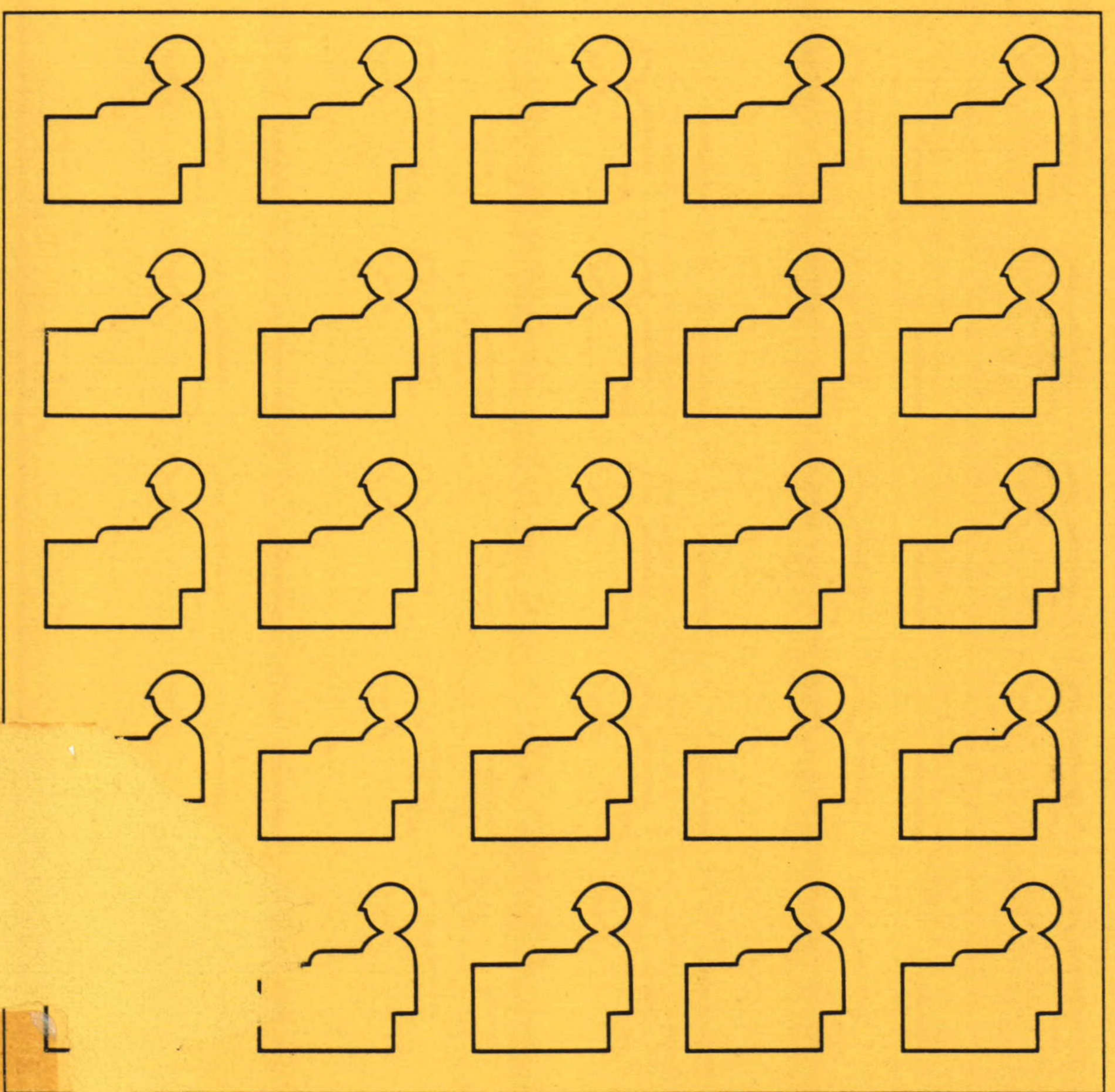
OFFICE COMMUNICATIONS SYSTEMS PROGRAM

PROGRAMME DE LA BUREAUTIQUE

AN INTERDISCIPLINARY INVESTIGATION INTO THE ISSUE OF OFFICE AUTOMATION AND PRODUCTIVITY



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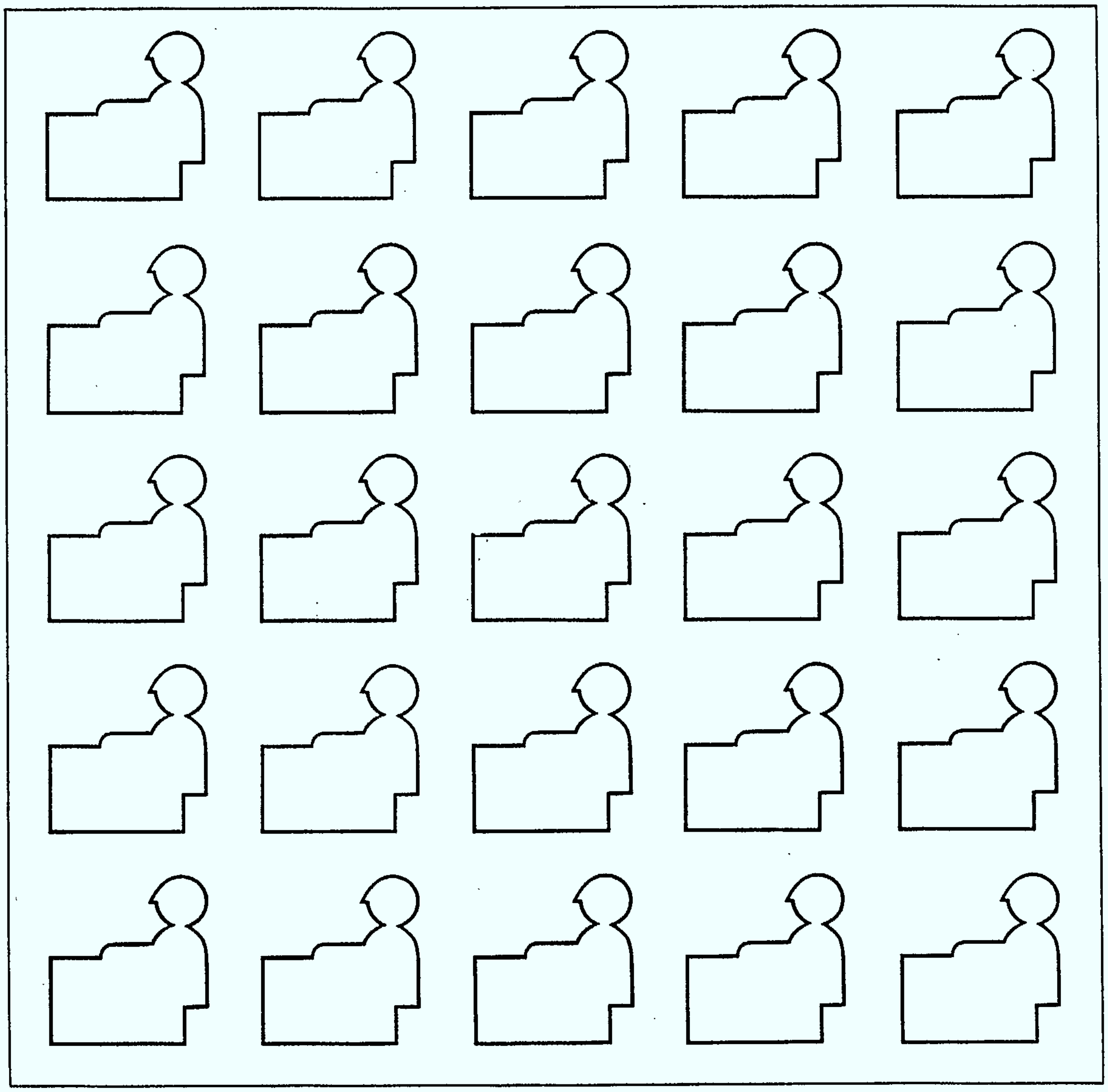

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An Interdisciplinary Investigation Into The Issue of Office Automation and Productivity

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PREFACE

This report is part of the extensive research program carried out by the Office Communications Systems Program of the Department of Communications to address various economic, technical and behavioural aspects of developing and introducing new integrated electronic office systems.

The purpose of the research program was to focus on particular areas of concern where questions need to be more clearly articulated, the state of the art reviewed, or new concepts and methods of study developed.

This particular report provides an interdisciplinary perspective on productivity research as it relates to office automation focussing on the disciplines of economics, behavioural science and management science. The need to take this somewhat unique approach was prompted by the fact that, in most cases, office automation is introduced to achieve significant productivity improvement but productivity is not well understood by most managers because it is complex and interdisciplinary in nature, comprising as it does economic, organizational and behavioural elements.

As the authors state "This study does not attempt to predict the future. Rather it offers different perspectives... specifically directed towards the issues of office automation and productivity, rather than productivity itself, which serves to enlarge the context from which to approach office automation and... (which) increase the range of questions that must be asked before a true understanding of the impact of office automation can be reached".

This report will be useful to executives and managers and systems professionals who must make or implement the stategic decision to introduce office automation technology by providing to them a different way to view their organization and its operations and the contribution office automation can make to their prouctivity and competitive situation. Researchers from several disciplines will also find it useful because it provides them with a framework to pursue this subject and achieve a better understanding of the dynamic and complex issues relating to office automation and productivity.

Robert Hoganson
Special Advisor
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Systems Program

Department of Communications

March 1985

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CHAPTER 1

INTRODUCTION

Probably no single technological development has engendered such fierce debate as that which surrounds the impending automation of the office. Proponents argue that this technology will revolutionize office work, freeing clerks and managers alike from routine tasks, allowing them to reap large productivity gains by becoming more effective and efficient in their more complex roles. Critics propose a more Orwellian future, with highly routinized and mechanized jobs, massive structural unemployment, and highly intrusive performance monitoring. Productivity will increase, but with enormous social costs.

This study does not attempt to predict the future. Rather it offers different perspectives from which to view the issues of productivity and office automation. In a sense, it is a continuation of the recently published Productivity: Three Perspectives by James Pickworth. In that work, Pickworth adopts three different perspectives from which to study the issue of productivity, namely those of the economist, the behavioural scientist, and the management scientist. As a conclusion, he offers different strategies for productivity improvement based on the three perspectives.

Three major perspectives are also presented within this study; however, they are specifically directed towards the issues of office automation and productivity, rather than productivity itself. In addition, the perspectives are different ones, which serve to enlarge the context from which to approach office automation. The analysis provides no answers, but increases the range of questions that must be asked before a true understanding of the impact of office automation can be reached.

