoring current resources.

The Swedish government has realized the importance of international communication and cooperation in the field of research in a way that supports its objectives. Sweden holds a 1% share of the total international spending on R&D. Thus, Sweden depends heavily on cooperative and joint endeavors with other countries in its research. The government also encourages agencies and organizations to engage research communication and exchange. While Sweden grants priority to cooperation with Scandinavian states, it also participates in broader European and international activities.

In spite of the fact that Sweden’s R&D spending on defense cannot be compared to its counterparts in the USA and the UK, still a considerable portion of Sweden's financial allocations go to R&D for defense. This portion is bigger still than its counterparts in most states

with similar economies. This is but one feature of Sweden's foreign policy.

Some similarities exist between priorities of civic research in Sweden and in Holland, in spite of the fact that Sweden has not yet put into practice the broader type of scientific policy management that Holland has. Most importantly, Sweden has not put into practice the concept of the sector council that is applied in Holland: Still, Sweden has increased the sectoral representatives in its councils and agencies to gain a bigger share of social connectivity for approved R&D projects.

(2) Priorities of Scientific Research in Germany

The main objective of modern research and technological activities in Germany is solving societal problems. The German government deems this to be attainable through the following priorities:

- Developing the efficiency and competitive capacity of the national economy (referred to as the industrial objective of modernization).
- Improving the standards of living and the conditions of the labor sector in Germany.
- Raising the efficiency of German scientific and research organizations.
- Maintaining national security (defense).

The government believes that the importance of the first item on the above list is dictated by international economic trends on a broader level, and by a high degree of interdependency, as the government is faced by the problem of ensuring and protecting the efficiency and competency of its industry and factories by all means of modernization. The economic situation and competition along with providing for new job opportunities gives the first priority on the above list ultimate importance.

The concern is to focus on improving the standard of living and working conditions, and removing negative impacts of social and technological change. The research required deals primarily with illnesses, problems of urbanization, amelioration of labor conditions, provision of better social environments, and restoration of natural environments.

Basic research supports the path of applied research, the need to continue high levels of pioneering science, and giving defense priority, in spite of the fact that otherwise it might have ranked as a low priority item on the scale of scientific research.

It is worth noting that one important trait of scientific activity and research in Germany is related to the existence of established scientific institutions that possess an ability for self-sufficiency like the German Research Association, the Max Planck Association for the Dissemination of Science, the Fraunhofer Association and other scientific institutions in Germany.

(3) The Priorities of Scientific Research in the USA

During the 1970s, expenditure on scientific R&D and research activities stabilized at 2.3% of the GDP in the USA, after reaching 3% in the 1960s. The American administration expressed its desire that this rate not continue to diminish gradually, since it was well aware of the importance of S&T in sustaining development.

The military-industrial complex has been the main driver and the main beneficiary of the USA's research output and utility. During the previous century, the focus of the USA was in the fields of national security and defense, with half of the allocated rate of expenditure going to defense. This percentage declined from 52% to 50% of the national budget allocated to R&D during the period between 1968 and 1969. Correspondingly, the percentage for non-military research increased from

21% in 1968 and 39% in 1979; as for, space research, the allocated percentage of the national budget for R&D declined from 27% in 1968, to 11% in 1979.

American Regulation No. 205 for the year 1976 determined the most important policies and priorities of scientific research in the USA to be as follows:

- Organizational reforms that include the realization of the institutions designed federal agencies that are devoted to mainly scientific and technological research, and agencies that are exclusively or mainly devoted to activities of fuel, energy and raw materials, to exist in a framework independent of governmental constraints and bureaucracies.
- Initiating improvements in the current systems to deal with scientific and technological information on a broader governmental basis, concentrating on the suitable role that can be played by the private sector to disseminate this information.
- Improving technological development in the executive sector of the federal government.
- Developing means that can affect creativity, and the transformation and utilization of technology.
- Exhortation to initiate communication and more harmonious coordination on the level of the federal government and the state, on the level of the federal government and industry, with S&T, including the formation of systems on a level related to states to achieve the joint execution of such objectives.
- Reduction and simplification of federal systems and managerial regulations that might technological innovation in ways that may delay their utilization.

- Finding a broader basis for supporting basic research.
- Working to find means to enable academic institutions to support the state, and its research and educational potentials in the area of scientific and technological research.
- Finding effective ways and means to boost scientific and technological factors with in the framework of national and international policy.
- Maintaining sufficient energy for S&T on the basis of quantity and quality.
- Improving the systems of planning and analyzing S&T programs.
- Conducting extensive studies by both analyzing and planning, according to the applicability of S&T, with scientific research relevant to national problems and concerns.

While it is difficult to make international comparisons, nevertheless the policy for scientific research in the USA is much more comprehensive those its counterpart in the UK, but less comprehensive than that of Germany and Japan. In general, all four of those countries show great interest in economic and social issues in their own contexts, that are related to the priorities of S&T and scientific research.

(4) The Priorities of Scientific Research in Japan

The Council for Science and Technology in Japan has set the following five main objectives for S&T and priorities for scientific research as follows:

- Contributing to the preparation and the economic utilization of resources (i.e., energy, food, water, and raw materials).
- Assisting in developing an environment that is desirable to live in, and presenting solutions to environmental and security problems.

- Contributing to health preservation.
- Producing pioneering scientific methods.
- Supporting technical methods that form the basis for international cooperation and that ensure the competency of Japanese industry.

These objectives do not differ much from those of the countries of the Organization of Economic Cooperation and Development (OECD). They are quite similar, for example, with the objectives and priorities of scientific research in Germany.

The Japanese Council for Science and Technology determined the main methods through which such objectives are attainable. Included in the first objective, as mentioned above, for example, as a major concern for the Council is energy. Thus, current and future research programs target optimal utilization of nuclear fuel, natural fuel, solar energy, thermal energy and hydrogen.

The Council for Science and Technology mainly supervises the nuclear program. The Ministry of International Trade and Industry (MITI) supervises research on non-nuclear energy. Moreover, there is concern over generating and distributing, thermal waste rationalizing thermal utilization in industry, and developing new means of transportation. This objective also includes details concerning food supplies, water resources and raw materials. The Council for Science and Technology has also issued details concerning the other objectives.

The last objective concerning the support of technical methods that form the basis for international cooperation, can be attained through self-realization in the international arena, making use of science, scientific research and technology in developing countries, with a specific bent toward fulfilling their needs, and additionally, establishing a mutual

system to enable the exchange of science, scientific research and technology in cooperation with developed countries.

To ensure the international competency of Japanese industry, focus is placed on developing technical skills and state-of-the-art products, with the following outputs:

- Value-added production.
- Development of new products, technical methods and systems.
- Technical methods leading to a reduction rationalization and simplification in the workforce in an endeavor to:

- Develop technological methods that add value to the production process, i.e., electronic mechanization, wireless communication, information processing, transportation mechanization, and nuclear energy; and target technological development through projects stemming from broader cooperation, on a more expansive scale, between technologies and industries both heavy and light.
- Develop necessary methods to develop basic products through self-development and technological development, and to develop new products from the accumulation of elements and functions, working to unify the mechanization and co-integration of other organizational processes; to discover and utilize necessary technological methods, to make production processes linear, along with the modernizing and computerizing elements to encourage scientific research and accomplish rationalization in various industrial fields.

(5) The Priorities of Scientific Research in the United Kingdom (UK)

Over the years, the UK has been accused of not conferring adequate attention on applied research, and instead, directing finances to

huge projects that have included the partial development of the fly jet and their missiles. However, it is important to note that many of these projects have been terminated due to the new wide spectrum that R&D finances of the state are now required to cover. These projects pay great attention to the scientific skills and research available that can be shared. Nevertheless, prominent British scientists should focus more closely on solving real problems that face the state and society, rather than serving the interests or fields that appeal to the scientists themselves. The challenge lies in encouraging scientists to do so.

In spite of this problem, comparing the UK to Japan and Germany indicates that the real composition of R&D activity in the UK is headed robustly towards application, and that the percentage of research conducted by British universities and institutes is relatively low compared to their counterparts in both Japan and Germany. Moreover, the USA was the sole country among the OECD countries to exceed the UK in spending on industrial research in 1975. All British industrial research was terminated at no more than 1.75% of the GDP, exceeding Sweden and Switzerland, by a small margin, and exceeding Germany and Japan by a lesser margin.

The lack of government-funded research dedicated to social and economic objectives suggests that knowledge accumulation in basic research was of lower priority in Britain than in Germany, Japan, Belgium, Sweden and other economically developed countries.

(6) The Priorities of Scientific Research in Belgium

Like many other countries, Belgium has given much concern to the social link with scientific research. The vision of the state sees that research should be applied with in a committed framework to help solve

society's problems, which was reflected in a keynote address delivered by the Prime Minister in 1976 that claimed:

- While the policies of the government lead to supporting the scientific base, it must leave a wide range of freedom to researchers. Other kinds of research should be placed more under governmental direction in a way that reflects the needs of our country. According to this opinion, academic research should be linked more to the priorities of society, especially to small-and medium-sized companies and industries. Since the declaration of this policy, universities in Belgium receive about half of the governmental funding allocated to research, and employ about half of the researchers of Belgium. The social link to university research does hold special importance.
- Belgium has a small, open and very productive economy. The Belgian government responds to changing international conditions by diversifying its scientific policy. The rising competition from developing countries, along with economic stagnation and the escalating prices of energy resources have all led the Belgian government to confer more importance on R&D relevant to the industrial sector. The Belgian government deems that:
- In order to survive the competition with countries possessing abundant raw materials and energy resources, from one side, and with countries possessing low economic opportunity cost, from the other, the industrial policy of Belgium should increasingly be built upon a more effective and systematic exploitation of its technological and scientific potentials.

The Belgian government has determined that some select industrial sectors are to receive targeted and preferential financial and other attention and resources. This is in addition to objectives set specifically

inside these sectors, namely, the effective utilization of energy and raw materials, amelioration of the environment and quality of life, preparation of better work conditions and more effective organization of social services. Governmental authorities have been directed to take these priorities in to consideration when presenting governmental financing to research projects.

While an important share of governmental expenditure went to R&D in the past to support research in Belgian industries, like heavy chemical and metals industries and mining, it is expected that, in the future, governmental finances and grants will be directed toward select sectors that have bearing on developed scientific and technological content.

(7) The Priorities of Scientific Research in Switzerland

Economic competition and competitiveness are matters of ultimate priority, not only for Switzerland, but for all nations. The main objective of a policy for scientific research should be to establish a scientific and technological environment capable of motivating and fulfilling industrial innovation. This principle leads to a desire to achieve the optimal exploitation of the available resources. Scientific efforts must be rationalized, to make them focus in those areas deemed most beneficial, eliminating deviations that might prove to detract from scientific activities. Like Sweden, Switzerland exerts great concentration on international cooperation in R&D activities, especially in large scientific fields such as nuclear energy.

In the absence of international cooperation and participation in scientific endeavors, a small state like Switzerland may forsake endeavors or to enter certain scientific fields due to a lack of resources allocated to R&D. As is the case in Japan, and other countries, national expenditure

on R&D activities is considered an important aspect of the decision-making process. Generally, and in spite of the fact that most of the OECD members are faced with a fixed financing process for R&D, Switzerland has managed to achieve a higher degree of coordination and rationalization in the usage of its available funds compared with the others. Through its federal framework, the concern and direction of the federal government were raised.

(8) The Priorities of Scientific Research in The Netherlands (Holland)

Some obvious characteristics are detailed in the structure of the priorities of scientific research in The Netherlands, namely, its particular support for labor, human resource development and employment, especially in the private industrial sector, realizing that it is the country's central economic driver, and hence deserves to be targeted. Commensurately, scientific research also targets this sector by giving it a sufficient degree of importance for the sake of the economic competence of Dutch industry on the international level. Government budget policy concentrates on utilizing R&D in a more streamlined and effective way, through improving research efficiency and granting greater concern to priorities.

In spite of the rising pace of planning and coordination in Dutch scientific activity, it is structured on a sectorial basis, and hence, it is highly responsive to social groups. In spite of dealing with issues related to the various factors present in the management of scientific policy and a degree of central planning, control and governmental coordination by the Ministry of Scientific Research has been clearly amplified (Al-Sultan, 1989).

Institutions of Scientific Research in Kuwait

Decision makers, both prior to and since the State of Kuwait gained its independence in 1961, have been concerned with scientific research, and have realized its role in supporting economic and social development plans and its unlimited contribution to the fulfillment of the needs of the society and its various economic sectors. This is clearly reflected in the obligations for institutions of the state, delineated in the declarations of the Kuwaiti Constitution, in Articles 14 and 36, such that (Al-Sultan, 1997):

- The state sponsors sciences, literature, and promotes scientific research. The state shall promote science, letters and the arts and encourage scientific research therein. The freely opinions and scientific research are to be guaranteed, such that each human can practice and publish freedom of opinion whether through speaking or writing or any other means. Freedom of opinion and of scientific research shall be guaranteed. Every person shall have the right to express and propagate his opinion verbally, in writing or otherwise, in accordance with the conditions and procedures specified by law.

In support of what is stated in these two articles, both the governmental programs and the development plans have identified criteria for determining the trends in and realities of scientific research in Kuwait, with the intention of directing scientific research activities toward recognizing the needs of applied research and its priorities, especially in fields of developing domestic production, conserving the environment and developing local resources, on the condition that such activities are to be conducted through a strategic framework that

determines the fields, main elements and priorities of projects, taking in to consideration the needs of the different national sectors.

It should not be forgotten that Kuwait, as an Islamic country, is proud of the early pioneering Muslim scientists, and their paramount role in and unlimited contributions to all areas of science, literature and knowledge.

In fact, Western culture and the developed countries of the northern hemisphere have always joined the Arab world in paying tribute to Arab scientists like Ibn Sinai, Al-Razi, Bin Hayan, Al-Khawarizmi, and numerous others, and openly acknowledges how these Arabs laid the scientific groundwork for world civilization at the time, especially in critical fields like mathematics, astronomy and medicine. The West itself has adopted and emulated Arab thinkers to further their own civilizations.

In fact, from its early beginnings, Islam has formed a distinguished framework, including all aspects of life and the after-life, in which networks and synergies with the state, vitally in politics, law and society. The *Holy Quran* itself includes scientific and empirical facts that modern scientists today have only recently discovered.

Thus, the concept of religion in Islam is comprehensive, making it a suitable framework for motivating comprehensive and sustained development. Development and the seeking of knowledge are integral to Islam, a religion that clearly identified over 1,400 years ago, the idea that advancing societies cannot be without a holistic approach, which is achieved through parallel advancement in all areas of social life.

For example, *Surat Yousef* (peace be up on him), includes the fundamentals of finance economics, planning and investment. In this sublime *Surat*, the elements of economic planning, are presented as follows:

- Increasing productivity, in his holy words, “For seven years shall ye diligently sow as is your wont” (*Ayat* 47), which includes an order to sow.
- Disciplining consumption and savings, as in his holy words “and the harvests that ye reap, ye shall leave them in the ear, except a little, of which ye shall eat.”(*Ayat* 47), which includes an order.
- Fairness of distribution, as in his holy words “But if you bring him not to me, there shall be no measure [of corn] for you with me, nor shall you come near me” (*Ayat* 60), which dictates no favoritism in distribution.
- Management, discipline and rationalization, as in his holy words: So the king said: “Bring him unto me; I will take him specially to serve about my own person”. Therefore when he had spoken to him, he said: ‘Be assured this day, thou art, before our own presence, with rank firmly established, and fidelity fully proved!’ [Yousuf] said: ‘Set me over the storehouses of the land: I will indeed guard them, as one that knows [their importance].’ (*Ayat* 54, and 55). These two *ayats* reflect the principles of sane, rationalized, management that is capable of arranging matters wisely and reasonably.

Undoubtedly, these principles have permeated time and have been reflected in the establishment of departments, centers and institutes of study and scientific research related directly and indirectly to science, scientific research and technology, in the following ways:

- Governmental inspection laboratories, established in 1953 under the auspices of the Ministry of Public Works, and renamed the Center for Governmental Research in 1980.

- The Agriculture Circle, established in 1955, under the auspices of the Ministry of Public Works and renamed the Public Authority for Agricultural Affairs and Fisheries Resources, in 1983.
- Kuwait University, established in 1966.
- The Kuwait Institute for Scientific Research, established in 1967 (KISR).
- The Al-Shubah Center for the Protection of the Environment, established in 1968.
- Center for the Development of Water Resources, established in 1968, in cooperation with the ministry of Electricity and Water and the United Nations Development Program (UNDP), and developed into a fully national center under the auspices of the same ministry by 1977.
- The Kuwait Foundation for the Advancement of Sciences (KFAS), established in 1976.
- The Center for Road Research, established in 1977, under the auspices of the Ministry of Public Works.
- The Unit of Health Research, established in 1978, within the organizational structure of the General Ministry of Health.
- The Environment Protection council, established in 1980, and reorganized become the public Authority for Environment in 1995.
- The Public Authority for Applied Education and Training (PAAET), established in 1982.
- The Higher Council for Planning, established in 1986.
- The Ministry of Higher Education, established in 1988.
- The Public Authority for Industry (PAI), established in 1996.

These institutions, in addition to other units, that were established prior to and since the Iraqi invasion of Kuwait in 1990, have conducted

and carried out many studies and much research that shall be reviewed in forthcoming segments of this book, to discern the degree to which they have contributed to comprehensive national development in Kuwait.

Chapter Two

The Economic Dimension of R&D

There are many ways of looking at this very broad subject of the economics of R&D, a research focus that has received a lot of attention, especially from researchers and investors alike, who need to justify their investments to stakeholders. This part of the study disaggregates this subject and analyzes it from various angles and at different levels in order to cover the subject holistically. A number of issues that feed into the economic dimension of R&D will be addressed, including: R&D capital and the structure of production in the market; the relationship between R&D output and productivity growth; TFP growth, spillovers and social returns, which all address the economic returns of R&D to the investor and society. In many cases, economic returns, in monetary terms, may be minimal, if not non-existent altogether. However, savings may result, and indirect benefits may be realized, especially in the long term, and that, in effect, is an indirect economic return.

Economists estimate that more than one-third of the growth of the USA's economy since the Great Depression has been due to new knowledge, including the results of R&D. Over that time, the USA's economy has grown from US $1 trillion, in today's dollars, to over US $5 trillion (Bromley, 1992). A more detailed look at the returns on R&D has been conducted by Mansfield, an economist at the University of Pennsylvania. Mansfield (1991) looked specifically at research at colleges and universities with federal support. In close to 100 corporations in seven major industrial sectors, he found an average social

rate of return to past investments in academic research of between 28 and 40%. In comparison, companies normally expect to receive returns on the order of 15% from investments in other areas such as plant facilities and equipment.

The physicist Weisskopf has a very succinct way of looking at the contributions of R&D to the USA's economy. He has written: "The total cost of all basic research, from Archimedes to the present, is less than the value of 10 days of the world's present industrial production." The USA's 1992 fiscal budget, saw an increase of 13% in total R&D, amounting to more than US $75 billion, in spite of the fact that this substantial increase came in a year when the overall growth of the budget was severely constrained by the Omnibus Budget Reconciliation Act of 1990, which was designed to reduce the USA's budget deficit to zero over the next five years (Bromley, 1992). This goes to show the vision and perception of the USA's government; even during financially challenging times, R&D is prioritized as a vital investment in the country's future, over and above immediate consumption.

R&D Capital and the Structure of Production in the Market

This section provides an overview of the theoretical underpinnings and the empirical evidence on the relationship between R&D capital and the structure of production. It highlights the special nature of R&D capital as a factor of production. Formalizing the role of R&D capital in the production process raises a number of issues that include; the lags in R&D capital accumulation; the effect of R&D capital on productivity growth, input proportions and output expansion; and the impact of R&D capital spillovers on incentives to undertake R&D investment.

R&D creates new knowledge as a result of accumulated, long-term investments and expenditures. The cumulative results of all R&D projects

constitute the stock of knowledge or the stock of R&D capital. Since R&D capital plays a fundamental role in promoting productivity growth and output expansion in any economy, it is important to develop an accurate measure of this capital. R&D expenditures may be considered a convenient measure of R&D capital. However, some blunders in calculation can produce misleading information. For example, nominal R&D expenditures are considered to be an imperfect guide because they incorporate the impact of price inflation and do not reveal fluctuations and changes in R&D activity. Nominal prices are also related only to current R&D activity, and so, do not account for accumulated expenditures from past projects, even though the very nature of R&D, and hence, its valuation, should ideally account for previous activity. To address this problem of representation, an appropriate deflator is used to arrive at real R&D expenditure. Bernstein (1986) argued that there is a bias associated with deflating R&D expenditures using gross national expenditure (GNE) or the Consumer Price Index (CPI) deflators, because these deflators reflect changes in output prices, while R&D expenditures relate to inputs in the production process.

R&D investment projects, if successful, result in new products and processes. However, there is a large time lag between the time the initial investment is undertaken and when the product and process development is accomplished. R&D takes time, and it may take several years for a project to proceed from the proposal to the development stage. R&D capital represents an aggregation and accumulation of projects. It is important to note that the transformation of R&D expenditures into R&D capital is affected by the speed with which new ideas are translated into product and process development, and the rate at which this knowledge is acquired by rivals in the industry.

Nelson (1982) argues that the R&D capital accumulation process is costly and time-consuming. One round of technological advance lays the foundation for the next round. The process of technical advancement is cumulative, and translation of results into processes and products goes through a sequence of long time lags. Some have argued that, based on empirical evidence and time-series studies, the overall adjustment process from R&D project initiation to product and process development takes three to five years (Nadiri, 1980), while Ravenscraft and Scherer (1982) have found that this process takes, on average, eight years. Furthermore, the latter have shown empirical evidence that supports the hypothesis that adjustment costs for R&D capital exceed the cost of physical capital. They further observe that this is more pronounced in industries that exhibit higher propensities to spend on R&D.

Economic Growth

Although GDP should not be used in isolation from other, more disaggregate indicators, as a general rule, it is considered to be a basic measure of economic performance. Gross national product (GNP) describes in monetary value the total annual flow of goods and services in the economy of a nation. The term "gross" indicates that it is calculated without subtracting any allowance for capital consumption; "domestic"; means that it measures activities located in the country regardless of ownership. It thus includes activities conducted in the country by foreign-owned companies, and excludes activities of firms owned by residents but carried out abroad. The term "product" indicates that it measures real output produced rather than output absorbed by residents. GDP is reported both in current and in constant prices.

In contrast, GNP is usually measured by totaling all personal spending, all government spending, and all investment spending by a

nation's industry both domestically and internationally. GNP, one of the main measures of economic activity, can also be configured using the earnings and cost approach of accounting, in which all forms of wages and income, such as corporate profits, net interest returns, rent, indirect business taxes, and unincorporated income are added together. Both methods produce the same result.[3] Kuwait's GNP is higher than its GDP due to the substantial growth in the net factor income from abroad (NFIA), which results mainly from increases in earnings from Kuwait's foreign assets, though other factors that may contribute to include higher petroleum prices and refining margins. The GDP measures the market value of the nation's output of goods and services for a given period of time. Real GDP is expressed in constant prices related to a base year adjusted for inflation. Nominal GDP is expressed in current prices, not adjusted for inflation. Current prices assume measurement of economic magnitude using prices prevailing at any given time. In effect, the prices in a chosen month of the year, or the average of prices over the 12 months of that year are used to determine current prices. In years of high inflation, these can differ significantly. Measurement of economic variables in current prices is contrasted with measurement at constant prices. Comparisons in current prices record nominal and not real differences, whereas comparisons in constant prices record real changes.

Most industrialized countries, including the USA, use the GDP as their chief economic indicator. The GDP measures the value of all goods and services produced within a nation's borders regardless of the nationality of the producer.

1. Basic GNP and GDP totals, and various other figures are derived via calculations.

The Relationship between R&D Output and Productivity Growth

One of the motivations for R&D capital is to combine traditional inputs in production to facilitate output expansion by reducing the cost per unit of output. Changes in the level of R&D capital change factor intensities by allowing substitution out of relatively scarce factors, which in term, decreases the cost of production. The demand for R&D capital as an input in the production process is influenced by relative factor prices and output quantities.

Empirical studies that have analyzed how changes in the prices of conventional inputs have impacted the demand for R&D capital have found that the demand for R&D capital is price inelastic, or in other words, a 1% increase in its own price will lead to a less than 1% decrease in the quantity demanded. Additionally, the long-term, price elasticity of demand for knowledge capital has been found to be higher than the short-term estimate. Nadiri (1980). It has also been found that the demand for R&D capital is sensitive to changes in the prices of labor and physical capital. Schwartz (1983) studied the relationship between R&D capital and three other factors of production, namely, labor, physical capital and energy, and suggested that exogenous changes in R&D capital lead to increased requirements for all three. Bernstein and Nadiri (1984) found that physical and R&D capital are complementary to each other. The demand for R&D capital, on average, declined by 0.2% for one percentage point of increase when the physical capital was being rented.

Output expansion has been considered an important determinant of the demand for R&D capital. Nadiri and Bitros (1980) observed that, on average, a 1% increase in output generated a 0.7% increase in R&D

capital. R&D capital is generally found to have a positive impact on output.

The Impact of R&D Capital on Total Factor Productivity (TFP) Growth

Research has shown that the rate of technological change is directly related to the growth rate of R&D capital, which by definition, representative of the nature of technological change, since it is a capital-intensive activity. Growth in R&D capital explains nearly 70% of TFP growth. In a study of the USA's manufacturing sector R&D growth explained about 40% of the TFP growth. (Grilches, 1964). Furthermore, Terleckyj (1980) considered both the direct and indirect effects of R&D on 20 manufacturing industries in the USA. He defined direct effects as those arising from intra-industry R&D investments and indirect effects as those associated with inter-industry transactions. His analysis attributed 30% of the growth in TFP to privately financed R&D capital. The indirect effects associated with privately financed R&D were found to account for nearly 78% of the total productivity. Government-financed R&D did not show any significant direct or indirect effects on productivity growth.

The studies surveyed have unanimously found R&D to have a sizeable and significant positive effect on productivity growth, for both basic and applied, privately financed research capital.

Total Factor Productivity

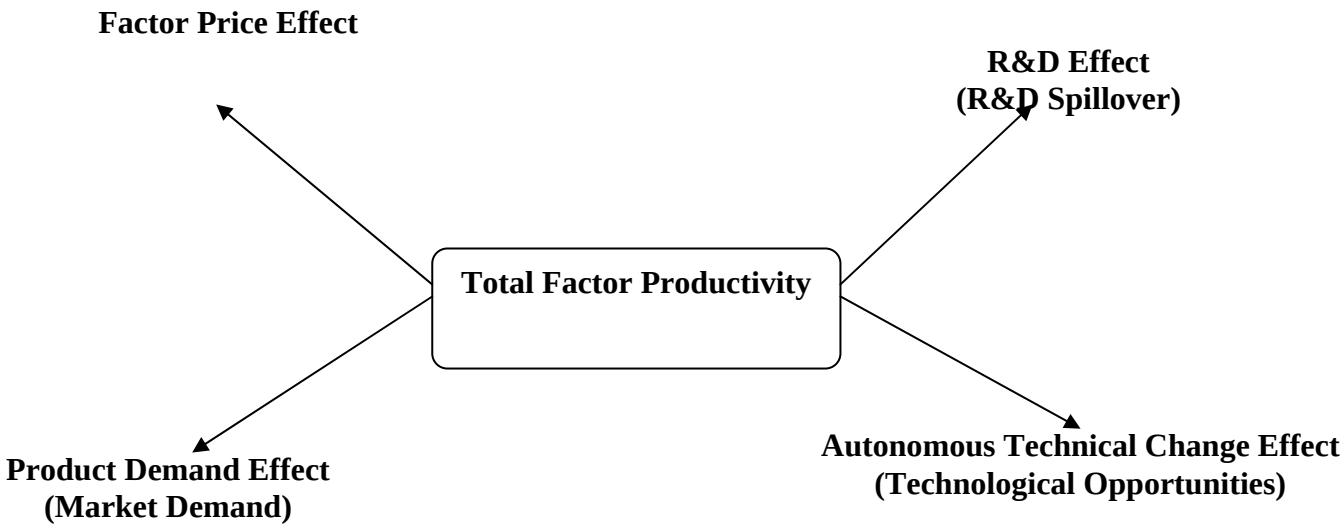


Figure. 2.1. TFP.

It was also found that when total factor productivity growth was decomposed into namely; factor price effect, product demand effect, R&D effect and autonomous technical change effect; R&D and exogenous technical change (the technology effect) dominated productivity growth in the earlier years of the 1960s, and factor price and product demand (the scale effect) were the prime motivations for productivity growth in the 1970s in the USA.

R&D investment is generally regarded as having a strong impact on TFP growth. In fact, R&D expenditure is used as an indicator of the intensity of technological change. The most important finding was articulated by Clark and Griliches (1984), who found a statistically significant relationship between R&D intensity and growth in TFP, implying a gross excess rate of return (ROR) to R&D of about 20%, and even more than that for process R&D, in contrast to product R&D (Shah, 1994). These returns also capitalize on previous returns and whatever has been reaped in the form of spillovers from previous R&D efforts.

R&D Capital, Spillovers and Social Returns

R&D spillover is a special feature or externality of R&D activities that occurs when a firm or an R&D performer augments its R&D capital stock by simply profiting from the R&D outputs, results and stock that another firm has already achieved. Spillovers are an inevitable externality or byproduct of R&D, because R&D is eventually disseminated, that being the objective of research in the first place. Spillovers arise due to the inability of R&D performers to exclude others from freely, or at a lower cost, obtaining the benefits of new R&D capital. However, the mere presence of this phenomenon is evidence that R&D performers cannot completely appropriate the returns associated with their own R&D capital. In other words, the existence of spillovers leads to imperfect appropriability of returns to R&D capital, which act as a disincentive for R&D investment. Hence, the larger the spillover, the lower the incentive to undertake R&D investment. Spillovers treat the technical knowledge that is 'spilled over', as a public good, like a radio signal, that is shared with non-contributors at no cost, thus affecting the rate and structure of capital accumulation.

