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Evka Razvigorova, Editor

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FORWARD

Technological development and its management is a topic which is interesting for all countries, companies, and for many researchers and business people. The aspects of study and interests are very diverse and it is difficult to unite them under one particular subject.

The dynamics of management along the life cycle of technology is a subject which can be analyzed from different aspects with different tools and methods. In times of discontinuity and rapid change, with new technologies available worldwide and globalized, management should be regarded as a main factor for future technological development. How to increase organizational flexibility through different phases of the technological life cycle is important for companies and countries. How to create favorable conditions for developing and implementing new technologies and how to facilitate acceptance of these technologies both inside and outside organizations are objectives and problems of managers worldwide, despite economic systems and the stage of economic development of the country. In search of right answers for these challenges and problems, young scientists from YSSP 86 at IIASA have explored different subjects closely related with the management of technology. Four collaborative papers are presented here which emerged from the young scientists' work during the summer and through which different interests of countries are presented. It is impossible to unite them under one title or connect them by the content and results of the study, but being closely related to a phenomenon called technological development and exploring different aspects of its management, we consider them related and we are trying to present them in one series.

The first study presented is entitled "Management of Technological Development and the Technological Life Cycle (Case of Bulgaria)" by Julia Djarova. Bulgaria has been undertaking a major study in the field of technological development. The study aims to describe and analyze difficulties in accelerating technological development and to make recommendations for improvements in the country's management system. The study described here has been developed in close collaboration with the MTL research team and is based on the methodology developed for the study. In Bulgaria, extensive research is already underway, using the methodology described in the paper. The main objectives of the author were to develop methodology which will connect Bulgarian study with the IIASA MTL study. The overlapping relations between stages of the process of developing a technology and technological life cycle are used to create a special framework for the analysis.

"Critical Success Factors in Strategic Control Systems" by Margarita Kaisheva is a general concept of strategic management in the TES/MTL activity, based on the hypothesis that strategic management is a management cycle, consisting of different functional activities including strategic control. Kaisheva advocates the importance of strategic control, outlines its main objectives as a sub-system of strategic management of technological development and develops the idea of using critical success factors as criteria and standards in the process of strategic control. The place of strategic control in helping organizations to develop alternatives for its strategy and achieve a high social adaptiveness is considered one of the main features of strategic control. The study suggested and its methodological approach are very promising and challenging; empirical proof will be important in increasing the value of the concept. The concept of strategic control and the use of critical success factors in it could be very useful for management of technology on a company level and will give possibility to create an integrated control system for fulfilling technological strategy of a company.

"Planning and Acquisition of New Technologies" by Gerhard Plasonig is a study which considers the problem of technological development for a small country with predominantly small and medium scale enterprises. Mostly a matter of technological transfer. The paper attempts to make recommendations to Austrian firms, suggesting a systematic procedure for implementing new technologies in an environment of technological availability. The procedure is only hypothesized and empirical proofs will be necessary to make this a real working concept. Two interesting ideas are discussed throughout the paper. The planning process should be carefully organized and prepared within the company. Management should not be separated from the technological process.

The fourth study, by Andrei Sterlin, is entitled "Environmental Analysis for Strategic Technological Planning." Many new technical systems, even in civilian economic sectors, present potential dangers to the environment, and the consequences of their possible disfunction are very difficult to foresee. Strategic technological decisions are thus being made in industrial organizations under conditions of high uncertainty. The soundness of strategic decision would be enhanced by a systemized analysis of business and the technological and social environment of an enterprise. Suitable methodologies for integrating environmental analysis in the field of technological development still appear to be lacking. This paper attempts to address this issue.

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MANAGEMENT OF TECHNOLOGICAL DEVELOPMENT AND THE TECHNOLOGICAL LIFE CYCLE
(Case of Bulgaria)

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YSSP 1986

INTRODUCTION

Excellent innovation management involves many requirements, mainly connected with understanding the innovation processes and the ability of adopting the management system to them. The more so as modern management aims to influence these processes in order to accelerate some of them. This result cannot be achieved without further examining improved managerial approaches to the system of leadership. That is why management is becoming more practically oriented in two directions: creating its own rules based on investigations of the innovation processes and gearing its efforts to put these rules into practice in an appropriate way.

In connection with the above and speaking in particular about technological development, especially the management of technological innovations, several questions arise:

* What does management have to know about technological development in order to accelerate it in the right direction?

* How can existing theories about technological development and innovations help to improve the management system?

To answer these questions, new technologies in Bulgaria will be studied in two aspects:

1. To meet the goal for understanding the real innovation process, the development of certain technologies will be examined from the idea to its commercialization (or practical implementation).

2. Organizational problems; planning system; material, financial, and personnel support problems; etc. will be investigated in order to find a reasonable basis for improving the existing management system.

The principal goal of the study is to define the main characteristics of the technological innovation process and to identify the problems in accelerating technological development in different branches of industry. This should be achieved based on an analysis of the advantages and disadvantages of management strategy during the phases of the technological life cycle. Further objectives of the study are as follows:

* To analyze the main weaknesses of the management system connected with technological innovations and development;

* To define the basic socio-economic factors influencing acceleration and to increase efficiency through the development and implementation of new technologies;

* To analyze the opportunities for improving the management of the technological innovation process.

GENERAL CONCEPTION OF THE STUDY

The investigation intends to identify the main features of the innovation process connected with new technologies, to analyze problems in technological development, to define the objective laws governing this development, and to propose recommendations for improving the management system of technology.

It is expedient to pursue the investigation in two directions:

1) Analysis of technology dynamics and assessment of technologies

2) Analysis and evaluation of the management of the technological innovation process.

The analysis of technology dynamics, based mainly on a study of the life cycle, has great practical significance and forms a basis for management decision-making. The possibilities of studying the technological life cycle as a concept and its use as an analytical tool can lead to identifying some of the laws for the development of technologies, of products produced by these technologies, and of organizations using these technologies.

The life cycle is considered a source for:

* Retrospective information on technology development in time, technology substitutions and effectiveness, history of technology families and generations, comparisons between different technologies used for the same purposes or between identical technologies at different levels of development.

* Long-term information on the expected future effectiveness of the technologies, their potential abilities, their competitiveness, etc.

To achieve the desired goals of the study of technology dynamics and to explore every possibility given by the life cycle, it is necessary to reach an understanding of the technological life cycle and the criteria both to build it and to differentiate the phases. It must be taken into account that the life cycle can be quantified through different measures in time as well as by different economic indicators. The changes of these indicators help us to distinguish the different phases. The indicators for building the life cycle will be chosen in accordance with the goals of the study. If the aim is to compare technological development on organizational, country, and international levels, common comparative dimensions (for instance, market share, production volume, sales volume) must be established. Such indicators as profit, investment, production costs, profitability, etc. are of great importance in using the life cycle as a tool to estimate technology effectiveness. Use of these indicators is connected with the problems of gathering data as well as with processing it.

Through the life cycle, the influence of used raw materials as well as the rest of resources connected with the development and implementation of the technology can be defined. In this respect, an analysis of the costs incurred during each life cycle phase can be obtained.

In summary, the first approach to analyze the technological innovation process from idea-generation to introduction and commercialization is based on the life cycle as defined by economic indicators. The main task of this approach is to distinguish several phases in technology dynamics based on the changing behavior of the economic indicators. To differentiate the most essential process features at a certain point in time as well as the crucial elements of each phase, it is necessary to define the technological life cycle by functional activities and determine specific stages in technological development

The development of an innovation is inherently an inter-functional process. Successful new technologies require close cooperation among the functional areas of R&D, manufacturing and marketing, under the guidance of the management system. Fast technological development, as well as ambitions to accelerate the innovation process as a whole make it more and more difficult to distinguish clearly the distribution of the functions through the life cycle phases. That is why defining the technological life cycle based only on the behavior of economic indicators is not sufficient to understand clearly the dynamics of technology.

It is expedient to clarify the stages of technological development by analyzing the special performance of the different functional activities observed through the transformation of the idea to prototype, final product, and then to its production and sale.

The main functional activities could be research, discovery, invention, design, development, production planning, market planning, tooling preparation, manufacturing, market start, production, sale, and transfer. Each one of the described activities has its own characteristics, as well as its own significance to and influence on technological development.

Research, discoveries, and inventions are the starting points of the idea-generation phase and conceptualization. The content of these activities defines to a great extent the kind of technology as well as the organizational strategy in respect of this technological development. The innovation can be initiated by discovery, invention or as the result of research and can lead to basic innovations or to imitations and to the appearance of new or improved technologies.

During these stages, the first signal of the coming technology substitution is observed. The appearance of research, discovery, and invention activities in the maturity life cycle phase can indicate organizational strategy concerning the transition from maturity to the decline phase. Either a strategy for technology substitution with a principal new technology or a strategy directed towards modifying old technology by improving certain functional characteristics and performances can be followed at this point.

During these technological development stages, such activities as adoption, refinement, and generalization can be distinguished. Adoption is aimed to make the idea more reliable and efficient enough to be employed for some useful purpose. Refinement includes a succession of improvements and changes of the first idea "adoption" in order to turn it into a simpler, cheaper, as well as more efficient alternative. Generalization increases the practical application of the idea and creates possibilities to diversify it. The activities of adoption, refinement, and generalization should exist throughout the entire technological development process.

The activities of the design stage are oriented to take the abstract idea and embody it into a material form. Design is a natural continuation of the invention stage, sometimes including invention activities based on new or revised purposes of a given idea.

Development is connected with "all those steps of analysis, experiment, building and testing which are necessary to bring a discovery, invention or preliminary design to the point where it is efficient, reliable and economic enough for ordinary production and use."[1]

The stages of production planning, tooling and market preparation have a key function to fit an already-developed idea to the specific features of the organization-producer, to production requirements, to consumer needs as well as to ensure the successful manufacturing/marketing start-up. Production and marketing planning may be connected with the changes inside the organization as well as with new forms of cooperation and contracts outside the organization. In these stages, the investment policy concerning production and sale, and cost/benefit analysis is being established.

Taking into account and comparing both sets of the technology's dynamic characteristics (life cycle phases and tech-

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[1]Archer, L. Bruce. (1971) Technological Innovation -- A Methodology, London: Science Policy Foundation.

nological development stages) to each other will allow further analysis of the relationships between them (Fig. 1).

Due to this overlap of the technological life cycle phases and the stages of technological development, it becomes important to study the following questions:

* What is the duration of each stage of development of different technologies under different circumstances?

* Is there a gap between the stages or do they overlap each other?

* How do the stages of technological development compare in time with the phases of the technological life cycle? In our opinion, the technological life cycle mainly describes how technology changes in connection with its purpose of satisfying certain needs (market, production, organizational). The comparison will give an opportunity to identify the coordination among the functional activities in the organization as related to the achievement of this purpose.

* During which stages does the technology effectiveness, as measured by economic indicators, increase or decrease?

* Which activity in each stage of technological development is a key one for successfully fulfilling the stage where the efforts of the organization are directed?

* Which stages of technological development are the key ones? Is their importance defined by their influence on the technological effectiveness, their duration, their frequency of appearance, the investments involved, and/or their labor force requirements?

To observe the points where the stages appear during the life cycle phases and the frequency of these appearances, Matrix 1 demonstrates the significance of the stages corresponding to their impact on the effectiveness of technological development as well as to the included costs.

The comparison of stages and phases can provide information for further analysis and decisions as well as about the most appropriate time for their fulfillment. Of great importance are the following questions:

* How to manage the stages in order to increase the technology effectiveness during the life cycle?

* What kind of investment policy in each stage should an organization have, especially in the field of R&D? What is the structure of investments and how should it change with respect to the management of the life cycle?

* Which activities should emphasize a strategy of transitions from one to another stage?

This part of the study connected with the assessment of technologies is aimed to identify the state of the technology used in the organization compared on one hand to similar technologies (used for the same purposes and/or from the technology generation) and on the other hand to the same technologies used by other producers inside and outside the country. In order to fulfil such an assessment, it is expedient to answer the following questions:

* What is the level of the technology used, and how are the effectiveness and technological lifetime estimated from the point of view of its basic characteristics?

* Is is a basic technology in terms of its significance for the economic and technological development of this and other branches of industry, influencing to a great extent the variety and quality of products?

* What is the technology innovation rate?

* What are the boundary potentialities of the technology used, and what is the present position in the technological life cycle?

* What is the level of automation and computerization of the technology?

* How is R&D structured and organized, and what are the scientific and applied levels of the R&D projects as well as their duration and time of implementation?

One of the main prerequisites for fulfilling an estimation of the technology is to find the appropriate basis for comparison. This will allow defining the technology's position among the other technologies-competitors as well as identifying the potentialities for the technological development. Creating the list of indicators to use for the technology estimation must take into account the requirement for comparison between the indicators described by different technologies.

MATRIX 1: DISTRIBUTION OF THE STAGES OF TECHNOLOGICAL DEVELOPMENT AMONG THE TECHNOLOGICAL LIFE CYCLE PHASES

STAGES OF TECH. DEV.[a]	TECHNOLOGICAL LIFE CYCLE PHASES			
	INTRO.	GROWTH	MATURITY	DECLINE
RESEARCH				
Discovery				
Invention				
Preliminary Research				
Feasibility Study				
DESIGN				
Design Development				
Prototype Development				
Trading Study				
DEVELOPMENT				
Technology Development				
Production Development				
PLANNING				
Production Planning				
Marketing Planning				
Organizational Planning				
MANUFACTURING/ MARKETING START-UP				
Tooling Preparation				
Marketing Preparation				
PRODUCTION				
SALE				

The analysis and evaluation of managing the technological innovation process should be connected mainly with the organization's strategic management. Several reasons exist which deter-

[a]A more detailed description of the development stages is given in L. Bruce Archer's Technological Innovation -- A Methodology.

mine the innovation strategic management as a cornerstone in leading the organization develop successfully.

Modern organizations need strategic management and their own developmental strategy more than ever. This is determined by the characteristics of today's organizational activities. This is as important when the organization is "fighting" competitors in order to increase market share as when it is trying to make the most effective decision to meet social needs and to achieve economic and social goals and interests. The most considerable reasons which make strategic management important for a small open economy such as Bulgaria are the following:

* Necessity of increasing products' competitive abilities

* Necessity of expanding the possibilities for fast and appropriate reactions to the increased need for products and services and to the increased demands for improved quality

* Objective development of the centralized state planning system and the implementation of an economical approach under circumstances of the organizations' active role

The significance and role of innovation strategy as a factor for developing the overall organizational strategy are defined by the fact that strategic decisions for managing the innovation process have the most powerful influence on future organizational development. Strategic decisions in the field of technical and technological development are closely connected with other decisions. On one hand, the problem of production realization and structure and that of investment policy set certain requirements to the development of new products and technologies. On the other hand, achievements in the field of technology provoke changes in organizational strategy with respect to the market, production structure, and capital investment. A typical feature of innovation processes is their wide influence on all factors and conditions of the organization's activities. Innovation is not only a tool in answer to existing demands in products, technologies, and services, but at the same time, an effective way to activate new needs through new and improved technical devices, products, and technologies. In the relationship between technological development and the market, the role of the innovation process manifests itself in creating effective and efficient production and technological structures, as well as in undertaking appropriate investment policies.

The innovation strategy is a condition (even a precondition) for the development of production, organizational, and managerial strategies. In the complex system of relationships determining the creation of overall strategy, innovation strategy plays an important role. The innovation strategy discloses and defines the impact of scientific and technical achievements on production technologies and structure, and the organization of the production process, as well as on the development of the management system: methods, structure, style.

Speaking about the innovation strategic management, the first problem arising today is connected with technological innovations and development. For each country and organization, it is necessary to answer the question: "Where are we now in technological development, where do we go, which is the most appropriate way to select based on existing social and economic conditions and the future goals and needs of the society as a whole as well as of the organization itself?"

The transition from a product to a technological approach in strategic management is carried out everywhere. The most important point in defining the strategy of technological development as a key one in an overall strategy is to have management bring the technologies to the fore, to prevent any imbalance in the production and organizational structure, the labor resources, the human factor in production, and especially to avoid creating premises for negative consequences. At the same time, the feedback from the technology's economic, organizational, and managerial environments must be taken into account. It is unreasonable to consider and study technological innovations separately from their environment, which defines the driving forces of the technological development. On the other hand, while creating the technological innovation strategy, the necessity arises to take into account the expected changes in the environment, to coordinate decisions with respect to the long-term technological directions; the problems of science and structure of R&D; the economic, production, organizational, and social goals and needs. That is why technological development cannot be analyzed and forecasted separately from:

* Produced products and structure of product groups on the production list, in connection with production technologies;

* Market segmentation and market share of products and technologies;

* Directions of scientific development, R&D structure, technological development, ratio between fundamental and applied research;

* Organizational forms and methods for accelerating, effectively implementing, operating, and developing the most high-priority technologies;

* Supply the technologies with a highly skilled, educated, and creative labor force;

* Economic conditions defined mainly by planning systems, economic methods and tools used to manage technological development. In particular, the important points here are the finance-credit system and the way in which the requirements of modern technological development are reflected in it, ways to stimulate and motivate both people and organizations, prices and price formation, salary levels, etc.

INDICATORS FOR THE STUDY OF TECHNOLOGICAL DEVELOPMENT AND ITS MANAGEMENT

On the basis of the study's general conception suggested and described above, two main practical problems arise connected with the fulfillment of the study. The first is what kind of methodology indicators must be chosen in order to analyze the technology dynamics and to estimate technologies as well as to analyze and evaluate the management of the technological innovation process. The second problem is connected with the choice of appropriate techniques and methods for discovering the problems of technological development and of the management of the innovation process as well as with the structuring and summarizing of empirical information in such a way both to describe the problems and to identify the similarities and differences between the different technologies studied.

One of the main leading points to define the indicators for the study of the technological innovation process and its management is to follow the structure and content of the organization's technological strategy. The strategy of technological development consists of the following:

* analysis and estimation of the present and future status of the technologies;
* management decisions for the selection of technologies;
* activities for putting the strategic decisions into practice.