The first perspective is that of the macro-economist interested in the possible interactions among productivity, office automation and international competitiveness. The first point presented is that Canada is experiencing a major productivity slowdown, the causes of which are not understood. Part of the reason may be the shift in industrial composition away from goods production to service provision, accompanied by more difficult measurement and interpretation problems. That shift is expected to be exacerbated by technological change, so simulations are presented which look at the shifts in industrial composition due to such change, when different income and price elasticities exist and when different rates of productivity increase take place. The results are then examined, giving due consideration to Canada's historical record of high labour growth rates and high labour mobility or turnover. The structural unemployment debate is challenged through the historical conclusion that technological change has created high growth in both demand and supply, leading to higher levels of total output. Finally, problems of technological diffusion are examined as potential keys to Canada's productivity performance. The conclusion reached is that technological diffusion, including office automation, should be viewed as an economic strategy to improve Canada's competitive position in certain high payoff sectors.

The second perspective picks up on this theme, that of the interrelationship between technology and corporate strategy. It begins by looking at the broader issue of automation in both process and product as a strategic weapon. Technological choices directly impact a firm's capability of sustaining a competitive edge. However, Canadian firms do not apparently have a sufficient appreciation of that fact, especially when computer and office automation technologies are involved. This section continues by drawing parallels between office automation and factory automation and by introducing the concept of the "automation triangle". Inherent in the successful application of technology are not only the understanding of the hardware and software involved, but also the construction of the appropriate management/control systems that are necessary for success. Such management systems provide the integration between the technology on the one hand, and the organization on the other that allow the organization to reap full benefit from the automation process. The implications of this approach are large. Office automation is but a futher movement in the "softonomization" of industry. As such it must be approached from a strategic point of view, to take advantage of its potential to create sustainable competitive advantage. Otherwise, Canada will persist the pattern of high cost and high unemployment of recent years, with the concommitent fears of job loss and technological displacement.

The final perspective attempts then to fit the "most remarkable" technology into the organization. Office automation technology is not simply an enhanced communication technology because communications is not a simple, well-bounded concept. Rather, organizational communications are interrelated with decision making processes and with information processing activities. The "new" technology is an information technology, and as such is not new in a revolutionary sense, but the obvious continuation of evolution in information processing technologies. Thus, to understand its potential place in the organization, one has to understand the existing information technology bases and the interrelationships among them. By examining simplified models of organization and information flow, the processes of information processing within the organization are unravelled, culminating in the delineation of three distinct, but highly interrelated, types of information systems. Then, the "automation triangle" is once again employed to examine the nature of the complexity of each system and the ways in which they interrelate. As a conclusion, an attempt is made to place office automation technology within this framework, complete with what appears to be a natural evolutionary path for the different types of information systems within an organization. The role of office automation systems appears once again to be one of strategic choice. It can be viewed either as another form of the more simple, transaction-based systems, or it can be approached as the ultimate form of integration of technology and managerial need.

There is a consistent theme that runs through these three perspectives. Office automation, as a technology, will not solve productivity dilemmas on its own. It has the potential to dramatically affect the ways in which firms operate. But it is only when the application of this technology is in consonance with an overall competitive strategy, fit within the existing technological base of an organization, that significant impacts on a single firm's, or for that matter Canada's, productivity and competitive situation can be achieved.

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CHAPTER 2

ECONOMIC ASPECTS OF PRODUCTIVITY - MACRO AND MICRO

2.1 INTRODUCTION

There has probably been more written on productivity from an economic perspective over the last two decades than from all of the other social science disciplines combined, and there is also a large amount of literature on the engineering, scientific and technical side. This is reflected in the accompanying bibliography. This chapter does not attempt to summarize the vast number of studies, partly because three recent studies emphasizing Canadian material have been published (Maital and Meltz 1980; Denny and Fuss 1982; and Daly, ed., 1983).

This chapter will concentrate on four important economic aspects of productivity, namely its relationship to living standards; its relationship to changes in industrial and occupational composition; the interrelationships of productivity and employment; and the relationships between productivity and international competitiveness and the balance of payments. Each of these areas are inter-related, and together they impact on and are influenced by the state of existing and future technology. Moreover, as technological development progresses, the complexity of the economic system increases, leading to the number and type of market and organizational transactions. The informational requirements for coordinating and managing these interrelationships grow considerably as economic productivity increases, a main reason for changes in information handling occupations, managerial roles, and equipment resources.

Most of the economic analysis has been for the economy as a whole, or changes in broad industrial and occupational composition, including international comparisons. There has been relatively little written directly related to office automation, which can be more appropriately dealt with using the tools of the behavioural and management sciences that are covered in later chapters of this multidisciplinary survey. However, many of the substantive conclusions from economic analysis - in particular some of the areas on information economics - are just as applicable to blue collar workers in the factory as white collar employees and managers in the office, although there are measurement problems on output indicators. A concluding section to this chapter will point out some of the implications of productivity for office automation.

2.2 ECONOMICS OF PRODUCTIVITY: MEASUREMENT

In principle, measurement of productivity is relatively simple - it is a comparison of output with the resources that have been used to produce it. That concept can be applied in practical situations to changes over time, or to comparisons between countries. It can be applied to the economy as a whole, to industry sectors, to individual firms, to factories, or to individual units within organizations (such as a production line or a stenographer pool).

Its practical application and measurement are not that simple, and there has been much debate about these methodological issues. In certain cases it is relatively easy to measure output - bags of cement, tons of steel, cases of beer, and the like. It is less simple for more complex and non-standardized products. How can a 1950 car and a 1982 model be compared as equivalents? How does one make allowances for automatic transmission, power steering, increased horse power, changed miles per gallon and different pollution standards? How can a 1975 computer and a 1982 computer be compared?

There has also been even more debate about the inputs to measure and how to measure and combine them. Is only one input measured? Labour is most often used in a single factor index, which is often appropriate and not misleading as it is normally the most important single input, as measured by share in national income, as a share of value added costs, or even as total costs. If capital is included as an input, should inventories in addition to plant and equipment be included? Should the stock of capital available, or the input of capital services be included? Should the stock of capital gross or net of depreciation be measured? What measure of depreciation (straight line, diminishing balance, etc.) should be used? When one combines two inputs (such as labour and capital) to make a measure of total factor input, should one use an income shares approach (and the related marginal productivity theory of income distribution), or an econometric method to estimate the marginal contribution of each factor? What can the theory of index numbers say about how these inputs should be combined when shifts in weights take place over time? These and other related issues have been debated in the academic literature and there is probably more of a concensus on these matters among economists in the recent years than would have been the situation a decade or more ago (See Daly (1972) for a discussion of these issues at the macro level.)

What can one say about the measurement issues? At the theoretical level these issues will probably be debated forever, but the practical question is: are the existing measures misleading for the broad purposes for which they are used?

A reasonable conclusion would be that the existing measures are not perfect and could be improved; they are usually not misleading for the economy as a whole and at the industry level. The finer one wants to go, the more practical problems are likely to be encountered. One could only answer the question "Are they misleading?" by knowing how one wants to use them, and how carefully they have been prepared. That can only be answered in a specific context, and not much more can be said on this point in this part of the survey.

2.3 PRODUCTIVITY AND LIVING STANDARDS.

Canadians are generally aware from former public and high school days how inventions and new technology have led to a tremendous increase in living standards in Western Europe and North America over the past four or five centuries. Citizens are all also aware that the degree to which technology, contemporary managerial practices, and physical capital are used and applied in different countries and societies has led to tremendous differences in real income per capita and per person employed between countries.

Three points can be made about the recent Canadian experience. For one thing, real GNP per capita has increased more than four fold from the 1920's to date, with the rate of increase from 1950 to 1973 being well above the experience of the previous eight decades or so. This was leading to its doubling about every quarter century, and significantly higher real incomes and expectations for young people than their parents have resulted.

A second major point is that high growth has been largely checked from 1973 to date. Part of this reflects the severity of the 1981-82 recession, but the slowdown began even earlier. The major reasons for this state of affairs is not fully understood in Canada, and no studies have yet been published which explore and quantify these issues to the same extent as has been done in the United States by Kendrick, Denison and others.

EXHIBIT 2-1

Canadian Manufacturing:

Selected Growth Rates, 1950-1973 and 1973-1981

CONTRIBUTION TO GROWTH RATES	1950-73	1973-81	Change
Labour (0.75 weight)	0.87	0.40	-0.47
Capital (0.25 weight)	1.25	1.09	-0.16
TOTAL FACTOR INPUT	2.13	1.49	-0.64
Output in relation to total factor inputs	3.40	0.16	-3.24
TOTAL OUTPUT	5.53	1.65	-3.88

SOURCE: D.J. Daly, "Inflation, Inflation Accounting and its Effect, Canadian Manufacturing, 1966-1982." Review of Income and Wealth, forthcoming.

The more severe recession and greater slowdown in productivity growth in the 1970's in Canada have been reflected in levels of real GNP per person employed in some of the European countries surpassing Canada in 1982. France, Germany and Belgium had achieved that, and higher levels of output per hour in manufacturing had been achieved by a number of European countries and Japan even earlier. This shift in living standards and economic power has not been fully recognized and discussed within Canada, either at the government level or within the private sector.

It is also significant that slower increases in output also reflect some slowdown in the rate of increases in factor input; however, it is equally significant that an estimated four fifths of the slowdown in Canadian manufacturing reflect the slowdown in technological change, rather than the slower increase in inputs. This is illustrated in Exhibit 2-1. It is significant that increases in output in relation to total factor inputs were more important in the increases in total output than the contribution of labour and capital combined. This occurred even when Canada had been experiencing increases in labour input that were one of the highest in the industrialized world. Comparable changes have occurred for the economy as a whole.

2.4 INDUSTRIAL AND OCCUPATIONAL COMPOSITION AND SHIFTS.

It has long been recognized that technological change and its related effects on supply, demand, and relative prices have a related effect on the industrial and occupational composition of the economy. Research in this area has gone furthest in the United States, and the lags in application of these ideas in Canada are even longer than for the economy as a whole.

One of the important developments of recent decades is the relative shift from agriculture and other commodity producing industries to the services. Agriculture, for example, was about 45 percent of the labour force at the start of the present century, and the number of workers employed in agriculture has dropped about 60 percent since the Second World War, while output per person has increased to about 4.5 times the level of the turn of the century. Total agricultural output is almost double the level of the late 1940's with only a fraction of the number of farmers. Increases in output per person were higher in agriculture then in the commercial non-agricultural industries, but there was <u>not</u> a comparable increase in the demand side in Canada and elsewhere to match the comparable increase in the supply side. With persistently lower incomes in agriculture than in the non-agricultural sector, there has been a significant net outward movement of people from agriculture.