Empirical evidence on R&D spillovers is scant, and only a few studies have estimated their impacts with any rigor. Mansfield et al. (1991) calculated social and private returns, and found that the median social return was twice as large as the private return (56% vs. 25%). Furthermore, Mansfield also found that the private rate of return (ROR) in one-third of the cases "was so low that no firm, with the advantage of hindsight, would have invested in the innovation, but the social rate of return from the innovation was so high that, from society's point of view, the investment was well worthwhile (Mansfield et al. 1977). Bernstein and Nadiri (1986) reached similar conclusions. Using data from the USA, they found that the excess social return over private return varied from a low of 9% for machinery to a high of 76% in the petroleum products

industries. Spillovers are responsible for the high rates of social returns associated with R&D investments, eluding to the justifiable argument that society's demand for R&D projects is not expressed in reality, since actual demand is much higher than that being expressed through the utilization of spillovers.

More recently, Bernstein and Nadiri (1989) have estimated "the cost-reducing, factor-biasing and capital adjustment effects of the spillovers," for four industries (i.e., chemicals, petroleum, machinery, and instruments) between 1965 and 1978. The existence of R&D spillovers implies that social returns exceed private returns in each of the four industries
analyzed.

Economic Returns of R&D

The value of R&D activities aimed at reducing production costs is determined by the investments' profitability, and since private returns from R&D activities and investments will always under-state true social returns, R&D will be under-provided. In other words, profitability will never be an incentive to increase investment in R&D, especially considering the large fixed costs inherent in R&D investment. However, what is unique about R&D is the nature of spillovers that occur that may reduce industry costs in the long run, but since they result in inappropriate returns to the R&D performer and in turn, incorrect pricing of R&D and resulting social costs, the R&D performer does not find it to be profitable or effective to venture into further investment. Hence, it is often argued, and quite rightfully, that the social ROR from R&D is higher than the private ROR due to either the presence of spillovers or information assymetries. The spillover effect of R&D is probably the most socially rewarding aspect of R&D investment; however, because of

this, the R&D performer is not able to fully appropriate benefits associated with the R&D activity, which in turn, acts as a disincentive to invest in R&D. Additionally, the lack of symmetric information between the R&D performer and the financier limits financing of R&D projects and hinders R&D firms abilities to achieve licensing gains from trade.

Most developed, industrial nations, like the USA, Canada, and the UK, among others, have in place a tax code through which appropriations for R&D expenditures and investments are made annually. R&D performers receive tax credits as an incentive to engage in R&D activities. Empirical evidence on the effectiveness of such initiatives is limited. Nevertheless, when Shah (1994) examined the impact of the Canadian tax credit system on R&D investment by using a production structure framework that employed detailed data on inputs, outputs, and factor and output prices for 18 Canadian industries over a 20-year period, his analysis of parameter estimates for this cost function suggested that the R&D tax credit had a "significant positive impact" (Shah, 1994) on R&D investment in Canada, and that for every dollar spent, $1.80 (Canadian) worth of additional R&D was invested (Shah, 1994). The Canadian study demonstrates that target-strategized tax incentives can "further public policy objectives in a cost-effective manner" (Shah, 1994).

Justifying Public R&D Expenditures

Justifying government intervention in R&D is firmly grounded in the argument that the social ROR from R&D is higher than the private ROR. That being the case, private initiative and investment will always be less than necessary due to the limited and unappealing long-term financial returns that are expected, if any, due to the long gestation needed for research projects. There are several reasons that explain the disparity between social and private returns. First and foremost is the issue of

externalities, mainly in the form of spillovers, in which the R&D performer is not able to fully reap the benefits and returns associated with R&D activity. Alongside this explanation is the equally appealing argument that extenuates the public good of R&D capital. However, a diametrically opposed perspective of spillovers reveals a rather interesting dimension to this seemingly negative externality. R&D expenditures, in general, would be undertaken beyond optimal levels because too many forms would be 'fishing' for the same information and technical breakthroughs. It is also argued that restoring or striving to achieve 'appropriability' may give rise to monopolies, and may, hence, incorrectly price the good that the R&D has created. An alternative effect of near-perfect appropriability would be the creation of redundant and excessive R&D at the industry level, creating a trade-off between positive incentives and appropriability on the one hand, and cost-cutting efficiency on the other (Shah, 1994). Therefore, it may be concluded that spillovers have a positive partial effect on industry's costs and a negative effect on incentives. In fact, it can even be argued that potential industry performance is considerably better with high spillovers and low appropriability, because R&D is essentially a public good, and hence, should not be priced as a private good, so as not to adversely affect the performance of the system.

Another explanation of the disparity between social and private returns is information asymmetry. The lack of symmetric, equitable information between the R&D performer and the financier's limits on R&D projects is perhaps the strongest argument for public support of R&D projects. This is because project success requires secrecy, whereas project financing warrants the release of vital information. As a result, many projects lapse, and lacking financing.

Figure 2.2 clearly shows how private returns on R&D investment are considerably lower than public returns. In most industrialized nations, like the USA and Canada, where economic performance, profitability and prowess is closely tied to industrial development and hence, R&D investment, government activities to stimulate R&D investments vary. However, implementing a tax policy that provides incentives and tax breaks for R&D investors is one of the main tools for increasing R&D output and, hence, for increasing the overall national economic benefit.

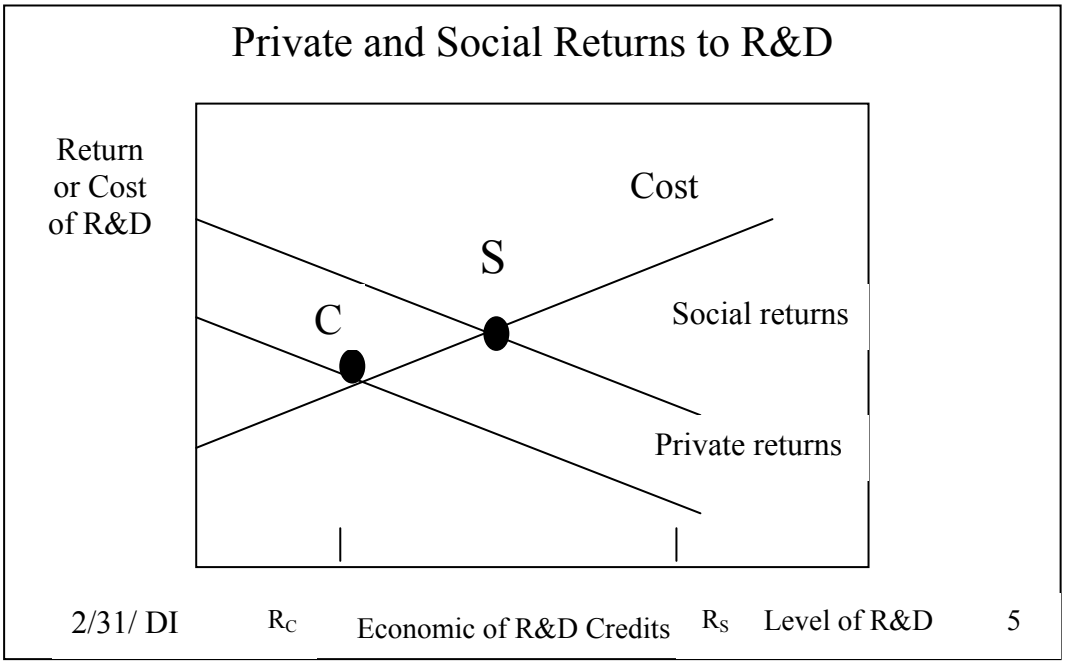


Figure. 2.2. Private and social returns to R&D.

Capstone

R&D capital is a production input that includes funds, scientists, laboratories and equipment, along with other inputs. R&D capital is an input in a joint production that produces multiple outputs that include knowledge that is either transformed into products or processes, or work toward the development of either. From an economic dimension, R&D capital facilitates the transformation of technological possibilities into economic opportunities. A critical feature of R&D capital is the "imperfect appropriability of returns as a result of intra-as well as inter-

industry capital spillovers", (Shah, 1994), that diffuse this knowledge through various channels, marifested as patents, cross-licensing agreements, R&D personnel mobility and scientific outputs that include publications. A survey conducted by the World Bank (Shah, 1994) concluded the following:

- The overall adjustment process from R&D project initiation to product and process development takes 3 to 5 years, on average.
- The marginal adjustment costs for R&D are higher than those for plants and equipment.
- The own price elasticity of demand for R&D capital is less than unity, regardless of the time period or duration considered. (Price elasticity may be defined as the proportional change in quantity demanded to a proportional change in price: -(p/q) (dq/dp).
- However, the long-run output elasticity of demand for R&D capital is close to unity, unlike short-run elasticities that are much smaller.
- R&D is a complement to physical capital.
- Most importantly is that the contribution of R&D capital inputs to economic productivity growth is inconclusive; yet, a positive and significant relationship seems to exist between the two.
- R&D capital spillovers are siginificant in the public domain, and less significant in the private domain, which amplifies their social RORs.

﴾ Chapter Three ﴿

Planning Indicators and Prioritizing R&D Activities in the State of Kuwait

Decision makers, planners, and their technical support staffs use planning indicators to support their decision-making and planning processes. Each economy is unique, varying in the structuring and the sizes of sectors, performance and outputs. Though they have many differences, economies also share similarities. In general, the economies of the GCC region derive their revenues, to varying degrees, from oil or natural gas exports. The overwhelming feature of Kuwait's economy is undoubtedly its heavy dependence on oil-export revenues, which act as the primary driver of government expenditure and paternalistic policies. R&D policies are set and implemented within this economic scene; hence, it becomes very important to account for the surrounding economic environment, because it is in that light that R&D is planned and carried out.

Current high oil prices are producing a surge in oil-export revenues for Kuwait, with 2004 and 2005 being the years of highest earnings during the past decade. Non-oil sectors of the Kuwaiti economy, particularly services, have experienced strong growth fueled by the inflow of oil revenues. Kuwait's real GDP grew by 5.7% in 2004, and was forecast to grow by 5.8% in 2005. Despite its currently strong macro-economic position, including sizable fiscal and trade surpluses, Kuwait has been planning to diversify its economy away from near-complete dependence on oil revenues, by energizing alternative sectors, in addition

to the private sector, in order to increase their contributions to the GDP, although such efforts have had little real economic effect. Currently, the country continues to rely on oil revenues for around 90 to 95% of its total export earnings and around two-fifths of the GDP. Kuwait invests approximately 10% of its oil revenues in a Future Generations Fund, as a long-term national savings strategy.

With approximately 65% of the population under the age of 25, and with around 90% of the workforce employed in the public sector, attracting Kuwaitis to the private sector is a major objective of the government. Kuwait hopes to attract additional foreign investment and has started a program to privatize state-owned businesses (outside the oil sector). Privatization is challenged by the need to protect the jobs of Kuwaiti citizens, most (over 90%) of whom have traditionally been employed by state-owned enterprises and the government.

In this study, institutions and agencies have been reviewed as a function of their objectives to plan for and pursue diverse scientific research and studies. However, to develop a clearer picture of this process, matters that are related to the planning and devising of developmental plans, especially those plans that are related to scientific research, are touched on in order to identify their weaknesses and strengths.

The Concept of Planning and the Formulation of Development Plans in Kuwait

Planning is defined as a conscientious process for managing the resources of a society and directing them toward the attainment of desired objectives, according to a scientific plan that has been previously formulated, by a planning apparatus overseeing its preparation, follow-

through and modification, utilizing all possible policies and means, whether economic or non-economic.

Thus, planning is not merely the formulation of plans on a scientific basis, as is traditionally believed, but it constitutes a set of means and steps that involve management, design, evaluation, review and tracking. Formulating a plan is but one phase, albeit important and fundamental, of the many phases that constitute the process of planning, which is characterized as being continuous and involves related series of successive plans, with the latter being dependent on the results of the former, yet simultaneously constituting what eventually results in the framework of a long-term planning process.

Setting a plan requires monitoring and tracking its execution, evaluating it, and the existence of an apparatus that is governed by an effective organizational framework that determines both its vertical and horizontal networks with and externalities to other apparatuses and agencies of the State, as well as its internal impact. Such planning also involves defining the method of application in accordance with some sort of managerial and legislative framework.

Planning in this sense is also represented also as a method for managing a national economy on all levels, with the aim of abbreviating the dimensions of time required for simultaneous growth by limiting and condensing human and capital resources, in effect, directing them along a path that realizes optimal development in the shortest time with reasonable costs. It is by determining the future desired, and setting suitable and necessary policies that such plans can be realized, although any given plan is not necessarily an achievable target, due to inflexibility in the plan itself and/or the probable need to modify the plan's objectives in accordance with the possibility of unpredictable variables arising unexpectedly.

Capitalist industrial economies adopt programmed planning to realize economic stability and to ensure a high level of employment of available resources. Socialist economies, on the other hand, consider planning to be a tool for directing the national economy and undertaking the task of economic development, as the State dominates the means of production and natural resources. As for the developing States, they have their own views of planning: it is to help in the achievement of economic and social development, the growth of a strong production base, and the creation of an adequate social structure and institutions. However, in these developing States, it is the government that sets the national basis for scientific research, delivering it from the top down in a centralized fashion. Such planning has various dimensions as follows:

- Long-term planning: By definition, planning that exceeds 20 years is long term. Its importance is related to the fact that many social variables, especially demographic variables, are considered slow changing, requiring a long time for any measurable change to occur. In addition, the real impact of development in technological know-how, regardless of how successful it is, does not become evident in the production structure of production, base or levels, except in the long term. The basic assignments of long-term planning are represented in the definition of the required changes in the structural variables of the social, economic and macro-economic infrastructure, i.e., population, natural resource, technological advancement etc.
- Medium-term planning: This category of planning includes processes ranging between 5 and 25 years. The most common form this type of planning takes is the 5-year plan, which usually derives its targets from long-term plans, and provides detailed expositions of growth trends during the period along with detailed programs for developing social and economic variables involved, and setting schedules and

priorities for execution of the plan along with the policies and procedures involved.

- Short-term planning: This category of planning includes annual plans and plans for up to 3-year periods, in which much more detail is provided, making such plans function as mirrors in which comparisons can be made to track performance.

In Kuwait, the Ministry of Planning undertakes the task of directing the social and economic development process, according to scientific plans designed to achieve advancement and prosperity in accordance with the available resources of the State and the customs of Kuwaiti society.

An Emiri decree identifying and the responsibilities, duties and assignments of the Ministry of Planning was issued in January 1979, and specified that the Ministry was to specialize in the following (MOP, 1996):

- Collecting, preparing, coordinating and analyzing data, information and reports related to the economic and social activities of the State.
- Proposing public plans for social and economic development; and conducting required research and studies.
- Reviewing and analyzing constructive projects proposed by governmental authorities and public institutions, evaluating proposed projects in light of the State's strategic national plans, and contributing to the preparation of projects.
- Proposing and tracking public policies for environmental planning, and coordinating such efforts with the concerned parties.

- Collecting and maintaining statistics for the State, and acting as the central statistical repository and reference for the country, in accordance with laws and regulations.
- Coordinating and tracking economic and technical cooperation with Arab and foreign countries, and with Arab, regional and international organizations.
- Designing and implementing general policies of the State in the area of computer utilization, and providing technical supervision of the various ministries' computer assets, along with designing and tracking computer training programs.
- Assessing the needs of the ministries, public authorities and institutions, except for excluded parties, with specific statements for utilizing foreign consultancy houses and selecting suitable homes for proposed projects and studies, in accordance with organizational regulations.
- Tracking the implementation of programs, in cooperation with other ministries and governmental authorities in the design and implementation of sub-plans for each.

It is noticeable that environmental planning was assigned to the Ministry of Planning without the integration of any scientific research or policies, in spite of the degree of importance of the matter to the State and the absence of an institution assigned to perform such a task. Moreover, the Ministry of Planning issued a decision (No. 63) in December 1977, that reorganized the work of the Ministry according to six specialized areas: measuring developmental performance; planning and tracking; statistics and information; technical cooperation; and developmental managerial and financial projects, each headed by an assistant deputy minister under the supervision of the Deputy Minister. Again, the

decision failed to target the areas assigned with the policies or priorities for scientific research needed to promote development in the State of Kuwait.

In spite of this, the nation's 5-year development plans have identified specific directions and objectives for the State to accomplish. Yet, by the end of the plan for 1985-86, which devised an integrated scientific policy that set priorities for scientific research in its diverse endeavors, along with the needs of national institutions, attempts to link the activities of and the requirements for the development plans determined that much of that plan had not been realized. Nevertheless, a decade and a half later, none of the directives mentioned related to scientific research had materialized, nor had the State issued an integrated scientific policy.

In a study on the planning path in Kuwait (Al-Shaigi, 1997), the difficulties faced while tracking the implementation of a plan were described as follows:

- Rarity of planning competency on the level of governmental apparatuses.
- Instability of functional competencies in the preparation of follow-up reports in some authorities.
- Incapability to fulfill some of the necessary variables in the evaluation of the implementation of the plan.
- Irregularity of data on some variables during throughout the years covered by the plan.
- Unclear understanding by many State officials and authorities of assignments made by the Planning Council, despite the passage of more than 30 years since its founding.

The Planning Council was established as an advisory body to prepare and analyze various studies and statistics, and make recommendations to help the executive and the legislative authorities make decisions and formulate public policies, without their being mandatory or obligatory for the executive authority.

In December 1993, an Emiri decree (1993/2000) was issued to reformulate the High Council that had been in existence since May 1987. The Emiri decree set out the following general objectives for the High Council:

- To propose strategies and targets for social and economic development plans, and participate in the formulation of policies suitable for achieving them.
- To set long-term goals for social and economic development, approve plans and their time-schedules, and present them to the Council of Ministers (i.e., the Cabinet).

If the development of a policy for scientific research is one of the targets of Kuwait's social and economic development plans, then the High Council, a decade later, had not yet envisioned even a proposal for a policy for scientific research, unless the current study and the assignment of several researchers to conduct it is considered to be a step on the long road towards that end.

Thus, it can be concluded that despite the passage of 5 decades since the establishment of a Council in 1952, that was assigned the responsibility for planning in the State; despite the passage of nearly 3 decades since the establishment of the Planning Council itself, and despite the affirmations stated in the developmental plans of the State to prepare an integrated scientific and research policy, such has yet to be

done, which constitutes an obvious breach and a glaring misdeed in the path of developmental planning in the State of Kuwait.

Planning Indicators (PIs)

Planning indicators (PIs) are used n benchmarking and efficiency programs. They provide the government and policy makers with information to benchmark their own performance, identify areas where their performance may be improved, and fulfill obligations under the law to report to the National Assembly (i.e., Parliament) on the performance of ministries and public authorities. PIs include trend analyses of macro-economic variables such as inflation, unemployment, interest rates and GDP growth, among other factors. They feed integrally, as inputs, into R&D planning, giving R&D plans clear targets, within the contexts set. This makes R&D plans purposeful and target-oriented. Because such plans rely on indicators, this approach is called 'indicative planning.' In effect, PIs also constitute an early warning system, capable of alerting policy makers to sudden, potential economic distress.

PIs can provide planners with historical trends and perspectives on underlying variables. Valuable insights may be drawn if policy instruments are viewed in their historical contexts, which can be provided through trend analyses. Change in an indicator over time can be determined through analysis of the growth rate of that indicator during a given period of time. Important historical developments, such as internal and external shocks, should be used as milestones in analyzing PIs. This not only leads to analysis of the PIs in isolation from other indicators, but it also enriches the analysis with a cross section. PIs focus on areas that require in-depth research and analysis, and that may be used as inputs in the formulation of the Computable General Equilibrium (CGE) and macro-econometric (ME) models.

Planning Indicators (PIs) vs. Economic Indicators (EIs)

The formulation of reasonable PIs requires intensive and extensive analyses of the macro- and micro-economic conditions, and the resultant policy making in these areas. In this regard, it is important to distinguish between PIs, which can be focused on a specific issue in a sector, and economic indicators (EIs), which can cover a wide range of issues and are less useful for policy makers and planners. PIs focus on areas related to investment, external trade, government budgeting, employment, deregulation and privatization, among others. PIs can be developed to focus on major policy issues that include:

- Dominance of the oil sector (fiscal and trade).
- Labor market imbalances.
- Increasing the role of the private sector in the economy.

At later stages as more policy issues are identified, other PIs can be developed related to human resource development, the environment, and any other issues that will be addressed during the tenure of the project, reflecting the urgency of and changes in national priorities.

PIs and Indicative Planning

An indicator is a variable employed in making decisions on the use of policy instruments. Policy instruments are distinguished from both targets and indicators. Economic policy targets include objectives such as high levels of employment and growth; low, stable levels of inflation; or maintenance of particular exchange rates. Policy instruments are variables the government or central bank can control, or at least influence, such as tax rates or the money supply. PIs may themselves be

targets but frequently are not. They are preferred over targets for use in decision making, because they are available sooner and can be measured more reliably than targets.

Policy instruments cannot be indicators for the authority that decides them, but where decision making is decentralized, one authority's instrument may be used as another's indicator. Indicative planning is an attempt to promote economic growth by influencing expectations. Indicative planning attempts to combine the advantages of decentralization and central planning. Growth in an economy may lag because of pessimistic expectations; firms do not expect other firms to invest, and do not believe that market prospects make it profitable for them to invest. Through indicative planning, the government sets out to produce a set of forecasts of activity in various sectors, which if believed, would persuade each firm that its own investments will be profitable. However, in view of the difficulty of forecasting technical progress, it is doubtful that indicative planning can do any better than simply proclaiming overall targets for a country's macro-economic policy.

Utility of PIs

PIs can be utilized in many areas, such as early assessment or as a performance measure or early warning signal, in addition to their use as instruments of review and evaluation, which determine whether or not the original objectives have in fact been achieved.

PIs may be typological in many different ways. Examples of PIs may include, but are not limited to, consumption indicators, investment indicators, production indicators and the external sector. The types of indicators developed by a planning body are a reflection of the issues that are central to their economies. For example, EIs published by the Malaysian government include consumption indicators that provide sales figures for new commercial goods, imports of capital and intermediate

goods; approved projects; base lending rates, risk-weighted capital adequacy ratios, non-performing loans, and registrations and liquidations of companies. PIs published by the Malaysian government provide data on the activity and productivity of the agricultural sector, the industrial production index, the mining sector, the manufacturing sector, power and electricity, construction, transportation and tourism. Again, it is important to note that the indicators developed are a direct reflection of the kind of economic activity that occurs in an economy and in which that activity is most intensive.

PIs would be useful to researchers and policy makers in Kuwait, in countless ways. Accordingly, development of sets PIs would be of immense assistance to policy makers, policy analysts and researchers in diverse areas. A short list of areas of research and decision making that would benefit from the use of PIs includes:

- Assessing the impact on welfare of government expenditure in Kuwait.
- Identifying sources of revenue growth and options for reducing budget deficits.
- Assessing the impacts of population dynamics on the environment.
- Analyzing and evaluating industrial policy in Kuwait.
- Evaluating employment policies in Kuwait.
- Evaluating the impact of import tariffs on public deficits.

PIs for Policy-Issue Application: Dominance of the Oil Sector

The main objective of PIs with regard to policy issues is to investigate commodity concentrations and the structure of exports and imports. Many indicators can be useful in this regard:

- The export of non-oil products as it relates to the GDP.
- The export of oil product as it relates to the GDP.
- The import of consumables as it relates to the GDP.

Such PI's would assist planners and policy makers in dealing with issues related to the export of non-oil products through export promotion and product development policy measures. PIs would also guide the way to the best strategy for diversifying export markets through export market development policy measures.

Policy Options and Liberalization of Trade

PIs for policy options and trade liberalization would be focused on effective protection for local industry against imports, which are believed to be high, inducing inefficiency, reducing competitiveness and raising price levels. PIs might also be used to assess the impacts of specific protection rates and other trade barriers on various aspects of the economy. Governments may use PIs to gain insight into ways to create greater efficiency, improve quality and remove burdens from consumers. PIs may also be used to assess the impact of free trade on a region. For example, the impact of the GCC's Free Trade Area on Kuwait's macro-economic variables, including GDP, employment, trade, fiscal balance, inflation rate and protection for domestic industries, among others. An indicator that calculates the net gain from trade could be constructed at a later stage depending on the availability of data.

Fiscal Policy and PIs

With respect to fiscal policy, PIs are aimed at evaluating the impact of rationalizing components of individual public expenditure on the fiscal

balance and other macro-economic variables. Many PIs can be constructed to do this, such subsidies and taxes as they relate to the GDP and government expenditure.

Many other PI's can be developed to help policy makers and planners in the fiscal sector, and in planning of the revenue and expenditure sides of the budget. In the case of non-oil revenues, for example, many PIs can be constructed, related to tax and non-tax revenues, reflecting the structure of revenues and explaining the historical trends in non-oil revenues, in addition to proposing possible techniques for enhancing the share of non-oil revenues as a percentage of total revenues.

Labor Market Issues and PIs

Authorities in Kuwait are trying to follow strategies that address the challenges of a rapidly growing labor force. In 2001, a team from the International Monetary Fund argued that the Kuwaiti population had grown by an estimated 3.4%, while the Kuwaiti labor force had grown by 7.1% (IMF, 2002). The rate of growth of the Kuwaiti labor force is expected to accelerate in the period ahead and exceed the current capacity of the economy to generate employment opportunities, in both the public and the private sectors. The unemployment rate of Kuwaitis in 2001, was officially reported at about 2% (IMF, 2002).

The indicators that are important in the labor market are employment indicators, which can be constructed using the Labor Force Survey. (The last survey was conducted in 1990, and the latest employment census available is from 1995). Many PIs can be used to deal with labor-market issues confronting the Kuwaiti economy, such as

- National jobs as they relate to total labor force
- Public labor force as it relates to total labor force
- Private labor force as it relates to total labor force
- Labor force in the industrial sector as it relates to total labor force
- Labor force in the oil sector as it relates to total labor force
- Labor force in the non-oil sector as it relates to total labor force
- Labor force in the services sector as it relates to total labor force

These PIs can be used to assess the situation and help the government in its drive to create more jobs for nationals in the private sector, reduce the size of the public-sector workforce, encourage new entrants to the labor market to seek jobs in the private sector, encourage private-sector firms to employ nationals, and encourage nationals to move from public-sector jobs to private-sector jobs. PIs would also help in assessment of the challenges faced by policy makers in inducing Kuwaitis to move from public- to private-sector employment, while reducing the hiring of Kuwaitis in the public sector, and the impact of such a shift in employment on the government budget, GDP and other macro-economic variables in the medium term. For example, the substitution of less-experienced Kuwaiti workers in place of seasoned and skilled expatriates may negatively impact the GDP, in the short term.

PIs and the Role of the Private Sector

Numerous PIs can be used to assess the dominance of the pubic sector over economic activities and the minor role that has been played by the private sector in Kuwait's economy. In this regard, PIs may be used to tackle a number of pertinent issues, that include:

- Economic growth in the last decade.

- Economic growth in the public sector.
- Economic growth in the private sector.
- Foreign direct investment (FDI) and the GDP.
- Total investment and the GDP.
- Private-sector output as it relates to total GDP.
- Public-sector output as it relates to total GDP.
- Privatization in different years and the GDP.

In this regard, well constructed PIs would aid in evaluating the challenges facing policy makers in designing polices to increase the role of the private sector in the economy and to create jobs for Kuwaitis. In sum, the role of the public sector should be changed from that of a service provider to that of a service regulator. It is important to remember that the main objective of developing quantitative planning tools is to help planners and policy makers achieve sustainable economic growth without compromising the economic and social interests of the society.

PIs Used by Kuwait's Ministry of Planning

Kuwait's Ministry of Planning has used many current-situation indicators, such as general finance indicators, to tackle issues such as

- The apparent lack of connection between changes in the public expenses and the public revenues of the State.
- The domination of oil revenues over the total public revenues of the State.
- The marginality of tax revenues and, thus, the loss of a major source of and tool for public finance.
- Increases in the volume of current expenses and decreases in capital expenditures.

The Ministry of Planning uses EIs to aid in the process of economic development, since developments during previous periods have not led to fundamental changes in the economic structure of the Kuwaiti economy, which has remained largely dependent on the oil sector as its main source of revenue formation and of financing for non-oil activities, especially in the service sector. Kuwait has continued to depend on the oil sector, i.e., on the production and exportation of a single commodity, for its national income, and to finance local economic and social activities. The Ministry of Planning's indicators have revealed Kuwait's reliance on services activities in the makeup of its domestic proceeds from non-oil sectors, imbalances in the structure of expenditures relative to the GDP and in the patterns of wealth utilization, increases in rate of outflows from the national income to pay for the increasing importation, and dominance of the public sector over local economic activity. The Ministry of Planning's indicators for the labor market have been concentrated on

- The greater number of immigrants relative to nationals.
- The decreasing percentage of citizens in the global workforce.
- The concentration of the Kuwaiti national workforce in the public sector:
- Imbalances in the professional distribution of the domestic workforce.
- The relatively high concentration of the Kuwaiti national workforce in less productive activities.