The development of the technological strategy is a process based on complex and systematic approaches. They require the close connection of the decisions corresponding to the long-term technological directions on one hand and to problems of R&D, economic, production, and social tasks of the organization on the other. That is why the technological strategy cannot be defined separately from:

* requirements and expected lifetimes of the produced products and the structure of the different product groups in the production list;
* duration, opportunities and market segmentation of the production realization;
* R&D directions of future development, the structure of the scientific and technological research in order to maintain a certain level of knowledge and skills corresponding to the respective technologies;
* the analysis of the state-of-the-art and duration for effective support of the technologies with highly productive and modern techniques and raw materials;

* organizational forms and methods for accelerating and effective implementation, functioning and developing of the technologies;

* technology supported by a highly educated labor force, with well developed technological thinking.

In summary, strategic management should define the appropriate environment for the desired technological development.

In connection with the above, the methodology indicators are structured in four main groups. The first group (A) is aimed to describe the technology dynamics and, together with indicators from the second group (B), identify the features of the technological process to discover the main problems inside the technology and the production conditions in the organization. The other two group (C & D) are aimed to identify the problems caused by the technology environment defined as the economic, organizational and managerial conditions for the technological development of the given organizations. Structuring the indicators in such a way allows structuring the future analysis in the following directions:

* Analysis of the conditions describing the technology's environment and at the same time the strategic activities observed over the technological life cycle and over the technology development stages (Matrix 2):

MATRIX 2

TECH. DEVELOPMENT STAGES:

TECHNOLOGICAL ENVIRONMENT CONDITIONS:	Phase I	Phase II	Phase III	Phase IV
	Research	Design	Production	Sale
Technical Production Market Conditions				
Organizational Conditions				
Managerial and Social Conditions				

* Analysis of the technology effectiveness over the stages of the technological development (Matrix 3):

MATRIX 3

TECHNOLOGICAL EFFECTIVENESS	TECH. DEVELOPMENT STAGES Research/Design/Development/Planning/Manuf./Production/Sale Marketing
Profitability	
Costs	
Export effectiveness	
R&D effectiveness	Rate of increasing or decreasing of the effectiveness indicators
Funds distribution	
Labor force effectiveness	
Effectiveness of use of raw materials	

* Analysis of the technology performance, lifetime, and effectiveness (Fig. 2; Matrix 4):

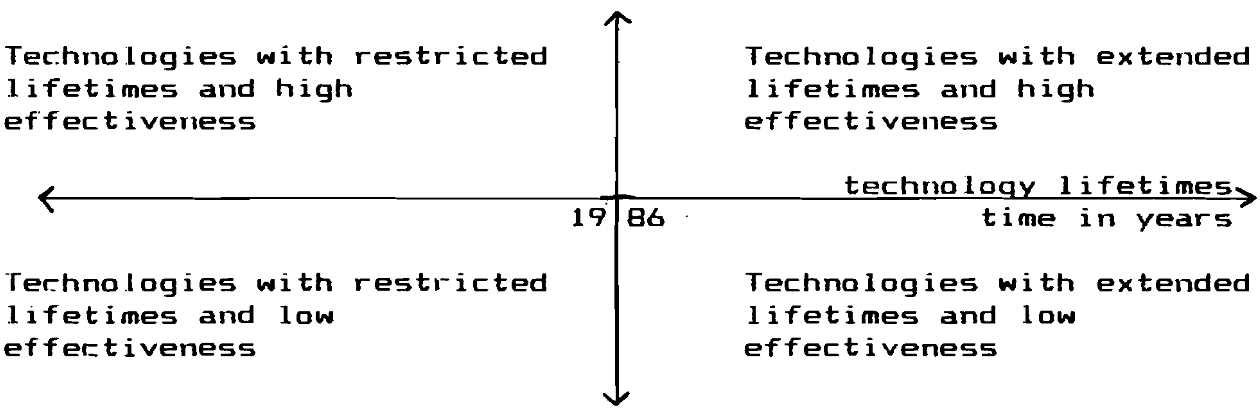

FIG. 2

MATRIX 4

TECHNOLOGY PERFORMANCE*	TECHNOLOGY LIFE CYCLE PHASES Phase I	Phase II	Phase III	Phase IV
Significance				
Source of the New Tech.				
Relative Position of the Tech.				

* Follow the characteristics from Group B.

INDICATORS OF THE STUDY

GROUP A. Indicators for Analyzing Technology Dynamics[3]

Characteristics	Description	Output
1. Technological Life Cycle[3]	* Defined by several indicators: production volume, sales volume, market share, profit investments, production costs, etc. from the time of technology introduction through to production.	* Technology life cycle phases divided into 4: introduction, growth, maturity and recession.
2. Technological Development Stages	* Defined by differentiating functions in time; research, discovery, invention, design, development, prototype, trading, production development, production & marketing planning, tooling & market preparation, production, sale.	* Duration of each stage * Gap between stages * Overlap of stages
3. Life Cycle of Products, produced by the studied technology[3]	* Defined by several indicators: production volume, sales volume, market share, profit, investments, production costs, etc.	* Product life cycle phases.

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[3]The technological and product life cycles are built using the same indicators, but the technological life cycle is based on the indicators' performance of entire production, starting with the point of introduction until the present time, independently of product changes during this period. The product life cycle is connected only with the concrete product or group of products.

4. Technology Innovativeness	* Distinguishing the principal changes in technology used and improvements (modifications) of technology. Identification of two kinds of technology innovativeness: 1) new technologies defined based on the changed principle of functioning; 2) improved technologies defined based on improved technology functions.	* Number of technology substitutions * % of principal new technologies and of improved technologies * Rate of technology innovativeness = time/-(new technologies + improved technology)
5. Product Innovativeness & Quality	* Examining two kinds of products, produced by studied technology: 1) new products and 2) improved products.	* % of new products/-year * % of new products/-technology's lifetime * % of improved products/year * % of improved products/technology's lifetime * Number of different products produced by the technology
	* Levels of product estimated as a deviation from standard.	* % bad quality products * Deviation from standard, scrap
6. Innovativeness of Technological Equipment	* Examining the age and changes in used technological equipment.	* Average age of equipment * % of equipment changes/technology's lifetime.
7. Changes in Raw Materials Used	* Examining changes with respect to quality, quantity and type of raw materials used in a given technological process.	* % of changes/technology's lifetime.
8. Dependence between Technological and Product Innovativeness	* Defining the time gap between implementation of new technology and production of new products which occur as a result of implemented new technology.	* Time period * % of new products arising from new technology or products.
9. Characteristics of R&D	* Amount of R&D investment * R&D investment by type of innovation * Source of R&D investment.	* % of total investment * % of R&D investment for new product or process & improved product or process.

GROUP B. Features of the Technological Process

1. Type of Technologies Used		* Name, kind.
2. Significance of the Technology for the Organization	* Defined based on production volume using this technology as well as the volume of the outcome (profit) from these products.	* % of producing these products/total production volume * % of outcome/total outcome.
3. Source of the New Technology	* External, internal * License, know-how, R&D activities, etc.	* % of external/internal sources * % of different sources.
4. Type of Manufacturing		* Single prices/small lots/large lots/mass production.
5. Technology Competitiveness	* Defined compared to other technologies on the market.	* Market share, dynamics * Export of technology & of produced products.
6. Automation Level of Production	* Using CAD, CAM, CIM, robots.	* Ratio between CAD, CAM, CIM, robots used.
7. Relative Position of the Technology		* Rate of patents.

GROUP C. Characteristics of Managing the Technological Innovation Process

GROUP C.1. Organizational Characteristics

1. Type & Changes in Production Units		* Hierarchy * Organizational levels.
2. Type of Organizational Structure	* Identifying present & past organizational structures used during the different stages of technology development.	* Succession of different organizational structures: informal, centralized & functional, decentralized, life-staff and project groups (product or process), matrix of teams.
3. Special Structural Forms	* Special structural forms connected with technological innovations.	* Description of these special structural forms.

4. Scale of Management	* Defined by the number of administrative staff.	* Administrative staff as a % of total employees.
5. Organization of Strategic Management with respect to Technological Development	* Estimating the independence of strategic management from external decisions * Role of strategic decisions compared to operational ones	* Body creating strategic policy * Ratio between external & internal strategic decisions * Segregation of strategic & operational management
	* Distribution of responsibilities in the strategic decision-making process.	* % of full-time employees * Description of the organization, affiliation * Description of correspondence between organizational levels & strategic decisions.
6. Environmental Analysis Units		* Organization, affiliation, % of full-time employees.
7. Consultants		* Background, affiliation, number, role (driving force, teaching).
8. Committees/Teams		* Subject, organization, affiliation.

GROUP C.2. Managerial and Social Characteristics

1. Methods for Planning	* Examining the methods for planning mainly in 3 directions: 1) connected with the sources of the methods defined as external & internal sources; 2) connected with the flexibility of used methods, depending on circumstances; 3) level of standardized methods for planning.	* Ratio between external & internal planning procedures * Level of flexibility of the used methods * Ratio between standardized & non-standardized.

2. Methods for Strategic Planning	* Description of the kinds of methods used for strategic planning distinguished as traditional forecasting & planning methods (i.e. extrapolating past trends into the future, optimizational methods, etc.), new methods of scenarios & portfolios (experts' scenarios, morphological approaches, cross-impact approaches, others).	* Description of the methods.
3. Methods for Decision-Making	* Based on managerial intuition & experience, standard procedures available, quantitative & qualitative approaches, modern procedures.	* Description of the methods used.
4. Information Data Base Support for Management Decision-Making	* Distribution & description of the data base available among the functional organizational levels * Examining the level of automation of the information data base used.	* % of the information data base distribution by organizational functions * % of the information data base computerized * Description of the main kinds of information data base used, particularly new information technologies.
5. Orientation of Managerial Functions	* Description of management functions from the point of view of their orientation to: marketing problems (i.e. market planning & organization; supply, service, quality problems; market segmentation); production problems (i.e. planning & organization, production design, production documentation, tooling, pre-production prototypes, raw materials planning, relations with suppliers, production R&D, structure of labor force, control); & technological problems (R&D, documentation, implementation, improvements, transfer of technology).	* Number of departments oriented to: market, production, technology * % of administrative staff by functional orientations.
6. Patterns of Decision-Making	* Managerial autocracy model, systematic bureaucracy model, adoptive planning model, political expediency model, others.	* Description & % of managerial models used.

7. Manager & Management Style	* Structure by position	* President, Chairman, Directors of: R&D, R&D Unit Manager, Technological Development, Economics, Marketing, etc.
	* Qualification	* Education background by specialty
	* Experience	* Career pattern (years)
	* Length of service	* Years at the company
	* Age	* In numbers
	* Span of control	* Direct and/or indirect
	* Responsibility for implementing and/or developing new technologies	
	* Ratio between the rights & responsibilities of managers	* In %
	* Functions in addition to main position	* % of whole number of functions
	* Signing authority for R&D budget.	* Either in %or in actual amount of money.
8. Individual Skills	* Training for new technology	* Months, weeks, hours per person for workers * Months, weeks per person for engineers, technologists
	* Rotation of personnel (R&D & production, etc.)	* As % of rotated persons
	* Personal creativity	* Average number of suggestions per year by personnel categories
	* Employee participation in the decision-making process	* % of decision made with employee participation
	* Types of stimulation systems used, estimation of their effect, budget for these systems	* Description of the different types of stimulation systems used * % of the final effect
	* Special systems and/or approaches for training, for improving qualifications, for stimulating creativity	* Description of systems * Qualitative estimation of systems' effectiveness * % of persons involved with these systems
	* Loyalty.	* Average length of service with company.

GROUP D. Economic Characteristics

1. Profitability		* Growth rate

2. Costs		* Reduction rate
3. Export Effectiveness		* % of export/volume of production * Profitability * Return on export investments.
4. R&D Effectiveness		* Return on R&D investments.
5. Funds Distribution	* Distribution of organizational funds among R&D, production & marketing activities.	* Ratio between the different uses of funds.
6. Labor Performance	* Labor productivity * Working conditions.	* As % * % of manual work * % of automated work * % of polluted working places * % of highly protected work places * % of investment for protection of employees to total investment.
7. Effectiveness of Use of Raw Materials	* Level of raw materials manufacturing used by studied technologies.	* % of raw materials manufacturing.

THE USE OF CRITICAL SUCCESS FACTORS (CSF) IN BUILDING STRATEGIC CONTROL SYSTEMS

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INTRODUCTION

This paper outlines the importance of strategic control function in fulfilling strategic plans and reaching strategic goals by applying the CSF concept. The main principle of the strategic control function and the links among strategic control and other strategic management activities are underlined.

> "Would you tell me, please, which way I ought to walk from here?"
>
> "That depends a great deal on where you want to get to."
>
> "I don't much care where."
>
> "Then it doesn't matter which way you walk."
>
> " -- so long as I get somewhere."
>
> "Oh, you're sure to do that, if you only walk long enough!"

This is one of the most popular citations from Louis Carroll's book, Alice in Wonderland, the conversation between Alice and the Cheshire Cat.

Everyone should definitely know where he wants to get to. Then it is easier to choose the way which will take him there. But how can he be sure he walks on the shortest, easiest, least dangerous way? Without many big surprises and possible troubles? Nobody could promise him that. He should take care himself of his own way and check its correctness continuously.

If we try to interpret this situation in terms of strategic management, we could conclude that it is very important to settle carefully chosen and defined strategic goals. It is very important to choose the most appropriate strategic alternative and to develop consistent strategic plans, too. But it is no less important to estimate the goals, strategies, and plans. That means to realize strategic control on overall movement forwards, on the overall management process.

Many scientists concentrate their attention on the problems of setting strategic goals, choosing the strategy, and especially developing strategic plans.

But only a few approach strategically the problems of strategic control and try to answer questions connected with the strategic control function. It is hard even to say there is a dominating opinion on what strategic control means. No accepted definition on this topic exists.

Thus, what is strategic control and how does it work? Most scientists consider control function (control to support the processes connected with attaining strategic purposes) as being included in the strategic planning process and do not even mention the term "strategic control." They assume it is understood. Those who do mention it feel satisfied with a brief reminder that the implementation of a strategic plan requires designing a strategic control system to aid the fulfillment of those strategic goals defined in the strategic plan.

Some scientists connect the strategic control function with implementing the strategy only,[1] others with reformulating strategic goals.[2] In Glueck's opinion, control is the last function in the strategic management process (Glueck does not even use the term "strategic control"), and in this consideration, the control is not connected with other processes except that of evaluating strategy and of feedback.

In recent years, the opinion that the most important thing is to plan a strategic perspective (as Ansoff suggested in 1969) has changed. Certain authors such as Lorange & Anthony consider strategic planning and strategic control as closely interconnected and interdependent, but separately designed, management activities.

The control function, in Ansoff's opinion, is fully subject to strategic planning. It is connected only with the implementation of the strategic plan. He considers the planning function before the fact and the control function after the fact. If we accept his proposal, we would have to consider strategic goals, strategy, strategic plans, once defined as relatively consistent in time. But our world is so dynamic and challenging that it is unreasonable to keep our ideas and projects (even if, or especially if, they are strategic in nature) consistent.

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[1]Glueck, 1980.

[2]Hofer & Schendel, 1980.

It is a one-sided approach to prefer planning to control, or control to planning. Probably because of the former preference, many managers are becoming disappointed with strategic planning recently, as Rosenberg concludes.

Strategic control should take part in all steps of the strategic management process. We need control in implementing the strategic plan, of course, but even more control in defining the strategic perspective, strategic goals, the strategic management process as a whole.

Let's return to the conversation between Alice and the Cheshire Cat. If we do not think carefully about on which long range goals we should concentrate our attention (strategic control could help with that), we can find ourselves planning the future attainment of less than actual strategic goals. This might be a real disaster for a business firm, because it is not possible to go back and redo all that has passed. That is why leaders of business organizations need a strong control on the process of defining strategic goals.

It is necessary to underline that the strategic management cycle included the same phases as every management cycle:[3] definition of goals, planning, organization for implementation, implementation itself, control, and feedback. The cybernetic idea of management as a cyclical informational process should be followed at the strategic level of management, too. That means we should pay attention not only to the planning function, but to all management functions equally. To realize a strategic management cycle means to pass through all the typical management phases, without preferring any one of them.

As a conclusion, a strategic control system should be designed to observe the processes connected with defining strategic goals, choosing the proper strategic alternative, developing a strategic plan, its implementation and evaluation, and lastly, to realize the feedback to top management. In our opinion, it is logical to consider strategic control as a separate activity integrating all other activities into a united management process.

As an interpretation of the connection of the strategic control function with other strategic management functions, the following scheme could be suggested (see Fig. 1).

Because of the integrative ability of the strategic control function, it is possible to reach a strong inter-relation and communication among all strategic management functions.

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[3] O. Panov, 1985.

Thus, the strategic control system should be directed toward continuously scanning the environment, both external and internal, to identify and interpret the most important signals for future organizational development. This is very important for the strategic level of decision-making. Observing the external environment -- its threats and opportunities -- is even more important on this level than defining internal strengths and weaknesses of the organization.

Most authors consider environmental scanning and identification of threats and opportunities facing the firm as a function of the strategic planning process. So, the control system has nothing to do with deciding which trends should be used to direct the efforts of the planning systems, on choosing what to do and how to do it.

But the function of the control system is to compare actual (or predicted?) results to the planned ones. This requires a very strong relation between planning and control systems. Sometimes, it is hard even to outline a clear border between the two activities, which could be a formal proof of the possibility at least for the control system to be involved in the process of identifying indicators of success or failure of the business organization through environmental scanning.