EXHIBIT 2-2

Share of Services and Goods-Producing Industries as a Proportion of GDP at Factor Cost (1980), Canada

SERVICE INDUSTRIES	
Transportation	5.4
Storage	0.3
Communications	2.8
Electricity, gas and water	3.5
Wholesale trade	4.7
Retail trade	6.3
Finance, insurance and real estate	10.6
Public administration and defence	7.5
Business and personal services	5.5
Services sub-total	61.9
GOODS-PRODUCING INDUSTRIES	
Agriculture	3.3
Forestry, fishing and trapping	1.1
Mines, quarries, and oil wells	6.5
Manufacturing	21.6
Construction	5.8
Goods-producing sub-total	38.3
TOTAL	100.0

This could occur reasonably easily over time as long as there were employment opportunities in the non- agricultural sector (Daly 1955).

By 1980, this long-term shift had resulted in about 62 percent of output being produced in the service industries and only 38 percent in the goods industries. This can be seen in Exhibit 2-2. It is widely expected that this shift from goods to the service sector will continue in the 1980's, but at an accelerated pace.

Important shifts in the distribution of employment by occupation have taken place in the United States over the last decade, as shown in the Exhibit 2-3. Comparable changes have presumably taken place in Canada, given the parallel nature of the two societies.

The long-term shift from goods producing industries to the service producing industries has important broad occupational effects as blue collar workers amount to 66 percent of the goods producing industries, while white collar workers are 64 percent in the service producing industries (Ehrenhalt, 1983, p. 45). (See also Chapter 3, below).

2.5 TECHNOLOGICAL CHANGE AND INDUSTRY COMPOSITION SIMULATIONS

The previous sections looked backward. In this section a few basic simulations will be presented to illustrate the effects of technological change and industrial composition. This is partly designed to indicate the compositional effects of rapid technological change at the industry level, and thereby reduce some of the present day confusion concerning technological change and unemployment arising from process technological change, including office automation.

The discussion emphasizes the employment effects of technological change on industrial composition, when different income and price elasticities exist and when differential rates of productivity increase take place at the industry level for Canada.

The issues will be set out in a simplified and forward looking simulation from 1980 to the year 2000. Rather than using point projections, the scenarios will show the differential effects of high, medium and low growth productivity changes. The simulations will also show the effects of high, medium and low demand changes. (The economic term "elasticity" in this case refers to the percentage increase in demand for a product group, related to a one percentage point change in real income per capita

EXHIBIT 2-3

Changes in Employment by Occupation, U.S., 1972-1982

Professional and technical	+46.9
Managers and administrators (non-farm)	+42.2
Clerical and kindred	+28.7
Service	+24.6
Sales	+22.2
Craft and kindred	+12.9
Nonfarm laborers	+6.5
Operatives	-5.9
Farm workers	-11.5
TOTAL	+21.1

SOURCE: Ehrenhalt (1983), p. 46.

over the next two decades.) The initial employment levels and the alternative magnitudes for productivity growth and income elasticities are all close approximations to recent experiences in Canada and other Western countries, and illustrate the types of effects to be realistically expected in this time frame.

2.5.1 Assumptions in Simulations:

Assumptions in five key areas have been made for this study, namely assumptions relating to employment, to productivity on the supply side, to aggregate demand and to income elasticities (both relating to the demand side and its composition). Attention is concentrated on the private sector, so the influence of government and the international economy and their effects is ignored for the sake of simplification.

1. An employment level of 12,000,000 is used as the base for 1981 (a rounding off close to the labour force for that year). A growth in the labour force and employment of 2.0 percent per year compounded from 1980 to the year 2000 is assumed (which may be a bit on the high side, but the alternatives are not significantly effected). It is also assumed that aggregate employment in the three categories of income elasticity are the same initially, namely four million in each category.

2. Alternative productivity assumptions of <u>no</u> change, 1.5 percent per year, and 3.0 percent per year are assessed. The lower estimate approximates the experience from 1974 to 1984, and the higher figure is close to the increase in output per person in all commercial industries from 1946 to 1974 (Statistics Canada, 1982, p. 26.) It can be assumed that the productivity increases are the same in all industry groups.

3. It is also assumed that the degree of labour force utilization is the same at the beginning and end of the period. This implies that the increase in the supply side from the previous assumptions is reflected in a comparable increase in the demand side, a pattern in line with past history in Canada and elsewhere, a theme to be developed more fully later. There is thus no technological unemployment in the economy as a whole.

4. With higher real incomes, there can be a significant shift in industrial composition in terms of both employment and national income. Three alternative assumptions are made, namely low, medium and high income elasticities, with these being roughly 0.75, 1.0 and 1.5. (Some adjustments have been made later to ensure consistency with the over-all employment levels in the year 2000.)

EXHIBIT 2-4

Employment Composition, Year 2000 Scenarios

Elasticity Assumptions	Productivity Assumptions			Growth Rates to 2000 (high growth case)
	Low	Medium	High	
High	5,943.8	6,677.2	7,413.0	3.13
Medium	5,943.8	5,779.4	5,582.0	1.68
Low	5,943.8	5,374.7	4,836.4	0.95
	17,831.4	17,831.4	17.831.4	2.0

5. The effects of government and the international environment are ignored for the sake of simplicity. This does not affect the main themes and results in this section, but some of these questions will be explored later in the report.

2.5.2 Implications:

Similar productivity growth rates in different industries are reflected in a changing industrial distribution, caused by differing demand elasticities. The high income elasticity products and industries experience increases in relative prices and factor prices; the low income elasticity sectors experience declining relative prices and incomes on these assumptions and projections. Real incomes would be greater in the high growth industries and lower in the low growth industries, even though the productivity increases were almost similar. The resulting differences in income levels encourage labour to shift to the areas of higher growth in employment and income. Agriculture is a good example of this trend. The consumption of food on a pounds per capita or calories per capita are about the same now as at the start of the century, even though consumption per capita in the non-agricultural area is more than five times the level at the start of the century.

Similar shifts have occurred in the United States. By way of example, large productivity increases in U.S. agriculture, combined with low income elasticities, permit each farmer to provide food and fibres for 78 people, while in 1850 the average farm worker could only provide for four people (Rasmussend, 1982, p. 77).

Greater changes in industrial distribution occur when productivity growth rates are high rather than when they are low. In the above example of the low productivity growth case, the distribution of employment at the end of the century is the same as in 1980. In no instance was a lower employment level encountered two decades from now, compared with the initial distribution of employment in each sector of four million. Absolute employment declines could occur if major shifts in industrial composition were occurring at the same time that little change in total employment was taking place. In the 1970's, the increases in employment and the Canadian labour force were as large as the changes in all of the Northwestern European countries combined!

The discussion so far has dealt with how differing income elasticities of demand for different product groups has led to a change in relative distribution of employment during periods of economic growth (both high and low). It is also important to recognize that the rates of productivity growth vary significantly from industry sector

EXHIBIT 2-5

Industry Composition Magnitudes, 1980 and Year 2000

	Growth Rate	1980	2000	Ratios 2000/1980
Employment (000's)	2.0	12,000	17,831.4	
Real GNP (1980 $'s)				
High	5.0	150,000	397,995	2.65
Medium	3.5	150,000	298,468	1.99
Low	2.0	150,000	222,892	1.49

to industry sector over time. This point is critical, because sector by sector variation both in the salience and the impact of office automation are evident already in Canada, as well as in other countries. How would such changes affect changes in relative prices, which in turn could have some secondary effects on the distribution of employment by industry?

W.E.G. Salter has carried out one of the few studies of the relationships between productivity growth and the distribution of employment and output in the United States. Increases in total compensation per hour were broadly similar over time, while changes in output per hour diverged dramatically, especially during periods of rapid economic growth in the total economy. These differences were reflected in changes in relative costs and prices. Industries with high rates of productivity growth tended to experience relative declines in the costs and prices of output. The lower prices for such products tended to be reflected in higher levels of employment and output, rather than a dispacement of labour as so much current discussion seems to assume. A quotation illustrates Salter's conclusions:

> Industries which have achieved substantial increase in output per head have, in general, been successful in other respects: their costs have risen the least, the relative prices of their products has fallen, output has expanded greatly, and in most cases employment has increased by more than the average. On the other hand, industries with small increases in output per head are generally declining industries - at least in relative terms. Their costs and selling prices have risen the most, output has increased much less than average (or even fallen), and increases in employment are below average (Salter, 1966, p. 124).

Two factors contribute to a change in the distribution of employment between industry. One would be a high rate of growth in total labour force and employment rather than a low rate of growth. A second consideration would be a high rate of regional migration and occupational turnover. On both counts, Canada is relatively well off, having had for two decades or more the highest rate of labour force growth among the industrialized countries, a trend which will continue to be true for the balance of the current century, even though the growth rates of the adult population will be slowing down in Canada and elsewhere. In addition, most measures of turnover (hirings and separation rates, gross turnover, internal migration, changes in address of families in receipt of Family Allowance cheques) show consistently higher rates in Canada than the U.S., and North American rates are higher than in Western Europe.

2.6 TECHNOLOGICAL UNEMPLOYMENT AT THE MACRO LEVEL.

Early in the 19th century, the increased use of mechanization in the textile plants of the United Kingdom led to the opposition of the Luddites - a group of roving workmen who destroyed textile machinery at night. An earlier incident came from a historian of the Middle Ages who said that he had come across discussions of the opposition to the use of wheelbarrows to move bricks around at construction sites. Clearly the tendency for some people to go from specific adjustments at the company level to conclusions about the economy as a whole has been around for a long time, and such concerns about technological unemployment recur during almost every recession, especially during the more severe ones.

What is frequently overlooked is that technological change has an impact on the demand as well as the supply side. For example, there was a fourfold increase in real GNP per capita in Canada from the late 1920's to the early 1980's (before the recent recession). Over the same period, however, there was also a fourfold increase in real consumption per capita, which is what one would expect when personal income and personal consumption are a dominant part of total output. Increased productivity need not lead to an increase in unemployment, and increases in unemployment result from basically quite different economic and social factors.

Past Canadian business cycles, including both shorter-term inventory cycles and longer term construction or "long cycles", reveal that the most rapid increases in productivity occurred during periods of rapid growth, rather than during recessions and periods of slow growth. During periods of recession and slow growth, productivity increases have occurred more slowly and may even have declined. High rates of unemployment occurred during periods of slow productivity increase rather than fast, the exact opposite of the implications suggested by some recent newspaper reports. The common problem here is to overlook the important positive contribution of the supply side of productivity growth for the economy as a whole to the demand side, an issue which has particular salience and relevance for the impact of office automation.