Three main groups of indicators that show the performance of a particular dimension of the Kuwaiti economy will be discussed below. The first group of indicators collectively portrays economic performance and national growth through GDP, government expenditure, exports, imports and the balance of trade. The second group of indicators reveals

Kuwait's dependence and external economic status (DEES), through the ratio of exports and imports to GDP, comprehensive foreign trade indicators, local direct investment and FDI, and agricultural value-added. The last group of indicators that will be discussed is the general financial indicators (GFIs), which show the status of M2, net foreign assets, local investment, local bank claims on the private sector, average exchange rate of the dollar against the dinar, and loans granted by the savings and credit banks. Analysis of the indicators relies on 5- or 10-year time-series. The raw data used was derived almost exclusively from the Ministry of Planning's annual statistical abstracts for varying years, and from the Global Development Report (2005).

Economic Performance and National Growth Indicators

(1) GDP: A Basic Measure of Economic Performance

As is evident from Table 3.1, while the value of Kuwait's GDP has grown progressively over the years, year-on-year growth has fluctuated, achieving an annual growth rate of approximately 4% over the years between 1994 and 2002. While this figure is expressive of relative economic well-being, it also reveals that Kuwait's GDP and income are very closely tied to oil exports and the price of oil during a specified period. The higher the price, the higher the oil revenues and in turn, the higher the GDP. Other value-added activities in Kuwait are limited in comparison to crude oil sales. With the oil sector driving growth, it is expected that increases in expenditures on GDP come from the external economy. In 2000, for example, exports, made up primarily of oil products, rose by 57%, and accounted for over 57% of the GDP. In contrast, domestic demand (government and private consumption and gross capital formation) grew modestly over the previous 5 years.

Table 3.1: Kuwait's GDP at Current Prices

Year	GDP Value (KD million)	Year-on-Year Growth(%)
1994	7,532.1	1.9
1995	8,113.9	7.7
1996	9,429.1	16.2
1997	9,206.7	-2.3
1998	7,906.5	-14.1
1999	9,169.7	15.9
2000	11,356.7	23.8
2001	10,495.5	-7.5
2002	10,737.5	2.3

Source: MOP (2003a)

*Calculated by the authors

(2) Government Expenditure

Government expenditure or domestic demand (government and private consumption and gross capital formation) has grown steadily over the years, commensurate with government revenues in Kuwait (Table 3.2). Nevertheless, growth in domestic demand has tended to fluctuate dramatically over the past two decades, as a result of various shocks to the economy, such as fluctuations in oil revenues, the stock market crash and the Iraqi invasion. After 1995, the government's capital expenditures grew steadily, reflecting a renewed interest in domestic investment that was initially put on hold after the immediate post-war years, in an effort

to eliminate the budget deficit that accumulated in that early post-war period. However, the fact that solid growth in the government wage bill has been the single dominant factor that explains the growth of government expenditure cannot be ignored. This is in addition to huge water and electricity bills that have accrued as a result of the government's heavy subsidies.

Table 3.2: Government Expenditure

Year	Value (KD million)
1993	4,241
1994	4,193
1995	3,722
1996	3,888
1997	3,977
1998	4,040
1999	4,010
2000	3,188
2001	4,746
2002	4,927

Source: MOP (1996, 2001, 2003)

(3) Export Rate

Over 90% of Kuwait's exports are composed of petroleum and petroleum products (Table 3.3 and Figure 3.1). Non-oil manufacturing activities still do not contribute more than 12% to Kuwait's GDP, in spite of efforts to augment this share by promoting and subsidizing inputs and facilities to this sector.

(4) Import Rate

Kuwait's import bill has remained steady throughout the years (Table 3.4). Kuwait imports almost everything, due to its incapacity to fulfill domestic needs for a whole myriad of consumables, such as food, water, clothing, cars, and construction materials, to name only a few. Although productivity has been spurred in some areas, such as construction materials, and has grown in others, such as retail garments; nevertheless, supply is limited in quality and quantity.

Table 3.3: Petroleum Exports as a Percentage of Total Exports

Year	Petroleum Share of Total Exports (%)*	Value (KD million)
1993	92	4,281
1994	95	4,056
1995	90	2,575
1996	91	3,349
1997	94	5,568
1998	92	4,578
1999	91	3,349
2000	94	5,568
2001	92	4,578
2002	92	4,286
2003	93	2,900

Source: MOP (2003a)
*Calculated by the authors

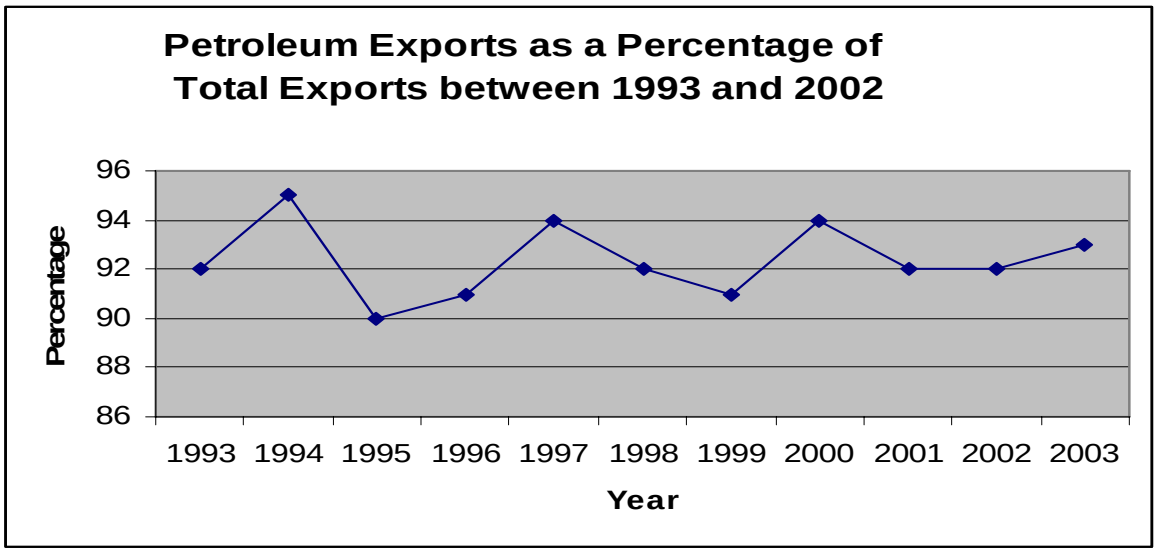


Figure. 3.1. Petroleum exports as a percentage of total exports between 1993 and 2002.

Table 3.4: Value of Imports

Year	Value (KD million)
1993	2,507
1994	2,502
1995	2,626
1996	2,318
1997	2,195
1998	2,413
1999	2,318
2000	2,195
2001	2,413
2002	2,736
2003	1,464

Source: MOP (2003a)

(5) Balance of Trade

World geopolitical interests impact world oil prices heavily. At times when oil prices are high, as is currently the case, and during the winter season, when oil prices rise, Kuwait's oil income increases, as is reflected in the country's total imports (Table 3.4). This is further reflected in augmented government revenues and expenditures. The price of oil is thus the determining factor in increased exports rather than the number of barrels exported (Table 3.5).Hence, the balance of trade favors exports (Table 3.6).

The contribution of manufacturing activities to Kuwait's GDP remains very low, as shown in Table 3.7. Manufacturing activities in Kuwait are limited to a number of light industries that include food, beverages and tobacco, textiles and wearing apparel, wood and wood products (carpentry), paper products and printing, non-petroleum chemical products, non-metallic products, basic metal products, fabricated metal products and other manufactured items. The percentage of these activities has never surpassed 12%.

Table 3.5: Value of Exports

Year	Value (KD million)
1993	4,673
1994	4,285
1995	2,858
1996	3,696
1997	5,952
1998	4,957
1999	3,696
2000	5,952
2001	4,957
2002	4,680
2003	3,119

Source: MOP (2003a)

Table 3.6: Balance of Trade

Year	Value (KD million)
1993	2,168
1994	1,783
1995	232
1996	1,378
1997	3,757
1998	2,544
1999	1,378
2000	3,757
2001	2,544
2002	1,944
2003	1,655

Table 3.7: The Contribution of Manufacturing Activities to Kuwait's GDP

Year	Value (KD million)	GDP (KD million)	Contribution (%)
1998	914	7718	11.9
1999	1016	9033	11.0
2000	801	11590	6.7
2001	667	10057	6.6
2002	707	10242	6.9
2003	836	11141	7.5

Source: Global Development Report (2005)

Dependency and External Economic Indicators (DEEI)

The set of DEEI indicators measures the degree of openness to the external world and to international markets. External economic indicators

investigate foreign debts and service charge on foreign debts. Since petroleum and petroleum products compose over 90% of Kuwait's exports, the prevailing price of crude oil plays a critical role and directly impacts the 'value' of the country's exports, in spite of the fact that Kuwait may export a roughly constant volume. On average, approximately one-half of Kuwait's GDP is derived from its exports, and on average, imports account for approximately 25% of the GDP, due to the overwhelming reliance of the country on imported goods.

(1) Ratio of Exports to GDP

The ratio of exports to GDP, or the composition of the value of exports as a percentage of GDP, as shown in Table 3.8, and Figures 3.1 and 3.2, has averaged approximately 50% over the past decade, with crude oil and petroleum-product exports accounting for the bulk of it. Continuous, strategic effort has been exerted to change this configuration so that non-oil exports constitute a greater share of the total exports, in order to diversify the country's income-earning economic activity. Nevertheless, Kuwait still suffers from the presence of a narrow and limited production base that is neither linked with nor collaborates with any center of expertise, like a university or a research institute. Hence, its industrial and service activities are merely turnkey projects that transfer ideas and business. This failure to internalize capabilities has left Kuwait, in general, with poorly developed, shallow industries, and hence, exports that cannot compete with superior imports inside the country, let alone outside the country.

Table 3.8: Exports in the Composition of Kuwait's GDP

Year	Total Exports	GDP	Total Exports

	(KD million)	(KD million)	(% of GDP)
1993	4,281	7,385.1	57.9
1994	4,056	7,532.1	53.8
1995	2,575	8,113.9	31.7
1996	3,349	9,429.1	35.5
1997	5,568	9,206.7	60.5
1998	4,578	7,906.5	57.9
1999	3,349	9,169.7	36.5
2000	5,568	11,356.7	49.0
2001	4,578	10,495.5	43.6
2002	4,286	10,737.5	39.9

Source: MOP (2003a)
*Calculated by the authors

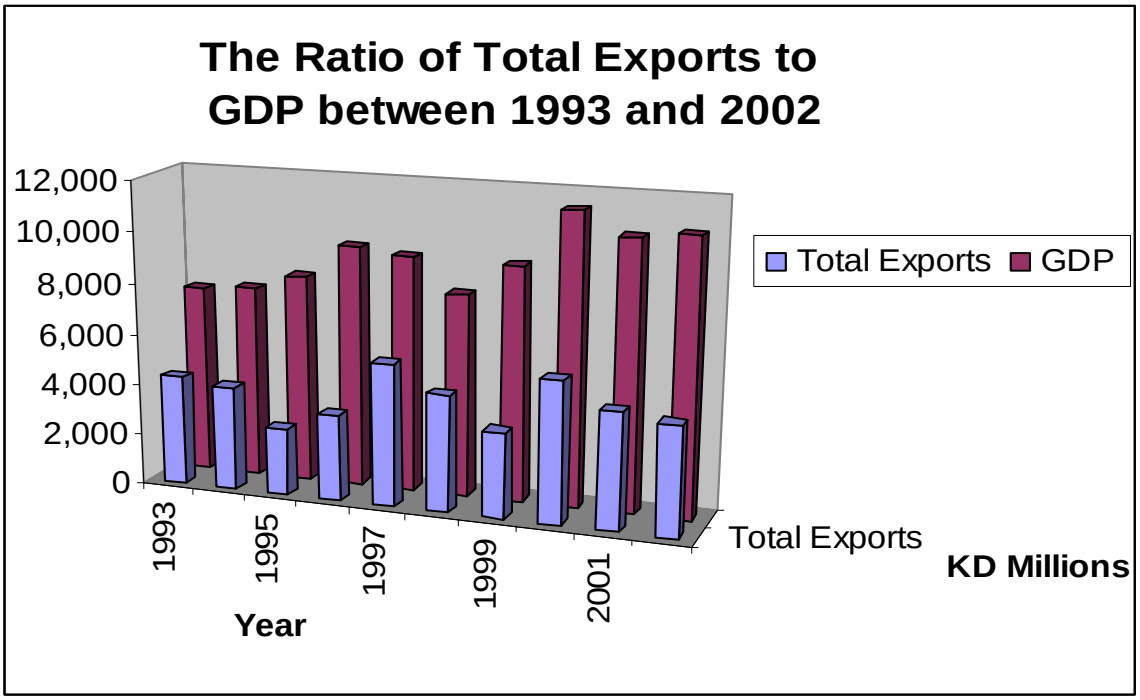


Figure. 3.2. Ratio of total exports to GDP between 1993 and 2002.

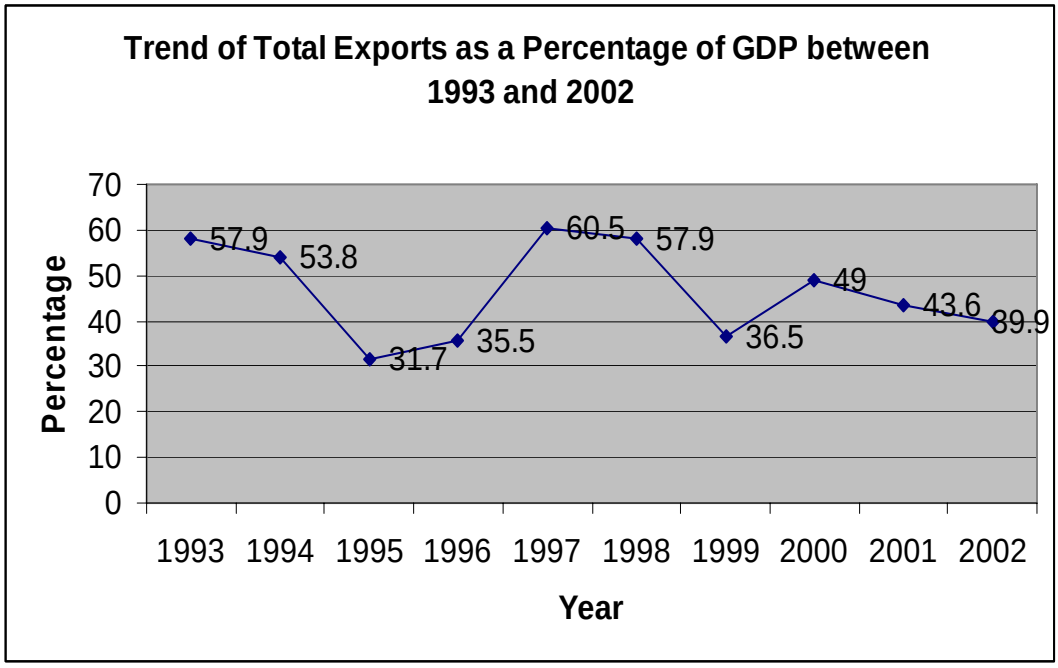


Figure. 3.3. Trends in total exports as a percentage of the GDP between 1993 and 2002.

(2) Ratio of Imports to GDP

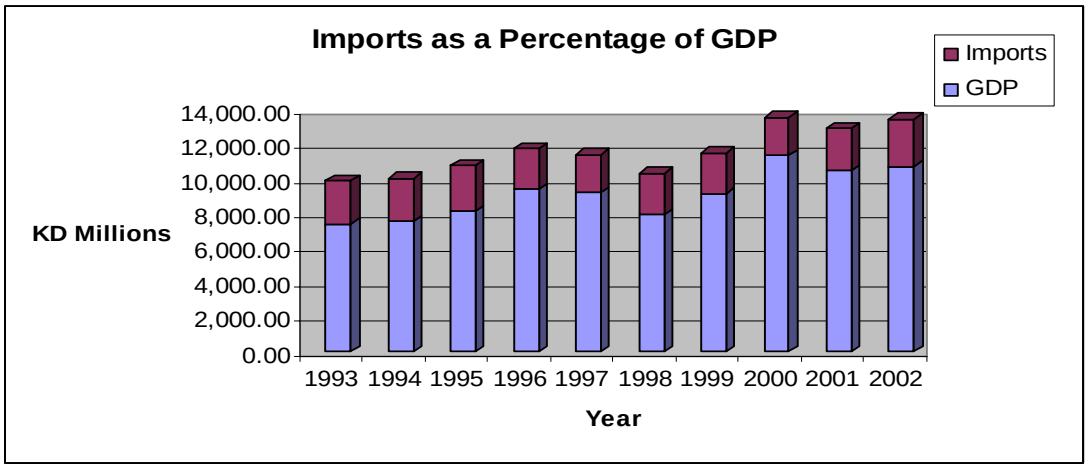
Kuwait imports almost everything, and yet its import bill is on average consistently 20% less than its export earnings. Table 3.9 and Figure 3.3 show the ratio of imports to GDP between 1993 and 2002.

Table 3.9: Imports in the Composition of Kuwait's GDP

Year	Total Imports (KD million)	GDP (KD million)	Total Imports (% of GDP)*
1993	2,507	7,385.1	33.9
1994	2,502	7,532.1	33.2
1995	2,626	8,113.9	32.3
1996	2,318	9,429.1	24.5
1997	2,195	9,206.7	23.8

1998	2,413	7,906.5	30.5
1999	2,318	9,169.7	25.2
2000	2,195	11,356.7	19.3
2001	2,413	10,495.5	22.9
2002	2,736	10,737.5	25.5

Source: MOP (2003a)
*Calculated by the authors



Source: Global Development Report (2005)

Figure. 3.4 Imports as a percentage of the GDP.

(3) Local and Foreign Trade Indicators for Kuwait from 1997 through 2002

Table 3.10 shows Kuwait from a comparative perspective, with respect to domestic direct investment and FDI, with Saudi Arabia, another GCC country; and with other Arab countries, namely, Egypt, Jordan, Morocco and Tunisia; and with industrial countries such as Germany, France, Japan, Singapore, the UK and the USA. It is evident from the table, that FDI in Kuwait is low. This is probably due to numerous factors, which include the country's geopolitical disadvantages

and the high level of restrictions on independent investment in Kuwait, in addition to the presence of excessive controls on the freedom of movement in and out of the country, a factor that investors, in particular, expect to encounter. Domestic savings are also low, indicating capital flight due to the lack of a profitable and secure domestic economic climate.

Table 3.10: A Comparative Perspective:
Local Direct Investment and FDI across Select Economies

Region & Country	Domestic Investment Rate (2003)		Domestic Savings Rate (2003)		FDI (US$ million)
	Private Sector	Private Sector	Total	Total	
GCC Countries					
Kuwait	4.2		21.2	9	7
Saudi Arabia	8.6		18.0	20	-
Other Arab Countries					
Egypt	13.6		18.0	18	647
Jordan	16.2	25.3	27.0	23	56
Morocco	20.4			24	428
Tunisia	23.7		25.2	28	795
Industrial Countries					
Germany			22.0	18	35547
France			20.6	19	52020
Japan			27.0	26	9087
Singapore			42.1	13	6097
UK			14.7	16	29179
USA			15.0	18	39633

Source: Global Development Report (2005)

(4) Agricultural Production and Value Added in Kuwait

Food production is composed of three sub-sectors: agriculture, livestock and fisheries. Agriculture and livestock play a minimal role in

Kuwait's economy for obvious reasons, including poor weather conditions, lack of green grazing space, infertile soil and scarce water resources. In addition, skilled manpower, especially indigenous labor; is non-existent in this sector, making this sector very unfeasible economically, in spite of the continuous flow of subsidized capital, under the guise of food security, to increase its productivity.

For fisheries, the story is quite different in Kuwait. Kuwait has a vibrant, high-quality, productive fisheries industry due to the abundance of numerous distinctive fish species that are available in the Gulf. As is shown in Table 3.11, the value-added of agricultural activity in Kuwait is quite dispensable.

Table 3.11: Agricultural Production in Kuwait

Year	Total Agricultural Production (KD thousand)	Total Production Requirements (KD thousand)	Value-Added (KD thousand)
1999	75,454.2	31,312.2	44,142.0
2000	78,897.7	29,361.5	49,536.2
2001	88,579.6	27,062.6	61,517.0
2002	96,156.7	29,835.3	66,321.4

Source: MOP (2003a)

General Financial Indicators (GFIs)

(1) Money Supply

Money supply, specifically, M2 (from a defined range between M0 and M5, depending on liquidity level), is a very important indicator due

to its reflection of financial liquidity. It is composed of private deposits, sight deposits, savings deposits, time deposits, certificates of deposit (CDs) and fixed-cost (FC) deposits. M2 is reported on a monthly basis; however, Table 3.12 combines the monthly values into annual averages for reviewing convenience. Growth in the money supply may slow down periodically, in spite of increases in credit and net foreign assets, which are the major factors in increased liquidity, due to seasonal outflow of funds, for example, during the summer travel season or in other circumstances that cause excessive outflows.

Table 3.12: Money Supply

Year	Value (KD million)
1998	7,607.1
1999	7,469.7
2000	7,947.3
2001	8,788.4
2002	9,646.3

Source: MOP (2003a)

Kuwait's net foreign assets are sizeable and growing, particularly in light of the government's interest in continuously augmenting this fund, in line with the government's comprehensive, long-term strategic objective to diversify the country's sources of income and reduce its dependence on oil exports. Kuwait's net foreign assets compose, at any point in time, between 40% and 50% of the country's GDP, on average. Table 3.13 shows Kuwait's foreign assets between 1998 and 2002.

Local Investments and Local Banks' Claims on the Private Sector

As is evident from the data shown in Table 5.14, local investment is relatively sound, representing a sizeable portion of Kuwait's GDP, although strategic efforts are at work to further increase this share of capital, as a substitute for capital flight. Table 3.15 shows what the private sector owes to local banks in Kuwait, in terms of loans and letters of credit (LCs) for business and investment. Both Tables 3.14 and 3.15 express the proportional value of local investment.

Table 3.13: Net Foreign Assets

Year	Value (KD million)
1998	3,011.7
1999	3,103.9
2000	4,102.3
2001	4,887.1
2002	4,973.8

Source: MOP (2003a)

Table 3.14: Local Investment

Year	Value (KD million)
1998	5,324.6
1999	5,642.3
2000	5,946.2
2001	851.0
2002	7,824.1

Source: MOP (2003a)

Table 3.15: Local Banks' Claims on the Private Sector

Year	Value (KD million)
1998	5,302.9
1999	5,572.5
2000	5,870.9
2001	6,851.0
2002	7,824.1

Source: MOP (2003a)

The Kuwaiti dinar has stayed robust and stable against the US dollar over the years, an indication of healthy, positive national economic well-being and income. Exchange fluctuations are representative of movements in world exchange rates. Table 3.16 shows the average exchange rate of the US dollar against the Kuwaiti dinar between 1998 and 2002, as representative years.

Table 3.16: Average Exchange Rate of the US Dollar against the Kuwaiti Dinar

Year	Value (KD million)
1998	301.74
1999	302.79
2000	307.55
2001	305.31
2002	300.94

Source: MOP (2003a)

Table 3.17 shows the value of loans granted by the savings and credit bank between 1998 and 2002. This indicator is directly related to the private housing real estate market and the number of houses sold in the market or to be built by eligible Kuwaiti applicants. The Kuwaiti government offers a non-interest-bearing, long-term loan to eligible Kuwaiti males for the purchase or construction of a private home or residential property. The value of the loan has changed over the years, from KD50, 000 to the current KD70, 000. The data in Table 3.17 are an expression of this activity.

The real estate market in Kuwait can be characterized by unreasonable and unjustified high prices that are constantly on the rise, and by oligopolistic, rent-seeking behavior. With the population growth of Kuwaitis progressing at the current rate, this governmental expenditure is expected to increase dramatically. All of the indicators presented above, their analysis and periodic updating, can be used in revising and updating the details of Kuwait's R&D policy.

Table 3.17: Loans Granted by the Savings and Credit Bank

Year	Value (KD million)
1998	296,373.91
1999	306,717.61
2000	288,096.62
2001	209,629.64
2002	286,863.73

Source: MOP (2003a)

Prioritizing Scientific Research in Kuwait

Developed and industrialized countries, and countries that are progressing rapidly along the development ladder, which were considered less developed 2 decades or so ago, and that have now caught up with and joined the ranks of developed countries, focus on scientific research, supporting it by any means, based on their conviction that scientific research is identifiably the secret to economic growth and sustained development, as is evidenced by the successes of such countries. Countries employing national planning have made scientific research a major factor in and an integral part of their developmental and strategic plans, coordinating the performance, benefits and outputs of scientific research with national institutions.

If the outputs of institutions responsible for research and scientific studies are not compatible with national needs, then the scientific content or results become irrelevant and insignificant, as they fail to address the problems or issues of concern to the State.

It was discussed earlier how the priorities of scientific research are based in the views of decision makers and political leaders, who must fulfill the needs of the State, as well as its aspirations and ambitions.

However, before proposing a methodology for determining the priorities of scientific research, it must be understood that any activity of scientific research in Kuwait should contribute to the following:

- The realization of national security.
- The achievement of economic and social development.
- The development of Kuwaiti society.
- Reduction of the budget deficit.
- The development of the national workforce.
- The dissemination and transfer of technological know-how.
- The introduction and enhancement of services and products from different sectors.
- The proposing and implementation of future research and studies that lead to applicable results.

It is also worth noting that the development of a scientific research policy in any country should be linked to a methodology for the evaluation of the activities of scientific research in that State, on the level of completed projects, in order to assess the effectiveness of such activities in meeting the intended objectives of the State's research programs and also to evaluate their impact on the development of the national economy. Many measurement tools and criteria can be utilized in evaluating the output of scientific research objectively and empirically, including the following:

- Level of contribution and support from scientific research to social and economic development plans, including other national priority needs that arise, particularly in solving dilemmas and challenges facing the production and services sectors in the State.

- Degree of similarity between the outputs of scientific research and the objectives intended for them by their institutions, in accordance with the specifications and requirements of legislation.
- Degree of responsiveness to the outputs of scientific research (especially in the case of contractual projects or those that are directed at solving problems of functioning sectors of the State) to the needs of various sectors.
- Involvement of scientific advancement, competence and content, embodied in the methodology utilized; the dissemination and transfer of technological know-how; the utilization of advanced techniques and technology, and scientific references, in addition to its participation in developing the workforce effectively and planning to utilize those resources in an efficient and competent way to achieve the desired objectives.
- Motivation and incentives to propose new research projects.
- Preparation of scientific experiences and measurements, and estimated costs for the projects that are compatible with the needs and potentials of the sector in need of such services, since the overestimation of the costs of conducting scientific research by the supplying institutions may have a negative impact on the various sectors and institutions of demand, leading the latter to resort to foreign scientific institutions, usually viewed as possessing more experience, to conduct research.
- Characterized by rigor, originality and creativity, as such traits are helpful in facilitating the transfer, utilization and dissemination of technological know-how through the different sectors of the society.
- Streamlining and limiting of the outputs of scientific research to the needs and requirements of the demanding sectors.

The United Nations Educational, Scientific and Cultural Organization's (UNESCO's) Methodology of Research Evaluation (UNESCO, 1978) identifies priorities of scientific research effectively. A select group and their elements have been extrapolated here to constitute a model of this methodology, bearing in mind that such priorities are susceptible to change. It is important to note that the selection of a group of priorities and their elements requires formation of a committee, or more, of experts who possess skills and experience, along with leaders acquainted with the policies and philosophy of scientific research, and developmental plans, ultimately to link the outputs of scientific research with the national development plans.

In Kuwait, the process of forming important committees with the objective of studying, setting or approving plans for the State requires the decision maker to involve representation from the different factions of the society, taking into consideration its tribal ethnic nature, sectors and social bonds. Nevertheless, the identification of priorities for scientific research should be fundamentally and ultimately based on scientific, administrative and managerial ability. Hence, specialized committees are expected to represent their fields of specialty with the required expertise and knowledge, regardless of the tribal or social affiliations of their members.

UNESCO's methodology adopts the application of simple and balanced mathematical equations, utilized in field surveys, with the core objective being the deployment of S&T in the process of national development in that State. The route leading to these mathematical equations can be summarized in 4 steps that comprise the determination of the general objectives of the State and the categorization of those objectives according to their degree of importance. Objectives are assigned weights or scales of importance depending on the current

condition of S&T in the State and the relationships of the various sciences with each other and with the objectives to be achieved. The following describes how the formulation of such equations can be achieved.

(1) Step 1: Identifying the General Objectives of Development in Kuwait

The general objectives of development are identified by surveying and determining the sectors (groups) of activities relevant to the main priorities of the country. For the State of Kuwait, and according to what has been imposed recently by political and economic determinants, 5 sets of priorities are proposed. Each priority includes a number of non-exclusive sub-sectors, which are not ordered by their degree of priority or importance (Table 3.18).

(2) Step 2: Determining the order of Priorities in Each Category

Table 3.19 reorganizes the information given in Table 3.18 into rankings of strategic importance to the State of Kuwait.