The three requirements of the strategic control system (as we can see in Fig. 1) are:

First: To choose the criteria to estimate performance and to define strategic control standards. It should be pointed out that, in the case of the strategic control system, the corresponding strategic criteria and standards should be formed in a different way than in tactical and operational control systems. These criteria and standards should meet the requirements of a strategic level of decision-making. They will serve this level in identifying future deviations in the external environment (negative, when certain problems must be met; positive, when there is an opportunity) and in the internal environment as well. Therefore, they should be formed through studying the environment, both external and internal. We need strategic criteria and standards during the stage of defining goals and determining strategy to ensure their adequacy. That is why we cannot and should not wait for the strategic planning procedure to identify future internal capabilities and opportunities or threats in the external environment. In other words, the strategic control system should be engaged with environmental scanning as well as with the strategic planning system. The criteria for evaluating both external and internal environments could be qualitative as well as quantitative.

It is very difficult and at the same time very important to make estimates based on qualitative criteria, such as: Is the chosen strategy consistent with the environment? Did we choose the most appropriate strategic alternative with respect to available resources? etc.

It is easier to evaluate the organization's performance and the external factors influencing this performance by using quantitative criteria such as growth in sales, market share, net profit, return on investments, etc.

Second: To evaluate the performance of the organization and the major environmental influences.

Third: To realize feedback to the board.

It is important to stress that, for the strategic level of decision-making, conclusion concerning the qualitative state of the organization are more informative for top management than quantitative ones. This circumstance should reflect design of the strategic control system. Its procedures should be directed to estimating the organizational qualitative state carefully.

The major task of a strategic control system is to recognize the factors which appear to be important for future organizational development, not only to compare actual results against planned ones. For the strategic level of decision-making, this is a necessity. Top management should concentrate its attention on these factors, both external and internal, to be sure of future organizational success.

It is impossible for the strategic control system (and it is not necessary at the strategic level of decision-making) to observe all factors important for the business organization. The factors may influence the main organizational activities such as production, marketing, R&D, etc. significantly in the future. There will be a long list of different factors. That is why it is necessary to identify those most important for the future organizational performance and to use them in a strategic control system to evaluate overall performance and environmental conditions. These factors are called "critical success factors" (CSF). As Rockart wrote, "critical success factors are, for any business, the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization."

A strategic control system should be designed to evaluate the CSF's (not the entire variety of performance characteristics, as most of them are the subject of tactical and operational controls), and, if necessary, to suggest changes in the set of CSF's used. According to Anthony and Dearden, the following are characteristics of a CSF:

"1. It is important in explaining the success or failure of the organization.

2. It is volatile, that is, it can change quickly, often for reasons that are not controllable by the manager.

3. Prompt action is required when a significant change occurs.

4. The change is not easy to predict.

5. The variable can be measured, either directly or via a surrogate. For example, customer satisfaction cannot be measured directly, but its surrogate, number of returns, can be a key variable."

From the entire range of different key variables, we should choose those which correspond to the upper characteristics.

It is not necessary to discuss the concept of CSF's. It is elaborated in management literature.[4] We will mention only that the CSF's method was created, developed and widely used by the MIT research group from the Center for Information Systems Research under the guidance of Rockart, Sloan School of Management, for purposes of management information systems. The method was used for identifying the factors which can aid in gathering and interpreting the information which is most useful and helpful for top management in making decisions.

All experienced managers have implicit factors which they carry in their heads and use for leading, but these factors are not always clearly and properly defined. They could even be wrong. The CSF-method helps to make them explicit. It assists managers to be more definite in setting strategic goals, choosing the most appropriate strategic alternative, and developing strategic plans. CSF's are also especially useful for overall control of business organizations.

Until now, there has been no tendency to use the CSF-concept for purposes of a strategic control system. The CSF's could be used for evaluation of strategic performance in the following ways:

First, we generate all the CSF's that reflect organizational goals and strategy. CSF's also reflect environmental conditions, their threats and opportunities, internal capabilities, and individual manager opinions. Then we rank them by importance and determine the correlation between them.

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[4]Rockart, 1979; Martin, 1982; Leidecker & Bruno, 1984; and others.

It may happen that some factors correlate strongly with others. If this is the case, we can choose those that can easily be measured as representatives for the others. The correlation procedure is very important because most of the CSF's are qualitative (at the strategic level of management) and it is sometimes very hard to find quantitative measures for them. It is not absolutely necessary to establish quantitative measures for all qualitative factors, but if it is possible, it would help us obtain more objective information about processes and events, making our judgement more precise.

After ranking them, we use prognostic methods to build up the future CSF's trajectories over the long run. The CSF's will serve as criteria for evaluating if things are going right, "for the business to flourish, and for the manager's goals to be attained".[5]

Second, we need specific standards, strategic control standards. They will ensure that we are reaching our strategic goals and resolving our strategic problems. As strategic control standards, we can use special points located on the CSF trajectories which are defined in time and space. These standards will allow the graduation (calibration) of the performance of the business organization on all CSF trajectories. The strategic control system could evaluate the firm's performance at these special points which we can call strategic control milestones (SCM). These standards could be both qualitative and quantitative (according to the CSF's).

The SCM's are boundary values which characterize the qualitative change of some critical business areas and therefore of the organization as a whole. If a strategic control milestone is reached and the deviations are within a previously accepted corridor, we should prepare ourselves to reach the next one. So, step by step, we will move towards achievement of the strategic plan and goals.

The conclusions drawn by evaluation of CSF points (the same SCM) could guarantee extensive feedback information (which is Rockart's main reason for developing this methodology). Most important is not the volume of the feedback information, but how representative is it, necessary for top management to make the right decision.

Thus, the CSF's could be used by the strategic control system as strategic control criteria and the SCM's as strategic control standards.

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[5]Rockart, 1979.

Let us look at Fig. 1 again. If we reach the standard (SCM), this will ensure that:

1. The chosen criteria (CSF) are the proper ones;
2. The implementation of the strategic plan was correct;
3. The strategic plan was well developed;
4. The most appropriate strategic alternative was chosen, consistent with internal resources, management and organizational capabilities, adequate to the organization's mission and purposes, responsible to environmental challenges.
5. Realistic goals have been set.

The standards may not be reached if they are too high; if we used an incorrect set of CSF's; if the plan does not correspond with the chosen strategy or is not properly implemented; if the strategic assumptions have been improperly determined or included a high degree of uncertainty; or finally, if unrealistic goals have been set.

The evaluation, made by the strategic control system, should be done on CSF's at SCM points. If extraordinary deviations occur, then the goals, strategy, plans should be reassessed. The strategic control procedure is shown in Fig. 2.

As a conclusion: the strategic control function is to link the organizational strategy with the external and internal environments, to ensure adaptability of the organizational structure to the strategy. The strategy is developed to guarantee the firm's external success, but strategic control's task is to connect this strategy with organizational plans, programs, and structure. That is why we should not prefer one element (the strategy, the strategic plan or strategic control itself) over the others. All strategic management functions are inter-related, interdependent, and effective only if they are developed accordingly.

There exists a very important problem which complicates the operation of the strategic control system, but if we find a way to resolve it, we will have the better control which we can call "strategic."

The generally accepted opinion is that a control system is designed to make an after-the-fact (post factum) or real-time evaluation of a strategy and a strategic plan: whether they are working or have worked. As an example, we can use the scheme of R. Rumelt (Fig. 3) from W. Glueck's book. In our opinion, however, this approach should not be used by a strategic control system.

When a problem arises (generally speaking), the most favorable situation is to be prepared for it in advance and to have enough time to mobilize all resources to resolve it (i.e. to have the possibility to predict it early enough). This is equally important for "small" and "big" problems. That means to monitor the factors (CSF's) which form the circumstances and to prepare alternative decisions in time. Such a pro-active behavior is especially important for determining strategic problems because the results of strategic helplessness could cause major disasters for the organization (this explains why it is necessary to build up future CSF's trajectories using forecasting methods).

That is also why we should try to build up our strategic control system on the principle of pro-activeness (preventiveness). If the strategic control system evaluates and compares the actual organizational performance to projected, planned results, it could happen that it is too late to take strategic corrective actions and decisions. Therefore, the strategic control system should be designed to compare predicted results to the planned results for the future moments which will be indicated in SCM on CSF trajectories (i.e. strategic control should use special methods for predicting future organizational results on CSF trajectories at the special SCM points and compare them with the previously determined par values for the same points). Only in this case will our control be strategic and distinguishable from conventional controls. According to Glueck, these conventional controls are:

1. management control which is based on past performance and historical data;
2. real-time control, which is concerned primarily with the technical aspects of control so that information is as current as possible;
3. performance measurement, which is concerned with goal congruence and organizational effectiveness.

It is obviously not easy to do this. For predicting different kinds of CSF's (qualitative, quantitative, external, internal), we should use different methods, sometimes not very precise ones. But nevertheless, these methods will give us enough information for judgement.

Most scientists when they consider strategic control do not concentrate their attention on how it actually works. Only Lorange offers a profound analysis of differences between strategic and lower levels of control. This comparative analysis is very useful, but we need more than a comparison for designing our strategic control system. The CSF-method offers a beneficial technique for designing and using strategic control systems.

Someone might ask: why not use the PIMS method? The PIMS technique aims to identify the key determinants of profitability. Profitability is one of the most important measures of organizational success. The key determinants of profitability include market share, degree of vertical integration, new product activity, capital intensity, ratio of R&D, and that of marketing to sales. Is that not enough for evaluating the organization's performance? Why would we need another technique? PIMS is well developed, and more and more companies from different countries are joining this program.

The PIMS technique, however, provides only generalized key determinants. It does not provide information about the CSF's of particular firms or corporations. Therefore, we cannot apply the information received from PIMS results with assured accuracy to a specific firm. We must look deeply at the firm's specific characteristics and determine its own particular CSF's. Every firm is unique in some way. Furthermore, characteristics other than profitability are important to the business organization. We should consider the needs of personnel, social climate, environment, governmental policy, etc. These areas sometimes offer more important critical factors than the key determinants of profitability. The CSF-methods proposes a wider approach for investigating the business organization. It has been pointed out that strategic control's major characteristic is preventiveness. The CSF method allows a realization of the strategic control function through predicting a limited number of factors. If we use the PIMS technique, we should build up the future trajectories of many more factors, which is very difficult to do.

So, preventiveness is the most important feature of the strategic control function. It is a necessary, but not sufficient, condition for the strategic control system to work. The pro-activeness of the strategic control system calls for it to continuously adapt to changes and challenges in the environment. This means having the flexibility to adapt its own structure, methods, techniques; to allow the adaptiveness of organizational goals, strategy, strategic plans, structure.

The idea of adapting complex systems arises out of investigating the behavior of biological systems. The ability to adapt is their major characteristic. This is expressed in their ability to change their own structure through self-adjustment and self-regulation in response to changes in nature.

It is more common to talk about the adaptiveness of technical systems (the Theory of Adaptation of Technical Systems). It is also necessary to discover ways to adapt business organizations as well. It would be very interesting to determine the common laws of adaptation of biological, technical and social systems. The business organization includes all three. Such common laws could be a good guide for managers.

The strategic management process requires an adaptive regulator to investigate the nature of different influences and changes continuously during an on-going management process, as it is in nature. Each element of the business organization should adjust its behavior to changing goals and strategies through learning the behavior of the total organization (the principle of Holon). Through estimating deviations, the adaptive strategic control system should generate different alternatives, corrective measures and help top management choose the optimal one to reassess goals, strategies, and plans in light of the existing uncertainty. It could also help to set dynamically optimal values (SCM) of the control variables (CSF's).

As a conclusion: the strategic control system should be designed to provide not just simple feedback, but adaptive, learning feedback, as is found in nature in biological systems. Application of such a regulator will guarantee a successful development of the firm in the long run.

A question arises: how to identify the CSF's? What kind of sources could be used?

Some authors[6] assert that CSF's are obvious and that it is not necessary to look for specific ways to identify them. We can agree with two authors to a certain extent. Actually, there are some factors which are easy to define. For example, the following factors are common for almost every business organization of the 1980's:

* increased productivity,
* efficient utilization of resources,
* improved product quality,
* adequate strategic decisions, etc.

There is no doubt that these factors are real. They are formed in the organization's external environment, but there are also many factors formed in the internal environment. These are specific factors for specific development conditions, organizations, leadership style, etc., and they are not obvious. They should be identified using special procedures.

There are some differences in defining CSF's across different applications (MIS, strategic planning). For the purposes of the strategic control system, we could define CSF's as those factors, identified and ranked in importance for a particular business organization, which influence its major activities significantly and performance as a whole; which serve as criteria for evaluating the overall organizational performance and assessing the environmental threats and opportunities.

Let us first observe sources from which we can obtain the information we need for identifying the CSF's. It is necessary to observe three main levels: firm's specific, industry branch,

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[6]such as Hofer & Schendel, 1980.

socio-political and economic environment. In Fig. 4, these three levels could be shown as three concentric circles.

The firm's level. The ongoing strategy, organizational goals, and policy are the basis for formulating the set of CSF's. This set is specific to the organization and reflects also management abilities, social climate, financial status, technological level of production, personnel qualifications, social needs, position in the industry, geographic location, etc. Therefore, the information needed should be concerned with the organization's current performance, and history (previous goals, strategies, management style, etc.). A clear understanding of existing strategy, long-term goals, and perspective is needed, too. All this information will serve as a basis for defining the unique organizational CSF's characterizing its conditions of existence and development.

The industry level. Every organization develops its strategy and sets its goals in correspondence with industrial policy and strategy, industrial structure and forces that significantly impact any company operating in that industry. The links between the firm's specific development and its branch of industry are much stronger in countries with centrally planned economies than in Western ones. Therefore, it is necessary to gather the information from industrial long-range plans and programs concerning specific production, local plans (of different geographic regions) and programs.

The socio-political and economic level. All information sources beyond industry boundaries (long-range programs for socio-economic development; 5-year plans; specific governmental program such as one for technological development, for implementing new bio-technologies, etc.) must be analyzed. The information selected will reflect the economic, social, technological, environmental policy of the government, concerning specific industries and production.

It is very important also to gather the information about leading companies in the same field of production (as many authors suggest). By analyzing this information, the CSF's of these leading firms could be identified and used as an example for forming the specific organization's set of CSF's. But simply transferring the CSF's of a successful firm to another should not be allowed, because the circumstances under which they develop could be different. The leading firm's CSF's are not enough for the second firm to succeed. They can only be a basis for reassessing the second firm's CSF's.

Christine V. Bullen and John F. Rockart discuss in their paper[7] the interview procedure as a technique for identifying the organizational CSF's. The MIT research group used it successfully in many case studies in different firms. Through the carefully prepared questionnaire, the top managers and some of the most experienced line managers were asked to answer which factors are most important for the organization's success (or failure). Thus, a first set of CSF's was obtained.

For the purposes of a strategic control system, this questionnaire (based on a list of generalized sets of CSF's, previously prepared through an informal process of induction) should include the following task:

1. To assess the abilities of top managers to look ahead into the future and to think strategically;
2. To establish a set of CSF's which the strategic control system and corporate managers can use as the basis for evaluating organizational performance;
3. To create a systematic approach for managers to receive the right information at the right time. The identified CSF's could also help increase understanding among managers in their communication. They can also help them to concentrate on the most important events in the environment and organization itself.

After the first round of questioning, the CSF set could be offered to a broader group of people (not only staff, but also advanced specialists and even outstanding workers) for confirmation. This is very important from the sociological and psychological point of view. Involving the broadest possible group of people in the process of deciding which goals to choose, which strategy to follow and control is a question of organizational democracy and will motivate all personnel to accept the policy of high-level management. (If we look at how TQC is organized, we find the same tendency. It is not coincidence that Prof. Shiba calls his Total Quality Control theory "motivational management.")

In the theory of organizational control, the expression "a control gap" is used.[8] This means that as much control as you try to have over people and processes, the less real control you have. The less real control you feel you have, the more control you try to apply, which in turn further decreases your real control. To escape this control gap, it is necessary to remember that the control is only a phase in the strategic management process, not an outcome itself of business organization. We

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[7]Bullen & Rockart, 1981.

[8]Dalton & Lawrence, 1971.

should use the strategic control function as a means for integrating goals, strategies, plans; for implementing them in a united management process; and for coordinating individual and collective goals with global ones.

It is reasonable to assume that the "control gap" situation might occur if there is a great number of people involved in the process of control. This could happen at the operational or tactical level of control, but not necessarily at the strategic level of control. Involving as many people as possible in carrying out the strategic control function will aid in reaching the strategic goals. It will motivate people to direct their efforts towards a strategic perspective.

One of the most important aspects of motivation is the possibility for personal realization. If everybody knows what kinds of goals, strategies, plans the organization has as a whole and he is convinced that he has a chance to realize his personal goals within the organization, this can help a great deal in reaching the long-term objectives. It is not only the proper execution of the leaders' tasks that is important. The independent creativeness of individuals and personnel as a whole is needed, too. The involvement of many people in the strategy-making process is connected with the mechanism of their socialization. Management itself is directed towards building up the feature of "manageability" of the system.

This could be reached if the goals of socialization are coordinated with the goals and purposes of the management system, especially with the goals of strategic management. This is very important, because as the people will implement the strategy, they should take part in its development and accept it as well.

So, in the present turbulent times, a business organization needs an adequate strategy and a consistent plan to follow it. But this is not enough. Improvements in management control, which has been neglected for a long time, are needed, too. For current needs, a current control is required: "... positive, future-oriented, behavioral",[9] a constructive one. Control will help to achieve chosen goals, to escape threats and to take advantage of opportunities.

Strategic control is the type of control which meets the above requirements. But much still remains to be discussed in connection with the design of strategic control systems and their application.

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[9]Newman, 1975.