Another related question is the post-war experience in Japan, where economic growth rates, technological change, and employment creation have all been unparalleled. During the length of time it takes for real GNP per capita to double in North America, the Japanese have experienced roughly an eight fold increase (with a doubling every 8 years over about a quarter of a century). However, the increase in consumption and other demand sectors in Japan has been roughly in line with the increased supply, and the unemployment rate in Japan has been consistently below North

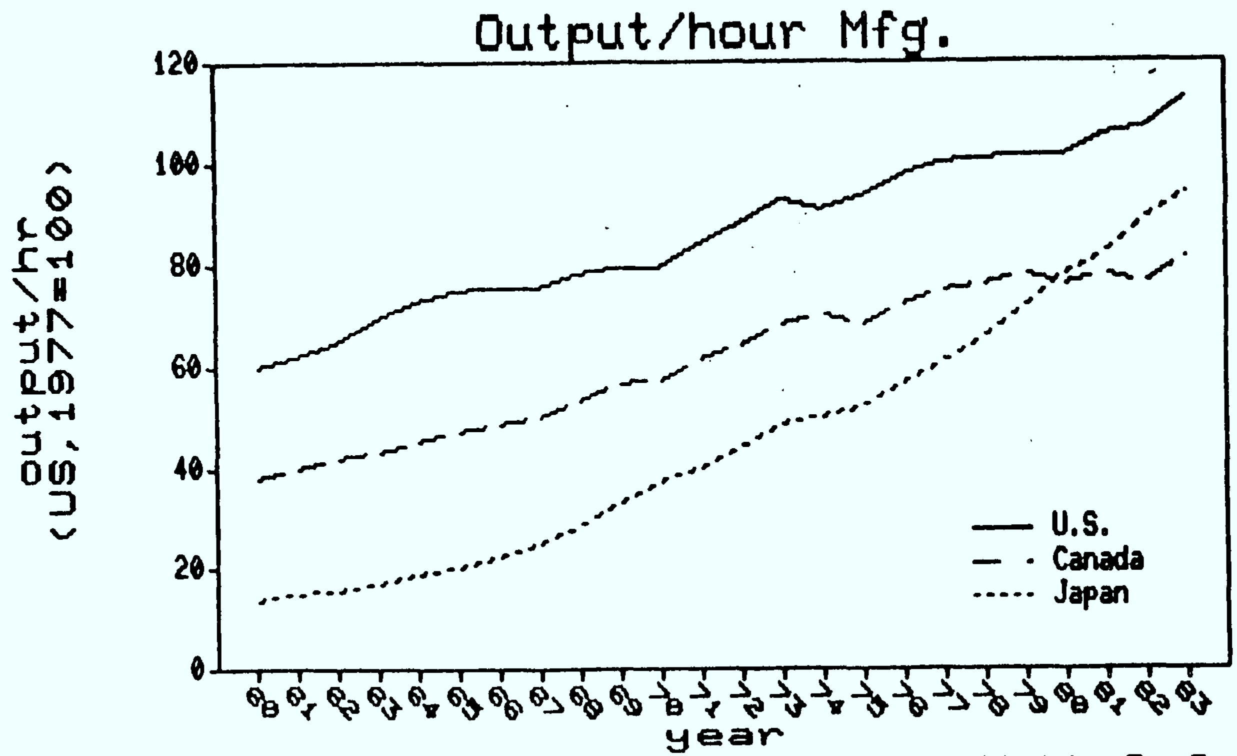

Output/hour Mfg.
output/hr
(US,1977=100)
120
100
80
60
40
20
0
year
U.S.
Canada
Japan

Exhibit 2-6

American levels (with comparable definitions of unemployment and the labour force).

For the Japanese economy as a whole, technological unemployment is a myth. However, any change is threatening, especially if it is not well planned and explained by management to employees and if there is insufficient training on the new production techniques. The real problems of technological change are at the management and organization level, rather than at the level of the economy as a whole.

2.7 INTER-COUNTRY PRODUCTIVITY LEVELS.

The levels of real GNP per person employed in Canada tended to be about 20 percent below the United States for the first six decades of the present century. Some narrowing of that longstanding gap has taken place in recent decades.

However, there are major differences from one industry to the next in the levels of real output per person employed or real output per man hour. Mining, for example, has had higher productivity in Canada than in the United States, although the extent of this difference has narrowed over the last decade. The manufacturing sector is an important contrast to mining, as the productivity levels in this broad sector have been appreciably below the United States since the 1930's, and probably before that. The manufacturing sector merits special emphasis here, as international trade in manufactured products has been a growing share of world trade since the Second World War. In addition, with the reductions in tariff and non-tariff barriers that have been taking place on a widespread basis since the early 1970's, there has been an increase in the extent of international competition in manufactured products, a factor which has been important in Canada's international trade performance. A further consideration is the entry of a number of the newly industrialized countries in international trade: some of these countries have been very fast in adopting new and especially foreign technology; they have adopted as well pay rates of total compensation per hour substantially below the levels paid in North America and in most Western European countries.

The levels of output per man hour in Canadian manufacturing are currently more than 25 percent below the levels in the United States. This gap was wider in 1982 than it has been at any time since the 1960's, and these comparisons can be seen in the accompanying exhibit. There is a considerable variation from one individual manufacturing industry to another as shown by earlier Canadian studies by Jim Frank with the Conference Board of

Exhibit 2-7

OUTPUT PER HOUR, MANUFACTURING,
MAJOR INDUSTRIALIZED COUNTRIES,
U.S., 1983=100, AND RATES OF CHANGE 1973-1983

	U.S.=100	Rate of Change 1973-1983
United States	100.0	1.98
Germany	89.9	3.69
Japan	82.8	6.83
Belgium	74.5	5.95a
Sweden	73.9	2.71
France	71.9	4.64
Canada	71.9	1.79
Italy	59.9	3.22
United Kingdom	37.7	2.35

a) The data for Belgium covers the years 1973 to 1982. Source: D.J. Daly and D.C. MacCharles, Canadian Manufactured Exports: Constraints and Opportunities (Downsview: York University, mimeo, 1984) for column 1 and U.S. Department of Labour, News (Washington: Bureau of Labor Statistics, May 31, 1984), Table 2.

Canada and an earlier study by Craig West for the Economic Council of Canada. These large differences have persisted for decades, in spite of the widespread knowledge to managers and others within Canada of the comparable production and managerial practices in the United States. Knowledge of process technology, engineering techniques and business practices in foreign countries have been facilitated by the degree of foreign ownership and control in Canadian manufacturing, but Canadian-owned firms are usually quite well informed as well about the state-of-the-art technology used in other countries. As a consequence, the lower levels of output per man hour occur in spite of the presence of higher levels of capital equipment and other capital facilities present in Canadian manufacturing, compared to the United States and other foreign countries. As a result, these lower levels of productivity occur even though Canada is the most capital intensive country in the world.

For instance, some direct comparisons can be made with Japan. In the 1950's the levels of output per hour in Japanese manufacturing were only about one-fourth of Canadian levels. However, the data underlying Exhibit 2-7 indicate that by 1983, the levels in Japan finally exceeded the Canadian level. This is a dramatic change. In the length of time it takes for output per man hour in manufacturing in North America to double, the levels in Japan have increased roughly eight-fold! This is a very dramatic difference, especially when it is realized that many of the technological developments which have been a part of the Japanese success story were initially practiced or initiated elsewhere and they have had to be translated into Japanese to make them fully available to Japanese firms (McMillan, 1984). It is also important to bear in mind that there are significant differences in productivity levels between the larger plants in Japan and the smaller ones, reflecting the pattern of the dual economy which is so important there. The larger plants have levels of output per hour about 50 percent above the average for manufacturing, and it is these larger plants that are a major part of the Japanese export market. By the early 1980's the levels of output per hour in the larger Japanese plants were about one-third higher than the larger Canadian plants.

Comparisons of value added output per employee with some European countries can be made as well to reinforce this point. By the early 1980's, real output per worker in manufacturing in West Germany and Sweden had exceeded levels in Canada, and the Benelux countries are also higher than Canada (Exhibit 2-7). The comparative rankings of the European Management Forum, showing Canada's fall from fifth place to sixth place overall in international competitiveness (behind Japan, the U.S., West Germany, Switzerland and the Netherlands) reinforce this basic point

EXHIBIT 2-8

Labour Costs per Unit,
Manufacturing, Selected Countries, 1983
United States = 100.0

United Kingdom	136.0
Canada	129.3
Italy	107.2
Belgium	106.3
United States	100.0
Germany	92.3
France	86.5
Sweden	73.3
Japan	61.2

Methods: These estimates incorporate the net effects of output per hour in real terms, total compensation per hour, and the 1983 exchange rates. This covers a major part of costs for GDP in manufacturing, and costs per unit for capital and depreciation can be approximated for some countries. The results are updates of the methods used in D. J. Daly, Canada's Comparative Advantage (Ottawa: Economic Council of Canada, 1979); A. D. Roy, "Labour Productivity in 1980: An International Comparison," National Institute Economic Review, August 1982, p. 35; updated by U.S. Bureau of Labor Statistics News, May 31, 1984, "International Comparisons of Manufacturing Productivity and Labor Cost Trends, Preliminary Measures for 1983."

on productivity comparisons and relative rankings in the global economy.

These are very significant changes in the relative position of Canadian manufacturing, as Canada would have been second only to the United States in manufacturing productivity in the 1950's.

2.8 COST COMPETITIVENESS.

Levels of output per man hour are only one aspect of cost competitiveness. Comparisons can also be made with the levels of compensation per hour in manufacturing. At the prevailing exchange rates, the levels of total compensation per hour in Canada in 1982 were almost 10 percent below the United States. However, when the levels of output per hour in 1982 reached about 28 percent below the United States, labour costs per unit of output in total manufacturing became appreciably higher than in the United States. This is an important adverse cost factor when labour income is a very major part of the value of gross domestic product in manufacturing, a factor which needs to be linked to the capacity of Canadian companies to understand and use office automation to develop a sustainable competitive position in global markets. Exhibit 2-8 combines the data on output per hour and total compensation per hour to give a measure of unit labor costs on manufacturing for 1983 for the major industrialized countries.

The levels of total compensation (including fringe benefits) in Japan were about one-third below the Canadian levels in the early 1980's. When this is combined with a higher level of output per man hour, Japanese manufacturing is very competitive with Canadian manufacturing, with unit labor costs half the Canadian level in 1983.