Table 3.18: Scientific Research Priorities by Category

Category	Priority 1	Priority 2	Priority 3	Priority 4
National Security	Homeland Security	External Defense	Unidentified Nationality Holders	Defense Treaties with Foreign States
Oil & Petrochemicals Sector	Geological Surveys	Crude Oil Extraction & Refining	Petrochemicals Industries	Corrosion
Water Resources	Water Treatment by Distillation	Aquifers	RO Water Treatment	Wastewater
Economic Activity	Labor Market	Budget Deficit	Banking & Finance	Real Estate
Manufacturing or Convertible Industries	Food & Beverages	Agriculture & Fish Resources	Construction	Paper Industries

Table 3.19: Order of Priorities within Categories

Priority 1	Priority 2	Priority 3	Priority 4
External Defense	Defense Treaties with Foreign States	Homeland & Internal Security	Unidentified Nationality Holders
Crude Oil Extraction & Refinement	Petrochemicals Industries	Geological Surveys	Corrosion
Water Treatment by Distillation	Aquifers	RO Water Treatment	Wastewater
Budget Deficit	Labor Market	Banking System	Real Estate
Food & Beverages	Agriculture & Fish Resources	Construction	Paper Industries

(3) Step 3: Determining the Importance (i.e., Weight) of Each Priority

As each category has an objective or degree of importance that is derived from its contribution to national stability, security, and support of economic and social development, a mathematical equation is utilized to reflect the importance, or weight, of each priority:

$$W = \frac{2^{4-O}}{S^{O}} \quad (1)$$

where W is the importance, or weight, of the priority; O is the order of the degree of priority, and S is the subject or item in each priority. The importance, or weight, of a first-ranked priorities is calculated using Equation 2:

$$\frac{2^{4-O}}{S^{O}} = \frac{2^{4-1}}{5} = \frac{2^{3}}{5} = \frac{8}{5} = 1.6 \quad (2)$$

The importance, or weight, of second-ranked priorities is calculated using Equation 3:

$$\frac{2^{4-2}}{5} = \frac{2^{2}}{5} = \frac{4}{5} = 0.8 \quad (3)$$

The importance, or weight, of third-ranked priorities is calculated using Equation 4:

$$\frac{2^{4-3}}{5} = \frac{2^{1}}{5} = \frac{2}{5} = 0.4 \quad (4)$$

The importance, or weight, of fourth-ranked priorities is calculated using Equation 5:

$$\frac{2^{4-4}}{5} = \frac{5^{2}}{5} = \frac{1}{5} = 0.2 \qquad (5)$$

It is not necessary for categories to have a similar number of elements or items, provided that they number not less than one. Also, the priority of a particular element or item can be raised or lowered, and an element or item can be added to or removed from any group to reorganize the order of priorities in keeping with shifts in the challenges facing the State and the aspirations of the various sectors of the State.

The weight of items assigned Priority 1 status is greater than the total sum of the weights of the other groups of priorities. In the example given, 1.6 is greater than the sum of 0.8 + 0.4 + 0.2, which means that it is not acceptable to replace elements or items from three lower priority groups, for a single element or item from a top-ranking priority group.

(4) Step 4:

Since scientific research requires inputs in most cases, i.e., technological know-how, scientific tools and devices, and support services, such requirements must be provided. It is important to note that decision makers need to maintain an open and flexible perspective while making choices, especially in light of the fact that the variables and requirements of R&D are ever-changing, and new entrants need to be taken into account.

Spending on R&D

(a) Financing Scientific Research and Studies in Kuwait

Adequate funding is considered one of the most important requirements of successful R&D. Financing scientific research involves providing the funds required to attract distinguished human resources, along with supplying a package of integrated programs to train and coach those resources. To be adequate, funding must be capable of providing the devices, tools and references required, as well as the infrastructure, laboratories, and public and support services needed for scientific research.

(b) Resources for Financing Scientific Research

The four main sources for R&D funding are as follows:

- Governmental spending: The government can allocate a percentage of its specified GNP, which may vary from one year to another, to finance the annual budgets of institutions and bodies conducting scientific research and studies.
- Contracting with the production and services sectors: Contracts for scientific research and studies can be arranged between research institutions and the relevant sectors.
- Research centers and bodies in the production sector: Most large companies and corporations establish in-house research units or centers that contribute to the study of the dilemmas and challenges facing their corporate performance and products.
- International funds and aid: Aid can be provided by governments and governmental agencies or by international organizations to institutions

for scientific research. Such funding is usually given to low-income, developing countries.

In the State of Kuwait, research units and centers are funded as follows:

- Units and offices are linked to decision makers and are allocated funds from the State budget.
- Independent institutions and institutes are allocated funds from the State budget. Both Kuwait University and the Kuwait institute for Scientific Research (KISR) also conduct contractual research for various sectors and institutions in Kuwait, and receive funds for research to be conducted for financing institutions.
- Subsidiary centers and units also receive funding from the State.

Thus, it can be concluded that most of the budgets and allocations for scientific research in the State of Kuwait are financed by the State or by financing institutions that act as repositories of State funds, and are hence, ultimately still considered government sources of funding. They include: KFAS and the Environment Public Authority (EPA), among others. It is not surprising for governments to be concerned about the activities of scientific research, when 90% of the increase in the rate of economic growth in developed States is linked to advancements in technological know-how and scientific development, and when 50% of the increase in the individual's share of the GNP is also linked to the same factor.

Many studies and reports have presented varied information on the percentage of the GNP allocated to activities of scientific research in the State of Kuwait. While one study (Al-Shishini, 1986) mentioned that the percentage of spending on scientific research in Kuwait was 0.01% of the

GNP in 1973, another study (Banoud, 1987) stated that the percentage of GNP allocated to R&D reached 0.9% in 1985. A third study (ESCWA, 1995) claimed that this percentage was 0.22% in 1992.

These and other numbers published regarding the determination of R&D spending as a percentage of GNP in the State of Kuwait, should be viewed with reservation, as

- The State of Kuwait does not designate or allocate an annual percentage of its GNP for scientific research activities.
- The studies did not indicate how the percentages mentioned were calculated, or whether or not they were only exclusive of the budgets of certain scientific, educational and financial institutions like Kuwait University, KISR, or KFAS. The budget of Kuwait University, for example, cannot be included as a whole in calculating this percentage, because the bulk of its budget goes to instruction-related spending and not research.
- The activities of scientific research do not only involve scientific, technical and engineering institutions, but also encompass research targeted at addressing and solving crises and challenges that face society. Hence, R&D has a broader, more comprehensive definition that includes research with humanistic, social and educational objectives, that is or can be incorporated in the social and economic development programs and plans of the State.

It is worth noting, or rather confessing, that the decision makers in any society are keen to establish institutions, centers and laboratories that are meant to contribute to the development of the society, even though their studies need not be concerned with scientific and technical matters exclusively, but may also be directed toward dealing with the problems

facing the society in any area of the human or social knowledge (Al-Sultan, 1998).

Table 3.20 shows the funds allocated to or spent on research and related activities during the period from 1998 through 2002.

Table (3.20): Budgetary Allocations for Scientific Research and Studies in the State of Kuwait, and their Percentage of GNP (1998-2002) (in KD)

Institution	1998	1999	2000	2001	2002
Center of consultation studies & researches for his highness the Emir of Kuwait	24.000	24.000	24.000	24.000	24.000
Office of social development (Emiri Diwan)	676.300	434.000	550.600	396.800	373.200
Strategic Studies Center for His Highness The Crown Prince And Prime Minister	145.000	189.050	167.000	142.000	142.000
Kuwaiti Researches & Studies Center	400.000	400.000	400.000	400.000	400.000
Researches & Studies Department at the National Assembly (Parliament)	400.000	131.220	145.800	162.000	180.000
Kuwait University (KU)	1.407.050	1.850.005	1.088.132	1.047.767	1.27.367
Kuwait institute for scientific Research (KISR)	21.869.359	20.304.825	17.782.860	16.799.115	16.814.080
General Authority for Affairs Agriculture & Fish resources	359.439	347.290	170.945	604.928	581.000
Water Resources Development Center	400.000	400.000	400.000	400.000	400.000
Governmental Center For Tests & Researches	-	-	100.000	100.000	100.000
Health Research Unit	-	-	-	27.000	134.850
Kuwait Foundation For the Advancement of Sciences (KFAS)	482.955	562.353	913.272	930.906	817.520
Public Authority for the Environment (PAE)	13.000	160.480	166.900	108.890	84.570
Waqf (Endowment) Funds	-	-	6.700	11.900	9.500
Public Authority for Applied Education and Training (PAAET)	190.000	70.000	18.000	-	117.520
Total	-	118.212	225.589	141.000	53.426
Gross National Product (GNP)	26.367.103	24.991.435	22.159.798	21.296.306	21.259.003
Percentage of allocations for scientific research and studies of the GNP	7.906.500.000	9.169.700.000	11.356.700.000	10.495.500.000	10.737.500.000
	%0.33	%0.27	%0.19	%0.20	%0.20

Note: Source of GNP figures: Ministry of Planning, Central Department for Statistics. Kuwait.

Source of budgets' figures of organizations and institutions is their annual and periodical reports.

As can be deduced from Table 3.20, the percentage of spending on scientific research in Kuwait, as a percentage of the GNP, during the years between 1998 and 2002 was

0.24%

It is also worth noting that at the end of a meeting held and sponsored by the United Nations in Morocco in 1979, for the ministers responsible for the application of S&T in the developing countries, the attendees recommended that the developing states adopt policies and issue the legislation required to allocate budgets equal to 2% of their GNPs for scientific research with the advent of the 1990s. Kuwait, a participant in the meeting, has not met that percentage yet, nearly two decades since this recommendation was made.

It is necessary to encourage and partner with the private sector to develop and fund scientific R&D. In Japan, the private sector contributes 80% of the total spending on R&D, while the government contributes the other 20%. In the USA, industry finances 60% of the total spending on R&D in commercial and the non-military fields, while the government contributes the remaining 40%, including spending on R&D in the sectors of armaments and defense, which represents around 28% of that percentage.

In Kuwait, the government covers the country's total expenditure on R&D; the role of the private sector is nearly insignificant due to a number of structural factors that include the small size of the private sector, the small size of the manufacturing sector (with the exception of the petroleum industry) and the absence of a network to connect industry with R&D to produce economic and development benefits. Thus,

encouraging the private sector to contribute to the funding of scientific research is a necessity. Nowadays, effort is being expended to motivate the private sector by

- Encouraging private-sector industry nation-wide to play a dynamic role in funding R&D, bearing in mind that the private sector will itself benefit from the returns of such efforts.
- Building bridges of trust between the sectors of production and industry, and the sectors of scientific and technological research.
- Initiating positive communicative exchanges between the sectors of production and industry, and the sectors of scientific and technological research, so mutual and constant gains can be realized.

Research centers, institutes and universities conduct scientific research and research projects of three main types, as follows:

- Internal projects, which are funded from the budget of the center or the institute provided by the State annually, according to the plans of each center and institute.
- Local projects, which are funded by local contracting parties, whether industrial, services or financial parties (similar to the Academy for Scientific Research and Technology), depending on the demands of these parties.
- Foreign projects, which are funded by foreign or international scientific parties.

Human Resource Allocations to R&D

R&D activities depend on the human resources that are allocated to the field of R&D and their scientific competency in the various fields of S&T. These resources are appropriately developed and prepared through

training to acquire up-to-date scientific and technological expertise to keep abreast of technological and scientific developments.

R&D Centers in Kuwait

R&D institutions in Kuwait vary to a large extent, in terms of their organization, objectives and working mechanisms. Nevertheless, they can be categorized as follows:

- Independent research organizations, which specialize in scientific research and study, e.g., KISR, which undertakes activities in the fields of food, biological resources, water resources, oil, environmental sciences and urban development, engineering systems, petroleum and economics, among other fields.
- Research organizations that are subsidiaries to sectors and ministries of the State, and governmental institutions, e.g., PAAFR, the Health Research Unit at the Ministry of Health, and the Water Resources Development Center at the Ministry of Energy.
- Academic institutions are pursue research activities, e.g., Kuwait University and PAAET.
- Research-funding institutions and organizations, e.g., KFAS, the EPA and the Endowment Funds of the Awqaf Trustees Council.

The primary exponents of scientific research are discussed below.

(a) KISR

Those employed at KISR as researchers, employees and technicians are distributed across a variety of research programs, i.e., food, management, the environment and urban development, water resources, techno-economics, and petroleum, as researchers, employees

and technicians, as shown in Table 3.21. Employees in the support departments are not included in the table.

(b)Kuwait University

The numbers of employees working on research as chief researcher, researchers, assistant researchers etc. in the various colleges, including the employees of the Research Department and others, are shown on Table 3.22.

(c) PAAET

The statistics available for PAAET include data on chief researchers only (Table 3.23).

Output of R&D Activities

Outputs of R&D activities include scientific studies, research, projects, articles, technical reports and patents. The outputs of some of the institutions responsible for R&D in Kuwait are discussed below.

(a) KISR

KISR is the main scientific research center in the State. It is dedicated to conducting applied scientific research in fields related to industry, energy, natural resources, food resources, and other main components of the national economy, with the aim of serving economic, technological and scientific development, and providing governmental consultation, including implementing the scientific research policy of the State. The Institute conducts contractual projects with a commitment to applying high levels of professionalism in its research services, both to the public and to the private sectors, to serve national development.

Table (3.22): Shows of human resources allocated to R&D in the Kuwait Institute for Scientific Research, distributed according to their categories during the period from 1998 until 2004

Division	Researcher								Technologist								Technician							
	1998	1999	2000	2001	2002	2003	2004	Rate	1998	1999	2000	2001	2002	2003	2004	Rate	1998	1999	2000	2001	2002	2003	2004	Rate
Food Resources	66	65	62	62	66	66	64	64	28	28	28	31	35	35	39	32	18	18	18	18	20	22	22	19
Environment and Urban Development	48	48	50	48	49	51	52	50	42	43	47	49	54	58	58	50	15	16	17	17	19	21	25	19
Water Resources	18	18	16	14	15	15	15	16	13	13	13	14	16	17	17	15	4	5	5	5	6	7	7	6
Oil Research & Studies Center	20	20	19	21	21	22	22	21	24	25	28	32	37	39	44	33	13	14	15	16	15	19	19	16
Techno economic	20	16	14	11	12	12	12	14	16	17	19	18	19	19	18	18	-	-	-	-	-	-	-	-
Total	172	167	161	156	166	166	165		123	126	135	144	161	168	176		50	53	55	56	60	69	73	

Source: Human Resources Department, Kuwait Institute for Scientific Research.

Table 3.22: Human Resources Employed in Research at Kuwait University

Category		Number	
Principal Researcher or Associate Researcher etc.		1000	
Referees		2000	
Project Manpower	Associate Scientist	6	167
	Research Assistant	70	
	Secondary Staff	51	
	Head Technician or Technician	33	
	Support Staff	7	
Administrative Authority	Assistant Deputy Director for Research		54
	Consultant		
	Manager		
	Office Manager		
	Department Head		
	Project Analyst		
	Administrative Coordinator		
	Computer Engineer or Programmer		
	Accountant		
	Translator or Editor		
	Designer		
	Purchasing or Inventory Manager		
Executive Secretary		10	
Technician		2	
Miscellaneous Labor		5	
Total		**3221**	

Source: Kuwait University Research Department

Table 3.23: Numbers of Chief Researchers at PAAET

Period	Chief Researchers
1999-2002	75
2002-2004	74
Total	149

The development that has occurred over time in the budget increases for KISR could not have been achieved without parallel, commensurate growth in the outputs of research and the technical workforce. Table 3.24 shows the results of research projects conducted at KISR, as the outputs of R&D provide evidence of continuous enhancement and growth.

(b) Kuwait University

Kuwait University is considered to be the main institution of higher education in the State. The initiation of scientific research at Kuwait University emanates from the University's policy for developing higher education, in which scientific research is a primary component. This is obvious in the dual mission of the University; it is responsible for transferring, maintaining and disseminating knowledge, on the one hand, and for developing research creativity, on the other.

By directing research, the University is inherently directing the potential for achieving the targets of that scientific research as well, with the aim being to excel and constitute a powerful presence by maintaining priorities and providing distinguished programs. The University determines its research priorities by means of a comprehensive survey of all of its colleges, in order to utilize optimally and effectively its potential for scientific research suited to the nation's needs. The research priorities at Kuwait University include programs in fields of environmental and pollution studies, water resources, energy and petrochemicals, economics, sociology etc., as shown in Table 3.25.

Table 3.24: R&D Outputs at KISR from 1998 through 2004

a. Research Projects

Fiscal Year	Completed Projects	Ongoing Projects	Total
1998/1999	30	64	94
1999/2000	34	54	88
2000/2001	23	44	67
2001/2002	24	60	84
2002/2003	35	67	102
2003/2004	54	73	127

Source: KISR, Assistant Director General's Office

b. Patents and Publications

Patents	Books	Conference Papers			International Publications	Regional Publications	Local Publications	Periodical Reports	Technical Reports
		International	Regional	Local					
7	-	40	36	11	63	10	8	81	61
7	-	54	29	15	45	5	5	70	70
8	-	21	22	6	42	2	4	50	53
8	-	55	16	19	31	10	23	46	79
9	12	63	37	20	69	10	12	80	79
9	3	56	21	12	60	2	3	81	85

Table 3.25: R&D Outputs at Kuwait University

College	Number of Research Projects	Project Productivity				
		Papers Submitted for Publication	Papers Accepted for Publication	Published Papers	Conference Papers	Books
Humanities	62	13	7	85	1	16
Administrative Sciences	91	1	12	66	3	0
Social Sciences	80	1	6	34	6	0
Education	75	2	7	30	1	0
Islamic Law	138	0	19	46	0	3
Law	24	0	1	3	0	1
Sciences	288	27	61	887	92	3
Petroleum and Engineering	260	29	37	346	74	3
Medical	198	23	25	511	58	7
Dentistry	33	2	3	5	13	0
Pharmacy	38	1	1	34	7	1
Supporting Medical Sciences	35	2	0	25	1	0
Girls College	7	0	0	0	0	0
Total	**1329**	**101**	**179**	**2072**	**256**	**34**

Source: Kuwait University, Research Department

(c) PAAET

One of the main purposes for establishing PAAET was to provide and subsequently develop the national workforce, in a way that addresses the shortages in the national technical workforce and fulfills the development needs of the State. In addition, PAAET organizes R&D activities through a coordinating mechanism specializing in R&D efforts. Table 3.26 shows the output of these efforts.

Table 3.26: Research Conducted by PAAET and Its Funding Agencies from 1999 through 2004

Funding Recipient	Number of Research Projects						Total		
	2002-2004			2002-2004					
	Completed	On-going	Total	Completed	On-going	Total	Completed	On-going	Total
PAAET	17	50	67	45	41	86	62	91	153
KFAS	6	9	15	5	9	14	11	18	29
EPAt	4	3	7	3	8	11	7	11	18
Total	27	62	89	53	58	111	80	120	200

Source: PAAET

(d) KFAS

KFAS is an independent body that provides financing as one of its main objectives. Thus, the institution is listed among those that fund activities of scientific research and studies, rather than as one that conducts R&D; hence, no human resources at KFAS are assigned for scientific research.

KFAS was established in 1976, and its objectives include supporting researchers and allocating monetary funds to conduct basic and applied research. The Foundation also funds research projects through organizations and institutions that actually conduct research, both inside and outside of Kuwait. KFAS has determined priorities for the social, economic and environmental fields, for which it encourages research and offers competitive funding. The main areas for such research include the development of water resources, petroleum and petrochemicals, the environment and public health. Tables 3.27 and 3.28 show the output of the research projects that KFAS has funded.

Table 3.27: KFAS-Funded Research between 1978 and 2003

Area of Research	Projects		Contribution	
	Numbers	Percentage	KD	Percentage
Humanities & Social Science	148	29	2,922,999	20.0
Life Sciences	54	11	2,455,809	16.5
Medical Sciences	90	18	2,455,564	16.5
Natural Sciences	74	14	2,350,750	15.0
Engineering &Technology	145	28	4,771,369	32.0
Total	**511**	**100**	**14,856,491**	**100**

Source: KFAS (2004)

Table 3.28: R&D Outputs at KFAS

R&D Output	1998	1999	2000	2001	2002	2003
New Research	32	28	24	19	14	35
Ongoing Projects	64	61	57	52	44	34
Completed Projects	28	29	3	28	30	22
Progress Reports	-	83	67	65	48	59
Final Reports	-	29	33	28	30	22

Source: KFAS (1999, 2000, 2001, 2002, 2003, 2004)

Evaluation of Scientific and Technical Networks and Linkages between the University, the Research Centers and the Production Sectors in Kuwait

In order to apply and utilize the results of scientific research to their full potential, valid networks must be available linking national planning and research organizations over the long run, especially during fluctuating economic conditions. In the short run, such networks must

also exist in order to impact the budgets allocated to research activities by the various sectors. It must be understood that conducting R&D is one issue, while transferring the outputs of research to industry such that benefits and investment is another. The latter requires partnering between those conducting the R&D on one side, and the production and services sectors on the other. Such partnering plans require the existence of certain mechanisms that are often absent or weak in developing countries. Partnering schemes may be categorized into six predominant mechanisms: institutional; financial, contractual (e.g., local, national, and international); human, legal, and political.

Chapter Four

The Implications of R&D for the Socioeconomic Structure of the State of Kuwait

Planning and Prioritizing R&D

R&D may be defined as the creation of the know-how for and know-why of new materials and technologies that eventually translate into commercial development (Wheelwright-Clark,1992b). R&D is a multi-phased process that involves generation of knowledge, transition to market, and diffusion.

The knowledge revolution has made technological development and innovation the primary fuel for industrial development and, hence, economic growth in this century. However, scientific and technological innovation is still dealt with implicitly by planners and decision makers, and is still not reflected in the reporting of national economic output growth rates. Knowledge and, hence, innovation are direct results of R&D. In principle, knowledge is an asset akin to capital; it requires management and is linked to innovation through expenditure on R&D.

A major difference between developing and developed countries is related to their ability to select, create, modify, adapt and use advanced technologies efficiently. A nation's economic prosperity has, therefore, become highly dependent on its level of technological advancement, which is always a function of the efficiency and effectiveness of their respective educational systems to produce able, world-class scientists, capable of adapting and transferring technological breakthroughs that have occurred and/or are capable of developing technological abilities indigenously.

Leading industrialized countries spend approximately 3% of their GNP on R&D, whereas less developed countries spend less than 1%. To worsen matters, "developing countries, with 80% of the world's population, account for only 2% of the global expenditures on scientific research and for an even smaller share of the research output, which is the quantity of direct importance" (Thulstrup, 2002). Developing countries that aspire to join the ranks of their 'developed' counterparts devote and appropriate a permanent share of their resources to scientific R&D, knowing that in the final analysis, this is their ticket to economic affluence, even though the process may be long-term.

Strategic planning is particularly important for R&D organizations, since their efforts have to be coordinated with the nation's planning efforts and with the outputs of its educational system. There is a direct relationship between productivity and strategic planning. High-performing companies plan 4 to 6 years ahead and review their plans every 2 to 3 years, whereas low-performing companies do not have long-term strategic plans (Al-Homoud and Al-Sultan, 2000).

In order to plan effectively, the output of R&D must be evaluated and assessed adequately, so that decision makers and policy makers are able to measure the benefits of a specific research program vis-à-vis its costs and its resource utilization capacity.

Developing a unit of measure or a set of indicators through which the outputs of a specific research program can be measured is a complex and controversial process, especially in a public, not-for-profit organization. The evaluation of corporate R&D differs greatly from its public, not-for-profit counterpart, in that it is primarily concerned with what is often referred to as the bottom line, or in other words, the achievement of adequate to superior financial returns, measurable by a host of indicators that include return on investment (ROI). Corporate

R&D has traditionally used performance measures for R&D that have been related to inputs, based in the belief that a positive relationship should exist between the amount of resources allocated to R&D and output.

Planning and prioritizing R&D activities and spending in Kuwait are decisions that are strongly influenced by the direction and performance of the economy because indigenous R&D activities and outputs in Kuwait have a vital impact on the socio-economic structure of the country. As in other countries around the world, R&D intensity is partly a function of the economy's performance for a given year and its expectations for growth. When GDP is on the rise, it is also expected that R&D allocations will be relatively high, and correspondingly, when GDP declines, so will R&D spending. Projects and R&D investments that may have been planned for a year or more ahead or that have been initiated, may be halted due to apprehensions about continued funding in times of economic uncertainty.

(1) Social Indicators

A number of representative indicators may be selected to depict the social structure of Kuwait, as it compares with other countries that share common grounds with Kuwait, whether they are similar in income, such as Singapore; or similar in identity, such as Turkey; or similar in culture, religion and ethnicity, such as Morocco and the Gulf States.

Undoubtedly, there are many indicators that can be used to gauge the social condition of a country. Some of those indicators have been chosen to reflect the social condition in Kuwait in comparison with some other States (World Bank, 1995). Indicators that reflect the level of education, health services and standard of living of the Kuwaiti individual have been chosen, as follows: size of population, income per capita,

survival rate after birth, adult illiteracy rate, birth rate, death rate, population-to-doctor ratio, population-to-nurse ratio, and infant mortality rates.

The Kuwaiti population its relatively small compared to that of other countries. A survey in 1993, reported 1.8 million population (Kuwaitis and non-Kuwaitis) in Kuwait. In 2006, the population count reached 3.2 million, with Kuwaitis not accounting for more than one million of this figure. Thus, the population of Kuwait is comparable to that of the United Arab Emirates (UAE). Based on its income per capita, Kuwait is considered to be a wealthy state (although it suffered a disturbance in its annual budget right after the Iraqi invasion). Kuwait is dependent on oil and gas export revenues for its GNP growth; Kuwait's relative GNP is above that of some developed countries, like the UK, and is similar to that of Finland, while it is slightly below that some other countries like Singapore and Canada. Kuwait's life expectancy after birth is 75 years, which is comparable to that in the UK and the USA.

Looking at the level of educational services in the State of Kuwait, the following can be seen:

- The illiteracy rate dropped from 45% in 1961, to 17.6% in 1988 (MOP, 1995). This was due to policies and actions undertaken by the Kuwaiti government to raise the educational level and reduce illiteracy primarily by making education mandatory and free-of-charge.
- The number of public schools and institutes rose a from merely 108 in 1961, to 611 in 1994.
- The number of students in public schools and institutes rose from 51,090 in 1961, to 277,992 in 1994. Enrollment at Kuwait University also increased from, 1988 in 1970, to 15,696 in 1995.
- The adult illiteracy rate in Kuwait, according to the World Bank statistics, reached 27%, and thus, is higher than adult illiteracy rates in

Morocco and Saudi Arabia. Adult illiteracy in Kuwait still lags behind the rate that prevails in developed countries, which is below 5%.

As for health services in the State of Kuwait, significant strides have been achieved. The number of beds in hospitals increased from 2,185 in 1961, to 4,171 in 1994. The number of doctors also increased from 441 to 2846 during the same period. The doctor-to-population ratio decreased from 958 in 1970, to 609 in 1994. Comparing health services in Kuwait with their counterparts in other countries, Kuwait enjoys the lowest mortality rate, being only 2% in Kuwait. In the USA, the mortality rate is 9%, and in the UK, it is 11%. The infant mortality rate in Kuwait is 17%, exceeding that in other Arab and Islamic countries, except for Malaysia and Singapore, where these rates are 13% and 6%, respectively.

In a specialized study (*Al-Rai Al-Am*, 1997), M. Johar Hayat mentioned that the rate of contemporary diseases like "obesity, heart diseases, diabetes, high blood pressure and elevated cholesterol levels" has increased among Kuwaitis in recent years, especially the young of both sexes, compared with that of advanced societies, causing a parallel increase in the mortality rates of such diseases.

In another study, Al-Shomar, Chairwoman of the Health Committee in the Kuwaiti Women's Society for Social Services (Al-Syasah, 1997) emphasized the conclusions from Hayat's study, and added that many factors lead to such diseases, including age, heredity and environment. Such factors cannot be completely controlled. There are also other factors related to daily nutrition, life style and poor habits, that include smoking, alcoholism, lack of sufficient exercise and drug abuse.

Moreover, A. Al-Isa, Professor of Medicine at the Societal and Behavioral Sciences Department of Kuwait University (Al-Nahda, 1997) published a study suggesting that 90% of women in the age range of 40 to

50 years old and 76% of men in the age range of 40 to 50 years old in Kuwait are obese. He added that the danger of obesity lies in the fact that it contributes to or causes more than 43 other diseases, including spinal diseases, high blood pressure, heart diseases, kidney diseases, irregularity of monthly menstruation, and problems in caesarean births, in addition to a myriad of negative societal issues that include poor self image, poor self-confidence and poor self-esteem, that may lead to other psychological problems.

(2) The Economic Structure

The economic structure of the State of Kuwait is considered to be the sum of the different economic activities comprising its GDP. The GDP is an essential factor in assessing the economic development of a given State. The GDP is defined by the value of all final goods and services produced within a nation in a given year. One study (Colman and Nixon) defined the concept of economic development and its relation to GDP as an evolutionary process assessed according to a set of measurements and values, stemming mainly from the individual himself, and not merely from the systems and surrounding factors. Development also stems from the recognition of the individual, of the realities of life, and his her assertiveness and faith in giving unconditionally to his work. Thus, development has become a final product of a man's life and the road to prosperity. The study added that measuring such development and the amelioration of the lives of men is best accomplished through improvements in standards of living, health and education.

The study maintains that development in any State can be measured by several indicators. States with free-trade economies require indicators to reflect the economic performance of the State in comparison

with other States, for reference. Thus, national GDP is considered to be a critical factor in determining the economic development of any State.

To identify the economic structure of the State of Kuwait, the GDP will be discussed in detail according to different economic activities, which can be categorized into major sectors, in accordance with international categorization:

- Agriculture, livestock and fishing
- Mining (quarrying and other mining)
- Manufacturing
- Electricity, gas and water
- Retail and wholesale, restaurants and hotels
- Transportation and communication
- Financial and real estate services
- Community and social services

Tables 4.1, 4.2, 4.3 and 4.4 show Kuwait's GDP by economic activities over the past 10 years (1985-1995). The years of and immediately following the Iraqi invasion of Kuwait, i.e., 1990, 1991, and 1992, cannot be included in the calculations of performance due to the high instability of this period.

Table 4.1 presents the average contribution that each sector made to the GDP. The contribution of the mining sector averaged KD 2351 million (44%). This is not strange for a State like Kuwait, where oil represents the main component of the GDP. Taking direct governmental subsidies for the economic sectors in to consideration (and thus subtracting them), the net contribution of the agriculture and fish resources sector to the GDP is negative. The contribution of the

electricity, gas and water sector to the GDP is also negative at KD–506 million, constituting –9% due to its large direct governmental subsidies.