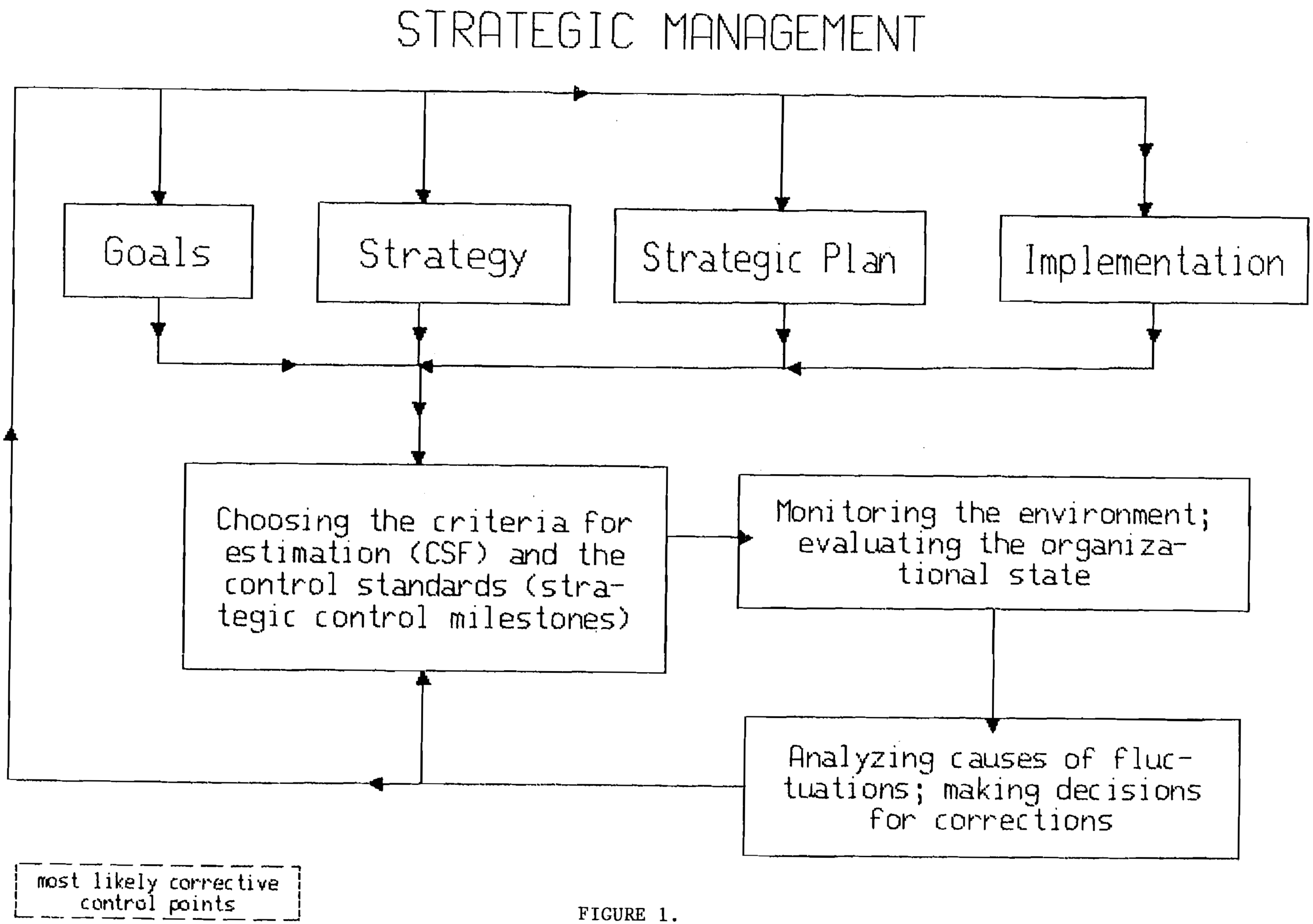

STRATEGIC MANAGEMENT
Goals
Strategy
Strategic Plan
Implementation
Choosing the criteria for estimation (CSF) and the control standards (strategic control milestones)
Monitoring the environment; evaluating the organizational state
Analyzing causes of fluctuations; making decisions for corrections
most likely corrective control points

FIGURE 1.

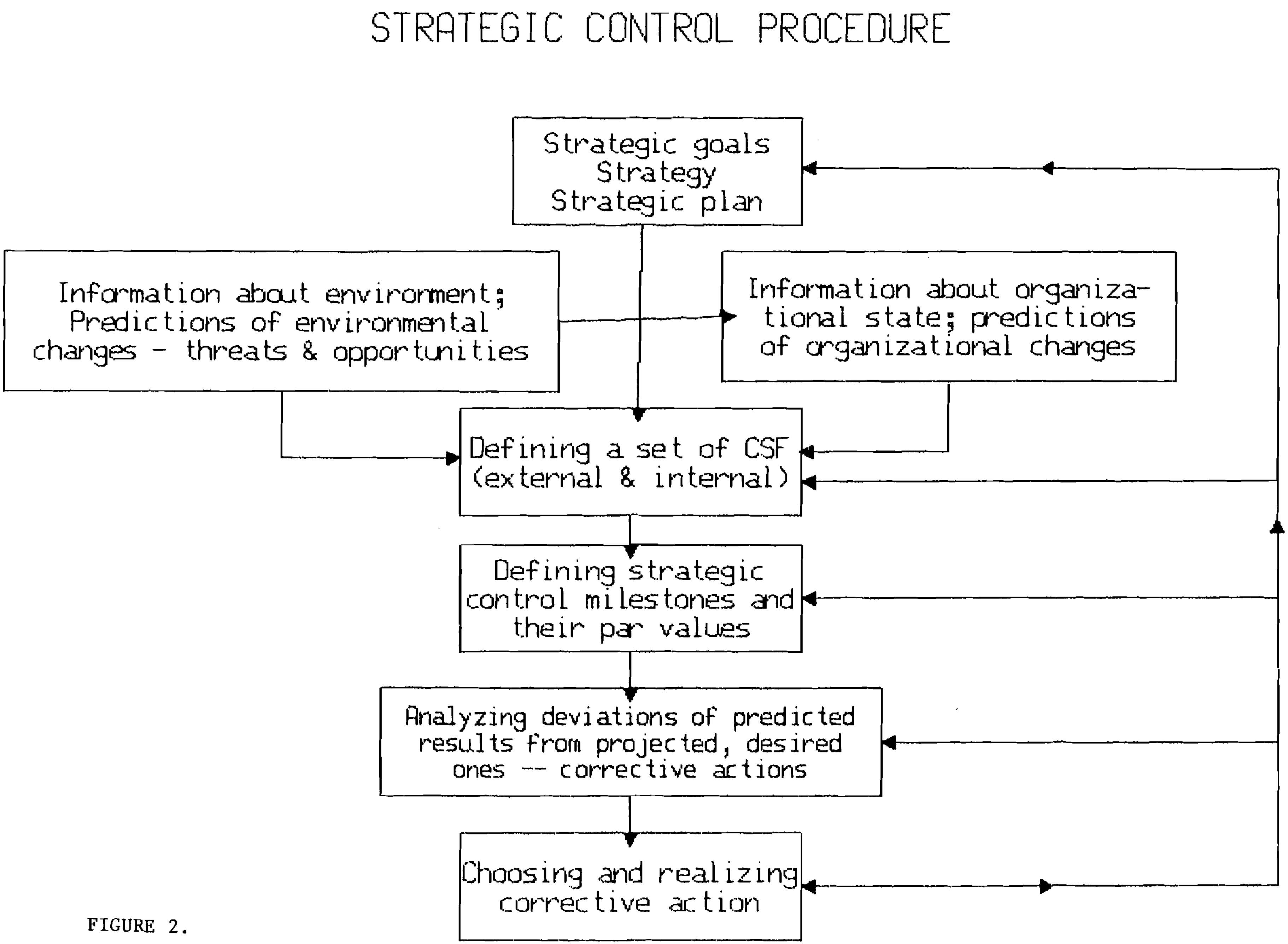
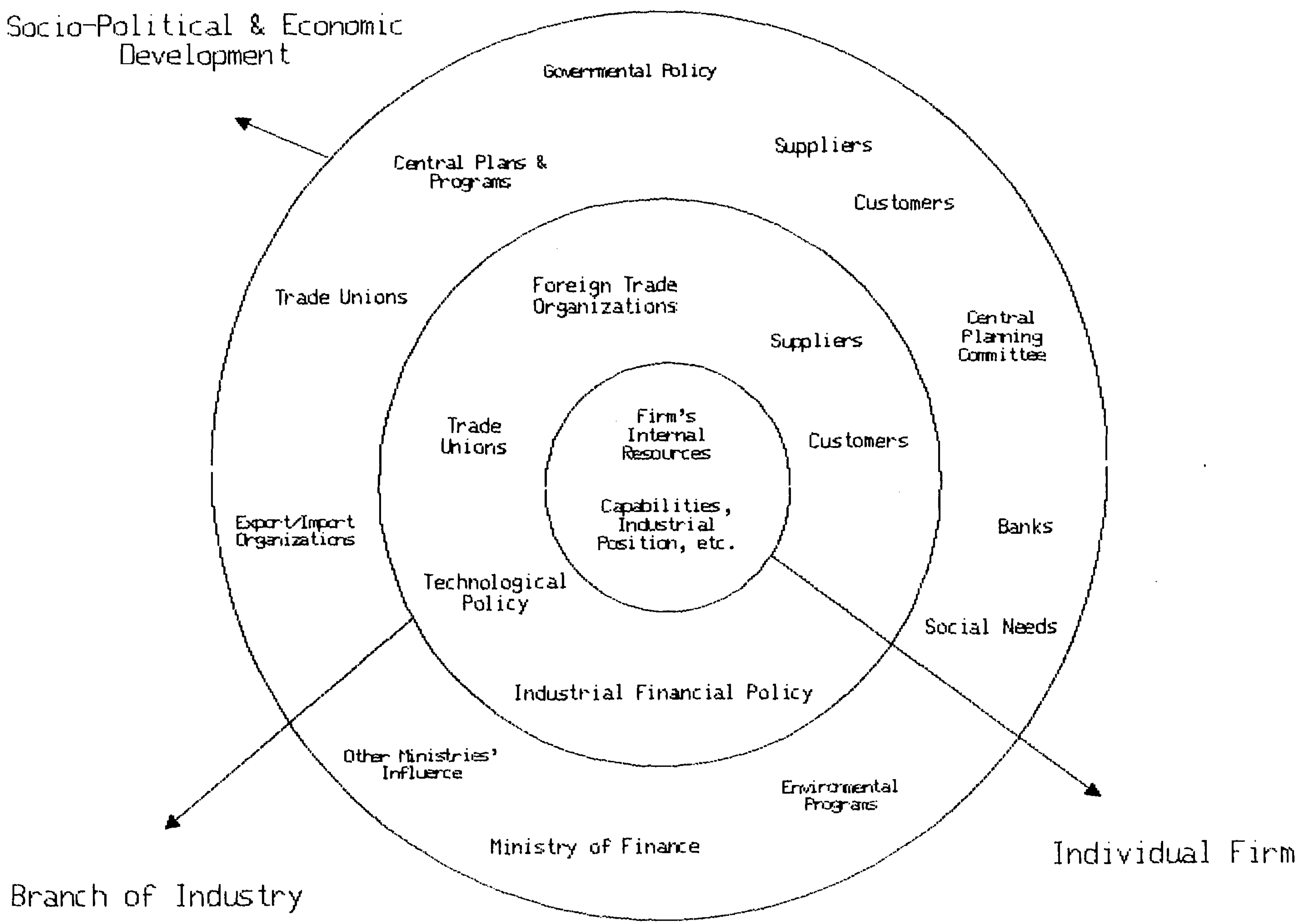

STRATEGIC CONTROL PROCEDURE
Strategic goals
Strategy
Strategic plan
Information about environment;
Predictions of environmental
changes - threats & opportunities
Information about organiza-
tional state; predictions
of organizational changes
Defining a set of CSF
(external & internal)
Defining strategic
control milestones and
their par values
Analyzing deviations of predicted
results from projected, desired
ones -- corrective actions
Choosing and realizing
corrective action

FIGURE 2.

Benchmarks for Evaluation

Key Success Factors	Overall Objectives or Assumptions	Expected Performance at This Time	Current Performance	Existing Deviations	Projected Deviations
Financial:					
Reduce overhead cost	5%	2%	3%	+1%	+1%
Profit on sales	12%	5%	9%	+4%	+2%
Marketing:					
Analyze new-product proposals	10	4	2	−2	−3
Sales per employee	$7000	$6800	$6900	+$100	+$100
Personnel:					
Number of key managers needed	6	2	3	+1	+1
Ratio of indirect cost to direct cost	12%	14%	13%	−1%	0%
R&D:					
Recruitment of senior engineers	20	16	10	−6	−6
Increase R&D-sales ratio	5%	4%	3%	−1%	−1%
Operations:					
Increase production capacity	50%	40%	40%	0%	0%
Competitor reactions:					
Increased R&D	4%	3%	4%	+1%	+1%
Product changes	4	2	3	+1	+1

FIGURE 3.



Socio-Political & Economic Development
Governmental Policy
Central Plans & Programs
Suppliers
Customers
Trade Unions
Foreign Trade Organizations
Suppliers
Central Planning Committee
Trade Unions
Firm's Internal Resources
Customers
Capabilities, Industrial Position, etc.
Export/Import Organizations
Banks
Technological Policy
Social Needs
Industrial Financial Policy
Other Ministries' Influence
Environmental Programs
Ministry of Finance
Individual Firm
Branch of Industry

FIGURE 4.

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THE PROCESS OF PLANNING AND ACQUISITION OF NEW TECHNOLOGIES

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1. INTRODUCTION

For the past few years, several studies have shown that the principal technical innovations, especially those in advanced technology, originated from large and well equipped organizations possessing huge budgets as well as research and development units. These new technologies allowing greater efficiency in the manufacture of current and new products are then transferred to smaller firms. Most of the time, the latter do not have a choice; they owe it to themselves to use the new technologies if they want to remain competitive and continue growing. This condition is all the more imperative when the market is limited as is the case in Austria; the firms therefore have to export a part of their production and the competition is very acute on the international markets. There are also other reasons inciting smaller firms to search for more efficient and less constraining technologies such as, for example, a lack of skilled labour, difficulties in obtaining certain raw materials, rising energy costs, new antipollution regulations etc.

Now, the problem that arises for most of the Austrian firms is centred around the adaptation of a technology developed elsewhere by and for international firms. Smaller firms do not have at their disposal the necessary production scales nor an adequate size for the most profitable utilisation of these technologies. They therefore have to adapt them to their specific conditions, find the adequate means of transfer (especially at the levels of expertise and autonomy) and set up accordingly an administration. In the context of high technology, in particular, the introduction process is not always evident; one must predict the changes to bring about in managerial practices, and prepare psychologically as well as technically the employees to take in this new technology often perceived as a threat. Furthermore, in this process of acquisition, the firms must aspire to a certain autonomy from the technological point of view so that they may undertake their own development and assure their growth.

This paper focuses on this perspective, and its object is to analyse the process whereby smaller firms identify, select, acquire, transfer, adapt and manage the new technologies in order to use them efficiently and to progress towards a certain technological autonomy.

This paper takes into consideration both technological and organizational environments in which the firms progress. In my further research I will go deeper into the planing constraints and contingencies that these firms must face when they consider and acquisition of a new technology, especially according to the stage in the life cycle of the particular technology.

2. THE NEED FOR NEW TECHNOLOGIES

For several years, technology has taken a considerable position in the economic growth and development of industrialized countries. Being conscious of the important relation between industrial R&D and innovation, on one hand, and economic growth and the increase in productivity on the other hand, governments tend more and more to put the emphasis on technological development in industry. For example, the Austrian government announced the importance of new technologies: "The installation of new technologies in Austria's industries and firms from now on hold a priority in the Orientation of government planning in economic matters"[1)] It should however be noted that the Austrian government has priorities in the following technological developments: microelectronics, bio-industries, electrochemistry, etc.

Thus, the governments put into effect a series of measures and programs in technical and financial aid hoping to directly or indirectly stimulate R&D and technological innovations in firms. But the question arises: Which firms benefit most from these programs? One can assume that it is the industries having the organisational structure and the adequate human, financial and technical resources to be able to carry out the R&D projects, i.e. large firms. "Observations indicate that the majority of government programs giving direct aid to technological innovation are not of much help to smaller firms"[2)] Just exactly what happens to these firms facing this reality?

Confronted by acute competition and a tough economy, how do smaller firms succeed in introducing and managing new technologies and staying at the vanguard of technological development? What errors shoult they avoid in future technological acquisitions?

What errors should they avoid in future technological acquisitions? Among certain salient points drawn from the socio-economic situation in Austria, on may remark that "very few small and medium firms invest in research or in purchasing technology and their products are often so conventional that they are not even protected by patents"[3] It therefore appears that few small and medium firms in Austria duce technological innovations, which implies that they often have to turn to foreign technologies or to those of multinationals. Since smaller firms have characteristics of operation tightly related to their infrastructure and more specifically to their size, a topic which will be elaborated in greater length in a following section, how can they adapt this technology as a function of maximum profitability and of increased productivity? Do they choose the technology truly suited to their needs?

On one hand, many Austrian firms are influenced by a series of factors which can incite them to introduce technologies in their firms, such as competition intensity and the competitors' performance, the increase in productivity, social and environmental changes, technological imitation, etc. On the other hand, in a decision of acquisition, the firms must adequately evaluate the appropriate technology with respect to their human, technical and financial resources, the market potential, production volume, the competition, the characterisitics associated to their size and to the type of industry in which they work, their size and to the type of industry in which they work, their organizational structure, etc.

3. ACQUIRING A NEW TECHNOLOGY

It is advisable to immediately specify what is meant by the concept of "new technology". For the aims of this paper, we are limiting the discussion mainly to the new inventions in machinery and equipment, and secondly to the new technical procedures and to manufacturing systems. As an example to the new technical procedures and to manufacturing systems. As an example of the latter, one may consider "manufacturing systems aided by a computer (CAM) which provide considerable advantages in terms of rapidity of execution, versatility and productivity. Thanks to microelectronics, automatization, formerly reserved to certain types of mass production, is becoming equally profitable for productions on a small scale"[4] It is becoming more and more evident that also smaller Austrian firms must acquire the machinery and equipment taking advantage of electronics, because of the numerous benefits entailed, if they wish to maintain their competitive capacities and their share of the market.