The net effect of changes in output per hour and compensation per hour in Canada, United States and Japan are shown in the Exhibit 2-9. These show the changes in labour costs per unit of output in the three countries. An advantage of such a measure is that it excludes the direct effects of higher energy and food prices, which occurred during the 1970's, but their quantitative contribution to inflation has often been exaggerated. For Japan, the increases in output per hour have been sufficiently high to more than offset the increases in total compensation per hour (including the large bonuses normally paid twice a year). Unit labour costs decreased over the eight year period from 1974 to 1983, and they were about 10 percent less in 1983 than in 1975. In the United States, unit labour costs increased about 80 percent, while in Canada the increases were about 120 percent over the same period. Differential rates of domestic inflation of this magnitude

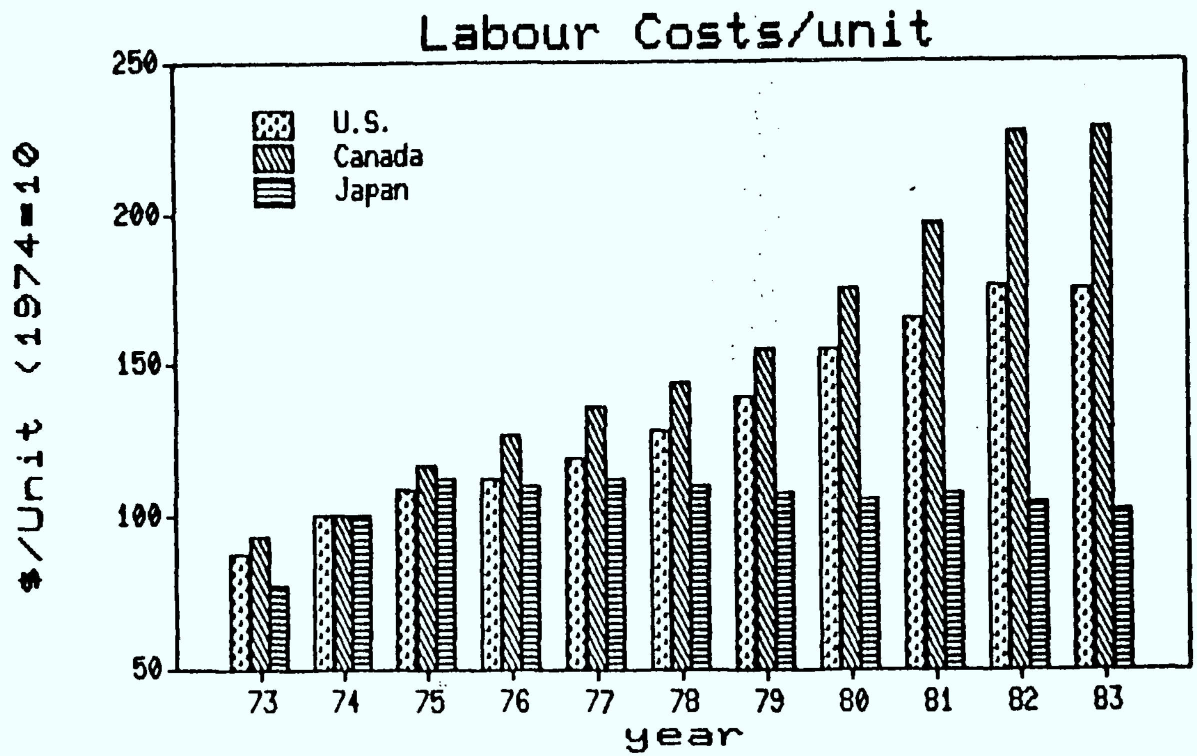

Labour Costs/unit
U.S.
Canada
Japan
$/Unit (1974=100)
250
200
150
100
50
73
74
75
76
77
78
79
80
81
82
83
year

Exhibit 2-9

were bound to be reflected in exchange rate adjustments such that a decline in the value of the Canadian dollar that begin after 1975 should have come as no surprise. Indeed, such a decline in the value of the Canadian dollar may have partly offset greater domestic inflation in Canada, but it has also clearly led to a higher cost of imports expressed in Canadian dollars and thereby it further contributed to the erosion of profit margins in domestic Canadian manufacturing.

Most of the emphasis of the economics literature in the past two decades has focused on blue collar worker productivity, on corporate and factory specialization and on problems of short runs and high production costs. The subject of office automation has expanded the focus, but as the next chapter shows, building a sustainable competitive advantage goes much beyond the economics of information technology.

This pattern of costs higher in Canadian manufacturing than in Canada's two largest trading partners contributes to a number of problems for profits, world market share, etc. Since 1970 the value of the Canadian share of the world market has fallen, and the extent of the decline has been larger than for most of the other industrialized countries, with the exception of Sweden. The extent of the decline in market share has been less in volume than in value, partly because the prices of Canadian manufactured exports have tended to fall compared to other countries, partly perhaps because they were so much higher initially. There has been an increase in Canadian exports of automobiles, because of the Canada-U.S. free trade arrangement. There has been a significant volume decline in the Canadian share of the world market for manufactured products excluding the automotive sector.

The high cost-low productivity position of Canadian manufacturing has also been reflected in a significant drop in profits and the rate of return in Canadian manufacturing. By 1982 the rates of return (including both interest and profits) were down to about 2 percent on total assets, with both profits and assets being valued at replacement cost. These are the lowest rates of return in manufacturing since the 1930's, and are well below the costs of borrowing the companies would have to pay to finance further capital expenditures. The comparable rate of return on total manufacturing in 1982 was seven percent in the United States. Such a differential in the rates of return is unprecedented and its persistence would discourage investment in Canadian manufacturing by both Canadians and foreign companies and parents.

What do these trends and data imply for Canada's position in technological trade and, in particular, office automation. Canada's trade in high value added, technological goods has continued to deteriorate. More specifically, however, Canadian manufacturing has not been notably successful at achieving a sustainable low cost competitive position - a factor which mitigates against the use of office automation as a useful strategic weapon to build an advantageous competitive position.

In terms of employment, the long term impact of office automation is essentially twofold: first, to apply the technology to sectors where competitive position is sustainable on a low cost or cost competitive basis, or to build on a related technological or marketing strength where office automation reinforces this organizational advantage.

What can one say about the potential relevance of office automation to the problems of cost competitiveness in Canada? For one thing, the evidence in Exhibit 2-8 and the related discussion indicates that office automation (or any other technique that will reduce per unit costs in Canada closer to the lower levels in many of Canada's close competitors) deserves close scrutiny , both at the level of the firm and in public policy. Overhead costs of the office and managerial functions have tended to grow as a share of total costs in many organizations in recent decades. Furthermore, there has been an increase in international competition both in manufacturing and in financial services over the past decade. In manufacturing this has come about from tariff reductions now under way under the Tokyo Round, the lower exchange rates in many of the European economies since 1980, competition from Japan and some of the newly industrialized countries in the Pacific Rim, and from increased pressure from lower operating rates in a number of industrialized countries with the slower growth since 1973. In the finance area, the entry of more foreign banks and the increased role of foreign currency assets and liabilities in the Canadian chartered banks have increased international exposure and competition from new sources. All of these developments suggest the need to consider office automation as part of a broader need to put high priority on improved cost competitiveness.

Another important source of advantage for the greater use of office automation are the changing pattern of costs. The costs of doing many of the functions in an office have been increasing about five to ten percent a year, based primarily on increased levels of compensation. On the other hand, the costs of doing specific functions on a computer have been dropping about 20 percent per year. In a period of pressure on corporate profits and rates of return, this will provide considerable financial advantages to organizations who shift to the newer computer methods.

However, the next chapter will look at this same issue from an organizational perspective.

2.9 PRODUCTIVITY AND TECHNOLOGY DIFFUSION

Several years ago, the Canadian author, J.J. Brown, highlighted an important paradox: whereas Canadians as individuals have a very good track record at producing ideas - the inventive process - Canada as a nation has a poor record at commercially exploiting them - the innovation process. Indeed many major innovations were adopted by foreigners, hence the title of his book, Ideas In Exile.

In recent years, various studies have documented the long lags in adopting state-of-the-art technology in Canadian industry. Canada relies heavily on the pool of foreign technology available in the international market place, where the NRC estimates that Canada's technological output is less than one percent of total output. However, even though imported technology is still the major source of Canadian technology - domestic patents, for instance, are a small percentage of total patents registered in Canada - the evidence shows that the record of technological diffusion still remains a major competitive challenge for Canadians.

For instance, De Melto et al. (1980), in a study for The Economic Council of Canada, studied innovations in five separate industries. In the case of new technological processes, the average lag for first adoption was an average of nine years. In the case of new products, the average was seven years. Globerman's (1974, 1981) studies of international comparisons of technology diffusion show that Canada's rate of diffusion, as shown by the proportion of firms adopting processes or equipment in a given time frame, was less than in Europe or the U.S.

The issue of technological diffusion is central to Canada's productivity performance, because technology is one of the key's to cost competitiveness and gaining a strategic advantage as competitive edge. Data are sparse on the performance of Canadians in the area of electronic data processing, computers, and office automation. Globerman (1981) has analyzed the use of computer technology in three service sectors. Hospitals and department stores in the U.S. adopted this technology earlier than in Canada; on the other hand, university libraries in Canada automated faster than U.S. university libraries.

2.10 CONCLUSION

This chapter has reviewed Canada's performance in productivity and international competitiveness. Four major topics were reviewed, namely productivity and living standards, changes in industrial and occupational distribution, the interrelationships between productivity and employment, and productivity and international competitiveness.

Productivity issues continue to point to fundamental problems in Canada's underlying competitiveness, both expressed by macro indicators of industrial performance, or by behavioral measures such as technological diffusion or attitudes to technological change. The previous analysis of productivity trends seen both in a domestic and in an international context suggests two conclusions - on the one hand, technology trends in and by themselves have a relatively benign impact. Significant market and user need changes have the greatest impact on long run "state of the art" technology. Yet a related point is the clear trend among all Western countries for the increasing need to understand more clearly how technological trends and the use of technology impacts on the underlying cost competitive position of all countries.