Only four sectors effectively contribute to the GDP, with the Mining Sector (mainly oil) being the dominant sector. Community and social services come in second, followed by the financial services sector, and lastly, the manufacturing sector. The construction sector makes a marginal contribution, which may be due to the fact that the State of Kuwait completed the bulk of its infrastructure construction during a boom in the sixties and the seventies. Table 4.1 also shows that the transportation and communication sector makes a weak contribution to the GDP. Regarding agriculture, Kuwait enjoys neither fertile soil nor suitable weather or growing conditions needed for agriculture to flourish. However, Kuwait is gifted with tremendous fish resources. In fact, continuous plans are in place to develop indigenous capabilities and resources that can be deployed to further investment in this activity and consequently contribute to the diversifying of the country's GDP resources.

Table 4.1: Contribution of Economic Activities to GDP in Kuwait (1984/85 – 1993/94)

Rank	Economic Activity	Value of Contribution (KD)	Percentage of GDP
1	Mining Quarrying and Other	2351	44
2	Community and Social Services	1354	25
3	Financial and Real Estate Services	834	15
4	Manufacturing	699	13
5	Retail and Wholesale, Restaurants and Hotels	557	10
6	Transportation and Communication	154	3
7	Construction and Building	44	1
8	Agriculture, Livestock and Fishing	-93	-2
9	Electricity, Gas and Water	-506	-9

Source: Ministry of Planning (1984/85 - 1993/94).

National Labor Force Distribution Across Economic Sectors

Table 4.2 shows the distribution of the workforce in the different economic sectors according to nationality during the post-liberation period. The table shows the Kuwaiti workforce reaching its peak contributions to the GDP in the electricity, gas and water sector (51.1%), followed by the mining sector and then the community and social services sector.

Table 4.2: Distribution of the National Labor Force Across the Various Economic Sectors

Economic Activity	Numbers and Percentages of National Labor Force		
	1970	1980	1996-1993
Mining	802 (19%)	3938 (43%)	45 (0.3%)
Manufacturing	1675 (23.4%)	2397 (36%)	3422 (47.6%)
Electricity, Gas & Water	6109 (19%)	3179 (7.7%)	5757 (8.3%)
Community & Social Services	2133 (29.4%)	2086 (25.3%)	3593 (51.1%)

Source: Ministry of Planning, (1987).

Comparing this data from the 1970s and 1980s, it is clear that most economic activities have not only retained their national workforce, but have augmented it, with the exception of the agriculture, livestock and fishing sector, where national employment has declined.

Imports of Food Products in the State of Kuwait

Imports of food products have increased in Kuwait, due to the fact that Kuwait is not an agricultural country and that the local food products have not decreased the country's dependence on importation of food products.

Government Expenditure

Tables 4.3 and 4.4 present governmental expenditure during the years from 1992 through 1995. They show that governmental expenditure rose constantly, although a small reduction was witnessed in 1995. Governmental expenditure may be divided into three categories according to the nature of spending; current expenditures, capital expenditures and real estate expenditures.

Table 4.3: Total Governmental Expenditure (KD million)

Year	Governmental Expenditure
1993/1992	347.371
1994/1993	374.920
1995/1994	373.424

Source: Central Statistics Department (1990-1995).

Table 4.4: Typology of Governmental Expenditure (KD million)

Year	Current Expenditure	Capital Expenditure	Real Expenditure on Estate
1993/92	295.191	52.180	----
1994/93	305.363	63.557	6.000
1995/94	314.884	57.276	1.264

Source: Central Statistics Department (1990-1994, 1994-1995).

Developmental Plans

Planning can be defined as the determination of the goals and objectives of an enterprise and the selection, through a systematic consideration of alternatives, of the policies, programs and procedures for achieving them. Thus, planning is an activity devoted to identifying, defining, and determining future courses of action clearly, before their initiation, as is necessary to achieve predetermined goals and objectives. Planning occurs at different levels: global, national and sectorial. This segment of the book is primarily concerned with the developmental plans of Kuwait, in the form of regional national, and sectorial planning.

Regional planning is a branch of planning that addresses the design and efficient distribution of activities and infrastructure across a significantly large area or field. Related developmental planning sets plans for several units of the apparatus of the State. This concept asserts the decentralization of management.

No doubt, the process of selecting targets and matching the appropriate response to them, taking into account operational requirements and capabilities, requires weighing trade-offs. This process does not only work as an automatic response to the needs of the community but also impacts the community and changes it through the targets that are set. The targets selected directly affect the process of selection, and the designing of operations and activities. Strategic planning suggests ways to identify and to move toward desired future states of economic and sectorial performance. It involves developing and implementing plans to reach goals and objectives. Strategic planning takes place primarily in military planning in business activities and in governments. Setting targets involves predicting and forecasting future scenarios. A prediction is a statement or claim that a particular event will occur in the future. Developing and identifying targets has central importance in any strategic planning. Ultimately, it involves the following.

(1) Coordination of Efforts

Coordination is defined as the process of systematically analyzing a situation, developing relevant information, and informing the appropriate command authority of viable alternatives for the selection of the most effective combination of available resources to meet specific objectives.

(2) Provision of Evaluation Measurements

Evaluation involves forming a judgment based on data collected with a view to determining the quality of one or more administrative tasks and improving the way they are performed. Normative evaluation involves making a judgment as to whether something is good or bad in some respects; the value judgment itself involves the evaluation of results and of what those results indicate about some natural phenomenon or the performance of the planning implemented. It also involves review of the overall efficiency and effectiveness of the planning process. The evaluation process also takes into consideration the alignment of the project's outcomes with the program's objectives.

Measurement is the determination of the size or magnitude of something. Measurement is not limited to physical quantities, but can extend to the quantification of almost anything imaginable. Examples of measurement range from degrees of uncertainty to consumer confidence to the rate of increase in a fall in the price of a good or service. It is important to know, however, that different kinds of quantities should be measured with different measurement tools.

(3) Provision of Monitoring Aids

Monitoring is the oversight and administrative effort that provide ongoing verification of progress toward the achievement of objectives and goals. Thus, monitoring encompasses supervision, observation, and testing, and appropriate reporting to responsible individuals. It also implies the collection and analysis of data as the project progresses to assure the appropriateness of the set objectives, the plan and its design. Three parts of the monitoring process are defined as follows.

- Ends: The results to be achieved by a program and the manner in which these results will be achieved over a specified period of time are called the ends. Usually, objectives are linked to one or more program goals.

- Mission: The mission describes the unique purpose of an organization, the fundamental reason it was created and what it is supposed to do in order to realize to its vision. It is the part of a goal or endeavor assigned as the specific responsibility of a particular organizational unit. It includes the task, together with the purpose, which clearly indicates the action to be taken and the related justification. It helps explain the distinctiveness of an institution, representing the assumptions and purposes that guide its planning and activities. The mission describes the organization's reason for being.

- Goals: Goals are specific objectives of specific systems and may be referred to as operating or program objectives or goals, operating standards, performance levels, targets, or expected results.

- Strategies: Groups of activities designed to produce outputs required to achieve planned outcomes. Strategies are usually comprised of several activities and outputs.

- Action Plans: A series of clearly defined steps and activities that explain or describe how to reach and achieve the set goals constitute an action plan.

Those responsible for planning units in the State of Kuwait work to formulate programs for the development plan of the State. Their efforts

have produced two main plans 1985/86-1989/90 and 1995/96-1999/2000. The current exposition of the planning process will be narrowed down to focus specifically on the scientific planning sector, which falls under two institutions, namely, the Kuwait University and the Kuwait Institute for Scientific Research (KISR). The mission of Kuwait University is to contribute to society through the pursuit of education, learning, and research, at the highest international levels of excellence. It also aims to provide strong support to individual researchers as well as research groups. Kuwait University is also concerned with its sustainability and its relationship with the environment, in coordination with other institutions in the State. KISR, on the other hand, has an entirely applied-research focus that is devoted to addressing the country's economic, environmental and resource challenges, and preparing it for the future.

Scientific Research Strategy in Kuwait

Scientific research is increasingly important, especially in the developed world. At the same time, scientific research and resources in developing countries tend to be difficult to manage and disseminate effectively. This is certainly true for data and information related to critical health and environmental issues for sustainable development. The successful development of and access to scientific research and resources that are related to scientific research are essential for advancing and building the overall capacity of the State and the local communities, in order ultimately to promote social welfare, sustainable economic growth, and good governance. Thus, it is essential for a scientific research strategy to focus on the following fields:

- Improving managerial efficiency and accelerating the rates of performance in all units of the administrative apparatus of the State,

utilizing the results of scientific advancement and its multiple applications in ways that support the process of decision making.

- Integrating support to privatize some public activities in accordance with the capacities of the private sector, and establishing a proper mechanism for undertaking such programs through an institutionalized system that addresses the task of studying all pertinent legislative, organizational, economic and social aspects related to it.
- Improving and developing scientific research centers, and publishing their work to enable the private sector units to utilize them to improve their capacity to implement advanced methods to improve the quality of their products and their competency in both local and international markets.
- Conducting surveys and studies about foreign markets and the problems of marketing Kuwaiti products in them, in a way that helps local manufacturers select proper means for promoting their own products abroad.
- Completing the process of simplifying managerial procedures and modernizing the organizational structures according to the fields of specialties in harmony with horizontal and vertical integration channels between the diverse units of the administrative apparatus.
- Applying the principles of scientific management and concentrating on the usage of suitable managerial techniques that can improve efficiency and simplify work loads.
- Improving the philosophy of higher education (for both university and applied education), and redefining the concepts related to managerial training and its programs, in a way that directs them toward build national ranks that are capable of undertaking the responsibilities of modern management.

- Considering the principles of experience continuity, with related requirements to change the reasons for the depreciation of the intellectual capital of human resources, by pursuing ways of providing continuous training to improve individuals' knowledge and increase their productivity.
- Developing the capabilities of individuals to think objectively and scientifically to understand ways of investigating and analyzing of any phenomena, grasping causal relationships and deducting results.
- Weighing and undertaking the calculations of trade-offs between available alternatives to transferring technology, and adjusting this to the conditions of the local environment, while providing the theoretical and applicable means for research, and directing them towards fields of importance for the process of development.
- Constructing an improved data base that is responsive to the needs of scientific research and technical development, and to support decision making processes in various fields at all levels.
- Organizing the scientific research sector to guarantee optimal coordination of efforts among the different institutions, in a way that achieves connectivity between the academic and applied scientific research programs, and provides means for utilizing them in all economic activities.
- Improving the efficiency of expenditure on scientific research, while rationalizing foreign education and training programs, taking into consideration the necessity of providing better opportunities to keep the educational attainment up-to-date with scientific developments and their applications in various fields.
- Boosting the role of scientific research in fields related to the protection and restoration of the environment, and measuring the cost

of maintenance as part of the factors determining the efficiency of production and investment.

- Focusing on programs of environmental awareness through all forms of mass communication and information, in addition to including them in the educational curricula of different educational grades and levels, focusing particularly on the formative years.
- Continuing the processes of monitoring and measuring any changes in materials that can lead-alone or combined with other materials-to a negative impact on the natural ecosystem and, hence, depress the quality of life.
- Making the maintenance and restoration of the environment a collective social responsibility that should be welcomed and followed by all citizens and inhabitants of the country, while placing direct or indirect penalties on environmental violations, in order to raise environmental awareness.
- Coordinating the relations of the State of Kuwait with international and regional institutions concerned with environmental affairs and bridging the gaps between scientific research institutions by participating in studies of pertinent environmental problems, and suggesting and seeing through suitable solutions for them.

It is worth mentioning that the development plan for the years from 1985/86 through 1989/90 setout clear directions and aims that were not completely achieved. Of those directions, the following comprised the core:

- Working to the end, that the State, by the end of the plan would own an integrated scientific policy that sets priorities for the activities of the various fields of scientific research and the needs of its national

institutions, and that links such activities to the requirements of the development plan.

- Assigning a formal institution in the State to coordinate the policies of scientific research with national centers and departments with different specializations, to approve their plans and programs, to ensure their relatedness to the state's development plans and the absence of any conflict or unwanted duplication, in order to improve efficiency and enable allocation of the necessary resources to scientific research in each.
- Defining a strategic goal to increase spending on scientific research in Kuwait, from its present level of less than 0.5% of the country's GNP to reach 1% by the end of the plan's period.
- Specifying a clause in the Ministry of Planning budget to spending on the needs of governmental authorities for studies and new, unplanned research. The procedure of spending under such a clause must be controlled according to requests of the authorities.
- Continuously working to encourage and involve national scientific talent in scientific projects and endeavors.
- Consulting with the concerned national authorities in research, and coordinating programs, and their activities and needs.
- Supporting the oil sector through a strategic framework.
- Increasing the number and proportion of Kuwaitis working in scientific fields to constitute at least 50-60% of the total scientific team, by the end plan's period.
- Increasing the percentage of contractual research to reach 40-50% of the total research activity in order to cover in their entirety operating and capital expenses.

This plan also addressed scientific research policy. It defined some of the approaches to be taken, most of which have not been fulfilled, because of the absence of authorities, groups or principles to assess and review the policy, and evaluate how far the policy goes toward achieving its goals. The following are the approaches were presented:

- Conducting research within the framework of a strategic program that defines the fields and most important elements, and identifies project priority, taking into consideration the needs of the beneficiary national sectors, and the development and inclinations of these sectors. Also, within the human resource and financial abilities of the institution, and in light of the results of the performance evaluation for the previous period, remarkable scientists will emerge from inside and outside the country.
- Preparing annual research programs that define the fields that the institute can participate in through its research programs, and within the present and future anticipated activities, which requires the following:
  - Increasing rational local food production, which may be justified on the basis of social and economic utility.
  - Extending and conserving water supplies and resources.
  - Supporting the oil sector by strategic inspection, and planning for its development.
  - Improving current practices in industrial production and services.
  - Maintaining the natural environment and achieving harmony with the industrial environment to meet increasing social needs, along with protecting the natural environment and national identity.
  - Bridging the high technology gap, along with its long-and short-term impacts in order to ensure its optimum application in the social and economic development in the country.

- Applying modern tools of economic analysis to serve development.

It may be concluded from the above, that the central mission and objectives of KISR are as follows:

- To contribute to, support and increase all economic activities in Kuwait.
- To prioritize those activities and sectors based on their relative importance to the country as measured by their level of contribution to the GDP. The oil sector is strategic because it is basically the country's breadwinner, composing the bulk of the GDP. However, other sectors may have trivial economic gains, but may still be strategic, such as water resources, and hence, are still completely deserving of preferential treatment.
- To reduce or eliminate scientific activities in invaluable fields, where no national value-added is created.
- To encourage research that effectively contributes to increasing returns to the GDP.
- To increase the operative abilities of the production and service sectors.
- To engage the greatest number of competent nationals in various specializations and ranks, in scientific activities, and developmental investments and endeavors.
- To contribute to improving the competency of governmental services, through efficiency gains and reducing governmental expenditures.

Social and Economic Programs

These types of programs involve the inclusion and addition of research that may not necessarily be part of aims of the program itself, yet is still considered necessary, as in the following:

- Bahnasa excavation (via an expenditure research project or private studies).
- Encyclopedia of machines in our life (via encyclopedic activities, reports and translations).
- Technical vocabularies dictionary (via dictionaries and translations).
- Qualifying Arabic children's language (via a physical sciences program).

Participation of the Kuwait Foundation for the Advancement of Sciences (KFAS) in the Activities of National Authorities, and National Institutions and Companies

There is no doubt that the research that KFAS has contributed to through its financing mechanism has added immense value to the progress and support of national development activities, and to reduction in the obstacles that face most of the production and service sectors.

KFAS has been particularly instrumental in pushing forth the country's development process forward by identifying the fields and types of research that it focuses on financing, in support of the holistic objective of comprehensive national development.

By comparing general economic state activities, and by analyzing scientific studies and research financed partially or wholly by KFAS, the following can be deduced upon evaluation of Kuwait's national economic activities and KFAS's focal direction in terms of research financing:

- KFAS has supported many research projects and studies related to mining and quarrying (especially oil refining and upgrading).
- KFAS has contributed extensively to financing research and studies related to social problems, financial challenges and the real estate market.

- KFAS has supported research related to transferring technology and applying the results to the local environment.
- KFAS has helped finance research and studies related to building, construction, and energy conservation.
- KFAS has contributed immensely to the support of research in agriculture and veterinary science; this program, in fact, ranks second in KFAS' activities.
- KFAS has financed many studies of economic value.
- KFAS has contributed to the financing of scientific research and studies related to diseases, poor habits and life styles, such as diabetes and obesity.

Examples of Economic, Social and Developmental Studies

(1) Economic Projects

- Building a macro-economic model for Kuwait.
- Distributing professional categories.
- The labor market in Kuwait.
- Building an economic development model to prioritize projects across the projects of the national economic sectors and sector developmental priorities.
- Prioritizing food safety by concept and in practice.
- The development of the agricultural sector (plant and animal production).
- Developing an Arabic data bank.
- The impact of the erosion of metals on the Kuwaiti economy.
- Constructing a data base of alternative energy sources.
- Control of energy consumption in industry.

- Industrial strategies and policies.
- A study to diversify national revenues through the development export viable industries.
- A guide for the selection of economic industrial projects at the sectorial level.
- A feasibility study for the establishment of a national marketing company.
- A study to enhance the efficiency of Kuwait University to meet the needs of Kuwait's labor market, and the development process and its human resource needs.
- Mergers and acquisitions in the banking sector in Kuwait.
- Financial liberalization and Islamic banking in Kuwait.

(2) Social Development Projects

- Wastewater and the sewerage networks.
- Traffic in Kuwait.
- A study on the effectiveness of consulting in the areas of business and management.
- Special education for challenged individuals.
- Energy conservation in buildings.
- Use of personal computers in training deaf children.
- Geophysical databank for the Arabian Gulf region.
- Reasons for the reluctance of university students to specialize in the Arabic language.
- Evaluation of the communications system.
- Study of the morphological variables of the coastal shores of Failaka Island for development purposes.
- Developing a hydrological, multi-purpose model.
- Establishing a museum of the maritime heritage of Kuwait.

(3) Development of National Industries

- Use of mud and contaminated soil as raw materials for building.
- Study of the manufacture of glass foam.
- Polymers for use in glass houses.
- Study on the separation of calcium carbonate for construction purposes.
- Evaluation of raw materials in Kuwait for the production of Portland cement.

(4) Petroleum Research

- Separation of raphinic hydro carbonate from its derivatives in heavy oil for processing into industrial cleaners.
- Separation of filtered wax.
- Polymer research.
- A diagnostic study of syndicated components in gas-oil.
- Organic compounds to prevent corrosion in crude oil distillation equipment.
- A study of the corrosion-fissure effect on alloys exposed to seawater.
- Non-destructive analysis of the heavy oil in Kuwait.
- Development of an economically feasible methodology to revitalize hydrogen re-utilization in oil refineries.
- Development of a mathematical model to determine the properties of oil and its derivatives.

(5) Water Resources

- Study of the aquifers of Kuwait and Damam in the composition or Umm Kadeer.
- Appropriate injection of desalinated water.
- The rationalization of the use of water in irrigation farms in Abdali.

- A study for the treatment and reuse of underground water in residential areas.
- R&D work related to desalination using RO.

(6) Reproductive System

- The impact of prenatal doses repeated during frequent pregnancies.
- Recurrent viral infections that are pregnancy-related.
- Nutrition for pregnant women.
- Effects of some drugs and hormones on pregnant women, the fetus, and labor.
- Immunity causing the failure of contraception.

(7) Urinary System

- The impact of the uni-pathogenic bacteria on the ureter.
- A study of the structure and methods of the composition of raw tissue of urinary system carcinoma.

(8) Respiratory Infections

- Epidemiological study on lung cancer: Factors and reproductive health.
- Study of the causes of respiratory diseases in Kuwait.
- Measurement and analysis of the real-time performance of respiratory disease related to the Shuaiba Area.
- Smoking and lung cancer.
- Repeated respiratory infections in children.

(9) Circulatory System

- Impact of exercise and sports on the circulatory system.

- Study of the relationship between coronary artery disease and antibodies present in the blood serum of membrane fat cells.
- Impact of hormonal therapy on the cardiovascular system.

(10) Immune System

- Treatment of vitiligo with herbal medicines.
- Testing of new antibiotics.
- A study on repeated spontaneous abortions.
- Establishing modern methods for the detection and diagnosis of newly emerging germs.

(11) Endocrine System

- Preparation and evaluation of diethyl starch to study the functions of the endocrine system.
- Insulin and protein generation.
- The isolation and diagnosis of microbes causing inflammation of bleeding lymph glands.
- A study of partially insulin-dependent diabetes patients.
- The quality and origin of cirrhosis of the liver and stages of liver cancer evolution.
- Genetic factors and immunity leading to the occurrence of type I diabetes.
- A study to examine the role of nutrition and family history of thyroid cancer.
- Evaluation of the nutritional status of diabetics in Kuwait.

(12) Digestive System

- Estimation of levels of pesticides in food.
- The impact of alarither on the gastrointestinal tract.

(13) Nervous System

- The importance of discouraging nerve cells and their demoralization in secondary epilepsy.
- Extract materials from plants that are effective against brain cancer.

(14) Other

- Family health.
- Surveying sources of harmful radiation and measuring its impact on the population.

(15) Research in New Scientific Fields

There is no doubt that KFAS seeks to be on a par with global technological developments and advancements in technology. Hence, it contributes to the transfer of technology to Kuwait. KFAS has actively pursued the financing of research in cutting-edge emerging fields, examples' of which have included:

- Developing a type of bacteria that grows on methanol by means of genetic engineering techniques.
- Transferring marketing and managerial know-how to developing countries and studying Kuwait as a case in point.
- Determining the age, sex and time of death for non-Kuwaitis using deoxyribonucleic acid (DNA) and chemical elements found in teeth.

Chapter Five

A Methodological Approach to Financing and Evaluating Scientific Research: The Economic Models

R&D is a key determinant of long-run productivity and welfare due to the long-term relationship that exists between R&D and productivity growth (Williams, 2004). The compelling question is whether the level of R&D investment is at a socially optimal level or not. Jones and Williams (2000), in their article "Too Much of A Good Thing: The Economics of Investment in R&D?" used an endogenous growth model to find that optimally, R&D investment should be at least quadrupled. If this analysis were to be extended to the Arab World and the GCC region, this multiplier would be even greater. Hence, R&D is an under-invested-in industry, which begs the question of unrightfully over-expected returns. Jones and William's central finding was that in the absence of a tax system that appropriates R&D funds or a subsidy system that entices such investments in a decentralized economy, under-investment in R&D will occur.

What is worse than the under-investment is the lack of a production base that links and manifests the outputs of R&D. The Arab World and the GCC region are to a large extent ready consumers of knowledge, technology and know-how. What is imported is even rarely improved upon or enhanced, and has any added-value to; it is merely sold and used. In contrast, in the USA, Japan, Europe and to some extent, in the newly emerging economies (NEEs), such is not the case, because R&D activities are expressed at the market level. This connection is very important in making R&D meaningful in the first place.

R&D Spending in the MENA Region

The Arab countries devoted US $750 million, or only about 0.2% of their GNP to R&D in 1995, compared to the world's R&D outlay of US $500 billion in the same year. Industrial countries devoted about 3% of their GNP to R&D in 1995. The two leading fields for research in the Middle East and North Africa (MENA) region are clinical medicine and applied chemistry. Research in various fields of engineering and pharmaceutical sciences has increased during the past 10 years. However, there does not appear to be a close relationship among ongoing R&D in engineering, chemistry and pharmacology and other related industries.

While international cooperation among scientists has been increasing, there is very limited cooperation among scientists in Arab countries. Only 8% of the papers co-authored with a foreign party, are between scientists from Arab countries, and there is no significant cooperation among Gulf Cooperation Council (GCC) scientists or among Maghreb scientists. Scientific cooperation among GCC countries accounts for less than 2% of their worldwide cooperation. Co-authorship among Egyptian scientists involves mostly expatriate Egyptian professors in oil-producing countries. In addition, there is limited participation by Arab scientists in international conferences held in Arab countries. Maghreb researchers are better connected to researchers in OECD countries than researchers from Mashreq states. Some 70% percent of publications from Algeria and Morocco are co-authored with someone from an OECD country (Gramlich, 1997).

Import Substitution for Technical Services

It is impossible for a country to apply scientific and technological methods properly without an effective S&T system. The S&T system

provides an enabling environment, which varies from country to country, and the quality of this system accounts for at least part of the differences in the competitiveness of nations. The record of Arab countries demonstrates conclusively that in the absence of an adequate S&T system, even massive investments can lead to a decline in GNP (David, 1992). Arab countries have derived little benefit from gross fixed capital formation which has totaled some US $2 trillion over the past 20 years.

Even though the Arab World has large numbers of highly trained professionals with university degrees, the Arab oil and gas sector employs about one million engineers and technicians from outside the Arab countries to generate the wide range of technical services it requires. The figures are much higher in the Arab construction industry, which employs 7 to 9 million expatriate workers. The Arab cement, textile and phosphate industries are also dependent on the importation of technical services. However, import substitution for technical services is feasible in all of these industries (ESCWA, 1995).

The evaluation of R&D activities is a controversial, yet critical, process that provides data, often referred to as management information, and alerts managers and decision makers to shortcomings in meeting their objectives. It is a process that encourages the delivery of specific critical targets and objectives, which in turn, serve the organization's strategic goals. Organizations develop or adopt performance measures in order to determine the ultimate outcomes and impact that the research will produce, determine the relevance of the work, determine the program's productivity and ascertain the quality of the work. Financial measures alone are not indicative of the value of the research output, especially in not-for-profit research organizations, where the socio-economic impacts of the R&D carry greater weight than financial returns.

Progressive, forward-looking R&D organizations have chosen to design performance measurement systems that place greater emphasis on outputs, rather than inputs.

The Evaluation Process

Scientific R&D is a strategic process, essential for development and "inseparable from scientific advance" (Hoffmann, 1992). R&D is one of the key, basic activities in an organization, due to its ability to build national capacity, and to develop and transform a nation from a developing exporter of basic raw materials to a developed exporter of high value-added, knowledge-intensive products and services.

The evaluation of R&D activities is a subject that has gained increased attention, especially in organizations and companies in the industrialized West that have realized that their niche and strategic competitive advantage lies in the strength of their R&D activities. In addition, it has become evident that the evaluation of R&D results brings about a more efficient allocation of resources, and implementation of more efficient and effective R&D in subsequent attempts. An evaluation is, in effect, an identification of the impact of action, whether it is scientific, technological, economic, societal or political, and whether it is in the past or future, direct or indirect, intended or un-intended.

Most indicator systems, whether used in a corporate setting or a not-for-profit setting, concentrate on R&D inputs due to their direct relationship to the cost element, and almost completely neglect output monitoring. There are mixed views regarding the optimal approach. The evaluation process that will be presented here involves a survey R&D assessment systems, presenting a sampling of the experience of various R&D institutions around the world, and recommendations for the Institute.

The evaluation of the outputs of R&D is a systematic, replicable process that is an analytical, independent management tool that is backward and forward-looking. To serve their purpose, indicators need to be standardized and normalized across the various program components to make possible periodic comparison among institutions and countries. The substance of the evaluation process may be tailored to the needs of the differing productive units of an organization, in a way that reflects their orientation, mission, priorities and direction. Kuhlmann (2002) defines the evaluation of R&D as a, "methodology-based analysis and assessment of the appropriateness of research innovation policy assumptions and targets, of the related measures and their impacts, and of the goal attainment". There are three main categories upon which to develop evaluation criteria: those addressing the quality and originality of the scientific and the technological content, those addressing the strategic goals of a program, and those concerned with operational implementation. Most R&D organizations develop an internal system of evaluation that combines the merits of these three approaches.

The evaluation of R&D activities may be addressed from a number of critical dimensions that can be categorized as procedural or substantive. The procedural dimension addresses the process of evaluation in and of itself, while the substantive dimension addresses how the evaluation occurs and what it entails.

The process of evaluation may be characterized by a number of factors: it is backward-and forward-looking, in that evaluations focus on citing achievements made and identifying lessons learned; it is an analytical process, in that quantitative and qualitative data are used to explore activities and issues; it is an independent process, in that, it is objective and unbiased; and it is a management tool, in that it is used to improve the direction of future work.

The process of evaluation supports four significant management needs:

- Information.
- Accountability.
- Advice.
- Learning and improvement.

Choosing Methods of Evaluation

This section will present a variety of the most utilized methods used to valuate R&D performance. However, it is important to note that greater emphasis will be later placed on the feasibility approach or the cost-benefit approach, when evaluating R&D economically, because it continues to be the most economically indicative

Evaluators use a variety of methods to address questions of R&D program performance. The methods share common features, but each has advantages, disadvantages, and special purposes. Former methodological wars over the relative merits of the different techniques have largely given way to an eclectic approach in which techniques are chosen for their appropriateness to the evaluation question at hand, to cost and administrative feasibility, and to a purposeful mixture of methodological paradigms.

The use of some methods of evaluation depends on how a program is positioned relative to the market and how mature it is. Some methods are particularly useful in assessing early-stage research programs, while others are better suited for assessing later-stage, closer-to-market programs. Both the utility and feasibility of a method may change as a program develops. Generally, the more an R&D program's scope spans from research to commercialization, the more methods evaluators can use to capture the full range of the program's impacts. Recognizing this, a

far-sighted strategy would be to design an evaluation program that lets data perform multiple duties. For instance, early evaluations may be designed to generate survey information on participants for immediate use, with the idea that the survey information can later be used as baseline information for subsequent evaluations. A far-sighted strategy would also use multiple methods to capture the full range of a program's impacts, to triangulate findings on salient program impacts, and to identify and validate relationships and impacts not readily apparent in the construction of the initial design.