If they do not opt for a structured and planned approach when decided to introduce a new technology in the organization, it may possibly evaluate inadequately, for example, the market potention, the competition, its own resources, etc. The consequences may therefore be harmful to the organization: in the case of a poor market study, if the demand appeared lower than expected for various reasons, there would be, for example, an insufficient use of the newly acquired equipment, which would be very costly for the organization. So, if the firm decided to maximally use the acquired equipment, this increase in the production capacity in the context of low demand would provoke an overproduction. This prove to be very costly at the level of inventory expenses and other operations expenses. Furthermore, the implantation of new technologies may have an impact on the organization of labour (tasks), on the other functions in the firm, on the profitability, on the workers and the union, who quite often resist technological change for fear of being laid off.

Consequently, the managers of an enterprise find themselves facing one of the most complicated decisional processes when it concerns the introduction of new technologies in their firm. They want to achieve the economies of scale, increase their productivity, their profitability and their competitive capacities, but at the same time, that implies investment and operation costs, in several important cases. Small and medium firms are not structured in the same way as large firms and do not have the same organizational characteristics. It is therefore possible for the small and medium firms to introduce and run differently these new technologies, when compared to large firms.

It is therefore easy to appreciate the phenomenon's complexity and to understand the decisional and strategic difficulties with which the small and medium firms'directors are confronted, regarding the technological needs.

4. THE TECHNOLOGICAL ENVIRONMENT

All firms, large or small, use certain forms of technology. In general terms, technology is the set of means serving in the production of goods and services.[5] Technological development is usually achieved in several steps, the two main ones being research and innovation.

4.1 Technological research

This is surely the most costly and most uncertain phase.[6] Basic research calls mainly upon the fundamental principles of science and tries to make advances in the knowledge of a specific field. Usually, this type of research is not involved as such in the aspects of a result's application for immediate use; that is why research is conducted mainly by university and government research centres. Sometimes, in some very specialized fields like computer science and telecommunications, some large firms can carry out basic research. Considering the very nature of these research activities, it is unusual to see small and medium firms involved in them. Besides, the technological small and medium firms, particularly those working in high technology sectors, are heavy users of results from basic research.[7]

In industrialized countries, where almost all of basic research is carried out, the results may by made accessible in several ways, but a certain form of interaction between the firm and the research centres appears just the same to be necessary in order to further master the phenomena. The geographical and physical proximity can even be a determining factor, as demonstrated by the well known example of Silicon Valley in California and several technology parks in Europe. In each case, the incubating environments were the neighbouring universities and certain government laboratories.

Basic research is not only the basis of technological progress but it serves also as its motor. A sound reservoir of scientific research confers to a country or a region the ability to proceed rapidly with substantial technological jumps.

Transfer mechanisms are usually installed to insure the widest use of the results and of the cross-fertilization of experiments.

This availability thus becomes an important element in the process of a firm's technological development. Evidently, depending on the type of technology intended, the accessibility to a reservoir of basic research can be crucial for a firm's, and more particularly, a small or medium firm's technological development.

4.2 Technological innovation

Research and development (R&D) comprises, in addition to the dimension of basic research, a developmental component which is mainly involved in applications, and is referred to when speaking of technological innovation. Innovation and invention are often confused with one another. In fact, invention is the production of a still unknown configuration, the outcome of a creative process while innovation, relating more to the fact of using, of implanting something new, refers to a process of adoption.[9)]

For the aims of this paper technological innovation will be defined as the adoption by an organization, of a technological change that is perceived as being new. The notion of newness relative to the adoptor avoids having to place oneself from the point of view of the diffusion process.

During the last few years, technology has become more and more complex and technological development has been especially concentrated in several large firms. The OECD's recent statistics show that more than half of industrial research in member countries of the OECD was undertaken by forty large firms. In fact, according to a recent research report by the OECD[10)] it appears that only 15% of small and medium firms have attained an adequate level of competence in order to develop technologically by themselves. Besides only 2% of the small and medium firms actually carry out work in R&D and less than 1% of all the small and medium firms appear to have the capacity to engage in it.

This study shows that the small and medium firms rarely appear to be directly involved in the technological changes but are instead destined to occupy the technological terrain by adapting these changes in various forms of application and use. The small and medium firms thus play an extremely important role in the diffusion of technological innovations achieved mainly by large firms, and in their useful application. Here, numerous transfer mechanisms must be readily available for the small and medium firms. It is usually up to the governments in power to promote the necessary infrastructures to this effect. It has often been shown that the survival and prosperity of smaller firms depended largely on the presence of large firms and the easy access to the latter.[11)]

4.3 Available technologies

Basic research and its logical result, technological innovation, through appropriate transfer mechanisms, should allow the formation of an adequate inventory of technologies that are potentially available to smaller firms.[12)] Evidently, this technological stock is not always present in an immediately utilisable form nor is it always possible for a given small or medium firm to have easy access to it. Even then, everything depends on the industrial fabric in place and on the supporting organizations. In most of the industrialized countries, there are institutional networks favouring technological changes and rapid diffusion of informations. In Austria, there are a few industrial parks where small firms are located side by side, as well as an infrastructure allowing the sound operation of economic activity.

It is obvious that the technological environment in which a given firm is situated can be more or less rich, but it can still be improved and often by a better coordination of the various sorts of interveners. Once more, it is almost deceptive to think that today a small or medium firm could develop technologically if it could not rely on a technologically well equipped environment. Modern technology is very dynamic, and in order to advance, a firm must be able to continually rely on an adequate supply of available technologies, and this is particularly crucial for firms in small countries like

Austria. Moreover, if the desired technologies are not immediately available on the local or national level, it ought to be possible to help a firm obtain them on the international level.[13)]

5. ORGANIZATIONAL ENVIRONMENT

A smaller firm can function very well in a rich and perfectly adequate technological environment without being so much at the vanguard of technology.[14)] In such a case, the environment concerned can be that of the organization itself, which will be called here the organizational environment. As we know, in a smaller firm, the process of administration and decision is usually very concentrated and it is either the entrepreneur or the owner-manager who plays the key role in the fate of his firm. In an over-all view, the technological innovation can be seen as a strateegy of adapting to one's environment. Therefore, in a small or medium firm, this role appertains to the owner-manager, and this is why it appears necessary to immediately deal with the variables linked with the individual himself.

5.1 Perception of a need for technological change

In general, the smaller firms do not innovate by themselves nor do they undertake activities in technological development for the sake of keeping up to date. A certain number of things must happen in order for the director to recognize the need for a change on the technological side. One can roughly classify in three categories these releasing elements of a perception of the need for change:

- diffusion mechanisms,
- international factors and
- external pressures.

5.11 Delays and diffusion mechanisms

When a new technology is developed, more or less long delays often occur before it becomes widely accessible. Quite often, it is the rapidity with which a firm can get hold of a new technology that makes the difference between a technological break-through and simply keeping up to date. In an equally dynamic industrial universe, the first to arrive are sometimes the only ones truly able to survive and progress.[15)]

The delays in diffusion are not under the control of the firm's director, but when he is not completely sensitized to the very existence of the main technological developments in his sector of activity and related fields, it is therefore deceptive to think about strategies based upon diligence. It is primarily his responsibility to be on the look-out for technological evolution. Evidently, he must be assisted and stimulated in this role, and the diffusion mechanisms come into account.

The diffusion mechansisms can be numerous and diversified or still be very poor depending on the industrial infrastructure in the region concerned, and the sector of activity referred to. In general, diffusion in done mainly from commercial and business contacts, commercial and industrial fairs and exhibitions, industrial and professional associations, technical and professional literature, chambers of commerce and industry, and certain special activities undertaken by governments and certain research organizations.[16)] In spite of the promotion, which is sometimes very intensive, carried out gy these go-betweens, in the long run it is still up to the director to gather the information, digest it and quickly determine its pertinence. This form of sensitization is more of the passive type, in the sense that the information is in some way imposed on the individual. Nevertheless, it is an efficient method having in mind a larger number and often forming the first step to a process of recognizing the technological needs.[17)]

5.12 Internal factors of the firm

In this case, the triggers are mainly of an organizational nature. Most often, it is the firm's performance which will be the centre of the director's awareness. In manufacturing firms, particularly, the organizational efficiency is expressed by different signs of productivity, which permits immediate inter- and intra-industrial comparisions. A drop in productivity is due most of the time to excessively high production costs, generated either by labour or by the techniques utilized.

As it is often difficult either to motivate the people to work harder, or yet to reduce their salaries, or yet to drive them to work with greater perfection and skill, we therefore have to resort to technology to solve the problems of productivity. A more modern technology, as for instance in the form of automated machinery, can have as an effect an important reduction of production costs because it usually allows to substitute labour; to produce more rapidly and without stopping; to bring out a product of superior quality; to increase the product's degree of sophistication.[18)]

Moreover, it often happens that machinery which is more automated is made necessary by a flagrant lack of skilled labour. The second problem concerns the availability, the prices and the quality of raw material. Even then, a new technology relying on alternative procedures and on more accessible replacement materials would be welcome. Ever since the oil crises of 1973 and 1979, the energy cost comprise another militant factor in favour of less energy-consuming technologies. Finally, in this category of internal factors in the firm, one should note the technological obsolescence of many smaller firms.

5.13 External pressures

There is a whole series of pressures arising from the firm's economic environment which literally forces it to look for other solutions towards technological modernization. The greatest of these forces is probably the one exerted by competitors. First there is local and national competition; the traditional sharing of this market has been particularly overturned during the last years by the intensive penetration of the multinationals and the dumping in countries undergoing development.[19] Austrian firms can hardly longer rely on protected markets and the only way to avoid elimination is to counterattack by becoming even more competitive than the foreigners and to progress even more by attempting break-throughs in the outside markets. Since technological modernization is still the surest way of increasing productivity, it is once again indispensable.[20]

Connected to competition, there is also the pressure exerted by the clients themselves. The changes in the market are coming about at a speed that is always accelerating; we have only to think about the revolutions in the fields of micro-computers, bio-technology, telecommunications, etc. to convince ourselves. All these new products require advanced technology and increased capacities in development. Even the sub-contractor firms are subjected to the same imperatives; the larger clients, for all intents and purposes, impose upon them their own technology. In a similar way, the suppliers, too, exert pressures. The technological changes operated in one firm induce changes of the same nature in others.

Finally, there is a widerange of socio-economic pressures and new laws compelling firms to utilize the least polluting, the safest, the least energy-consuming, the most efficient, the least dangerous for the worder's health, the least tiring, etc. technologies. Even if these restraints do not often require immediate changes, the firm will have to respect them as soon as possible if it does not wish to incur costly sanctions.

5.2 Research and identification of new technologies

The need for a new technology having been foreshadowed, the director must start the research process meant to lead him to an identification of one or a group of potentially utilizable technologies by his farm. We should remark here the sometimes very personalized characters of this process; the characteristics of the individual are very determining. A good open mind will permit the director to transcend the traditional schemes, to disregard biases which are sometimes too conservative, and to judge the propositions with more rational criteria. His role which consists in identifying one or several new technologies meaning to allow him to better adapt his firm to its environment, will be even better filled as he will treat the information according to its own merit and not according to his tastes and personal expectation.

The number and the diversity of the sources of information actively asked for, as well as the authorities, experts and professionals consulted, will determine his level of confidence in the subsequent steps. Well made choices in the field of specialized information will lead the manager to act rapidly and logically.

It is highly probable that the technological jump can be achieved only by individuals possessing the necessary traits, the characteristics of the true entrepreneur.[21)] Evidently, all firms are not subjected to the same technological imperatives, but it remains that in the field of innovations, the element of newness is uppermost and the way in which the individual will grasp it will determine to a great extent his success as an entrepreneur and manager.

5.3 Technical culture

This concept refers to an individual's predisposition, based on knowledged and organizationalability allowing him to recognize, to evaluate rapidly and to exploit successfully technological developments.[22)] With the aid of such a mental scheme, the manager will be able to identify new technologies that will be potentially appropriate for his firm, to evaluate them, to see how they can be favourably transferred and to choose the most suitable one. Several techniques and instruments can be utilized for these steps, but the responsibility of making the final choice still lies with the manager.

A question can be asked, concerning how one can appreciate an individual's level of technical culture. It probably concerns a mentality or more precisely attitudes and these can be the object of certain measures, especially witz regard to the level of knowledge and the predispositions; but, like all other measures of this type, they aree just indicative. However, what is even more important is the fact that the technical culture can be developed and considerably appreciated when a certain number of conditions are brought together. For example, education, values, information, training, promotions, can all contribute to the stimulation and the development of a technical culture; Japan is a case in point.

Therefore, with his level of technical culture, the manager should be able to evaluate the new technologies which are appropriate for his firm. Without immediately entering into the details of this process, it is however appropriate to take into consideration the firm's technological level and its stage of development. There is no universal definition of the technological level. For the purposes of statistics, the Bureau of Labor Statistics in the U.S.A. classifies firms als follows[23)]:

a) high technology:
firms whose expenses in R&D and whose number of technical employees are two times greater than the average for the whole of American firms; this includes especially the manufacturers of pharmaceuticals, computers, electrical components, airplanes, laboratory equipment as well as firms in programming, data processing, bio-technology, and communication;

b) strong technology:
the firms whose expenses in R&D and whose number of technical employees are above the average for other firms; these are mainly firms involved in chemical products, petroleum refinery, manufacturing of products like textiles, printing, electrical appliances and medical equipment.

c) medium technology:
the firms whose factors listed above, are in the national average; one can locate industries like machinery, instrumentation, transport equipment, automobiles, etc.

d) low technology:
those whose factors are below the over-all average; the pulp and paper, furniture, shoe, steelworks, food, etc. industries.

Even if one considers the firm's level of technological sophistication, the task of the manager working in a lax sector is not eased that much; that depends on the starting point and the goal. Quite often, the manager will have to look beyond his own sector of activities in order to find exactly the new technology best suited to his needs.[24)]

Another crucial dimension in the introduction of new technologies concerns the firm's phase of development, which can be divided into three principal stages: the start, the dynamic growth, and the consolidation. It is admitted that the managerial problems are very different from one stage to the other; the introduction of a new technology implies a particular managerial strategy which must be on equal terms with the firm's state of development.

6. THE STRUCTURE OF TECHNOLOGY TRANSFER

Parallel to the evaluation of technologies, the management must ascertain the available transfer mechanisms. One must the admit that the transfer of technology is similar to all commercial transactions in that the forms and conditions of this transfer, and consequently the benefits and costs which result from it, are the object of negociations between buyers and sellers.[25)]

It is pertinent to note that the transfer of technology in the world is mainly the work of multinational firms. The importance of their research budget related to their international vocation gives them a major position in the world market for technique and innovation; one even speaks of "a monopolistic type of market".[26)] In transfer of technology, one usually distinguishes direct flows from indirect flows.[27)]

Direct flows comprise the measurable factors that firms are able to figure out: licences, patents and direct investments come first, followed by the training of users and by after-sales service. Often, a licence contract is combined with an investment; this is a way considered as allowing the rapid acquisition of a given technology. The other ways are the training of employees, eihter at the transferee (medium level staff and performing personnel), or at the transferer (technical assistance, research aid, development and engineering aid). One can note here that the training of personnel can be a vehicle for the transfer of technology just as well as for managerial practices, notably in the framework of client/sub-contractor relations. Consulting firms play a significant role in the transfer of technology, especially in the fields of management and training.[28)]

The indirect flows are the result of the psychological effect, produced on the heads of transferee, by the direct flows. This induces various phenomena: the observation and imitation of new techniques allowing their diffusion from one firm to the other; the creation of a primary market by the transferer leads to its expansion through the progressive entry of new products into this market. The bringing of new techniques creates a considerable emulation in the country or the region where the local industry is in the position of imitation the innovations. All these indirect effects can lead to total modernization, restructurings, and changes having as a result the improvement of the firms' performance on the whole.

The means of information and communication constitute other methods of transfer, particularly technical publications, abstracts, specialized magazines and books. Certain countries or regions have at their disposition documentation centres and data banks. It seems however that these methods can serve as incitements with the heads of firms to turn to services for specialized personnel or to consultants.

6.1 Selection of an appropriate technology

The factors described up to now arise from the manager's culture and appeal especially to his level of technological sensibility and acuteness in spotting long and short term development opportunities within his enterprise and environment. This progress ought normally to lead to an ultimate choice of an appropriate technology for his firm. This choice should be based on an ensemble of technical and managerial considerations which would resemble a feasibility study. Additionally the management has to consider that every technology has its own life cycle[29) and each stage of the life cycle requires individual strategies for the firm. The crucial question of timing occurs in every case of technology planning and selection.

6.2 Organizational characteristics

In making the final choice of the technology to introduce into the firm, management ought to know thoroughly his possibilitys for internal and external financing. The costs can be grouped into three phases: the feasibility studies; the development and the adaptation; and finally the implantation. The feasibility studies represent a small percentage of expenses; it is mainly at the levels of development, adaptation and implantation that the costs can prove to be high and it is exactly at these stages that the evaluations are difficult to complete. Therefore the management ought to be ready to seek funds from several sources: internal funds of the firm, banks, the issuing of shares and debentures, insured contracts from large clients and government subsidies. Not only must these funds be available but these conditions must also be within the capacities of the firm.

Probably one of the most curcial resources for smaller firms wanting to introduce a new technology and at the same time the most problematic is qualified labour. These companies have a particularly hard time recruiting and keeping their skilled labour. Furthermore, they usually do not have at their disposition well conceived programs for training and development of personnel. Modern technology is so dynamic that public and private systems do not succeed in training the individuals to the firms need. Large firms have installed their own training centres; this in beyond the means of smaller firms.