CHAPTER 3

PRODUCTIVITY, TECHNOLOGY AND CORPORATE STRATEGY

3.1 INTRODUCTION

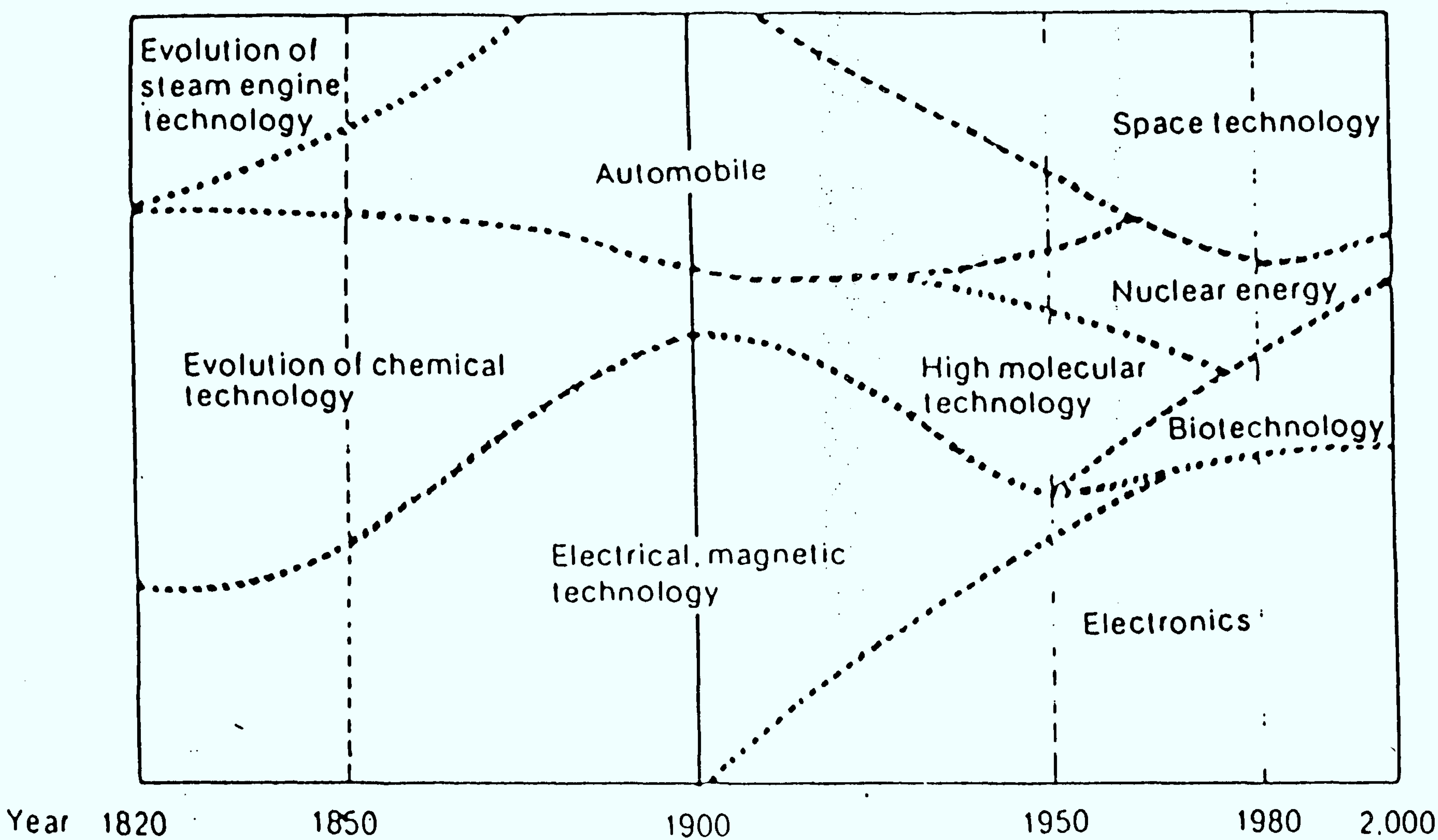
The previous chapter has examined the economic aspects of technology and productivity, with concluding reference to the issue of technological diffusion and the employment impact of automation. Despite the strong arguments made for the negative impact of technological change, especially for female and blue collar workers, the supporting evidence has been found to be weak. Indeed the basic argument is that employment creation opportunities exist primarily through economic growth and international competitiveness. What does this argument imply for Canadian firms? What does it imply for office automation?

This chapter addresses three fundamental issues: the impact of technological change and automation on corporate strategy in Canada, the application of automation to various kinds of production subsystems, and the analysis of productivity and the automation triangle in Canadian manufacturing.

3.2 TECHNOLOGY AND CORPORATE STRATEGY.

"The most remarkable technology ever to confront mankind." So wrote the former British government chief scientist at a 1978 conference on microelectronics in London, England. Today around the world, policy makers, the press, and the public at large are increasingly aware of the growing impact of "the most remarkable technology". Estimates vary enormously by country and by industry sector but the overall impact is identical: enormous change on employment patterns, styles of work, variations in production, and changes in process technology. In general terms, knowledge and information are the recognized resources by which human and material resources are transformed in the organization and which together are transforming industrial societies into a maturing information age. Billions of dollars are being spent in the

EXHIBIT 3-1 Waves of Technological Progress



Source: Nikkei Sangyo Shimbun

transformation not only of traditional smokestack industries but also in the electronics-based sectors such as telecommunications, informatics and computers. Advances in information processing technology have doubled the level of processing power every two years, in terms of dollars spent. The capacity of new technology to process and share information has changed radically - a single chip tomorrow may have the power of ten computers today. There is an explosive growth in new products, processes, and applications, giving rise to new questions for corporate strategy (Exhibit 3-1).

3.3 STRATEGY AND TECHNOLOGY ISSUES

Corporate strategy, or strategic management, is a relatively new development in Canada, although it has gained widespread acceptances in the U.S. and Europe during the past decade. Strategy defines the way an organization develops a sustainable competitive advantage over time, in terms of definable long term goals and measures of actual performance. A corporate plan is a written or unwritten set of policies and objectives integrating the plans and outlook for the organization's major components - marketing, manufacturing, engineering, technology, and personnel.

In today's information age, information and communications are fundamental components to determining an organization's sustainable competitive advantage (even nonprofit organizations, including government departments, compete, in the sense they must bargain, negotiate, or search for finite resources).

There is some evidence that corporate managers have failed to recognize the impact of computer technology as a resource in creating a sustainable competitive advantage. The complexity of various kinds of equipment, the need for overcoming technological resistance to change, the novel differences in outlook between old line managers and those with computer skills, and questions about the economic justifications of computer investments - all these issues raise serious problems and questions concerning the application and implementation of office automation in the Canadian context.

Yet there is a critical need to focus on the implications for corporate strategy for Canadian operations. The key questions relate to such issues as:

1. How can technology be used effectively to increase corporate competitive advantage?

EXHIBIT 3-2

Automation Elements	Top of the Hierarchy	Lower in the Hierarchy
Hardware System	Computer	Robots
Software System	Programs/Networks	Process controls/aids
Management Control Systems	Mail/MRP/Cad-Cam	Kanban/C.A.P.

2. What are the strategic implications of new developments in technology - both process and product?

3. How can trends in technology best be learned by Canadian managers, technicians, and workers?

Many of the studies on technological and scientific policies for Canada imply a rather narrow view of what technology actually means for a company or an organization. For example, too often a simple choice is made between making technology through indigenous research and development on the one hand, or by relying on technology flows from foreign sources, American or otherwise, on the other. In the latter case, the choice may be seen as a nationalist or a continentalist one, namely by developing Canadian R & D support through domestically owned firms or by relying on foreign-developed technology through foreign subsidiaries.

While this study is primarily focusing on office automation and its impact on Canadian productivity, the question of the wider context of automation and its meaning cannot be ignored. Canadian plants are fully integrated into the North American market. Through suppliers and subcontractors, Canadian firms are forced to compete in a domestic "state of the art" and the industrial culture which won't change in the short run.

Canada continues to lag behind the U.S. and other major competitors in certain key areas of process technology, although comparative statistics are difficult to gather. Globally, the information processing industry is estimated by Info Corporation to be $73 billion in 1982, comprised of $25 billion in large systems, $29 billion in small systems, and $18.5 billion for micro systems. The U.S. is the largest market for home computers, with 5 million sold in 1983 alone, an important indicator of "computer democratization" and individual acceptance. As noted in the next section, the concept of the "automation triangle" is a useful depiction of the close technological and managerial linkages among the hardware, software, and systems components. Moreover, these conceptual relationships are equally applicable at different levels of the organization (executive/white collar and operating/blue collar), as shown in Exhibit 3-2.

The traditional perspective of using automation systems in organizations has been straightforward: a decentralized or a centralized approach. The basic questions involve power and control. For instance, what should be the locus of information ownership and control? Which personnel should gain access to information; and what kinds? What configuration of accounting and informational systems

Strategic Choice and Technology

EXHIBIT 3-3

Technology Deployment	Technology Development: BUY	Technology Development: MAKE
Existing Knowledge/ Process	Scanning	Custom Applications
New Knowledge/ Processes	Diffusion	In House R & D

optimizes performance measurement and feedback? What architecture of CPU's, peripherals, and teleprocessing best serves the organization? The managers? The workers? Staff experts?

The decentralized model or approach allows each organizational component to design and develop its own requirements based on its responsibilities. The trend to distributed data processing and power of individual processors reinforce the advantages of the decentralized approach, particularly when local needs and conditions vary. Unfortunately, many organizations have developed almost by accident a decentralized mode in the absence of an overall, grand strategy for systems development. The declining costs of micros have allowed operating managers to purchase and use equipment for local use, but often at the expense of systems incompatibility across the organization. Incompatibility and high incremental cost of systems additions add to barriers to information diffusion throughout the organization. The result is lower innovation and technology diffusion in the organization.

By contrast the centralized approach is a system-wide planned development based on organizational compatability and two way information access. Although ownership and control are concentrated in the center, the needs of local units are carefully monitored and explored by managers. The decentralized/centralized dichotomy may not be the critical one in the future, however, since the strategic elements governing ownership and control will themselves change as the linkage between hardware, software, and control systems become much more integrated and altered by technological developments in each area.

Much of the dramatic emphasis in the field of computer technology has been on hardware development. Productivity and cost reduction have been the most dramatic features of this trend, but the spinoff implications cannot be ignored. In the few areas where other aspects of the automation triangle have been considered (electronic mail for management), the approach has been piecemeal and non-integrative with the production systems, for instance, or with production workers and their tasks.

From a management perspective, there are really four ways of seeing the strategic choices for computer technology. The two primary ways are usage and development. Conceptually, the strategies open to Canada may be seen as usage of existing technology or new technology on the one hand, or developing technology either by buying or by making on the other. As shown in Exhibit 3-3, these options relate the question of strategic choice and the state of technology development.

EXHIBIT 3-4

The Technology/Strategy Linkage

Provides Competitive Advantage	Critical to Operations? No	Critical to Operations? Yes
Low	*automated record keeping *computerized accounts	*airline reservations *multi-branch banking
High	*supermarket scanners *Kanban	*CAP/CAM/MPP *flexible manufacturing systems

The economic and productivity implications of each of these choices have important relationships to the occupational, decision-making and organizational structure of the maufacturing and service organization. Technology buying decisions decrease the need for in house research capabilities, but increase the need for marketing and productive adaptiveness. "Technology-make" decisions increase the need for engineering and scientific personnel, and complicate the interface between top management and professional personnel. In all instances the impact on general employees may be the same, namely the need for more organizationally specific skills, and for training and retraining. In each case, the adaptiveness of management to integrate the information and communication needs to the work tasks of particular organizational levels is not only critical but becomes dependent on the interface between the state of hardware, software, and control systems.