Economic Estimation

Economic case studies combine descriptive case histories with quantification of costs and benefits, and including treatment of the distribution of costs and benefits. Carrying out descriptive analysis in advance of quantification is generally an essential step in economic quantification. Indeed, developing an in-depth understanding of the problem in its case-specific context is invaluable to the analyst who must design an appropriate estimation model, track down diverse effects, choose supporting analytical techniques, establish reasonable assumptions, and develop data that will lead to reliable calculations.

Prospective and Retrospective Studies

An economic study may be retrospective, based on empirically estimated past effects, or prospective, based on projected future effects (Sheehan, 2003). The longer a project has been in existence, the more feasible an empirically based analysis is. Often, of necessity, economic case studies combine elements of existing data with forecasts in order to take the analysis into the outcomes or impact stage of a project. Because

economic case studies require that impacts be expressed in monetary units, their use is more feasible in evaluating applied research and technology development programs than basic science programs, where the ultimate outcomes and impacts may be decades away and difficult or impossible to capture. However, even with applied research and technology development projects, there may be difficulties in estimation related the project's distance from the market (Romer, 1990). Generally, the further upstream of the market a program is positioned, the more complicated becomes the task of apportioning costs and disentangling the contributions of various contributors to the development of the eventual technology, and of estimating downstream economic benefits.

Discounting Costs and Benefits

Economic case studies generally employ the techniques of cost-benefit analysis; a subject that will be revisited in greater depth in the ensuing part of this book, including adjusting costs and benefit estimates for differences in time (Ruegg, 1997). Costs and benefits occurring over time are adjusted both for the real opportunity cost of capital and changes in purchasing power due to inflation or deflation for comparison. One approach is to first eliminate the effects of inflation or deflation from the estimated cash amounts so they are expressed in constant dollars, and then to apply a real discount rate to adjust for opportunity costs. An alternative approach is to express cash amounts in current dollars, and use a nominal discount rate to adjust for the combination of opportunity costs, and inflation and deflation. Because an interest rate, called a discount rate is applied to adjust the cash flows, the procedure is called *discounting cash flows*. Discounting adjusts all dollar amounts to a common time so that they can be combined and compared with other discounted dollars. Amounts can be expressed either as a present value, i.e., a lump sum as of

the current point in time; an annual value, i.e., a series of annual amounts spread evenly over the study period; or a future value, i.e., a lump sum as of a designated future date. Often in public-sector evaluations, all amounts are adjusted to present values. Discounting costs and benefits reduces the value of amounts occurring in the more distant future relative to amounts occurring closer to the present time.

Comparing Costs and Benefits

An evaluator must also decide how to express the measure of project performance that compares benefits against costs. All except the ROR measures, use discounting directly to adjust dollar amounts prior to computing the performance measure. The ROR measures are computed by using the appropriate discounting formula to determine the discount rate that equates costs and benefits. The net benefits measure is computed by subtracting time-adjusted costs from time-adjusted benefits. If the net benefit measure is greater than zero, then the project is considered desirable, since the minimum required ROR is already accounted for through discounting. When a project results primarily in cost reduction, the performance measure may be given in terms of life-cycle costs by combining all relevant costs and comparing them with the life-cycle costs, of the best alternative to the project. A comparison of time-adjusted total costs among alternatives indicates which is lowest (Blundell, 1992). If the levels of performance are comparable, the least-cost alternative is considered the cost-effective choice. Project performance may also be expressed as a benefit-to-cost ratio, a variation of which is a savings-to-investment ratio. The ratio is computed by dividing benefits (or savings) by costs. The ratio indicates how many Kuwaiti dinars of benefit per Kuwaiti dinar of cost are realized, for example. The ratio must be greater than one to indicate a minimally worthwhile project. Again, the minimal

acceptable ROR is already built into the analysis through discounting, and a ratio greater than one means that the return is greater than the minimal acceptable rate.

Project performance may also be expressed as a ROR (Boardman, 1996). The traditional ROR measure is the internal rate of return (IRR). This measure determines the interest rate that will equate the stream of costs and benefits. For example, if KD712,990 is spent today to receive KD1 million in 5 years, the investment would yield a 7% IRR. After the value of the interest rate is computed, it is compared against a specified minimum acceptable ROR to determine the desirability of the investment, or performance of a project. If a return of, say, 10%, were required instead of 7%, the above investment would not be attractive.

The economics and financial communities have increasingly come to use an adjusted version of the ROR measure that makes explicit increases in the reinvestment rate because it avoids some problems associated with use of the IRR measure, such as the possibility of there being no unique value and the assumption inherent in the technique that the ROR on the initial investment will also be obtained on reinvested proceeds over the study period. Yet another related measure of performance is the discounted payback period, that is, the length of time until the accumulation of time-adjusted benefits is sufficient to pay back the cost. A shortcoming of this measure is that it focuses on a breakeven point rather than on net benefits, and, hence, is not recommended as a stand-alone measure of economic performance. It may be useful, however, as a supplementary measure.

Lead with Net Benefits, Supplement with Other Measures

A frequently used strategy in cost-benefit analysis is to lead with a net benefit calculation supplemented with one or more of the other

measures to help reach audiences familiar with the different measures. Those with primarily private-sector experience will usually be most familiar with IRR and business cash flows, and not the broader perspective of public-sector analysis.

Challenges

Challenges in expanding a case study to include cost-benefit measures include identifying the various pathways through which project effects occur, identifying the populations affected, and estimating difficult-to-quantify costs and benefits. Seldom is this information readily available. Furthermore, sufficient time may not have elapsed for a project to yield positive outcomes. The project may still be in the stage of net negative returns even though the potential for large positive returns in the long run may be strong. An additional challenge is attributing costs and benefits to individuals in cases of joint investment.

Treating Uncertainty and Risk

Given the uncertainties of the technical and economic outcomes associated with R&D programs, evaluations that seek to estimate costs and benefits or other economic impacts must deal with the presence of uncertainty and risk. Quantitative studies that express results deterministically, ignoring uncertainty and risk, tend to be misleading in their implied level of precision. If probabilities can be attached to different values, risk assessment can be added to the economic analysis, and the extent to which the actual outcome will likely differ from the best guess can be estimated. If probabilities are not available, then a technique for treating uncertainty can be used. Sensitivity analysis, for instance, tests how outcomes change as the values of uncertain input data are

changed, showing the estimated outcome of a project for alternative data estimates and assumptions, thus allowing the results to be expressed in terms of a range of possible values. Most importantly, it reminds the audience that there is uncertainty, and indicates how the outcome might vary. Scenario analysis allows the analyst to show results based on different scenarios of interest to decision makers and to present what-if hypothetical analyses.

Advantages and Disadvantages of Economic Case Study

An economic case study is widely considered to be one of the more highly developed methods of evaluation because of its focus on ultimate outcomes and impacts rather than on outputs. Its advantages include the fact that its scope extends from a project's start to its finish, and it provides quantitative estimates of results that are often considered to be more convincing evidence of value than qualitative measures. Another advantage is that its measures are stated in the language of finance, which facilitates comparison. Combined with a descriptive treatment of a project, a well-done economic analysis can shed light on the overall performance of a project and provide valuable insight for program administrators and policy makers. The method also has disadvantages. For instance, it may be impossible to estimate the value of important benefits in monetary terms. A further problem can arise if there is not a clear understanding of the essential differences between analyses performed for public versus private projects. For instance, spillover effects in case studies of publicly funded projects designed to deliver social benefits may be overlooked in the face of easier-to-capture private returns. A related disadvantage is that stakeholders may expect positive net benefits and large IRR, in the short run when, in fact, a public R&D program often takes substantial time for impacts to be realized,

particularly spillover impacts resulting from knowledge dissemination. Other disadvantages may be the risk of raising expectations based on a single project that all or most projects will be like that one, or the risk that policy makers will draw conclusions from an idiosyncratic experience. Some of these potential disadvantages, however, may be avoided through skillful execution, presentation, and interpretation of such studies.

Econometric and Statistical Methods

Econometrics is a branch of economics in which researchers empirically estimate economic relationships by applying mathematical models to structure the relationships, and by applying statistical methods to analyze the economic data, estimate model parameters, and interpret the strength of evidence for the hypotheses being examined. Thus, econometrics includes model building, estimation, hypothesis formation and testing, and extensive data analysis (Guellec, 2001). The method employs many techniques from mathematics and statistics, and is used in a wide range of applications. The results are quantitative, with the specific units of measurement being dependent on the nature of the individual analysis.

Application of econometric/statistical methods requires considerable care and skill in.

- Hypothesizing relationships that derive from or correspond to prior theoretical or programmatic concepts.
- Selecting or constructing measures for dependent and independent variables corresponding to the key concepts and relationships posited in theory.
- Using and interpreting appropriate statistical tests.

Reflecting the complexity of the phenomena examined and the absence of perfect empirical data to use in models, Griliches and Intriligator (1983) maintain in their extensive reference work on econometrics, the following, which captures the flavor of the method: there is, thus, a continuous interplay in econometrics between mathematical-theoretical modeling of economic behavior, data collection, data summarizing, model fitting, and model evaluation (Jones, 1997) Theory suggests data to be sought and examined, with the data available suggesting new theoretical questions and stimulating the development of new statistical methods. The examination of theories in the light of data leads to their revision. The examination of data in the light of theory often leads to new interpretations, and sometimes, to questions about its quality or relevance and even to attempts to collect new and different data.

Hypothesis Testing

Hypothesis testing first makes a tentative assumption, called the null hypothesis, denoted as HO. Then, an alternative hypothesis, denoted as Ha, is defined stating the opposite of the null hypothesis. The hypothesis-testing procedure generally uses sample data to determine whether or not H0 can be rejected. If H0 is rejected, then the statistical conclusion is that the alternative hypothesis Ha cannot be rejected. It may be postulated in HO, for example, that the number of collaborative research ventures is unaffected by public-private partnership programs, and in Ha, the opposite.

Regression and Correlation Analysis

Another application of statistical methods in evaluation is in regression and correlation analysis to identify the relationship between a dependent variable and one or more independent variables, and to

measure the degree of association between variables. Regression analysis develops an estimating equation from sample data to make projections about one variable (the dependent variable, y) based on another variable (the independent variable, x). Correlation analysis measures the strength of the relationship between the variables, that is, the variability in y that is explained by x, typically measured by the correlation of determination or its square root, the coefficient of correlation.

An example of a possible relationship that might be tested is an increase in the numbers of patents registered by firms in a given industry and the number or amount of federal research grants received by that firm. An estimated regression equation could be used to predict the change in the number of patents given an increase in federal grants. It is important to note that neither regression nor correlation analyses alone prove cause-and-effect relationships; rather, the analyses indicate how or to what extent variables are associated with each other.

Production Function Analysis to Measure Productivity

Evaluators also use econometric analysis to estimate a production function, the mathematical expression of the technical relationship between inputs and outputs. The production function equation quantifies the output that can be obtained from combinations of inputs, assuming the most efficient available methods of production are used (Munari, 2001). The production function can be used to estimate the change in output from an additional input or the least-cost combination of productive factors that can be used to produce a given output. It can be used, for example, to examine the impact of federal funding on private-firm R&D productivity.

Macroeconomic Modeling

Macroeconomic models can help in economic forecasting, and the analysis and formulation of public policy. For example, a macro-economic model based on national input-output tables and using a set of structural equations to explain economic relationships might be used to analyze the national effects of a product innovation that decreases its supply cost. An example of a macro-economic model is the Regional Economic Models, Inc. (REMI) Policy Insight superscript TM model, which is used to forecast national and regional economic effects of a wide range of policy initiatives and technological changes.

Advantages and Disadvantages of Econometric and Statistical Methods

One advantage of econometric and statistical methods is that the methods significantly add to the analytical capability of evaluators. Use of these methods can contribute to an understanding of the relationships between inputs and outputs in the face of complex and imperfect data. Econometric and statistical methods can be used to produce quantitative results with detailed parameters and to demonstrate cause-and-effect relationships. The disadvantage of using these methods is that both the approaches and results may be difficult for the non-specialist to understand, replicate, and communicate. In addition, not all effects can be captured in these highly quantitative methods, which are imperfect and variable in how well they capture relationships between changing technical knowledge, and economic and social phenomena.

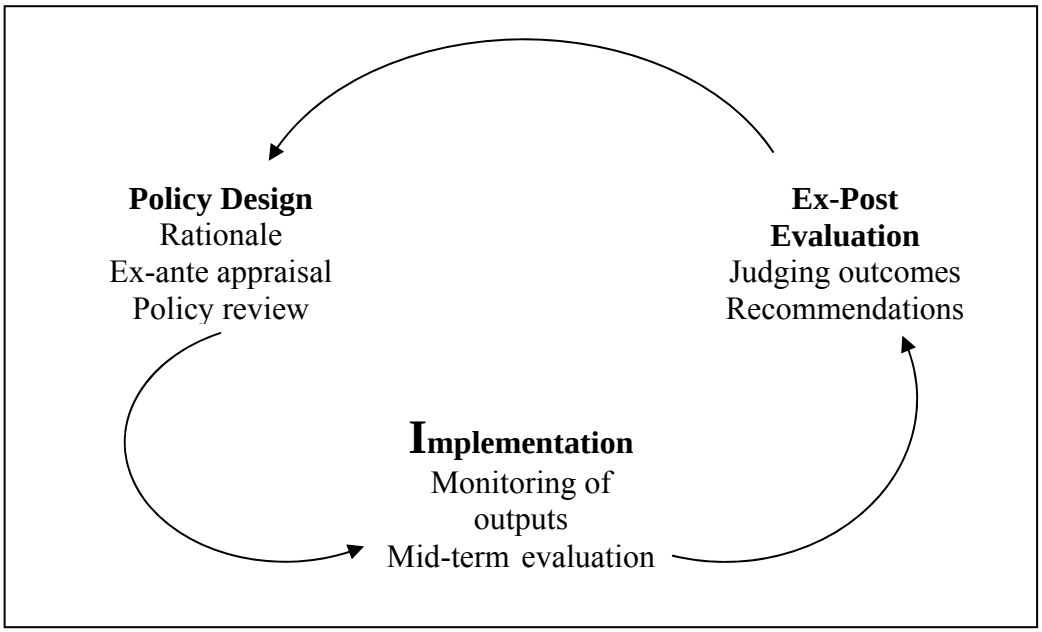
Sociometric and Social Network Analysis

According to sociologists, the fact that economic behavior is embedded in networks of social ties has a profound impact on economic outcomes. There is an emerging awareness of the significance of social networks and their dynamics on the economic impacts of research and technology development among economists who are engaged in program evaluation. There is growing interest in how social networks emerge (Nelson, 1993), how social networks evolve, and how social networks affect economic behavior. Additionally, there is growing interest in applying methods of sociometrics and social network analysis to learn more about the spheres of influence of scientists, technologists, and innovators, and the importance of their work, to identify evolving pathways of knowledge spillover, to improve the success of collaborative relationships, and to map the development and diffusion of human capital from projects.

The Battelle approach is representative of an evaluation process that occurs in most advanced R&D organizations (Fig. 5.1). Battelle has become known as a leader in sustainability performance measurement, because it helps its clients identify significant aspects of their organizations, set priorities for establishing performance objectives, and implement performance indicators and targets for monitoring progress against those objectives. Substantively, the Battelle approach of evaluation performance measures (EPMs) emanates from two basic principles:

- Consensus over the objectives of the R&D program.
- Consensus over the criteria that will be used for evaluation, which in turn, constitute an immediate reflection of the program's objectives.

The evaluation cycle



Source: Battelle Memorial Institute (2002).

Figure. 5.1. Battelle's approach to the evaluation process.

The process of evaluating R&D activities involves six steps

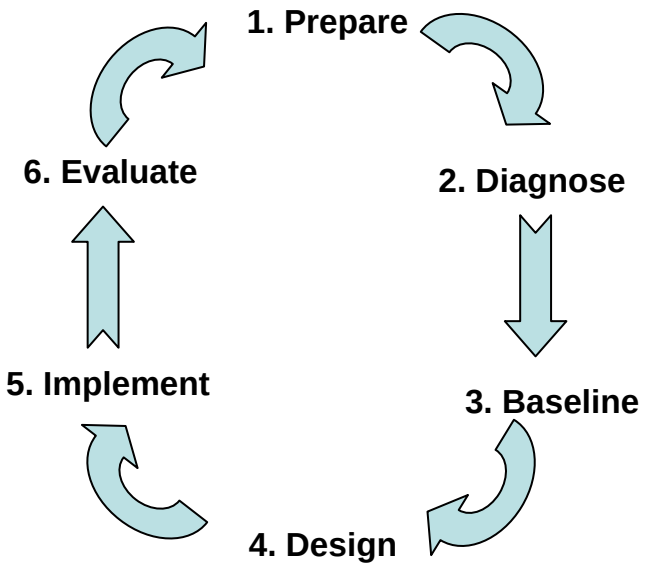


Figure. 5.2. The evaluation process.

Progressive organizations in the United States, Europe and Japan have realized the importance of designing and implementing integrated systems to measure the performance and evaluate the progress of their R&D activities, knowing very well that this exercise will feed into and improve successive research attempts.

The process of evaluating R&D activities involves six steps. In the first step, Prepare completes a number of actions that support the development and use of the performance measurement process. This step includes identifying key internal stakeholders and gaining their support. In the second step, Diagnose, the question, "What are we really trying to accomplish?" is answered. A review of the current evaluation program occurs in this step. In the third step, Baseline, the benchmark information necessary to enable future evaluation of the organization's achievements are developed. This step also generates important information to guide the design step. In the fourth step, Design, results in the specification of the performance evaluation program requirements and a program blueprint is designed. During this step, specific Pls and metrics are selected. In the fifth step, involves Implement, the on-going execution of the performance evaluation program. This step can include pilot studies and communications to the management team and other stakeholders. In the sixth step, Evaluate, the performance evaluation program is reviewed and refined periodically. The tactical elements of the program are typically evaluated more frequently than the long-term strategic elements.

R&D performance measurement systems may be classified using a number of dimensions:

- Internal vs. external.
- Quantitative vs. qualitative.
- Input vs. process vs. output.
- Objective vs. subjective.

Based on an organization's particular strategic needs and orientation, it will adopt an appropriate combination of these systems to formulate a customized package that will best reflect its organizational objectives and accomplishments. Evaluation can take place at four levels: the policy level, the portfolio level, the program level and the project level. At the policy level, policies that govern the selection, expenditure and management of activities and programs are reviewed. At the portfolio level, the quality and contribution of R&D activities across a range of activities and programs are reviewed. At the program level, the quality and contribution of each distinct research program in the organization is reviewed. The same occurs for each project at the project level, the lowest level in this hierarchy.

A Survey of R&D Systems of Appraisal and Assessment

Measuring the output of research activities has always posed numerous problems, due to a number of factors:

- The degree of risk and uncertainty about research is high, especially in the initial stages of the work.
- Once completed, R&D output is often fuzzy and not definable.
- The outcome of most R&D cannot be quantified in advance.
- The outcome of R&D may lag behind the output of the activities by several years (e.g., patents).
- The ultimate result of R&D activity can only be viewed after years, once an innovation has been brought to market.
- No one indicator can cover all dimensions. For example, the number of patents obtained does not reflect the quality of the work nor its impact on the scientific community and the world.

Initially, a distinction needs to made between corporate R&D and not-for-profit or public R&D. Corporate R&D will always place greater weight on financial measures, which will be discussed later, since the R&D in corporations is a function of the cost center. In non-profit organizations, on the other hand, the R&D function has a broader purpose that may place greater weight on socio-economic factors, among others. Traditionally, performance measures of the R&D function have more frequently been related to R&D inputs than output. This is a result of the belief that there should be a positive relationship between the amount of resources allocated to R&D and R&D output; hence, the higher the R&D expenditure, the more effective the output. There are obviously many exceptions to this theory, i.e., organizations that spend less and achieve more, but this kind of superior performance can be related to the breadth and depth of an organization's R&D skills, its R&D infrastructure, its R&D history, and its competitiveness, among a host of other variables.

Different corporate and non-profit organizations use a variety of methods to evaluate R&D activities and outputs. The following two examples, i.e., USA's Army Research Laboratory (ARL) and the UK's Evaluation Associates Ltd., will provide an overview of all of the tools that are used for the evaluation purposes (Davis, 1996).

Measuring Performance of R&D activities at the Army Research Laboratory (ARL).

In implementing its approach to measuring R&D performance, the ARL uses a combination of peer review, customer evaluation, and performance measures.

(1) Peer Review

Peer review involves is the judging of scientific merit by other scientists working in or close to the field of question. Peer review is premised upon the assumption that a judgment about certain dimensions of the science produced, for example, its quality.

(2) Customer Evaluation

Customer evaluations are produced using measures of end-user satisfaction.

(3) Performance Measures

Performance measures can provide useful information on the operational or functional health of an R&D organization. Measures such as maintenance backlogs, workforce diversity, procurement cycle time, papers published, and patents received, etc., are used here to quantify the achievements of several dimensions of the research work.

Research Evaluation Methods of Evaluation Associates Ltd

- Four primary methods are used at Evaluation Associates Ltd: surveys, peer reviews, and metrics.

(1) Survey Methods

Surveys are systematic ways of collecting data that are an important element in all evaluations. There are four main evaluation survey methods:

- Questionnaires.
- Telephone interviews.
- Face-to-face interviews.
- Case studies.

(2) Peer Review

The peer review at Evaluation Associates Ltd., is similar to the peer review conducted at the ARL, but at Evaluation Associates Ltd., (U.K), in addition to peers, experts are used and the process is conducted through commentators and juries. Peer juries meet together so that a range of commentators are able to deliver a collective judgment.

Measurement through peer review, in most contexts, evaluates the following:

- Performance (the proficiency and rigor of research concepts, design and implementation).
- Excellence (the eminence of the research activities).
- Potential sources of bias, including: protection of networks, ideological bias, and aversion to innovation.

(3) Metrics

Metrics is a major field of study involving the process of conducting different types of evaluations. Metric methods are by definition quantitative, and therefore, reduce complex phenomena to simple numbers and ratios, allowing comparisons between different activities to be made.

There are three groups of metric methods:

- Bibliometrics is also called scientometrics or citation analysis, because this field is concerned with counting publications and citations in publications. Counting publications in a work of research provides a basic measure of output. This measure is based on the practice of including lists of references or citations of previous works at the ends of papers.
- Technometrics is largely concerned with patents and citations of patents.

- Econometrics is concerned with financial measures, ranging from cost-benefit analysis to R&D expenditure.

The complexity of estimating R&D output has incited a wider use of indicators such as expenditure on R&D, numbers of R&D personnel, numbers of R&D projects in a particular area, and annual expenditure per researcher and per project; intellectual property indicators, like patents, copyrights, trademarks and industrial designs, and many other composite configurations.

Other R&D evaluation methods include calculations of R&D returns and benchmarking. R&D return is defined as the ratio of profits to R&D investments. It is a result of two major factors: R&D productivity, which is the ratio of technical progress to R&D investment and R&D yield, which is the ratio of profits to technical progress. Although it is valuable to quantify R&D performance, the above variables in and of themselves, are unidimensional, and should be treated as such.

Benchmarking compares the practices adopted in R&D against best practices. Benchmarking may be used to self assess its own capability for technical innovation using a method that includes both performance measures and process measures against best practice of a number of sub-processes identified as key for success. These sub-processes may include the generation of new product ideas, product development, production process innovation, technology acquisition, leadership, use of systems and tools in support of innovation and the funding mechanism used.

Table 5.1 clearly shows the objectives and outputs of innovative efforts throughout the life cycle of the technology, from generation through transition to diffusion. This may be effectively applied to R&D outputs that share the same substantive nature.

Table 5.1: The Framework of R&D Performance Measurement

		Measurement Domain		
		Generation	Transition	Diffusion
Object	OUTPUT	Quantity & quality of technological stock: excellence, originality long-term visibility, & short-term capability	Capability to sustain business goals: -no. of new products -impact on production efficiency -contribution to marketing & service strategy	Achievement of business goals: -profit margin from new product - market share - business growth - brand loyalty
Of	PROCESS	Quality & effectiveness of long-term planning Short-term selection, project management of operational activities	Time-Cost-Quality in new product development process new production technology development	Efficiency & effectiveness of commercial and marketing processes
Measurement	INPUT	Quantity of resources for innovation: - no. of researchers, - R&D, & expenses and Turnover	Quantity of resources for development: - no. of designers - investment for CAD technologies	Quantity of resources for commercial release: - no. of marketing and sales people - budget for ads

Source: Baglieri et al. (2001).

Table 5.2: Dimensions and Corresponding Indicators of the Technology Achievement Index (TAI)

Dimension	Indicator
Creation of technology	Patents granted per capita
	Receipts of royalty and license fees from abroad per capital
Diffusion of recent innovations	Internet hosts per capita
	High- and medium-technology exports as a share of all exports
Diffusion of old innovations	Logarithm of telephones per capita (mainline & cellular combined)
	Logarithm of electricity consumption per capita
Human skills	Mean years of schooling
	Gross enrolment ratio at tertiary level in science, mathematics and engineering

Table 5.2 shows the dimensions and the corresponding indicators of the Technology Achievement Index (TAI). This is an applicable indicator for KISR and other research organizations that aim to measure how their efforts and innovations have affected or transformed their societies. This is a very useful index that is indicative, especially when it is aggregated with other indices.

Table 5.3: The Evaluation of the Overall R&D Value Creation

R&D Component	Performance Indicators	Evaluation Methodology
Kos* in the generation phase	Quantity & quality of technological stock: - excellence and originality - long-term visibility - short-term capability	Reproduction cost Updating cost Empirical coefficients & sectorial indicators Multipliers & ratios
Kip* in the generation phase	Quality & effectiveness: - long-term planning - short-term selection - project management - operational activities	
Kos in the transition phase	Capability to sustain business goals: - no. of new products - impact on production efficiency - contribution to marketing and service strategies	Discounted cash flows Net present value Incremental profitability Expected royalties Cost of loss Real options Multipliers & ratios
Kip in the transition phase	Time-cost-quality in - new product development - new production technology development	

* Kos: the value of the knowledge on the shelf, consisting of all of the scientific and technical knowledge that can be counted, as it lies on paper or in digital documentation.

* Kip: the value of the knowledge in progress, consisting of two components: the overall knowledge embedded within projects in progress, and the knowledge fed by the competencies and expertise of the R&D people and used in the running of R&D projects.

Note: the value of the R&D activities consists of the value of both of the above kinds of knowledge: WR&S = Wkos + Wkip .

Table 5.4: Calculating R&D Value Creation

<table>
<tr><td colspan="4">$W_{R\&S} = W_{Kos} + W_{Kip}$</td></tr>
<tr><td colspan="2">W_{Kos} = "stock" value</td><td colspan="2">W_{Kip} = "flow" value</td></tr>
<tr><td colspan="2">$W_{KOSt-1} + \Delta W_{KOSt}$</td><td colspan="2">$\sum_{i=1}^{N} (E\,W_{KIPi} + PPIi)$, i= project $_1$</td></tr>
<tr><td>W_{KOSt-1}= the value of the knowledge "produced" by past R&D projects</td><td>ΔW_{KOSt} = the additional value of the incremental knowledge produced by the projects at the time of the valuation</td><td>$\sum_{i=1}^{N} (E\,W_{KIPi})$ = the expected value of the current R&D projects</td><td>Process Performance Impact $_i$ = the estimated impact of the practices and organizations on the expected value of the KIP</td></tr>
</table>

Tables 5.3 and 5.4 adopt a unique approach to performance measurement. The aim of this approach is not merely to provide a framework for the evaluation of research outputs from a non-financial perspective but rather to "define a general frame which should allow an objective appraisal of R&D value creation, i.e., of the specific contribution to value creation linked to the processes of technological innovation" (Baglieri, et. al., 2001).

Baglieri's approach provides an effective mechanism for monitoring contributions of productive technical units to value-creation, that being the final objective of any productive unit. While all of the entire components of the calculation matrix are important to the process

of evaluation. According to the approach suggested in this matrix, the following R&D related factors are monitored:

- The efficient achievement of results that occur in tandem with the project.
- Organizational objectives.
- The stock of technical and scientific knowledge generated.
- The availability of the resultant knowledge at the organization.
- The transfer of the resultant R&D to the capital market.

Performance measurement efforts often fail because they are not derived from a disciplined and well-articulated methodology. Results and recommendations for an evaluation are expected to feed into policy reviews or to provide evidence that can be instrumental in any future considerations of similar policies. This means that evaluations should not be viewed as an end in themselves, but rather as a key tool to help policy makers achieve their objectives.

Table 5.5 demonstrates how the various performance dimensions of competitiveness, financial performance, quality of service, flexibility, resource utilization and innovation may be quantified. Research organizations may select the relevant dimensions and aggregate their measures to produce a customized composite indicator that reflects their activities.

Table 5.5: Measures of Performance Dimensions

Performance dimension	Type of Measure
Competitiveness	Relative market share & position Sales growth (measures customer base)
Financial performance	Profitability, liquidity, capital structure, market ratios, etc.
Quality of service	Reliability, responsiveness, appearance, cleanliness, comfort, friendliness, communication, courtesy, competence, access, availability, security etc.
Flexibility	Volume flexibility, specification and speed of delivery flexibility
Resource utilization	Productivity, Efficiency, etc.
Innovation	Performance of the innovation process, performance of individual innovations, etc.

The Case for Financial Indicators

Financial indicators remain the fundamental managerial tool, because they readily quantify achievements. However, financial measures only measure financial performance. They fail to measure the quality of the research work produced or its socio-economic benefits, which is why most non-profit organizations do not perceive financial indicators to be indicative of their performance or mission accomplishments. Relying largely on financial indicators will lead decision makers to support only successful performers, which may lead to rigidity and stagnation of the research effort of an organization.