Since most of the transfers of technology are done from large firms, the factors of scales and sizes deserve special attention. The scale is more than the size; it's the size wih proportions and consequences. When the prportions are no longer in harmony, or when the consequences are not anticipated, firms then have problems of scale. In other words, the scale refers to the size and to the structure of the organization.[30)

However, rather than increasing the size, it is often more convenient to subdivide the process's functions and to try to find or yet to develop specialized equipment for each function or step.[31)]

The problems of complexity assiciated with size become more evident when one considers the infrastructure, the coordination of activities, the logistics aspect, the ability to make decisions, the employees' motivation. Thus, the issue dwells upon the fact that the organzation must find the optimal size considering the technologies utilized allowing it to effect the largest number of economies of scale possible.[32)] One must also note that different technologies can have different effects on the scale of organization. There is nonetheless a technological limit under which it would not be possible zu obtain economies of scale. Finally, without going into all the details of this issue, let us remark that the firm must attain al critical size effected from major process innovations like, for example, the introduction of microprocessors in manufacturing (CAM).

The structure of a firm, determined to a great extent by the size and by the core technology, can constitute a major curb on the adoption of new technologies if it is too concentrated, rigid, sclerosed, formalized or yet completely inexistent. In the case of a small or medium firm, the structure is often indicative of the sharing of responsibilities and of the division of labour; it therefore allows us to know if the technological innovation can be done only at the head of the firm or collectiviely. The same chain of reasoning applies to managerial capacities. All the studies on the matter have shown that it was impossible to dissociate technology and management.[33)] Therefore, to technological changes there must correspond certain changes in management practices and techniques. Among these is the ability to introduce changes, to overcome the resistance of the employees, to convince them of the benefits of the new technology and to show them, backed by proof, the wisdom of the management's decision. These practices in organizational development are particularly fundamental in the cases where the new technology questions the abilities and experience of the employees, threatens jobs or yet implies a redistribution of tasks. When one must come to terms with an unconvinced union and constraining legislation, all the expertise and the strengh of the managerial team ought to be pressed into service.[34)]

6.2 Characteristics of the transfer mechanisms

The important elements of transfer mechanisms concern the implied costs, the level of dependence, the ulterior development potential, the available expertise and assistance, as well as the various legal requirements.

The structure of costs related to transfer refers mainly to the initial payments, dues, financial plan as well as incidental fees. These elements are usually negociable; good planning in this field allows a better distribution of the forces present. It is unusual for any transfer og technology not to lead to a certain form of dependence. This is normal since the transferer has what the asker wants. There are evidently no magic recipes in this field but the golden rule seems to be: trying to get organized so that the agreement will be beneficial to both parties and that each will profit from the upholding of collaboration. A firm that is completely dependent on a supplier of technologies will have difficulty in achieving long or medium term technological autonomy, an essential condition for leadership. Related to this dimension, there are also the possibilities for the development of the technology to be acquired. If this does not allow improvements and subsequent refinements, it will constitute one more obstacle to the firm's technological autonomy and specific technological character.[35)]

7. ACQUISITION AND INTRODUCTION OF THE NEW TECHNOLOGY

The choice of the technology having been made, it is now a matter of proceeding with the transactions leading to the actual acquisition of the technology. Even if the whole process was well planned and prepared, there can still be problems in the acquisition. For example, delays in delivery can occur with the equipment and instruments; the financial arrangements can be more difficult than expected; experts having to advise the firm may not be available; certain misunderstandings can also occure on various points. What should be stressed here is that the acquisition of a new technology is not a routine affair.[36)]

With regard to the introduction, it concerns, as it has been already pointed out, a crucial step in the organizational development, especially with the employees. Unless the employees have been well prepared for this change, it is possible to encounter resistance, and even sabotage. A learning period must also be provided for, not only for the new techniques, but also for a different way of thinking and for tackling the new techniques, but also for a different way of thinking and for tackling the new technology. The new approaches can induce prolonged training periods, shifting of personnel and certain recruiting efforts. During this intensive period of introduction, the employees will have to get used to working alongsinde the experts, the specialists and often the skilled labourers from other firms. On the management level, the coordination efforts will be at the maximum, and all the available resources will have to be made useful. The amplitude of these efforts to be made use of depends mainly on the degree of previous preparation and the technological jump to undertake.

8. ADAPTATION AND IMPLANTATION

It is unusual for a new technology not to require several adjustments, modifications and alterations. In the case of transfers of ready-to-operate technology, these adaptations are mainly made by the supplier, usually at the expense of the buyer. The adaptation, is not only technological but is also managerial and psychological. The more the technologies introduced will be oriented towards intensive knowledge, the greater the adjustment in attitudes will be. In fact, it concerns passing from an essentially mechanistic approach of technology to a more globalistic and abstract approach. It is not at all evident that such a change in mentality can be made rapidly and without shocks.

Implantation is the starting up and the breaking in phase of the new technology and as such shoult not cause any special problems. Some adjustments will still be able to be made but one should already be in the position to judge the pace of the firm following the changes.

9. CONCLUSION

When technological implantation is followed closely by an intense managerial and organizational effort, especially where closely by an intense managerial and organizational effort, especially where control, coordination and scheduling are concerned, the results come more rapidly and are more convincing. The principal indicators on the firm's instrument panel provide the vigilant manager with useful information on the necessary administrative adjustments at the right time.

The impact depends mainly on the firm's strategy and will make itself felt especially in the immediate external environment of the organization. In the case of a small or medium firm, it is not always possible to identify exactly the causes of fluctuations because of their high degree of vulnerability with respect to their environment. However, a well established strategy comprises check points allowing the manager to interpret the progress of his firm. Therefore, the management must be ver aware that the impacts will make themselves felt in the short run as well as in the long run; one can often observe the managers' impatience when the desired effects take a long time to come.

This paper is an attempt to explain complex phenomenon and which ought to be verified in den solid reality of firms. If the above suggestions and guidelines are incorporated into a systematic process, the problems of planning, acquisition and implementation may be overcome. As a result the manager can propose future technological positions that will be most competitively strong and the means for achieving those positions.

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17) De Meyer (The flow of technological innovation) p. 315-325

18) Brose (Planung) p.1-4

19) Porter, M. (Wettbewerbsvorteile), p.22-29

20) Ansoff, I. (Implanting Strategic Management) p. 114-116

21) Drucker, P. (Innovationsmanagement) p. 204-208

22) Frohmann, A. (Technology) p. 23-30

23) OECD (Enquiries on Innovation) p. 76-78

24) Tushman/Moore (Readings) p. 574

25) Corstens (Technologietransfer) p. 43-44

26) Franko, L. (Japanische Multinationale Konzerne) p. 59-65

27) Plasonig, G. (Technologietransfer) Unpublished Working Papaer

28) ibid

29) Abernathy/Utterbach (A Dynamic Model) p. 639

30) Plasonig, G. (Technologietransfer)

31) Corstens (Technologietransfer) p. 268

32) ibid, p. 269

33) A.D. Little (Management) p. 55-64

34) Streicher, R. (discussion at the Vienna Universitiy of Economics, 1986)

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ENVIRONMENTAL ANALYSIS FOR STRATEGIC TECHNOLOGICAL PLANNING

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INTRODUCTION

Modern industrial organizations exist in complex and increasingly unstable environments. Even socialist enterprises functioning in more stable economic conditions produced by central planning economies have faced in recent years a volatile process of frequent changes in their state economic agencies' regulatory acts and decisions, problems adapting to rapid technological developments, and sudden events in the world economy. More than that, they are becoming increasingly involved in international business operations and consequently in interactions with less certain market forces.

Both theorists[1] and practitioners note an accelerated rate of social, political, technological, and economic change. The discontinuity of change most organizations are facing makes it difficult to predict the future development of their environments.

The great modern technological adventures -- micro-electronics, new developments in energy production and conversion, biotechnologies, production of new materials -- are reshaping industry's future. Broad implementation of micro-electronics in production and services allows many theorists to speak of a new industrial revolution based on flexible automation.[2] Adapting to these trends, many economies are in the process of structural change.

Revolutionary scientific discoveries, inventions, and innovations are changing the shape of industrial competition dramatically. A firm's competitiveness is becoming increasingly dependent on its technical subsystem. In part, this is caused by shortened product life cycles. "One moment, infancy; the next moment, old age. Blink and you miss the market."[3] But the main reason is the growing economic and market-efficiency dependence on the technical level of a firm's production facilities, especially equipment.

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[1]Toffler, 1970; Drucker, 1969; Ansoff, 1980.

[2]Ayres, 1984.

[3]De Bresson, 1985.

Both reasons are interconnected since the shorter product-innovation cycle in industrial goods production accelerates the rate of renovation in manufacturing processes or, to be more correct, produces a background for rapid process innovations.

Different factors, some of which are discussed in Ramanujam, 1985, limit the rate of process innovation, and lead to lower overall innovation intensity in industry, forcing manufacturers to focus their efforts, their financial and physical resources on product innovation. Generally speaking, this policy threatens the firm's competitiveness in the long-run. Research on the factors underlying an effective long-range technological strategy of organization might be very productive.

Phasing out labor-intensive industries in industrial countries and concentrating them in countries with lower wages adds up to the process of increasing the capital-intensive character of industry in developed countries. The competitiveness of their modern, capital-intensive, high-tech production both in domestic and international markets is mostly determined by their ability to maintain and advance to high levels of efficiency in the production technologies they exploit. Therefore, continuous technical renovation and hence process innovations are becoming the main concern of top executives and strategic planners at industrial organizations.

But since the renovation is usually a very expensive (even when limited to one production unit or production line), lingering and risky process, a new technology may become obsolete or cease to satisfy either production or market needs by the time it comes to operation.[4] As the process is also influenced by many tightly interconnected factors going far beyond only technical considerations, it is very hard for decision-makers to justify investment projects in renovation or process innovation properly.

In addition to the increased financial risk of a wrong decision, the world is now facing the much more dangerous risk of technical failure of increasingly complex production systems. Catastrophic accidents like those at the Bhopal plant or Chernobyl power station sharpen the problems of safety and reliability of modern technical systems, their internal consistency and fitness with existing systems and man-machine interface. Analysis of integrated factors is becoming an objective necessity in technological development decision-making, even at the level of the individual organization.

To decrease the risk of these projects failing both in technical and financial terms, a decision-maker has to improve the quality of prior analysis. This can be achieved either by widen-

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[4]see, for example, Mensch, 1985.

ing the scope of analyzed factors or by systemizing an analytical process or by both. Evidently, both external and internal (intra-operational) factors must be analyzed.

A review of current literature on the subject shows that several methodological as well as practical problems are involved. The main ones are as follows. First, despite a great number of theoretical works in the field, there is no unanimous concept; it is split rather into several, sometimes contradictory, branches. Second, no one concept embraces all the major groups of external factors having a strong potential impact on a firm's technological innovation strategy. Third, a large gap exists between theoretical recommendations and their practical application. Finally, since there is no systematic theory of business environment analysis, it suffers also in practice from a lack of an integrated approach which would emphasize the analysis of interdependencies between the external factors.

In this paper, we shall try to answer some questions arising in this short introduction. What is the current state of theoretical research in the field of environmental analysis? What are the limits of the major concepts? Is there a gap between current theory and practice? What are the reasons for this contradiction? Is it possible in principle to develop an integrative approach to environmental analysis with respect to innovation strategy?

In conducting this research, we are convinced that management policies must be directed towards creating forward-looking strategic analysis and planning systems suitable for uncovering problems caused by external factors in particular and solving them before they become critical. In other words, we assume that certain analytical forecasting and planning methodologies exist which increase an organizations's chances to avoid a crisis rather than to manage the crisis after it becomes apparent. But even if an organization fails to avoid the crisis completely, prior analysis (resulting, for example, in different scenarios or contingency plans) can help greatly to cope with it.

This preventive approach requires developing a methodology to select and analyze the most important environmental variables, particularly those which significantly influence technological development decisions in industrial organizations. One of the possible models which is suitable for an integrative analysis of environmental variables is suggested in the final section of the paper.

1. THEORETICAL APPROACHES TO ENVIRONMENTAL ANALYSIS: A BRIEF REVIEW

A large amount of work has been done in the field of environmental analysis research. It is quite natural that this problem attracts the attention of theorists in countries with market economies. But it is still essential for centrally planned economies, as well. Nevertheless, the commonly accepted point of view underestimates the crucial necessity of such research for socialists enterprises and central economic agencies. This position, held by some theorists and especially by the majority of practitioners, causes a deterioration in quality of economic plans and often leads to costly mistakes. We think it is wrong, and several theorists support this viewpoint.[5]

More advanced Western research on organizational environment is separated into five categories:[6]

1. Industry Structure model
2. Cognitive model
3. Organization Field model
4. Ecological and Resource Dependence model
5. Era model

The **Industry Structure** model sees the dominant aspects of an organization's environment in the industry or industries in which the firm operates. An industry environment consists of a particular set of competitive forces that establish both opportunities and threats. The forces' pattern changes due to the actions of "competitors." Porter (1983) uses this term to refer to buyers, suppliers, substitute products/services, potential industry entrants, as well as strategic groups of directly competing firms.

This model contains only passing references to the environment beyond the industry level. What might be termed the general environment is simple discussed as a source of "external forces."

The **Cognitive** model suggests that top management's collective understanding of its environment is assumed to be embodied in a cognitive structure. A cognitive structure serves as a context for formulating specific corporate strategies and is fashioned and sustained by those with requisite power and influence.[7]

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[5]Aganbegyan, 1979; Medvedev, 1983.

[6]Lenz, 1968b.

[7]McCaskey, 1982.

With this model, a change in an organization's environment is evidenced by the inconsistency between what a manager thinks should happen (i.e. causal relationships specified in a cognitive structure) and what actually occurs in his/her stream of experience. In this way of thinking, individuals detect environmental change after it has happened by reinterpreting experiences that did not make sense when they occurred.

The relative simplicity of organizing organizational learning and adaptation models employed by the theories of cognitive learning belies the complexity of the relationship between an organizational environment and strategic decisions. Strategic decisions are usually based on information about the environment, rather than on an executive's direct experience with aspects of the environment.[8] Hence, they are subject to all of the frailties of the information-gathering and filtering system both of the organization and of its individual executives.[9]

The **Organization Field** model postulates different approaches for conceptualizing environmental structure. There are several non-hierarchical conceptions of organizational environments.[10] They contain no explicit assumptions about the structure of organizational environments. This environment is simply assumed to be comprised of interdependent organizations that can influence organizational goals and resources and the public perceptions of a focal organization. Primary emphasis is placed on the goal structures and relative power distribution between interdependent organizations in the environment and in focal organizations and on the efficiency and effectiveness of exchanges.

In contrast to these approaches are hierarchical conceptions, rooted in the work of Dill (1958), that make more explicit assumptions about environmental structure. Thompson (1967) proposed dividing the total environment into a hierarchical arrangement of two levels. The general environment has no apparent outer boundary and seems to be the realm of everything beyond the task level. It is indirectly referred to as the source of trends, conditions, political actions, norms and/or broad societal patterns. The task environment is assumed to include organizations which directly influence the setting and achievement of an organization's goals. It begins where the general environment leaves off and ends at points of dependence defining the boundaries of an organization's domain.

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[8]Aldrich, 1973.

[9]Kiesler, 1982.

[10]see, for example, Williamson, 1975; Freeman, 1984.

Bourgeois (1980) has established a theoretical linkage between this conception of environment and the hierarchy of strategies (i.e. corporate and business-level strategies) that characterizes diversified corporations. We think that, despite its conventionality, this approach reflects the real state of things to the greatest extent, and we will follow it further.

It is usually asserted that environmental change originates among the broad trends of the general environment and flows in a non-directional path to the task level of the environment. As Lenz and Engledow (1986b) note, however, there is little systematic commentary about what triggers change at the general environmental level and how this change affects task environments of organizations.

Galbraith (1977) pointed out that the boundary between the organization and the environment is not sharp. Thus, the organization spills over into the environment and the environment intrudes into the organization. These factors complicate the definition of organization and environment.

The **Ecological and Resource Dependent** model uses two approaches to describe the structure of organizational environments. The first emphasizes a rather vaguely defined open-systems framework; the second employs the notion of hierarchy to disaggregate the overall environment into internally homogeneous levels.

In open-systems conceptions,[11] organizations are assumed to be the most important parts of the environment, which is characterized in global terms. Emery and Trist (1965) describe four types of environments: placid/randomized; placid/clustered; disturbed/reactive; and turbulent. Aldrich (1979) used the ideas of natural selection and resource constraints in formulating a population ecology model, which describes the environment in terms of the nature and distribution of resources. Organizations are seen as competing for resources as they seek liquidity (readily convertible resources), stability (resources with relatively fixed value over time), universality (widely sought resources) or simply lack other alternatives. An "environmental niche" or "viable form of living" is some combination of resources which proves capable of supporting a particular organizational form. Aldrich posits six dimensions to describe niches: environmental capacity, stability/instability, homogeneity/heterogeneity, concentration/dispersion, domain consensus/dissension, and turbulence.

In some works using ecological and resource concepts, it is assumed that organizational environments are hierarchically struc-

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[11]Aldrich, 1979; Emery, 1965.

ture. There is little agreement, however, concerning the number of environmental levels or what comprises each level. Pfeffer and Salawcik (1978), for example, describe environment in terms of three hierarchical levels; Thorelli (1977) offers a model in which there are five.

There is also little agreement concerning the pace of environmental change. Some authors argue that environmental change is systematic, continuous, and potentially predictable. Environments, it is said, cannot change randomly or discontinuously because of two opposing forces whose effects tend to dampen each other. One force is "innovation," the source of change, and the other is "acceptance," the source of order. An innovation is a variation in the environment and is broadly defined as any change that results from experimentation in patterns of living. An innovation that persists becomes an acceptance. Discontinuous environmental change is impossible in this logic because it takes time (sometimes decades) for an innovation to displace existing acceptances.

Other theorists[12] share more realistic views, arguing that organizational environments are becoming more turbulent. Management literature is full of hysterical phrases like: "shocks, jolts, and surprises seem to continuously upset organizational plans. The world seems to be a chaotic and frightening place".[13] It is considered that the growing turbulence stems in part from the increasing number and size of organizations, more complex organizational forms, the growing impact of governments, destabilizing effects of social change, the increasing inter-connection among organizations, ecological limits of the natural environment, rapid technological change, as well as other factors.