For instance, for any given sector - banking, insurance, or airlines in the service sector, or manufacturing at large - technological choices relate directly to the organization's capacity to develop a sustainable strategic advantage vis-a-vis relevant competitors. Where technology choices really involve industry norms (e.g. automatic record keeping or airline reservations), no competitive advantage is achieved, even though the technology is critical to the sector.

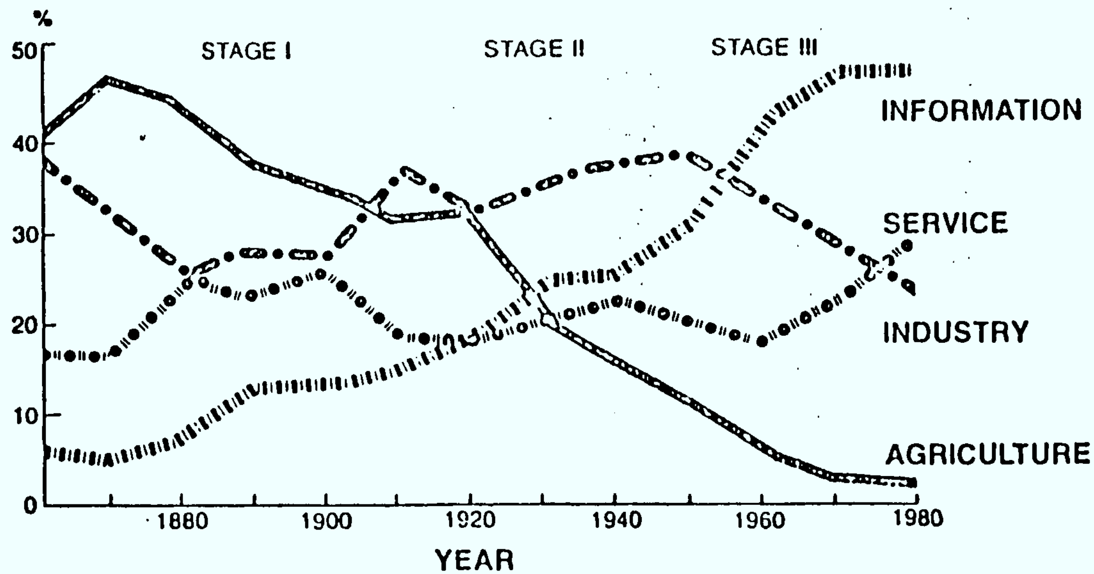
By contrast, some technological choices may be advanced for the sector (electronic mail), but since the technology is not operationally important, no significant competitive edge is achieved. An operationally critical dimension differs from the operationally noncritical where the day-to-day viability of the organization is dependent or at risk. Overall this technology/strategy linkage is shown in Exhibit 3-4.

What this exhibit suggests is that many firms in Canada may not have an adequate appreciation of the impact of computer technology in developing a sustained competitive advantage. The traditional approach to applying computer technology may be analyzed with reference to developing better economies to do traditional tasks, rather than to achieve strategies for productivity and competitive advantage. Fears of job loss and technological displacement stem from the former situation, especially since cost savings economics are generally rather high with accelerated use of computer technologies. The next section addresses this same issue further, but in the framework of the automation triangle.

EXHIBIT 3-5

The Four Sectors of the U.S. Labor Force by Percent 1860-1980

(using median estimates of information workers)



Source: Marc Porat, *The Information Economy: Definition and Measurement*, Office of Telecommunications Special Publication 77-12 (1), May 1977.

Most people in the United States worked on farms less than 100 years ago, but now fewer than 4% of the American people work in that sector, largely because of advances in agricultural technology. Recently, automation in the manufacturing sector of the economy has reduced employment there, too, and more people are working in the service and information sectors. Employment patterns in these areas may soon change as microelectronic intelligence automates these jobs.

32 THE FUTURIST, February 1981

3.4 PRODUCTIVITY AND ORGANIZATIONAL SUBSYSTEMS

Much of what has been written in regards to office automation is in isolation from the literature on flexible manufacturing systems and factory automation. Scores of books on office automation make no reference to the latter, in the same way that authoritative figures on factory automation ignore the trends in office automation (Poppel, 1982). The traditional distinction between the information sector of the economy and the physical production sector partly explains this dichotomy. The former is a "white collar" activity such as traditional office occupations like administrative or clerical work, including automated data processing or data storage, manipulation and transmission functions. The latter "blue collar" activities correspond to extractive industrial, construction, and agricultural functions in the physical goods sector.

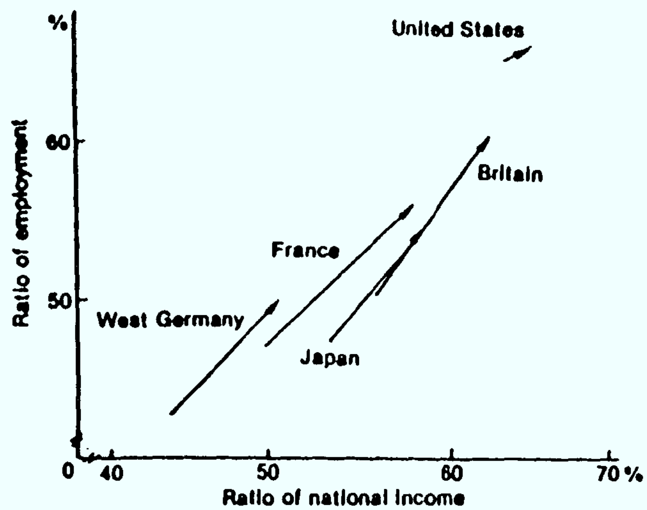
This section takes up the previous analysis on the links between technology, office automation and corporate strategy. The section begins with a conceptual framework of the automation triangle and explores how the changing patterns of process technology are integrating the informational and job requirements of both white collar workers and blue collar workers. Canada is trailing badly in this development. It is argued that if Canadian companies are to expand and improve their productivity in global terms, they must improve their understanding of technological processes, of which office automation is but one part.

The failure to recognize the close conceptual linkage between these types of automation and their impact on the workforce has resulted in a profound misunderstanding of the trends in modern industrial societies. True there are many broad themes on the impact of technological change and its clearest manifestation, namely the micro electronics revolution (Barron, 1980). The more fundamental trend is what has been termed SOFTNOMIZATION, which might be defined as the structural shift in the industrial structure towards sectors and functions which are non-material or information-based.

This shift to a service economy is often viewed as a contributor to a slowdown in productivity, and by an increase in intangible outputs - such as in medicine, law and finance - with rather large labour inputs. Yet there are many service sectors in Canada which are very high productivity performers - telecommunications and transportation, for instance - and many with high capital intensity ratios - i.e. sectors with large capital stock per unit of output or in terms of capital stock per worker hour - pipeline transmission, railways and urban transit, and radio and television broadcasting. In terms of the total economy, this means an increase in the output in the

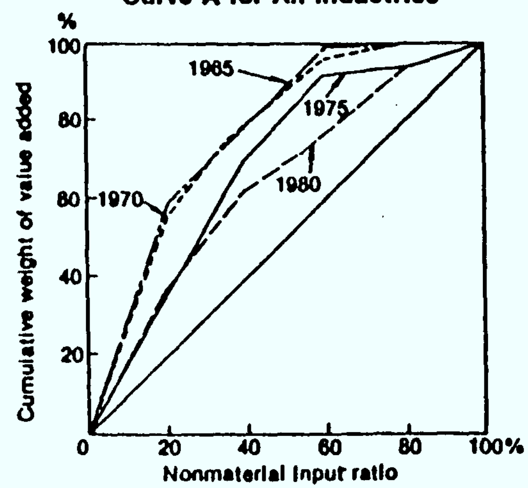
EXHIBIT 3-6

Change in the Tertiary Industry's Share of Employment and National Income from 1970 to 1980



Note: Figures for Japan are net domestic product; figures for France and West Germany are gross value added.

Movement of Softening Ratio Curve A for All Industries



Note: Nonmaterial input includes wholesale and retail business, business services, food and beverage services, cultural industries, leisure industries, transport, information, finance (excluding interest but including commissions), public service, and other services.

Source: Economic Eye, December 1983

service sector (see Exhibits 3-5 and 3-6) but in the service functions within the organization - product design, promotion, advertising, planning, coordination, marketing and research. In short, the modern economy and the modern organization are increasing very rapidly the softening ratio - i.e., non material input divided by material input plus non-material input. The increased ratio of the softnomics revolution is closely related to the concept of the automation triangle (Exhibit 3-7).

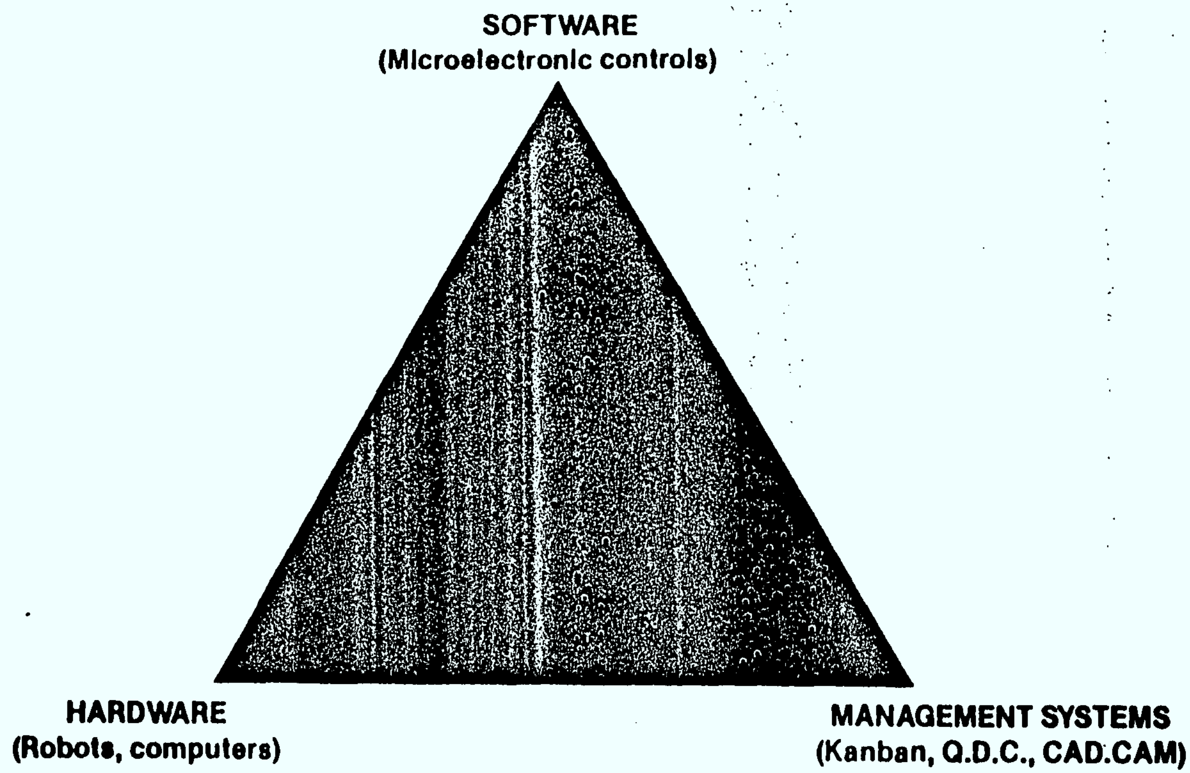
The essence of the automation triangle is the linkage between software systems (micro electronics based instructional programing), hardware systems (mainframe computers and robotics), and management control systems. At the core of the automation triangle are conceptual information linkages between the software component and the hardware component involving forecasting, scheduling, and data retrieval, and inventory management.