The following financial indicators are the main measures used to ascertain the feasibility or lack thereof, of a corporate R&D activity. In non-profit R&D organizations, financial indicators are used to give

decision-makers direction as to the financial performance of their programs. Important financial indicators include the following:

- Payback Period: The payback period (PBP) tells us the number of years required to recover an initial cash investment.

- Internal Rate of Return: The IRR is the discount rate that equates the present value of the future net cash flows from an investment project with the project's initial cash outflow.

- Net Present Value NPV: The net present value (NPV) is the present value of an investment project's net cash flows minus the project's initial cash outflow.

- Profitability index: The profitability index is the ratio of the present value of a project's future net cash flows to the projects initial cash outflow.

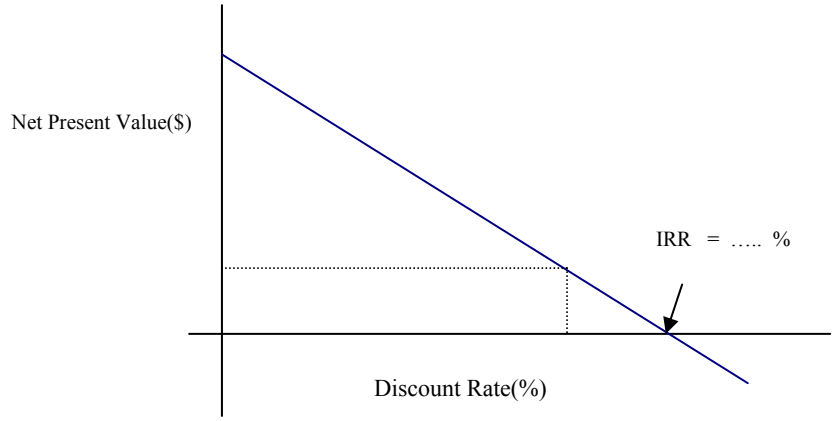


Figure. 3.5. Net present value

Developing an Evaluation System for R&D Activities at KISR

The Amiri decree, embodied in Law No. 28 of 1981, states that the mission and objectives of KISR are, the promotion of scientific and applied research, particularly in matters relating to industry, natural and food resources, and other primary constituents of the national economy, in an endeavor to serve the goals of economic, technological and scientific development and to offer advice to the government on scientific matters and on science policy issues.

(1) Contributing Factors

KISR's image, through which KISR justifies its mission and its contributions to society, and which should, in turn, reflect the needs of the country and its people is a strategic factor, given that 80% of KISR's budget is allocated by the Ministry of Finance, and KISR's work and output is subject to the scrutiny of the National Assembly (parliament).

The government's 5-year developmental plans, developed by the Ministry of Planning, are in turn reflected in KISR's own strategic plans.

The philosophy or ideology, (i.e., strategic long term interests) of KISR's upper Management is based on those 2 factors; thus, key decision makers should determine the criteria that they will use to evaluate KISR's R&D activities and outputs to reflect what is most critical for KISR, i.e., income or human resource development. Analysis of an organization's strengths, weakness, opportunities and threats i.e., (SWOT) [2] analysis, may be used to determine these factors. In addition, the core criteria

[2] SWOT analysis analyzes the strengths, weaknesses, opportunities and threats of an organization, and builds a strategy that reflects the organization's profile and optimizes its strengths.

should emanate from what KISR perceives to be its strategic competitive advantage, i.e., its niche, or its competitive edge.

(2) The Definition of KISR's Comparative Advantage, Its Strengths and Hence, Its Opportunities

In order to define these key aspects of evaluation, the following must be done:

- Criteria must be set, i.e., tools of evaluation have been chosen.
- Output at KISR must be defined.
- How output will be measured must be determined.

A variety of indicators can be used to assess an organization's performance, including non-financial indicators such as the following:

- Human resource indicators which reflect the rate of utilization of available manpower.
- Scientific indicators which can be measured by the number of papers published in each division, or from each project (in internationally refereed journals, regional, journals, local measure journals etc).
- Administrative indicators (e.g., the number of late reports to the total number of reports produced) measure efficiency and effectiveness.

The indicators currently used at KISR include:

Financial indicators: Unlike R&D that occurs in a corporate setting, where the value-for-money concept (VFM) is of utmost importance, [3] non-profit-seeking research organizations focus on other criteria to benchmark their performance and accomplishments. However, to the

3 VMF is conventionally defined as economy, efficiency and effectiveness (the 3 E, value for money is usually very difficult to measure for research and value for money assessments in evaluation tend to be based on broad opinions rather than technical assessments.

extent that financial indicators are relied upon in an R&D setting, the following criteria are used:

- The ratio of total project budgets to the total divisional budget.
- The ratio of total revenue resulting from projects to total divisional costs and expenditures.
- Profitability.

Human Resource Indicators: Human resource indicators measure the extent to which the available manpower is effectively developed and utilized in on-going projects.

Scientific Indicators: Scientific indicators measure the number of papers published by each division, or from each project, in internationally refereed journals, or regional or local periodicals. This methodology is often referred to as bibliometrics.

Administrative Indicators: Administrative indicators measure the number of late reports compared to the number of total reports.

(3) A Proposed Methodology for Evaluating R&D Divisional Output at KISR

- Cost analysis
- Profit indicators, (i.e., revenue/division) (cost/division) (US $ / division).
- Productivity analysis, in which inputs are measured relative to the outputs produced, as shown in Fig. 5.4.

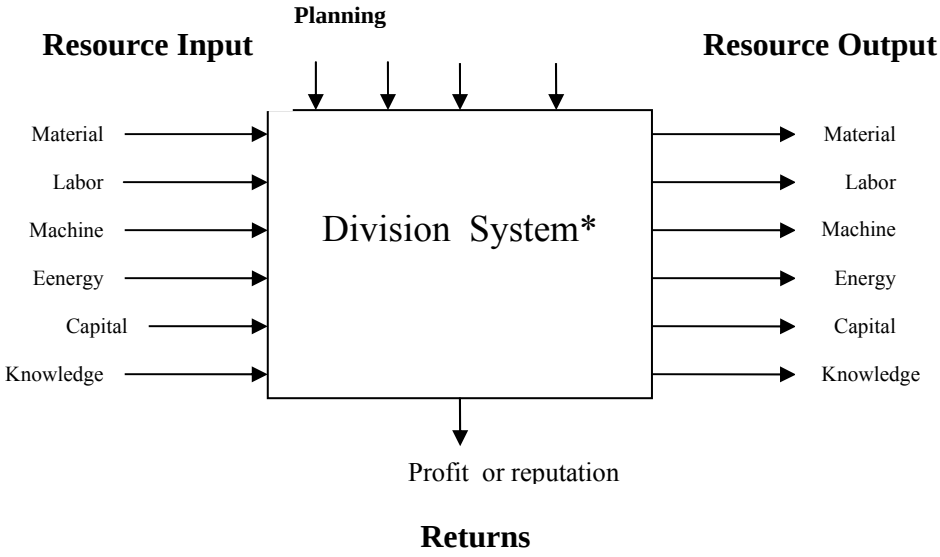


Figure. 5.4. Resource planning

* In using this analysis the division is considered to be a productive system.

Productivity is a function of both efficiency and effectiveness.

To Measure Productivity

- Define efficiency : To accomplish a task with minimum resources.
- Define effectiveness: To accomplish a task with minimum resources and high quality.
- Productivity indicator = (Output[4] of the division/Input [5] of the division)
- This approach ensures that 'value creation' is directly tied to performance assessment.

[4]- Out put of R&D division could be the number of projects, return from projects ($), etc.

[5]- The input of an R&D division could be the entire cost of the resources needed to accomplish a given project.

Cash Flow Analysis

- Methods to compare different alternatives (divisions):
- Present Value (Pw).
- (Internal rate of return) IRR %, to find it set Pw (IRR) = 0.
- Input/output ratio (cost/benefit) = Pw (all cost) / Pw (all benefits).
- Payback period, where there is a break even point

(4) Capstone of the Process and Challenges

Roesner (2001), articulates the dilemma of the evaluation process when he states that, "the choice of quantitative versus qualitative measures in research evaluation is a false one, especially for evaluators isolated from the real world." He elaborates by indicating that choices should be tempered by professional judgement emanating from experience and that it may be, "easier to develop quantitative 'indicators' of performance than to work out what the program has to accomplish" (Roesner, 2001).

Research organizations need to focus on their core strategic advantages and organizational mission to shape their evaluation process. For example, KISR's key source of competitive advantage lies in its human resource development program, its contribution to the nation's socioeconomic development, its organizational flexibility, and its scientific and technological merit. Hence, a viable recommendation may be to provide a system that is based on internal, quantitative and objective measures, and aims to include both measures of the process and measures of the output of R&D. Such a system will relate performance to the driving variables controlled by R&D managers.

A comprehensive objective involves not only providing a framework for the evaluation of R&D from a non-financial perspective,

but also for defining a general framework which allows for an objective appraisal of R&D value creation, as it is linked to the processes of technological innovation.

Indicators should have an aggregate focus, relying on data from publications, patents and R&D expenditures. A measure of an organization's technology capacity and strategy may also be integrated into this indicator, and will thus produce useful benefits for policy makers, managers and researchers.

Composite indicators that compare countries' abilities to acquire and use traditional and new technologies, and hence, participate in the global economy, are also quite useful because they focus on a program's technology achievement and the level of investment in technology creation, diffusion and intensity.

Thulstrup (2001) and Baglieri et al. (2001) suggest the utilization of a combination of strategies to evaluate the specific components of the overall R&D process. The cost-based approach is the recommended tool of evaluation at the early stages of the research process, i.e., the generation phase, when the technical feasibility of the research is fuzzy; financial methods that are indicative of the expected profitability of the research are more useful for R&D activities that are in the transition phase toward the end of the research work when the probability of technical success is high.

Output goals include research results, human resource development and training, and ultimately, building of research capacity, which is often neglected; monitoring instead concentrates on inputs (which include buildings, equipment, and travel) and adherence to a time schedule for expenditures. Output goals are often only mentioned in the project document, being rarely used to evaluate the project itself.

꧁ Chapter Six ꧂

Evaluating Investment in Scientific Research Using Feasibility Studies and Cost Benefit Analyses

Financial and Economic Analysis

The economic analysis of projects is similar in form to financial analysis: both appraise the profit of an investment. The concept of financial profit is not the same as that of economic profit. The financial analysis of a project estimates the profit accruing to the project-operating entity or to the project participants, whereas economic analysis measures the effect of the project on the national economy. For a project to be economically viable, it must be financially sustainable, as well as economically efficient. If a project is not financially sustainable, economic benefits will not be realized. Financial analysis and economic analysis are, therefore, two sides of the same coin, and are thus complementary to each other. Both types of analysis are conducted in monetary terms; the major difference lies in the definitions of costs and benefits. In financial analysis, all expenditures incurred under the project and revenues resulting from it are taken into account. This form of analysis is necessary to assess the degree to which a project will generate revenues sufficient to meet its financial obligations, assess the incentives for producers, and ensure that demand or output forecasts on which the economic analysis is based are consistent with financial charges or available budget resources.

Economic analysis attempts to assess the overall impact of a project in improving the economic welfare of the citizens of the country concerned. It assesses a project in the context of the national economy, rather than for the project participants or the project entity that

implements the project. Economic analysis differs from financial analysis in terms of both:

- The breadth of the identification and evaluation of inputs and outputs.
- The measures of costs and benefits.

Economic analysis includes all members of society, and measures the project's positive and negative impacts in terms of willingness to pay for units of increased consumption, and to accept compensation for foregone units of consumption. Willingness to pay and willingness to accept compensation are used rather than prices actually paid or received because many of a project's impacts that are to be included in the economic analysis either will be non-marketed, for example, biodiversity preservation, or incompletely marketed, such as, water supply and sanitation benefits. Thus, some form of non-market value must be estimated. Many project impacts that are marketed will be bought and sold in markets where prices are distorted by various government interventions, by macro-economic policies, or by imperfect competition. Shadow prices may be used to estimate the willingness to pay and willingness to accept compensation values in the face of these market absences and market imperfections.

The benefits from a project constitute the extent to which the project contributes to increasing the value of the consumption available to society.

What are the basic and most important and common economic indicators?

- Internal rate of return (IRR)
- Payback period
- Break even point (BEP)

What are the basic and most important and common financial indicators?

- Current ratio
- Debt to equity
- Rate of Return on Investment (RORI)
- Net Present Value NPV Note: NPV is a value.

Identification and quantification of costs and benefits

There are four basic steps to analyzing the economic viability of a project:

- Identification of the economic costs and benefits.
- Quantification of the costs and benefits.
- Quantification of the value of the costs and benefits.
- Comparison of the costs and benefits.

The first two steps can generally be undertaken together. However, there will be some types of benefits, and sometimes costs, that cannot be quantified and valued for inclusion in the cost-benefit comparison. They will simply be stated alongside the results of the economic analysis. To identify project costs and benefits, the situation without the project should be compared with the situation with the project. The without-project situation is not the same as the before-project situation. The without-project situation can sometimes be represented by the present levels of productivity of the relevant resources. However, present levels of productivity would frequently change without the project, and this should be taken into account in defining the without-project situation.

The comparison of without-project and with-project situations is the heart of the estimation of net benefits for any project. While, in practice, appraisal reports provide a clear specification of the with-project

situation, they frequently provide little analysis of the without-project situation. The without-project situation is often inaccurately described [6].

Important distinctions in identifying project benefits and costs are between no incremental and incremental outputs, and between incremental and no incremental inputs. The distinction is important because no incremental and incremental effects are valued in different ways. It should, therefore, be used in the identification and quantification of project effects. No incremental outputs are project outputs that substitute for existing production. For example, a new hydropower plant may in part substitute for existing coal-fired generation. Incremental outputs are project outputs that expand supply to meet new demands, for example, the growing demand for electricity as generation and transmission costs decline.

A feasibility study is a controlled process for identifying problems and opportunities; determining objectives; describing current situations and successful outcomes; and assessing the range of costs and benefits associated with several alternatives for solving a problem. In other words, it is the initial justification needed to determine, or discover, if a project is do-able. In short, does the project warrant further investment in time, money and further study, or is it a non-starter?

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[6]- The without-project situation is that the situation would prevail without the project. It is not the implementation of the next-best project alternative, unless there is clear evidence to suggest that this is most likely to be the case. Similarly, the without-project situation is not the delayed implementation of the same project. In most cases, it is a modification of the existing circumstances. In comparing project alternatives, the without-project situation follows the same scenario, and provides the basis for comparing with-project net benefit flows for each project alternative. Most projects or sub-projects are regarded as marginal in the sense that they would not have any effect upon the prices of project inputs and outputs, and would not have a substantial impact on the government budget or the exchange rate. Additional factors would have to be taken into account in the case of large projects that would have a considerable impact on the regional, national, or international economy.

Identification and Quantification of Costs

While several types of costs need to be included in the economic analysis of a project, some types of financial costs must be excluded. The underlying principle is that project costs comprise the difference in costs between the without and with project situations, that is, the extra use of resources necessary to achieve the corresponding benefits.

System Costs

If a project is part of a larger system, then the expected benefits may not accrue unless matching investments are made. For example, power generation benefits rely on investments in transmission and distribution. A highway section may need investment in preceding sections or interchanges for the expected traffic flow and cost savings to occur. The project's boundaries must include the total system investment required to achieve the benefits and, correspondingly, the total system benefits. If the total system of investments is viable, then the project can also be considered viable.

Sunk Costs

A project may require the use of facilities already in existence. The costs of such facilities are sunk costs and should not be included in the project cost, provided their use in the project involves no opportunity cost. Put another way, sunk costs are those costs that would exist both with and without the project, and thus, are not additional costs for achieving project benefits. Many projects will be implemented through existing enterprises or agencies. The project analysis must separate the additional agency costs from the whole cost structure of the enterprise. At the same time, the project may succeed only if the enterprise itself is

stable. An analysis of the whole enterprise, including sunk costs together with the project, is necessary to determine financial sustainability.

Contingencies

Contingency allowances, which are determined by engineering and financial considerations, also have implications for economic appraisal. When estimating project costs for financial planning purposes, both physical and price contingencies are included. Since economic returns are measured in constant prices, general price contingencies should be excluded from the economic cost of the project. Physical contingencies represent the monetary value of additional real resources that may be required beyond the base cost to complete the project and should be treated as part of the economic cost of a project.

Working Capital

Working capital is commonly defined in financial analysis as net current assets, consisting of inventories, including goods in process net receivables marketable securities, bank balances and cash in hand.

A certain amount of working capital is normally required to run project facilities created by investment in fixed assets. For purposes of economic analysis, only inventories that constitute real claims on the nation's resources should be included in a project’s economic costs. Other items of working capital reflect loan receipts and repayment flows, and are not included in the economic cost.

Depreciation

The financial accounts of agencies implementing a project will include provision for depreciation and amortization on the basis of

prevailing accounting practice. However, for project economic analysis, the stream of real investment required to realize and maintain project benefits is included in the resource flow, together with a residual value for those assets at the time they are released from project use at the end of the project's life. The stream of investment assets includes initial investment and replacements during the project's life. This stream of expenditures generally will not coincide exactly with the time profile of depreciation and amortization in the financial accounts.

External Costs

In many projects, effects go beyond the financial analysis from the point of view of the implementing agency. These external effects may include significant costs that must be accounted for in an economic analysis from the national perspective. For example, increased air and water pollution from an industrial plant may be measured and its effects on surrounding entities estimated. In some cases, it may be helpful to internalize these external costs by including all relevant effects and investments in the project statement, including, in this case, pollution control, equipment, costs and effects.

Treatment of Working Capital

Stocks of materials and spares need to be available to facilitate the smooth functioning of a project's operations. Stocks of final goods may be held before their sale and distribution. Other materials and inputs may be tied up in partially completed production outputs. For some projects, particularly in agro-processing or industry, such working capital stocks need to be allowed for in the estimates of initial project investments and

included in the project statement of financial and economic prices. They are separate from the annual project costs for operations and maintenance.

Break Even Analysis (BEP)

Breakeven analysis looks at the effects on probability of changes in a project's cost, volume of output and selling price. It is used to determine the lowest production and/ or sales levels at which the project can operate without impairing its viability. The technique is also useful for profit planning and decisions on pricing and production capacity. The analyst segregates the project's costs into fixed elements, which are independent of the volume of production, and variable elements, which change with the volume of production. The analyst estimates the volume of output at which sale revenues equal total cost (i.e., the BEP). The analyst also compares breakeven sales with the project's production levels until it reaches a steady state, to determine whether profits or losses will be incurred in the early years. Expected output during those years can be expressed as a percentage. The use of breakeven analysis as a tool is recommended, but its limitations should be noted:

- Fixed costs are not indefinitely constant. They may become variable at a certain volume.
- It is not always easy to divide costs neatly into fixed and variable components.
- Selling prices may change when a large volume of sales is made.
- Production and sales volumes may not always be equal.
- Multi-product output may add complications to break-even analysis.

Assumptions that are made in breakeven analysis include the following:

- Costs can be reasonably divided into fixed and variable components.
- All cost-volume-profit relationships are linear.
- Sales prices will not change in volume.

Once prices and the variable cost per unit, have been identified, the BEP can be determined where sales revenues (i.e., total revenue) equal the total fixed and variable costs (i.e., total cost). These allow measurement of the BEP as a specific level of sales volume. Hence, to calculate the BEP, the analyst needs to have the following data available:

- Unit estimated Selling Price .($/unit)……. Market Study.
- Variable Cost. ($/unit)…… …….. .. Cost Analysis.
- Fixed Cost. ($/year)…….. .. Cost Analysis.
- So breakeven point indicates the production level where total revenue equals total cost as follow:

Total revenue (TR) = Total cost (TC)

= Fixed Cost + Variable Cost

Production Level * Unit Price = Fixed Cost + Variable Cost

Assuming that the production level which must be produced to equilibrate the total cost with total revenues is X and variable cost equals the production level, multiplied by the variable cost per unit; then, the break-even point (BEP) in units is.

$$X = \frac{\text{Fixed Cost}}{\text{Unit Selling Price} - \text{Unit Variable Cost}}$$

The break even point in (KD) using the X Production level is:

$$\frac{X}{Y = \text{Annual Fixed Cost} - \text{Variable Cost}}$$

Cost Benefit Analysis

Cost-benefit analysis is a widely used analytical technique in project development and assessment. It allows one to make a quantitative assessment of the expected results of a project (expressed as financial, economic or social returns on investment) and to compare the effectiveness of the investment with alternative uses of the resources. In cost-benefit analysis, a valuation in money terms is placed on the financial, economic and social costs and benefits of a project. Increasingly, cost-benefit analysis also includes and quantifies environmental variables.

The main purpose of cost-benefit analysis is to look at project performance over time. To do this, the concept of discounting cash flows is used. Such as discounting requires estimating future costs and benefits, and calculating them at their present-day values. Cost-benefit analysis is also useful because it allows one to investigate and compare the possible effects of project alternatives and changes in assumptions. The results of cost-benefit analysis are expressed as values calculated for a series of pre-defined parameters. The values calculated help project proposers or funders to decide how to use natural and monetary resources. The key parameters of cost-benefit analysis are cash flow, NPV, IRR, and cost-benefit ratio (CBR).

Key Parameters for Cost-Benefit Analysis

(1) Cash flow information on a project's costs and benefits are used to calculate the cash flow, i.e. how much money is spent or accumulated during each year of a project. Simply, cash flow is the difference between the money coming in and going out of the project. Cash flow (CF) in any one year is the sum of the investment, operations and maintenance costs minus the revenue received.

(2) Cumulative Cash Flow is the running total of annual cash flows added together.

(3) Net Present Value (NPV) is a method for calculating the present-day value of all capital costs and net savings throughout the life of the project. NPV involves estimating all future cash flows generated by the project, and then adjusting them with the appropriate discount rate. This also allows comparison of the income generated by the project with other investment alternatives. If the NPV of the project is negative (i.e., the present value of cash inflows to be generated is less than the initial capital cost), the project will probably be rejected. If the NPV is positive, the project may begin to be seen as an attractive endeavor. An investment is good if it creates value for its owners. In a nutshell, the Net Present Value (NPV) is the difference between the present value of the inflows and the present value of the outflows of an investment. NPV is a measure of how much value is created or added today by undertaking an investment. The process of estimating a NPV is called discounted cash flow (DCF) valuation (Fig. 6.1).

Net Present Value

- Formula:

$$NPV\,(asset) = \frac{CF1}{(1+R)} + \frac{CF1}{(1+R)^2} + \frac{CF1}{(1+R)^3} + \frac{CFn}{(1+R)^n} - I / O$$

- I/O is the initial outlay.
- Profitability is measured, taking into account time value of money and risk; it is often referred to as the extra money available to the owners.
- It assumes that cash flows are reinvested at R.

Figure. 6.1. NPV

(4) Internal Rate of Return (IRR) - is the discount rate at which the NPV of a project is zero. It represents the rate of interest that money would have to earn elsewhere to be a better investment. If the IRR is higher than the capital cost, then the project is worth undertaking, from a financial perspective. The higher the IRR, the better the project. The internal rate of return IRR is the discount rate that equates the present value of a project's inflows and its cost. In a nutshell, it is the rate at which a project financially breaks even, i.e., the rate that results in a NPV of zero. An investment is acceptable if the IRR exceeds its required return.

Internal Rate of Return

- The IRR is the minimum return (yield) on a real investment so that the present value of the future cash flows is equal to the I/O - it is the (breakeven) rate that sets the NPV at zero.

$$I/O = \frac{CF1}{(1+IRR)} + \frac{CF1}{(1+IRR)^2} + \frac{CF1}{(1+IRR)^3} + \ldots \frac{CF\,n\quad 6}{(1+IRR)^n}$$

- IRR = Additional cents on the money invested.
- It assumes that cash flows are reinvested at IRR.
- It might include several (irrelevant) solutions.
- It might provide contradictory results with the NPV.

Figure. 6.2. IRR

If an investment's cash flows are not conventional, i.e., an outflow followed by a series of inflows, it is possible to compute more than one mathematically correct IRR. Also, if two investments, X and Y, are mutually exclusive, then taking one means forgoing investment in the other.

Although problems can arise with the use of the IRR technique, it is widely used because it is closely related to NPV, and it is easy to understand and communicate. All else being equal, an investment that is acceptable under the NPV rule will be also be acceptable under the IRR rule.

(5) Cost-Benefit (CBR) - The CBR is the ratio that exists between the discounted total benefits and costs. This enables a distinction to be made between projects having a high NPV simply because they are large scale, and projects having a genuinely high ROR.

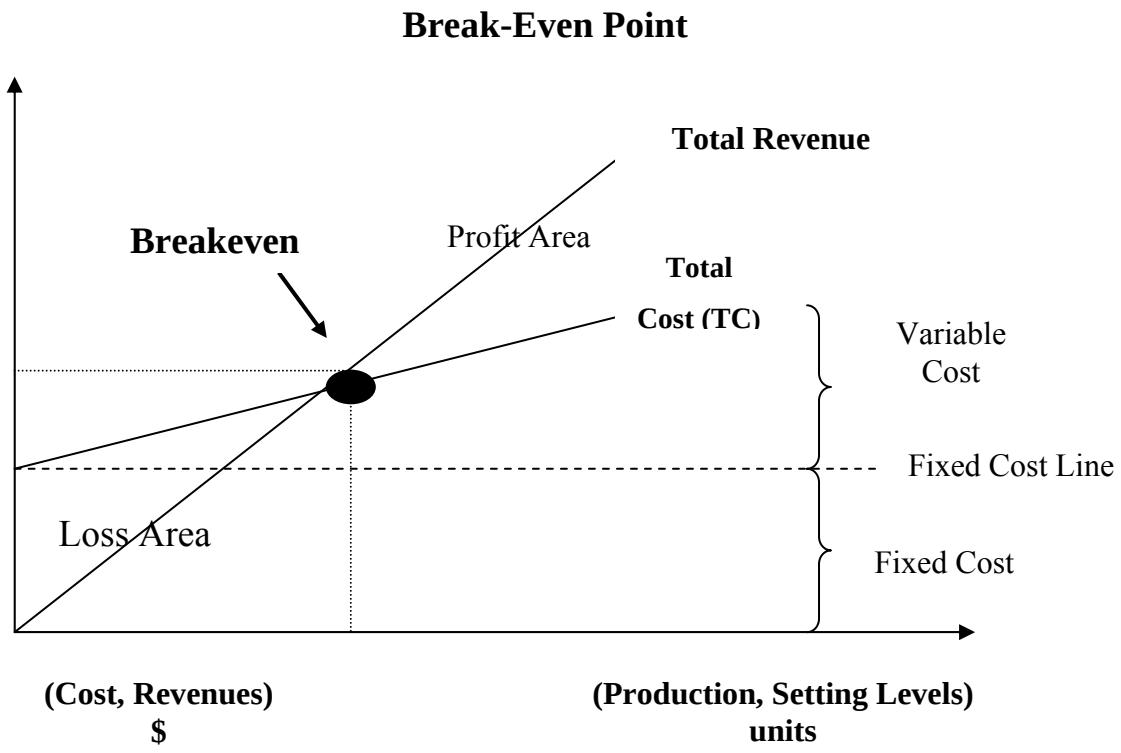

Figure. 6.3. BEP

The Payback Rule

The PBP is defined as the number of years necessary to recoup the original outlay for a project. According to this rule, an investment is acceptable if its calculated PBP is less than some pre-specified number of years. The PBP rule can be thought of as a kind of breakeven measure because it is the length of time needed for a project to break even in an accounting (although not necessarily an economic) sense (Fig. 6.3.).

Reliance on the Payback Rule is Likely to Bias the Decision-Maker Towards Shorter-Term Investments

The payback rule has a number of positive features:

- It is easy to use and, therefore, useful for projects that are too small to warrant more detailed analysis.
- It is biased toward liquidity.
- It (crudely) adjusts for the increased riskiness of later project cash flows.

Chapter Seven

Financing Scientific Research in Kuwait

R&D is vital today to support the needs of economic growth and sustained development all over the world. R&D activities differ from one country to another, according to the level of scientific and technological progress and prowess that a nation has achieved. In developing countries or less developed countries, the transfer and application of technology is challenged by many factors that include the relatively low level of educational attainment and poor scientific infrastructure in these countries, as well as the lack of realization and awareness of the benefits and returns from R&D, albeit, long-term, to their economies. Moreover, there are no basic or clear policies for scientific R&D in developing countries.

Although all of the aspects of development have not been completed, development is an on-going process in developing countries like Kuwait. It is vital to revise and evaluate policy to refine the inputs and outputs of R&D activities. As the financing process is one of the fundamental pillars for scientific research, and many institutions in Kuwait participate in the support of applied research projects, we shall shed light on these organizations and their valuable efforts.

Systems of Financing Scientific Research

There are numerous theories and methods regarding the financing of scientific research. However, regarding applied research, there are two predominant systems (Moravcsik, 1982).

(1) Dribbling Down Egalitarian System

In the dribbling down egalitarian system, allocations to scientific research are distributed equally between scientific research centers and institutions or scientific programs. Each institution then divides its allocations and resources equally among its research activities, researchers or research branches.

This methodology has the following advantages:

- It easy to manage and organize.
- It avoids sensitivity among research programmers.
- There is need to determine detailed policies for research programs.
- It elevates the spirit of competition among research programs.

However, the main disadvantages of this system are that it neither concentrates on disseminating the spirit of creativity and innovation among researchers, nor delineates a detailed policy of scientific research.