Among the ways in which environments come to be known and which only a few of the ecological models discuss directly, one notes the use of formal strategic planning processes,[14] the implanting of effective information systems,[15] and the development of assessment procedures for evaluating external demands.[16]

The **Era** model is used to describe organizational environments in their broadest sense -- as a context of institutional structures, social roles and human values. Its prospects suggest

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[12]Emery, 1965; Pfeffer, 1978; Aldrich, 1979.

[13]Stubbart, 1985.

[14]Thorelli, 1977.

[15]Aldrich, 1979.

[16]Pfeffer, 1978.

that certain broad societal processes establish the foundation of environmental structure. Toffler (1981), for example, postulates six on-going "spheres" of action as structural determinants of society (e.g. techno-sphere, socio-sphere). Each sphere has its own dynamics, yet is functionally related to the others.

All supporters of the era model agree that societal change results from individuals' actions; some of the authors add the effects of technology and the actions of institutions (e.g. corporations).[17] And nearly all branches of what is called the era model pay relatively little attention to the administrative procedures by which organizations come to know their environments.

A large body of research has been done in recent years in the field of technology assessment. It can be viewed as a branch of the environmental analysis studies, although it does not correspond directly with any one of the main theoretical models. Technology assessment as an area of applied research deals with such issues as an assessment of societal and ecological impacts of new technologies, the development of assessment techniques, and the functioning of public and government technology assessment agencies.[18] There are certain links between technological planning from the firm's perspective and the technology assessment concept. It should be underlined, however, that while the latter emphasized the indirect or delayed consequences for society of a new technology introduction, the former considers first of all the influence of external variables on a firm's technological policy.

While Porter et al. (1980) noted close connections between technology assessment and "environmental impact analysis," they succeeded in not mixing both conceptions. They stressed that special attention should be paid to varying accents in these approaches. This applies especially to "innovation research," which analyzes conditions favorable or unfavorable to the adoption of new technologies and products and their diffusion.

Although technology assessment research lacks a systemic view of industrial technology applications in the broad framework of a firm's general and competitive task environments, the industry structure model and in particular works by M. Porter fill this gap to a certain extent. Porter's (1980) approach to analysis of a firm's task environment includes "five fundamental competitive forces," that of industry competitors, suppliers, buyers, potential entrants, and substitute products. This ap-

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[17]Lodge, 1975.

[18]Porter et al., 1980.

proach was reproduced in his later works[19] and is currently accepted by many researchers.[20] Although not without certain advantages, Porter's methodology does not directly include the impacts of societal and other general environment variables on a firm's technological development. He views technology only as a competitive force and notes that the competitive significance of a technological change depends neither on its scientific merit nor on its effect on the firm's ability to serve market needs per se, but rather on its impact on industry structure. Technological change can potentially affect a wide spectrum of determinants of the industry structure. When a firm's technological innovations are appropriate, these impacts of technological change on structure are the fundamental motivations underlying the firm's choice of technological strategies.[21] But in this logic, general environmental determinants are not even mentioned.

1.1. LIMITATIONS OF CURRENT THEORY AND PRACTICE

The models briefly characterized above are not alternatives equally useful for organizational environment analysis. Instead, they are based on fundamentally different assumptions regarding the scope, structure, and behavior of environments.[22] The limited character of each model gives no means to systematically focus environmental scanning and analysis activities. Even the broadest era model suffers from a lack a conceptual development about the structure and functioning of the general environment and threatens to trap analysts in an almost open-ended process in which it is difficult to sort out relevant from irrelevant information. Current theory gives no integrative conceptual framework for guiding and interpreting the full range of economic, technological, social, and political forces that are known to influence the strategic actions of organizations. As a consequence, reliable environmental forecasting and experienced-based conjecture are largely limited to short-term assessments of incremental changes in the economic and technological aspects of task and industry environments. Identifying and interpreting the consequences of longer-term change remains a highly intuitive and often haphazard process.[23]

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[19]for example, Porter, 1983.

[20]see, for instance, Bates, 1985.

[21]Mensch, 1979.

[22]Lenz, 1986b.

[23]Lenz, 1986b.

It is not surprising therefore that, according to the surveys, the majority of corporate analysts engaged in environmental analysis on an almost daily basis had no coherent notion of how their portions of the environment were structured or what caused them to change.[24] The study of Fahey and King (1977) revealed that only a small proportion of firms were undertaking continuous scanning. A more recent survey found out that even among large corporations recognized as "leading edge," the mortality rate of formal environmental analysis units has been relatively high.[25]

Contemporary business history contains a number of examples of a firm's failure to recognize environmental changes in time, especially in new technology fields, and to react in an appropri ate manner.[26] Strategic planning models as well as the majority of other analytical methods that firms use in their planning activities are not well suited to the character of the problems firms are facing. As Stubbart (1985) noted, while strategic planning models have borrowed the form and language of algorithmic models (e.g. linear programming), strategic problems and their context are totally unlike the problems for which algorithmic models were designed. Strategic problems occur in complex social environments; they are aperiodic, unstructured, and "wicked."

It can be suggested therefore that some corporate failures caused by external factors could have happened not only due to the turbulence and unpredictability of environmental change, but also due to a lack of adequate analytical tools for environmental scanning and analysis and because of relatively little attention paid by firms' executives and analysts to the study of external factors. It is worthwhile to state that the latter is to a large extent a consequence of the former.

Although there is a scarcity of empirical data, some studies[27] show that in general environmental analysis is an extremely rare activity in the great majority of industrial firms and, if it exists at all, is undertaken on an ad hoc basis. These studies focused primarily on technology assessment practice. According to twenty-five interviewed corporate executives who had attended technology assessment workshops, it appeared that technology assessment was not a commonly understood concept in the private sector. Respondents frequently listed the following activities as technology assessment: technology forecasts, engineering

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[24]Lenz, 1986a.

[25]Engledow, 1985.

[26]see, for example, Cooper, 1982.

[27]see, for example, Coates, 1982; Szyperski, 1983.

evaluations, site analyses, environmental scans, competitive analysis, and economic and business projections. A large number of respondents identified market analysis as technology assessment.[28] It was also discovered that assessments of the social and ecological impact of a firm's activities had usually been done only to the extent necessary to satisfy regulatory requirements. It is clear, therefore, that what most industrial firms label as technology assessment is an irregular, unsystematic activity which, quite naturally, can give satisfactory results only by chance.

A study by Fahey et al. (1983), based on interviews with 11 business consultants, 8 government officials, and 17 corporate executives representing 12 firms, allowed the researchers to estimate the degree of integration of environmental scanning/forecasting and long-range planning (Table 1). It indicates the perceived potential applicability and the actual usage of environmental scanning/forecasting practices at various stages of the planning process by corporate segments of the study. Although corporate forecasting professionals indicated a strong potential for futuristic scanning, their actual usage was not so high. All the respondents agreed that the basic purpose of employing any mode of futuristic forecasting is to identify those trends, events and discontinuities which may have a significant impact on the firms' long-range plans. But all the practitioners admitted they presently do a highly inadequate job in this regard. Most were involved in, or preoccupied with, the short-term implications of events which have already come to pass.

TABLE 1. Applicability of Scanning/Forecasting at Various Stages of Planning

(adapted from Fahey et al., 1983)

	Corporations	
	Potential	Actual
Establishing corporate goals	5.3*	4.8
Setting environmental premises	6.1	5.0
Collecting information and forecasting	6.1	5.0
Establishing divisional goals	4.0	3.8
Developing divisional plans	3.1	2.0
Revising objectives and plans if objectives are not met	2.1	2.0

(* measured on a 7-point scale)

[28]Coates, 1982.

It is not surprising then that, as the project NewProd (aimed at investigating and defining the components of risk as perceived by a decision-maker at a firm undertaking new product ventures) showed, new product risk, and hence that of technological innovation to a great extent, was largely determined by the non-controllable environmental variables.[29] But does the non-controllable character of environmental factors mean that environmental analysis is useless? Or can it be improved, both in the sense of the organizational process and in its content, and increase its effectiveness? We will try to answer these questions in the next section of the paper.

1.2. DOES A FIRM NEED A REGULAR ENVIRONMENTAL ANALYSIS?

This is not an empty question since it concerns the fundamental principles of a business organization's strategy and long range planning. Conventional strategic management assumes that:

* an organization can be managed in such a way that adaptation to its environment is achieved;
* top management decides what the mission/strategy should be;
* organizations can control future outcomes through their own clever strategic actions.

But recently some Western theorists have questioned the validity of these principles. They argue that both task and general environmental linkages have become progressively less understandable and less manageable; that the number of potential environmental linkages is astronomical for any organization; and that organizations have no reliable way to decide which linkages to investigate. Thus, they conclude that environmental linkages are unpredictable and troublesome to any organization.[30] Furthermore, it is said that in tightly inter-connected systems, like that of a modern business environment, actions of one organization affect actions of other organizations in a way that makes it practically impossible to understand the cause-effect chains and to predict local effects of distant events and the consequences of the organization's own actions.[31]

These and similar arguments have led some authors to come to the general conclusion that environmental analysis, prediction,

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[29]Cooper, 1981.

[30]Stubbart, 1985.

[31]Stubbart, 1985.

forecasting and planning are not only impossible, but even harmful for business organizations in turbulent environments. Instead, such misty recommendations as "to set energies free -- free to find amazing new insights, free to use different kinds of metaphors, and free to experiment with bold, new behaviors"[32] are suggested. It is also said that "the only way turbulent conditions can be brought back under control is through a collective and cooperative search for new values and rationales for behavior".[33]

No doubt both general and task environments are becoming more and more complex and in that sense more turbulent. But it is also obvious that environmental stability, especially in the task environment, is underestimated. Environmental turbulence is limited; there is chaos at either extreme. But a proper analysis of environmental facts and trends and of certain patterns of organizations' behavior reduces the unpredictability and turbulence of the environment from the organization's point of view. The majority of mistakes made by organizations and leading to more or less serious failures are rooted in wrong policies reflecting selfish biases and expectations of top management and consequently lacking underlying objective information. Certainly, it is impossible to obviate to a full extent the fluctuating character of a market economy. Environmental analysis, however, increases the soundness of strategic decisions. After all, it does not reject other approaches to increase the quality of managerial policies. A search for increasing environmental stability through cooperative actions as, for example, a number of recent inter-firm deals in the R&D field have shown, can go along well with environmental analysis. One does not exclude the other. The methodological shortcomings, however, in the way analysis of external factors and their relationships is undertaken can still cause problems. Although the general economic and political background of capitalist and socialist firms is quite different, certain requirements for improving the quality of managerial actions through sounder strategic business decisions apply equally to both.

2. TOWARDS AN INTEGRATIVE APPROACH

As a rule, a lack of answers is caused by a lack of questions. To further develop this rule: a lack of the right answers is caused by a lack of the right questions. In our opinion, this statement is quite applicable to the current situation in environmental analysis, especially in the technology field. To change this, it is necessary to integrate the positive features of all

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[32]Stubbart, 1985.

[33]Stubbart, 1985.

models mentioned above and to show the interdependencies of a certain set of environmental variables concerning the technological development of a business organization.

It is quite obvious that a business organization's environment may vary in different periods of its life. It may be more turbulent and more stable, more complex and more simple; it may be viewed in general terms and in task terms; it may be divided into economic, politico-social and technological contexts, etc.

To analyze a firm's environment along all dimensions that have an impact on its technological development concerns, one must systemize a process of environmental analysis. Conceptually, we agree with Bates (1985) who suggested three steps for environmental analysis: 1) monitor the environment, 2) analyze it, and 3) predict it.

Monitoring: The process of environmental scanning must include identifying trends and changes in the entire environment that may ultimately affect the firm; selecting from this large mass of information those variables which have a significant influence on the firm (identification of Relevant Variables); and reducing the set of Relevant Variables to a handful of Critical Variables which represent environmental forces substantially influencing the firm. The necessity of this process reflects the "bounded rationality" of a decision-maker (according to H. Simon). It must attract the special attention of analysts since the possibility of throwing away a significant piece of information is rather high.

Analysis: During the analysis stage, three kinds of relationships are to be examined:

1) between the Critical Variables and the possible future states and directions of the economy's development;

2) between the Critical Variables themselves (their interdependence and a degree of mutual influence);

3) between the Critical Variables and the internal parameters of the firm.

Prediction: The prediction stage -- the goal of environmental analysis -- begins with drawing a picture of the present state of the organization's environment. Then, applying the understanding gained from the analysis stage about how the environment works, the analyst draws the picture of the future. It is worthwhile to note that the usefulness of forecasting is severely constrained in practice. Utterback (1982) pointed out that this is because predicting the effects of trends and events is much more difficult that foreseeing the primary changes themselves.

The systemic approach to environmental analysis assumes a classification of variables. Our study is limited to those variables which may have a significant impact on the technological development of a firm.

2.1. CLASSIFICATION OF ENVIRONMENTAL VARIABLES

A particular complexity of environmental analysis for strategic decisions in the technological sphere comes from the high dependence of these decisions on a great number of external factors. The analyst's attention must focus on the following environmental areas and concrete variables.

1) General-Economic Factors:
   * major economic indicators: rate of growth, inflation, interest;
   * business cycle;
   * present state and future directions of structural change in the economy;
   * global issues -- the above variables applied to other economies whose development influences the organization;

2) General-Socio-Political Factors:
   * major goals of state industrial policy;
   * government tax policy;
   * protectionism;
   * unemployment, labor market, availability of skilled labor;
   * changes in government philosophy;

3) General-Technological Factors:
   * rate of technological change in society;
   * general technological developments;
   * government R&D policy;
   * academic (university)-industry relations;

4) Task-Economic Factors:
   * industry life cycle;
   * industry structure;
   * intensity of competition;
   * barriers to entrance, new entrants;
   * consumer/market parameters;
   * characteristics of products, substitute products;
   * characteristics of suppliers;

5) Task-Socio-Political Factors:
   * projections of macro-policies on industry;
   * local social environment requirements;
   * local environmental pollution laws, etc.;
   * local labor market;

6) Task-Technological Factors:
   * life cycle of basic industry's technology(ies);
   * technological change in industry;
   * technology(ies)'s state of maturity;
   * competitors' state of technological development.

No doubt the list of variables is too broad for most technological planning analytical efforts. The particular task of the analysts is to sort variables, identifying the most important ones. Identification of Critical Variables requires a situational approach and is a great challenge for analytical staff. A choice of too many variables embarrasses the planning procedure. On the other hand, a reduced number of environmental parameters increases the probability of omitting an important one. Furthermore, the list of Critical Variables for an organization may change from year to year, from one strategic technological area to another.

Although the analysis of identified variables may be productive by itself, more important in our opinion is a systemic study of the relationships between them and especially between critical factors. An outline of such analysis in respect to strategic technological planning is proposed below.

3. THE OPERATIONAL MODEL OF ENVIRONMENTAL ANALYSIS FOR TECHNOLOGICAL PLANNING

The aim of this paper is certainly not to propose a single model for environmental analysis for technological planning. The multiplicity of general economic and market situations makes it impossible to suggest a technological strategy which would be suitable for each situation and all firms involved. That is why it is only possible to set up general guidelines for developing an appropriate framework for environmental analysis. Some factors must be stressed while other eliminated in certain conditions describing technology/market(industry)/economy/society interactions.

The proposed model may be viewed as an impact, first, of the general environment variables on a firm's technological strategy intermediated through the task environment variables, and second, of the immediate task environment variables and their dependencies (see Fig. 1).

The proposed model is a cross-impact matrix constructed by arraying one list of factors vertically and a second list horizontally (see Fig. 2). The cells display data portraying the interaction between each row and column entry. The versatility of this form allows us to incorporate different dimensions of analyzing factors and their relationships: trends, activities, goals, policies, impacts, etc.

In this paper, we consider only the impacts of dependencies mentioned in cells 1-7. We realize the impossibility (and lack of necessity) of analyzing all interconnections between the factors and attributes of different environment segments. Therefore, we emphasize only those linkages which may be perceived as the most crucial for and having a direct impact on an organization's technological strategy development.

Cell 1: 1) Major economic indicators, especially inflation and interest rates, influence investment decisions greatly; they specify to a large extent the overall economic and innovation climate in the country, the main directions of capital flows, investors' requirements for their capital utilization by industrial organizations (rate of return, payback period, etc.), diversity of financial sources, availability of venture capital and so forth.

2) Business cycle (and generally speaking, all macroeconomic cycles) influence the availability of capital in general and of the labor force, industrial equipment loading and consequently the firm's, its competitors', suppliers, and customers' productive potential, the state of their R&D programs which are usually the first to be reduced during recession (Mensch's research, 1979, showed that "...every fifty years when stagnation developed, the economy first reacted adversely by cutting down research and development and experimentation. Instead of redirecting it, firms released large amounts of capital and manpower. Instead of increasing expenditure in research and development, firms saved on investment in innovation") and to be intensified after the crisis has passed.[34]

3) The present state and future directions of structural change in the economy pose certain threats and opportunities to the technological development of the task environment population. Knowing the structural policy preferences may lead us to expect the development of certain technologies (and, inversely, the replacement of others).

[34]Mensch, 1979; Sahal, 1985.