(2) Reaching Down Merit System

In this system, determinations and evaluation of the various research programs and their importance to the country are made, and thus, allocations are distributed according to the degree of importance and the efficiency of the researchers. This system has the following advantages:

- Flexibility of administration and appreciation of scientific creativity, as it is considered an important measurement and indicator for acquiring more funding and allocations.

- Ability to adopt research that is new and may have a positive return for the State.
- Capacity for comparing research programs with recent counterparts and predecessors.

This system necessitates the availability of a number of factors:

- The designing and configuration of a set of objective indicators and parameters to measure and evaluate the impact on research projects and researchers' productivity. In addition, the system fails to give junior researchers a fair chance to perform, as it focuses mostly on senior researchers, and hence, does not make way to new and emerging research.

Public and Government Allocations

Public and government funding of R&D can take three forms:

- Allocation of a specific percentage of a country’s GDP to finance research, with the actual amounts differing from one year to another, and for various agencies, units, institutes and scientific centers.
- Contracts with centers and units of research in the production and service sectors.
- International aid and allowances, especially for low-income developing countries.

Independent Sources of Funding for Scientific Research in Kuwait

Few sources of funding for scientific research exist in Kuwait. Reliance is predominantly on government allocations made to the institutions that conduct R&D, channeled through organizations like KFAS. The Kuwait Foundation for the Advancement of Sciences, KFAS derives a good portion of its funds, which it then channels to various R&D organizations to fund their R&D activities, after a standardized and objective refereeing and selection process, from miniscule private corporate levies that currently do not supersede 1% of their annual profits. Over the years, this percentage has dwindled from slightly over 2% to less than 1%. In addition, the contributing private sector corporations, firms and companies reap the benefits of their compulsory investments or contributions by determining and communicating to KFAS the specific fields of research where R&D is required. Inadvertently, corporations communicate their challenges and the problems for which they wish to develop solutions, and KFAS responds through its internal organization by matching the corporations with the most suitable problem solvers, or researchers, who approach the organization display their expertise and ability to address the organization's challenges by submitting the required research proposal, which is subjected to a high-caliber refereeing process.

As mentioned in the previous chapters, the relatively small size of the industrial or manufacturing sector (excluding the oil industry) in Kuwait has impacted the role of R&D and its development in Kuwait in a number of ways:

- R&D is relegated to the university and specialized research institutes and agencies, first and foremost among which is the Kuwait Institute

for Scientific Research KISR, because their research outputs do not have an industrial or market (end-user) application for the most part, and the spillover effect of R&D is, hence, unattainable. This disconnection or lack of a research-market network minimizes the role of R&D and its benefits.

- The private sector is reluctant to venture and independently invest in R&D deemed to be too financially risky by corporate standards. This has left financing of R&D a predominantly government-led endeavor.
- A relaxed culture of imported solutions has predominated over the years.

Organizations Funding Scientific R&D in Kuwait

The independent institutions that fund scientific research in Kuwait are as follows:

- Kuwait Foundation for the Advancement of Sciences, KFAS.
- The Environment Public Authority, EPA.
- The Public Authority for Waqf (Philanthropic) Funds.
- The Public Authority for Assessment of Compensation for Damages Resulting from the Iraqi Aggression, PAAC.
- The Public Authority for Applied Education and Training, PAAET.
- The Public Authority for Industry, PAI.

(1) Kuwait Foundation for the Advancement of Sciences (KFAS)

KFAS was established by Amiri decree in 1976, for public benefit. It is a non-profit organization, similar to the sector-specific organizations outlined below. It is managed by an administrative council that is led by the head of state. In addition to corporate levies that go into the KFAS pool of funds (a small share of their net profits that is ultimately re-invested in the form of research to generate efficiency gains and benefits back to the investors; i.e., the corporations themselves), the Foundation also accepts gifts from other persons and institutes.

KFAS supports researchers in a number of ways:

- Supporting scientific research requirements by facilitating capital and non-capital research needs.
- Providing training and educational scholarships and encouraging participation in scientific conferences.
- Providing financial awards and other forms of recognition to outstanding researchers in their respective fields.

The aims of KFAS are as follows:

- Support applied and basic research, especially in the fields of biology, engineering, food, sociology and economics.
- Encourage research investment developing experimental aspects related to Kuwait is economy.
- Provide rewards to support intellectual and scientific initiative in Kuwait and other Arab countries.

- Train Kuwaiti nationals through opportunities to study abroad, and to attend training courses and conferences.
- Support and encourage multi-faceted programs between Kuwaiti institutions and multinationals.
- Support the spirit of cooperation and collaboration across generations of Kuwaiti nationals.

KFAS support research in the basic sciences to develop a high level of awareness and skill in the natural sciences focusing particularly on the skill of deduction and the application of research results to benefit the community. More specifically the aims are as follows:

- To acquire knowledge that deals with future technological applications, and developments which lead to improvements in the country's social and political welfare.
- To have input in the formulation of curricula that shape the main content in the basic sciences.

The reward system favors special projects that aim to:

- Develop high-caliber, specialized scientists and researchers.
- Support Kuwait University, especially its research-intensive, graduate programs.
- Foster cooperation between scientists in Kuwait and scientists all over the world, and encourage the exchange of ideas and research results.

(2) The Environment Public Authority (EPA)

According to the objectives that are determined by the rules of the original Environment Protection Council, now the Environment Public Authority (EPA), the EPA's central objective is to conserve, preserve and manage Kuwait's natural resources and its environment. The research office follows the general manger directly. Technical and applied environmental reviews and searches are conducted, after a thorough outline of the methodology and content is refined and applied.

The EPA, established in 1995, years after integrated efforts in 1980 resulted in a decree that enforced the basic rules for the protection of the environment in Kuwait, officially proclaims that; "minimizing the risks arising from industrial and economic development and the resultant degradation of the environment has been a matter of great concern to Kuwait for a number of years. Various institutions have come together for the preservation of the environment." (EPA, 2007). The EPA further proclaims officially that its main responsibilities, as delineated in its mission and objectives, are to:

- "Prepare and apply public policy for the protection of the environment and to develop strategies and action plans to achieve sustainable development.
- Prepare and supervise the execution of the complete action plan relating to the protection of the environment.
- Control the activities, procedures and practices concerned with the protection of the environment.
- Identify pollutants and specify environmental criteria and standards and prepare regulation and systems for the protection of the environment.

- Prepare and participate in directing and supporting environmental research and studies.
- Identify the problems resulting from environmental pollution and deterioration with the assistance of state agencies.
- Study and review the ratification or accession of the regional or international conventions related to environmental protection.
- Prepare an integral action plan for training citizens on the ways and means of environmental protection.
- Study environmental reports submitted to it relating to the environmental conditions of the country, (EPA, 2007).

The EPA has recently unveiled a ten-year strategy designed to address specific concerns about the atmosphere, water resources, environmental preservation, education and awareness, as well as industry and power. The strategy includes laws particularly targeting the protection, conservation and maintenance of many buildings, heritage and numerous archaeological sites in Kuwait. Old mosques and historical buildings are being renovated. In fact, this strategy provides a mechanism and a safe environmental framework for protecting and preserving components of the urban environment and infrastructure that are an integral part of the country's history and culture.

(3) The Public Authority for '*Waqf*' (Philanthropic Islamic) Funds

Kuwait has known and practiced 'waqf' (charitable, philanthropic, fund-raising for a righteous cause, justified on the basis of Islamic religious reasoning) for a long time. People used to extend payments out of goodwill and righteousness, by allocating funds or other forms of

capital or land, in addition to a small portion of their profits to benefit numerous charitable purposes, that include mosques, school water supplies and other philanthropic projects. However, with time, waqf's became secondary in public life.

The general administration of *waqf* in Kuwait has attempted to revive the interest in *waqf* activity in a number of ways:

- By attracting people to make new entitlements and contributions in religious service and homeland building.
- By investing the profits generated from *waqf* activities in projects with high social profits.
- By developing investments according to the most sophisticated and efficient methods of finance.
- By boosting public participation and spreading philanthropic work among citizens.

As a result, the following organized and active 'Waqf' funds have been developed:

- Fund for Scientific Development and Education.
- Fund for Health Care.
- Fund for Culture.
- Fund for the Environment.
- Fund for Childhood & Family Affairs.
- Fund for Islamic Definition and Studies.
- Fund for Psychological Support.

(4) The Public Authority for Assessment of Compensation for Damages Resulting from the Iraqi Aggression (PAAC)

In 1991, the Public Authority for Assessment of Compensation for Damages resulting from the Iraqi Aggression, better known as PAAC, was established as the authority responsible for all dimensions of the United Nations Compensation Commission (UNCC) claims process in Kuwait. PAAC is an independent governmental body, subordinate only to the Cabinet. This organization was created in the midst of grave efforts to reconstruct the nation and its functionality. PAAC's primary role is to assess damages suffered as a result of the Iraqi invasion of Kuwait. The organizational structure of PAAC includes technical and judicial committees that complementarily facilitate this process.

PAAC studies and active research have investigated numerous and diverse dimensions related to repercussions of the Iraqi aggression against Kuwait. Studies have ranged from studying the impact of reparation funds on the Kuwaiti economy (through a macro-economic, sectorial and total assessments of Kuwait's economic loss due to the invasion), to studies on environmental degradation, mental illness and a host of other diseases. Assessing the impact of the Iraqi invasion on Kuwait has extensive dimensions covering all facets of life, which are investigated by PAAC, in terms of their short and long-term impacts.

(5) The Public Authority for Applied Education and Training (PAAET)

PAAET was established in 1982, with the objective of developing and upgrading the required vocational and technically sophisticated manpower in numerous applied fields in order to meet the challenges

presented by the industrial and economic development of the country. The strategy for applied education and training in Kuwait was originally laid down along with the initiation of oil exploration, production and export in Kuwait in the 1950s, when the State began to establish training centers and organize programs to prepare manpower to staff the oil industry. After building the fundamental structure of the educational system, the Ministry of Education established a number of specialized institutions to meet the increasing demand for skilled manpower. The other ministries established their own training centers and institutes as well. The State found it essential to establish a central body to supervise and coordinate the activities of these numerous institutes (PAAET, 2007).

The central goal of PAAET is to develop the national technical manpower required to meet the applied and vocational human resource needs of the country, through education and training. The applied education sector includes four colleges: the College of Basic Education, the College of Business Studies, the College of Technological Studies and the College of Health Sciences. In addition to the four colleges, there are a number of training institutes such as; the Telecommunications and Navigation Institute, the Electricity and Water Institute and the Industrial Training Institute. PAAET funds research related to its applied fields, focusing on the applied dimension of studies. It is a very active and dynamic contributor to R&D activities in Kuwait.

(6) The Public Authority for Industry (PAI)

The Public Authority for Industry (PAI) was established in 1996, with the fundamental goal of developing and augmenting the industrial sector in Kuwait, primarily in order to diversify the country's sources of income, and in light of its growing importance in the process of sustained

development. The PAI funds dynamic and strategic research that aims to develop a forward-looking vision and approach toward industry and its development in Kuwait. It works with small and medium-sized businesses to identify their challenges and develop innovative solutions. Although industrial activity in Kuwait has grown, partly as a result of these efforts and the incentives that are embedded for industrialists in Kuwait, still the industrial sector composes less than 10% of the country's real GDP.

The PAI supervises and monitors the progression and activity of the industrial sector in tandem with the goals of national development, which officially include the following:

- To encourage the development and protection of local industries.
- To expand the industrial and workshop production base.
- To diversify the sources of national income.
- To support, develop and encourage the production of required strategic commodities for food and national security.
- To enhance industrial awareness among citizens.
- To coordinate between existing and proposed industries within the GCC countries, in particular, and the Arab countries, in general, to achieve cooperation and harmful competition.
- To strengthen industrial cooperation with different countries and international organizations.
- To provide necessary experience and information for local industrial development, (PAI, 2007).

Chapter Eight

Recommendations and Outlook

Throughout the chapters of this book, a scientific panorama has been presented of the economic dimension of R&D, from a variety of diverse angles that include: planning and prioritizing R&D, reviewing the methodological approaches to financing and evaluating scientific research, and evaluating R&D investments using cost-benefit analyses. It has been shown that R&D returns to investment in developed countries have clear costs and benefits due to their outputs, which are directly impact either short-term or long-term market performances. The expensive and extensive manufacturing, productive and industrial base and cycle in the USA, Japan and Europe, account for and effectively utilize R&D outputs; hence, the famous and notorious military industrial complex of the USA, in addition to the huge research consortiums that often combine the golden tripod, i.e., university (the research arm), industry (the company or corporations and firms) and the government, if it is present in this particular formula. In the occident, R&D is a tradable commodity. There are many cases where research on a specific medication showed but the slightest promise, for example curing diabetes or a specific type of cancer; yet, resulted in boosting the price of that particular company's stock. The mere specter of such news can create huge financial gains for these corporations, which have research budgets that at times rival the budgets of many small nations. However, this is the case in these countries because they actually engender the product or the service, whereas, the developing part of the world, including Kuwait, is a mere consumer. Thus, in order to approach the required level of

efficiency and investment efficacy required, our long-term goal should be first to develop our productive and manufacturing bases and our markets.

A more research-specific recommendation is the dire need to place greater emphasis on forging regional research networks and consortiums, in order to conduct collaborative research, the numerous benefits of which include reduced costs, reduced duplicity, greater research exposure and higher quality output. In addition, the invaluable element of merging and comparing various philosophies, outlooks and perspectives to challenges that the region shares will result from such collaboration. National boundaries should be set aside, and replaced by conceptual and global perspectives.

In the meantime, the economics of R&D in the developing world will have to be satisfied with being less than profitable in order to encourage and target more research. The argument to justify governmental intervention in R&D is deeply grounded in the position that the social ROR from R&D is higher than the private ROR. Contrary to the perspectives of classical economists, in fact, specifically those expounded by the father of classical economics, Adam Smith himself, (1723-90) who articulated in his famous *Wealth of Nations*, that this is a case in point where the 'invisible hand' will not direct market forces to distribute the required resources for R&D to occur effectively. That being the case, private initiative will always under-invest due to the limited and unappealing long-term financial returns that are expected, if any, due to the long gestation of research projects.

Several factors explain the disparity between social and private returns. First and foremost is the issue of externalities, mainly in the form of spillovers, in which the R&D performer is not able to fully reap the benefits and returns associated with his R&D activity. Hence, profitability will never be an incentive to increase investment in R&D,

especially considering the large fixed costs inherent in R&D investments. What is unique about R&D is the nature of spillovers that occur that may reduce industrial costs in the long run, but since they result in inappropriate returns to the R&D performer and in turn, incorrect pricing of R&D and the resulting social costs, the R&D performer does not find that it is profitable or effective to venture into further investments. Hence, it is often argued, and quite rightfully, that the social ROR from R&D is higher than the private ROR due either to the presence of spillovers or due to information asymmetries. The spillover effect of R&D is probably the most socially rewarding aspect of R&D investment, however, because of this, the R&D performer is not able to fully appropriate benefits associated with his activity, which in turn, acts as a disincentive to invest in R&D. Additionally, the lack of symmetric information between R&D performer and financier limits financing of R&D projects and also hinder the R&D firm's ability to achieve licensing gains from trade.

The spillover effect is a very important aspect of R&D; it is often an unforeseen or unplanned way of getting more by paying less. The R&D spillover effect is a special feature or externality of R&D activities and it occurs when a firm or an R&D performer augments its R&D capital stock by simply profiting from the R&D outputs, results and stock that another firm has already achieved. Spillovers are an inevitable externality or, byproducts of R&D. Spillovers are inevitable due to the inherent nature of R&D to eventually disseminate; that being the objective of research in the first place. Spillovers arise due to the inability of R&D performers to exclude others from freely, or at a lower cost, obtaining the benefits of new R&D capital. However, the mere presence of this phenomenon is evidence that R&D performers cannot completely appropriate the returns associated with its R&D capital. In

other words, the existence of spillovers leads to the imperfect appropriability of returns to R&D capital, which acts as a disincentive to make R&D investments. Hence, the larger the spillover, the lower will the incentives be to undertake R&D investments. Spillovers treat the technical knowledge that is 'spilled over', as a public good, similar to a radio signal, that is ‘costlessly’ shared with all non-contributors, thus affecting the rate and structure of capital accumulation.

Having analyzed the status of R&D activities in Kuwait, we envisage recommendations related to the practice of R&D in Kuwait, and specifically related to the economic dimension of R&D, in order to foster an improved R&D outlook for the nation.

Recommendations Related to the Economic Dimension of R&D in Kuwait

- Stress the importance and practice of an entrepreneurial vision and a long-term investment vision.
- Develop national human resources by investing heavily at a very young age and focusing on developing curricula that foster scientific creativity, imagination and innovation.
- Achieve demographic balance and stability.
- Develop a society with a high level of social and scientific awareness and consciousness. National development requires investment, albeit at a cost. Benefits are long term.
- Diversify national income.
- Develop the private sector.
- Internalize and globalize technology and its utility.

- Implement strategic planning.
- Form a specialized higher council for S&T to administer and orchestrate all scientific units and authorities regardless of their dispersion networking the various R&D performers in Kuwait, common challenges are likely to arise across the different sectors, requiring common resources and solutions, and hence, economizing expenditure and realizing synergy, i.e., planning is economizing.
- Allocate a small percentage of the GDP for R&D annually.
- Develop innovative and entrepreneurial (market-focused) ways to fund R&D.
- Expound a clear S&T policy by promulgating laws and decrees that foster the specific tactical administration of R&D activities.
- Establish and maintain R&D institutions with quality infrastructure, capital and human resources.
- Institutionalize scientific innovation.
- Encourage technological incubators to foster a tangible sense of applied R&D.
- Disseminate public awareness to ensure that the benefits of R&D are communicated effectively to the society and impact the country's socio-economic development, these being the ultimate expression of successful and feasible R&D.
- Ensure the participation and partnership of all sectors of the economy in designing R&D policies and strategies, in order to develop plans that suit their needs, and hence, are more capable of developing solutions for their problems.

- Network and partner with the private sector by providing governmental incentives and by matching their corporate needs with what R&D can offer to improve their business and market performance. Involvement of the Chamber of Commerce would be advantageous.
- Organize venture capital.

In the final analysis, basing R&D investment decisions, and research project evaluation and selection processes on cost-benefit logic, presented in detail earlier, would be a fallacy for this part of the world at this point in time. In fact, it would only short-change long-term interests to strictly relegate research choices to the purely economic dimension. Investments would continue to be high, because we are still in the formative stages of the R&D process, and we are at a greater disadvantage because our markets are limited, and even worse, we already have ample suppliers from the developed world, which makes us very comfortable consumers. Thus, strategic, tactical planning and indicators must be put to good use to target and focus on research ideas and projects that will feed into the larger strategic plan. The R&D outlook will be positive once our capital and intellectual resources are synergized effectively under an optimistic, yet achievable, strategic plan.

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Appendix

GLOSSARY

ACCOUNT. A term used by sales people for a customer. It is most often used for a business customer. Also see Active, Prospective, Suspect and Inactive Accounts.

ACCOUNTS RECEIVABLE (DEBTORS) The amounts that are owed the business from the sale of goods and services.

ACCOUNTS PAYABLE (CREDITORS) The amounts owed to suppliers of goods and services to the business.

ACCRUAL BASIS ACCOUNTING. The accounting method that is used by most larger businesses. It records the sale, expense or other event when it actually occurs, rather when the cash changes hands. It is not the actual receipt of payment that is important but the right to receive it. The sales or costs are said to be 'accrued'.

ACTIVE ACCOUNT. A customer who is actively buying from your business.

ADVERTIZING. The act of drawing attention to a business, product or service through the use of an outside medium. The medium by its very nature reveals that the business, product or service has paid for this exposure.

AMORTIZATION. The gradual payment of a debt through a schedule of payments, or the process of writing off an intangible asset against expenses, over the period of its useful economic life.

BACKWARD INTEGRATION. When a company owns or controls the suppliers of goods or services to its primary operation.

BAD BEBT. Debts to the business that are either unpaid or likely to be unpaid.

BALANCE SHEET. Describes the assets, liabilities and net worth of the company on some fixed day.

BREAK-EVEN ANALYSIS. The method of determining the exact point at which the business neither makes a loss nor makes a profit. It is usually calculated as a point where sales have grown at a greater rate than costs, and thus the lines cross.

BUSINESS PLAN. A written document that describes the business, its objectives, strategies, operating plans, business environment, marketing strategies together with a financial forecast. It is the road map for managing the business.

BUSINESS RECEIPTS. Sales and/or receipts from the operations of the business.

BUSINESS SITUATION ANALYSIS. This clarifies the current position of the business. It includes an analysis of the strengths and weaknesses, and an overview of the business, position in the business or industrial environment.

CAPITAL. The general term for funds invested in the business.

CAPITAL PLAN or CAPITAL BUDGET. A plan that describes the purchase of capital items such as equipment, buildings and plants.

CASH FLOW or CASH PROJECTION. The systematic charting of the sources and uses of cash in a business.

CASH BASIS ACCOUNTING. An accounting system where the sale or expense is recorded only when the transfer of cash occurs. It is primarily used by small businesses that operate with cash.

CLOSE. A selling term used to denote the customers commitment to purchasing the product or service.

COLLATERAL. Personal assets that a borrower assigns to the lender to help ensure debt payment. If the loan is in default, then the lender may assume possession of the asset.

COMPANY THRUST. Describes the overall direction of the company.

COMPETITIVE ANALYSIS. An analysis of competitors that compares them to one's own business. It includes a comparison of market share, target customers and markets, products, service, promotion and advertising, and financial strengths.

COMPETITOR. A business that markets similar products or services to another's actual and potential customers.

CONVERTIBLE LOAN. A loan to a business whereby the lender has the option of either receiving repayment of the loan or taking part ownership of the business at some future date.

COSTS AND ESTIMATED EARNINGS IN EXCESS OF BILLINGS The difference between the total costs and recognized estimated earnings to date, and the total billings to date.

COST OF SALES. Also known as variable cost or cost of goods sold. Cost directly associated with making or providing the goods or services. These usually include raw material costs, utility costs, labor, and variable overhead.

CRITICAL ISSUES. Issues that are currently unresolved or unpredictable or outside one's control that could impact the performance of the business.

CURRENT ASSETS. Cash and property, in one's possession that can be liquidated quickly.

CURRENT LIABILITIES. Debts that must be met within a relatively short time period, such as short term loans, accounts payable, accrued taxes etc.

CYCLICALITY. Rise and fall of the business in relationship to economic ups and downs.

DEBT FINANCING. The use of borrowed money to finance a business. The loan is to be repaid and the lender does not receive part ownership of the business.

DEMOGRAPHICS. Profiling customers by; age, sex, family size, income, occupation, education, religion, culture and / or social class.

DEPRECIATION. The process of writing off the decrease in value of a fixed asset over its useful life against expenses.

DISTRIBUTOR. A business that buys products or services from a manufacturer or other source and resells them to smaller customers.

DISTRIBUTION. The act of selling products or services to a wide range of customers and geographic locations.

DIRECT LABOR. Labor costs directly associated with production or contract work.

DOUBLE ENTRY BOOKKEEPING. A bookkeeping method in which transactions are first entered in a journal or long and then posted to ledger accounts to show income, expenses, assets, liabilities and net worth. In the double entry system, each account has a left side for debits and a right side for credits.

EQUITY. The value of assets minus liabilities for the business.

QUALITY FINANCING. The securing of funds from an investor, in which the investor becomes part owner of the business in exchange for the investment.

EXIT. The ability of an investor to exit a venture by turning his investment and profit into cash or some other easily traded instrument.

FISCAL YEAR. The definition of the year for a company for financial, accounting, planning and tax purposes. Usually 12 calendar months.

FIXED ASSET. Equipment, plant, buildings and machinery used in the normal course of business.

FIXED EXPENSES or FIXED COSTS. Business costs that essentially do not vary when sales volume changes.

FORWARD INTEGRATION. When a company owns or controls the marketing or distribution of its products or services.

GENERAL AND ADMINISTRATIVE EXPENSES. Expenses that are directly associated with the management of the business and not with either making or selling the product or service.

GEOGRAPHIC MARKET FACTORS. The geographic service area for the business and the different natural of population clusters.

GOODWILL. An intangible asset related to the customers' positive attitude or perception of the business. It often includes a complete listing of customers.

GROSS PROFIT MARGIN. Gross profit divided by sales or revenues and multiplied by 100, i.e. a percentage.

HORIZONTAL INTEGRATION. When a company owns or controls many like businesses in the same industry.

INCOME (PROFIT & LOSS) STATEMENT. A standard accounting method for determining the profit and loss of a business over some time period, usually a year, quarter or month.

INDUSTRY LIFE CYCLE. The almost universal cycle of events that virtually every industry undergoes from the embryonic stage, through growth, maturity and finally slow retrenchment.

INTANGIBLE ASSET. Assets that are associated with goodwill, trademarks, patents, copyrights, formulas, franchises, brands, customer lists, mailing lists, etc.

INVENTORY (STOCK). Items that have been produced or purchased and will ultimately be sold. These may include raw material stocks, work in progress stocks and finished goods stocks.

INVESTOR. A person or entity that holds equity ownership or shares in a business.

JOINT VENTURE. Partnership (often short-term) between two or more businesses to accomplish some task or business.

LEVERAGE. The use of credit or borrowing to increase one's ability to buy a business or to conduct business. Being highly leveraged means that a business has a high debt level.

LIQUIDITY. The degree of cash that can be generated in a short time from the sale of assets.

MAJOR ACCOUNT. A term used by sales persons to denote an active customer who represents significant sales, often being listed in the top ten accounts.

MARKET. A clearly defined group of people, area, or group of things that can be classified together as having some common need or other common trait.

MARKETING. The act of identifying customers, determining their needs, attracting them to the business, satisfying their needs, and selling to and servicing them.

MARKETING MIX. The array of marketing methods used to sell to customers.

MARKET NICHE. A clearly defined segment of the market or group of customers that the business has chosen to target.

MARKET RESEARCH. The act of uncovering information on a particular market. Such information typically relates to the type of customers in that market, their buying habits, unfilled needs, product or service information, or many other factors.

MARKET SEGMENTS. The logical breakdown and grouping of customers or customer needs or products.

MARKET SHARE. The sales of a business divided by the total sales of the industry for the local, national or international market, usually expressed as a percentage.

MARKETING PLAN. A written document that describes the future marketing activities of a business. It includes objectives, strategies, market research and marketing strategies.

MARKETING STRATEGIES. The route or method for achieving marketing objectives.

MARGIN. Also refer to gross profit margin. Usually defined as profit divided by sales multiplied by 100, i.e., a percentage.

MISSION STATEMENT. This qualitative statement describes the overall vision, direction and commitments of the business in the marketplace, from the perspective of senior management. It is a long-term view, without quantitative data.

NET SALES. Total sales less discounts, returned goods and freight costs.

NET WORTH. The value of the assets minus the liabilities for the business.

OBJECTIVE or GOAL. A target to be reached some time in the future.

OPERATING EXPENSES. Those expenses of a business that are not directly associated with the making or provision of goods or services. They usually include administrative, technical and sales expenses.

OPERATIONAL PLAN. A detailed action plan used to implement strategies and reach goals. It usually covers near-term actions, up to three years in the future.

OPERATIONS. The daily, weekly or monthly activities of a business.

PRIVATE COMPANY. A company that may or may not issue shares. If it does issue shares, they are not traded on the stock market.

PRIVATE PLACEMENT (PRIVATE OFFERING). The offering of shares in a company to a limited number of contacts. Not generally promoted to the public. The shares are not publicly traded.

PRODUCT MANAGEMENT. The management of a product or product line by an individual or team.

PRODUCT MIX. The grouping of products into categories so that changes in their relative amounts can be compared.

PRO FORMA. A projection of future (often financial) activity.

PSYCHOGRAPHICS. Usually profiles of customers' by life style, personality, purchase occasions, benefits sought, usage rate, and / or loyalty.

PUBLIC COMPANY. A company for which stock is publicly traded on one of the stock markets or over the counter.

PUBLIC OFFERING. When a business enters the financial market to secure capital financing by offering company shares or stock to the public.

QUICK RATIO. Current assets minus stock, divided by the current debt.

RATIO. A number, calculated by dividing or multiplying one entry of a financial statement by another. A relation comparing one factor with another.

RETAINED EARNINGS. The net profit after taxes that is retained in the business as working capital.

RETURN ON EQUITY. Profit on the total equity in the company.

RETURN ON GROSS OPERATING ASSETS (RGOA). Profit on the total assets used in the business.

RETURN ON INVESTMENT (ROI). Profit on the invested capital.

RETURN ON SALES. Profit on net sales.

REVENUE. Used interchangeably with sales. Often used by businesses that do not physically sell anything, such as rental companies, contracting businesses etc.

SEASONALITY. Annual rises and falls of a business according to seasonal demand variances.

SINGLE-ENTRY BOOKKEEPING. A system of recording business transactions in which single entries are made into a daily, weekly or monthly log.

STRATEGY. The basic method used to reach a goal.

STRATEGIC ROLE. A term used by larger, more mature businesses that identifies the type, charter and operating boundaries of the business.

STRATEGIC OPPORTUNITY. An opportunity or goal that will change the basic thrust or tactical plans of the business.

TARGET MARKETS. A market or group of customers that is the focus of marketing efforts.

TERRITORY. A geographic area that defines the selling activity of a sales person or business.

VARIABLE COST. Costs that vary directly with sales. These usually include raw material costs, utility costs, labor, sales commissions, etc.

VARIANCES. An accounting term referring to the difference between what was forecast and what actually happened.

VERTICAL DISINTEGRATION. The breaking up of manufacturing and supply operations into smaller discrete units that are completely separate entities and are often independently owned.

VISION. The ultimate destination of a business from the perspective of senior management. A picture of the business as it is envisaged in 5 to 19 years time.

WORKING CAPITAL. Current assets less current liabilities.

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