Cell 2. 1) The goals of government industrial policy create a climate favorable (or unfavorable) for innovations in general and for development of certain technologies in particular. Japan's industrial policy is a classic example.[35]

2) Tax policy directly influences the amount of scarce resources available to a firm. Such resources may be used in innovation either for capital investment in new technology generated by the firm or by others, or for investment in R&D, the direct generation of such technology. Tax policies can affect either variety of spending. The most direct effect of taxation is probably on the firm's decisions about how much to spend on R&D or about the distribution of R&D by categories. A portfolio of research and development projects is assumed to be ranked in some order of priority, based on expected financial gain and other investment possibilities. Tax concessions for R&D would presumably tend to induce a firm to include more projects in its portfolio, to intensify its efforts on existing projects, and possibly to include a greater number of high risk projects. The premised is that there is a direct relationship between commitments of extra resources to R&D and discernable gains in innovation.[36] The validity of tax policy depends heavily on the country's overall economic climate. For example, some studies of the U.S. tax policy's effects on innovation showed that lower taxes leave corporations with plenty of cash on hand, but with the incentive to engage in R&D and production investment blunted by high interest rates, corporate leaders turned to paper investments.[37] Mergers amounted to $125 billion in 1984 and will have been even higher in 1985.[38] According to Mansfield,[39] special tax benefits for R&D expenditures in the U.S. (the investment tax credit) provided only a 1-2% increase in industry's R&D spending in the beginning of the 1980's, while the budget losses due to reduced taxes were much greater than the benefits of such a small increase in innovation.

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[35]see, for instance, Johnson, 1982; Tsuruta, 1985.

[36]NSF, 1983.

[37]Epstein, 1986.

[38]Greenwald, 1985.

[39]Harvard, 1984.

3) Protectionism as a part of industrial policy may have different objectives. It may be oriented towards propping up sunset industries, limiting their will to innovate, as in the U.S. steel, television, and textile industries.[40] Or it may, on the contrary, stimulate innovation by protecting infant products from predatory competition.[41] Evaluating the environment, a firm's analysis must be aware of what kind of protectionist policy (if any) concerns his business.

4) The situation in the labor market and the system of higher and special education specify some of the human factor requirements for the introduction of new technologies. It may expose, for example, the future need for skilled labor and whether a firm should focus on internal training (with appropriate funding and spending of other resources) or should hire an already trained work force.

5) Government and public institutions, policies, and attitudes indirectly affecting innovations and technological development in society should be considered.

Cell 3. 1) General characteristics of the overall technological environment's prime forces influencing the industry and market place in which a firm operates; macro-technological policy and appropriate trends in science and technology.

2) The changes in industry structure due to technological issues were widely studied by many theorists in the field of natural selection concept.[42] In these works, interconnections between such variables as population density in industry, organizational life cycles, industry age, rate of technological change, and diffusion of innovations, etc. have been studied. Some of the findings relate directly to the subject of our analysis. For example, Brittain and Freeman (1980) noted that the rate of organizational founding is inversely related to the age of the industry and level of capital required for entry and directly related to the industry's growth rate. Furthermore, since the industry's growth is based on a whole series of technical

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[40]Thurow, 1980 and 1982.

[41]Ayres, 1984.

[42]see, for example, Aldrich, 1979; Hannan, 1978; Brittain, 1980; Freeman, 1982; Aldrich, 1976; Hiller, 1977.

innovations, the ecological processes of foundation and failure in general have been greatly accelerated.

3) There is some empirical evidence (for example, the U.S. semi-conductor industry during the 1960's and 70's) confirming the pattern of an industry's maturation, or in other words, the industry life cycle model.[43] An analyst, therefore, may forecast with probability the future developments in industry evolution, changes in its structures and in the patterns of innovation, and the overall competitive and technological behavior of firms operating in the industry.

4) An analyst must be aware of the conditions that create environmental wealth since it may very well limit the viability of some populations, while allowing other populations to expand seemingly without limit. For example, the munificence created by decreasing prices and on-going innovation in semi-conductors in the U.S.A. was extremely rewarding for those organizations heavily involved in product and process development. But many other organizational types may have found the scale required to use plentiful resources beyond them.[44] Industry population may expand through schism. Freeman (1982) wrote that organizations sometimes break up when corporations "spin off" subsidiaries. Sometimes a venture proves to be inconsistent with the rest of the organization (for example, due to a new technology it has developed or adopted) and is sold off.

5) The characteristics of organizations operating within an industry (or at least of the major competitors) are vital to know since they determine to a large extent the firms' behavior, particularly in the field of innovation. Freeman (1982), relying on some previous works, pointed out a number of reasons for expecting organizational inertia. Existing organizations derive their competitive advantages from the stability of their internal social relationships and on the basis of their relationships with other organizations. This often leads to the development of ideologies and traditions that at once legitimate the status quo and dampen innovative tendencies.

6) A study on new and emerging technologies in the field should be done to answer, for example, the following questions. Does new technology spread across

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[43]Abernathy, 1978; Utterback, 1975.

[44]Brittain, 1980.

industry boundaries? Can the firm and its competitors (namely, who?) enter other industry(ies) or markets? What impact does this process have on industry structure? When and on what scale should new and emerging technologies be adopted by organizations in the industry? Etc.

Cell 4. We do not concentrate on social impacts of new technologies here since for a long time it was within the focus of technology assessment studies and very well described in literature.[45]

Cell 5. 1) The analysis of general-technological environmental impacts on task-technological variables may include a study of government efforts to affect innovation in industrial organizations, in joint industry and academia activities in science and technological development.

2) Attention must be paid to current scientific developments in fields indirectly connected with the core business of the firm, as well. For example, microelectronics has left no industry untouched. Obviously, new materials will have (and partly already have had) the same effect.

3) Information concerning these issues should be obtained not only from scientific and other publications, but more importantly by direct contacts between scientific organizations and R&D departments of industrial firms.

Cell 6. 1) As Porter (1983) wrote, most research on the relationship between technological change and industry development has grown out of the product life cycle concept, examining the ways technological change varies as an industry moves from the emerging state through growth, maturity, and decline. The view of technological innovation evolution according to industry maturation has been deepened and refined considerably by the work of Utterback and Abernathy (1975). Initially, as they have pointed out, product design is fluid, and substantial product variety is present. Product innovation is the dominant mode of innovation and aims primarily at improving product performance. Successive product innovations ultimately yield a "dominant design" where the optimal product configuration is reached. Process innovation is initially of minor significance, and early production processes are characterized by

[45]see, for instance, Coates, 1982; Szyperski, 1983; Porter et al., 1980; NSF, 1983.

small scale, flexibility, and high levels of labor skills. As product design stabilizes, increasingly automated production methods are employed, and process innovation to reduce costs takes over as the dominant innovative mode. Ultimately, innovation of both types begins to slow down. Some industries, mentioned as examples by Abernathy and Utterback, fit well with these hypotheses.[46] They are not, however, general and do not apply to every industry. The study by Ramanujam and Mensch (1985) of 46 firms, widely diversified in terms of size, industry, current profitability, maturity of product lines, and age of manufacturing process, revealed a violation of Abernathy's and Utterback's prescription. Explaining their findings, Ramanujam and Mensch (1985) consider it not a contradiction, but rather an extension of the industry growth theory. Their results make evident the need for analysts to conduct deeper and more comprehensive analysis of both macro-economic conditions and industry economic variables underlying the process of technological change.

2) Porter (1983) divided the determinants of the pattern of technological innovation during industry evolution into two types: a) dynamic processes and b) underlying structural parameters that influence the extent and speed with which these processes occur.

He elaborated the most important dynamic processes:

* scale change;
* learning curve in product design and process;
* imitation and uncertainty reduction;
* technological diffusion;
* diminishing returns to technological innovation in product and process.

The speed and extent to which these dynamic processes proceed are a function of the following most important structural parameters:

* intrinsic physical differentiality of the product;
* intrinsic segmentation of buyer needs;
* unit volume (scale) at maturity;
* potential scale economies and learning effects;
* linkage between product design and process;
* motivation for substitution;
* technological opportunity.[47]

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[46]see, for instance, Wilkinson, 1983.

[47]Porter, 1983.

The pre-planning stage in developing a sound technological strategy has to be based on a proper analysis of at least these factors.

Cell 7. (See comments on Cell 4.)

An analysis of the described variables and of their inter-relationships will help managers to define objectives for the technology strategy. It will provide a deeper understanding of what the situation will look like over the planning horizon and what the technological bases for the organization's activities will be.

Several environmental variables must be analyzed in order to achieve this understanding. First, the current situation and possible future trends in the general environment influencing strategic technological interests of the organization must be taken into consideration. Second, the task environment variables influencing the process of innovation in appropriate industry and market segments must be analyzed. Special attention must be paid to the evolution of industry structure caused partly by technological developments. Third, an analysis of the variables directly influencing technological innovation must be accompanied by analysis of other forces (social, economic, legal) which seemingly have no direct impact on innovation strategy. Fourth, the main challenge an analyst faces is the necessity for cross-impact analysis of at least the major dynamic variables: changes and their inter-influences in economic, legal, and social conditions, science and related technologies, and patterns of other organizations.

Having thus identified its own future environment, the organization greatly increases its ability to develop a sound technology strategy and to increase its adaptability in an unstable economic and technological environment.

CONCLUSIONS

1. The industrial enterprise as an economic and social organization is a part of a macro-system with which it is tightly inter-connected in different ways. The impact of external factors may differ in strength and continuity of reaction.

2. Any sudden external event, which has a significant impact on the organization, places it in a situation which may be called a crisis. This situation is usually disruptive for any organization.

3. To avoid a crisis or to prepare to cope with one in advance, an organization must at least be informed about the present state and possible future developments of the influencing external factors.

4. Technology becomes a dominant factor in an organization's strategy and one of the more or less uncertain external forces determining the success or failure of a firm's future operation.

5. The effectiveness of contemporary technology, its competitive power, is a function of many variables which represent not only intra-organizational, but also external factors: technological, economic, competitive, socio-political, etc.

6. Only a systematic approach makes it possible to select the significant and major (critical) variables from the whole set of external factors influencing an organization's technological development.

7. Such an approach assumes the classification of variables, the selection of the critical ones, and the analysis of both the variables themselves and the interdependencies among them.

8. The paper suggests a model which allows us to systemize the process of environmental analysis. It also describes some of the important interdependencies between critical variables which must be the focus of analysts' and top management's attention in the process of technological strategy development.

9. A systemic analysis of external forces increases the soundness of technological strategy and decreases the financial risk of innovation projects. It also allows us to estimate the environmental impact of new technologies and products, to foresee the consequences of their introduction, and to avoid a serious mismatch between introduced innovations and external conditions and requirements.

FIG. 1: IMPACTS OF GENERAL AND TASK ENVIRONMENTS ON A FIRM

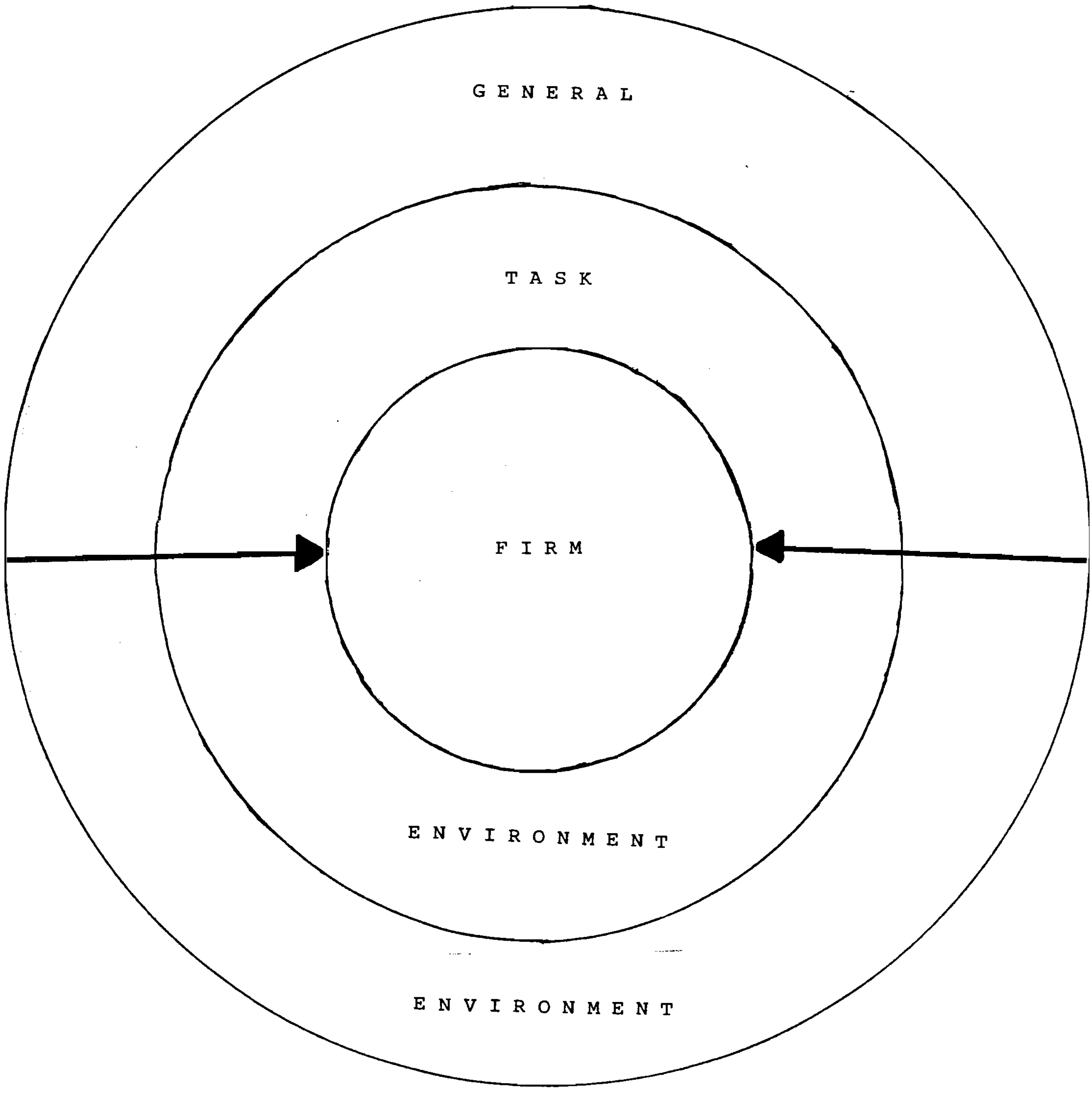
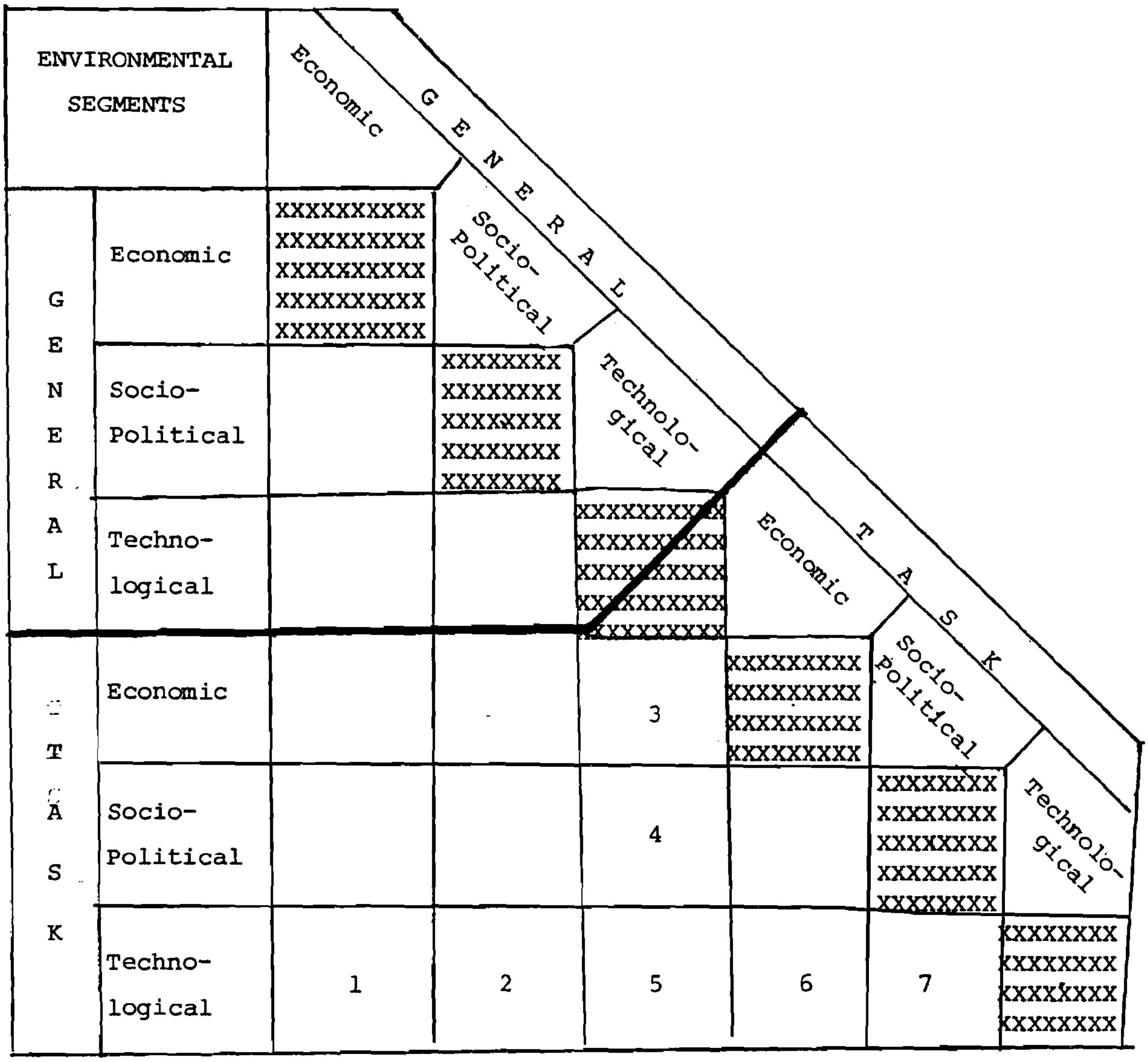


FIG. 2: MATRIX OF DEPENDENCIES BETWEEN SEGMENTS OF GENERAL AND TASK ENVIRONMENTS INFLUENCING A FIRM'S TECHNOLOGICAL STRATEGY



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