The automation triangle illustrates the rationale for close linkages between office automation and factory automation. Office automation stems from what Vincent Giuliano (1982) analyzes as "the accelerating introduction of new information-processing machines, programs for operating them, and communications systems for inter-connecting them." Further, this transformation "entails not only a shift from paper to electronics but also a fundamental change in the nature and organization of office work, in uses of information and communications and even in the meaning of the office as a particular place occupied during certain hours".

Typical of this transformation is the introduction of electronic terminal equipment. The vast increase in output of word processors and personal computers, together with the major significant decrease in their overall unit capital cost and the decrease in transaction costs, have led to predictions of between 40 and 50 percent of workers using by 1990 some form of electronic equipment. In the U.S., Arthur Little estimates the total market for office information systems will grow from $45 billion in 1983 to $91 billion in 1988; by the same year, the total office automation market will represent 40 percent of the overall information processing market. However, the managerial impact of office automation is most profound. After all electronic terminal equipment is hardly the first historic move to mechanization of the office. Quill to pen, pen to typewriter, verbal language to transcribed language by telephone or telegraph, dictating machines, tape-recorders, and photocopiers - such has been the long but steady increase in the use of impersonal, mechanical instruments of office work.

EXHIBIT 3-7

The Automation Triangle



What is different in the electronics age is the power of <u>integration</u> of these mechanical instruments using management software. The power of office automation in the electronic age is the potential to develop two way information linkages between distinctive elements of output in the office. Instead of the division of work being premised on a division between discrete functions, with individual workers coping with quite specialized and repetitive tasks, the division of labour in the case of the automated office is not on discrete functions but on several functions performed simultaneously. The emphasis is on volume of work at lower cost, but with less specialized and repetitive functions leading to individual boredom and dissatisfaction. In many respects, office automation converts the flow of work from a batch system of small lot production, using Woodward's (1965) terminology, into a continuous flow of information. Batch production, which accounts for about 40 percent of value added in U.S. manufacturing (about 60 percent in many European countries), involves small lot production and is very labour intensive. Given the extreme diversity of parts in a batch production system, there is a great need for flexibility in the operating environment, the major reason why costs remain high and productivity is relatively low. That factor explains why the traditional office, run on batch production principles, is relatively inefficient. Conversion of the office away from batch principles to continuous flow or even mass production greatly accelerates productivity and cost economics.

The conversion and transformation of the office through automation are exactly what is happening to factory automation. Flexible manufacturing systems (FMS) is the term often used to describe the transformation of traditional assembly lines, using electronics to substitute for mechanical functions and robotics to take over many human functions. Indeed, this shift is so widespread now in Japan that they have invented the word "mechatronics" to describe the link between "mechanical" and "electronic" processes.

Why is there a parallel to office automation in the case of factory automation? Traditional production engineering as applied to assembly line sectors - cars are the classic example, but there are numerous others - has favoured minimum economies of scale, relatively long production runs, and minimal product diversity, except through add-ons, special features, and component interchangeability. Economies of scale result because of the declines in unit cost of production as absolute volume increases over a period of time. Long production runs decrease costs because of learning and sequential improvement as a consequence of cumulative volume. Production specialization adds to productivity because of the decreased need to change equipment and to incur set up costs as a result of product diversity. Inherent in this kind of automation is a system that manages data flow while still directing and controlling material flow and production conversion activities. More to the point, there is an enormous ability to organize, control, and direct "on line" huge information databanks required to produce even the smallest item in small lots.

The automation triangle illustrates the transformation of the traditional factory, not simply in the use of hardware, but in software systems and management systems. On the hardware side, the introduction of main frame computers or robotics is parallel to the increased use of largely automated equipment for forging, bending, extrusion, lifting, etc. Capital intensification simply results in more output per cost of input of all factors of production. Software systems can add to the overall output and productivity of capital intensive hardware systems by increasing the programmability of diverse instructions; the example of scheduling and delivery of components is a typical case.

However, management systems involving improved plant layout, flow of production, and linkage between suppliers and factory, or setup time of equipment, also add to productivity through the automation triangle concept. Consider two examples. Traditional assembly line technology using capital intensive processes for extrusion and pressing, for example, involve increasing capital intensity for increasing productivity. Dramatic improvements in productivity typically came with dramatic increases in capital investment - witness the conversion of the Japanese watch industry around only four producers compared to the thousands of craft production units in Switzerland, or the very large investment and retooling required in the North American automobile industry in recent years.

However, novel management systems have turned this traditional approach on its ear. Instead of having large scale, capital intensive processes geared to relatively inflexible outputs, flexible maufacturing systems such as quick die change and Kanban inventory allow dramatic improvements in productivity. Under traditional manufacturing, production diversity permitted complications of costs incurred for setup times of equipment. Quick die change can permit set up time reductions from as long as weeks, days, and hours to only seconds. Quick setup times lead to more small lot production, hence greater product diversity. An indirect benefit is lower in-process inventories and instantaneous lead times. The integrated production organization, in its extreme form, will be characterized by production changeover costs that approach zero. Economic order quantities will change from large lots to one unit. The learning effect will disappear since the system is as smart on the first unit as the thousandth. For productionpurposes, the learning curve will be flat.

About only 30 major companies have introduced these kinds of management systems into their manufacturing plants in the U.S., but the approach is much more widespread in Japan - indeed some companies have as many as 30 different plants operating with quick die change, CAD/CAM and other management systems. Toyota and the major automobile manufacturers have introduced these techniques together with the Kanban inventory system of delivering parts "just in time", such that the same production line can produce not only numerous variations on similar car models but also different Toyota models on the same shift. Robotics, of course, is the latest embodiment of integrated hardware/software systems permitting the production of an almost infinite range of extras and special features such that mass assembly production can produce truly unique final outputs.

Indeed, the impact of robotics for small firms is no less revolutionary. Small companies will have the opportunity of entering many new market niches normally reserved for larger firms because within certain volume ranges, the automation triangle will equalize costs for big firms and small firms alike. Small firms will no longer be faced with the cost disadvantage of competing against better work skills and staff support of big firms, yet they can still cope with the small lot production and flexibility characteristic of the small business sector.

The full integration of the elements of the automation triangle thus interpret the real productivity advantages of both kinds of automation - of the factory and of the office. The different elements must be seen as a package in terms of the productivity payoff, a point which explains the dire predictions of lost employment opportunities and displacement of jobs. Yet skilled workers are central to the success of the automated triangle, because workers are the focus of information flow. In the traditional factory, or in the semi-automated office, workers are subordinate to the needs of the production line. Individual skills are not the major priority. The norms of production are efficiency. The norms of feedback are time-based. The decision-making system is not a learning system for workers.

The work flow of the automation triangle is one of skilled technicians, supported by high levels of capital intensive equipment. Monetary rewards are based on responsibility. Corporate functions will be much more integrated. There will be less specialization, more general managers and workers. Interrelationships and integration are central components of information flow.

EXHIBIT 3-8

AUTOMATION AND COMPETITION PRODUCTIVITY

Strategic Advantage		Lo	Hi
	Small	<u>Competitive Decline</u> Run of the Mill Process and Equipment	<u>Standstill</u> Updated Process and Equipment
	Large	<u>Investing In Future</u> State of the Art Process and Equipment	<u>Competitive Edge:</u> Integrated Systems

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Conceptually, this point can be examined with reference to Exhibit 3-8. As noted previously, management can develop a variety of instruments to gain a sustainable competitive edge in the market place, where investment in capital, people, and systems is central. The success of particular instruments can be gauged only with reference to competitors. For instance, some companies may operate with run of the mill equipment which, because of the aged production process or the inherent age of the equipment, cause them to lose their competitive position. In this case, there is unlikely to be any advance in productivity, nor is there any inherent strategic advantage. The consequence is a long term case of competitive decline.

Many organizations invest in updated process and equipment. Automated banking machines (ATM's), personal computers, mainframe computers and work stations are classic management responses to applying office technology to the workflow of white collar workers and executives. However, in most cases, this amounts to what is essentially a "me too" standstill response to automation because while productivity is enhanced, at least after a learning period, there is no strategic advantage inherent in the investment because other organizations are applying similar technology. Canada's slow record of utilizing and applying technology, whether of domestic origin or of foreign origin, is a key factor in this "me too" approach, since any lag in technology diffusion quickly reduces or eliminates real strategic advantage in automation systems.

Productivity may in some cases be low, but the level of strategic advantage is quite large. This seeming paradox comes from the case where state-of-the-art technology is of a pioneering kind involving real breakthroughs in utilizing various systems. Case studies of applying computer technology to office work are a good case in point, but they illustrate the fact that once many companies get a handle on using similar methods, such as in insurance and government bureaucracies coping with fairly programmed instructions for similar outputs, the level of productivity increases but the sustainable strategic advantage is low.

As indicated in Exhibit 3-8, the real form of competitive edge comes from the successful implementation of automation systems providing both high levels of productivity and a large strategic advantage. In both factory automation and in office automation, the principal advantages lie not only in state-of-the-art hardware and software systems, but also in management systems. In the former case, rapid advances in cheap, technically advanced equipment brought about by the vast market for computers and voice transmission telephones create a fundamental alteration in communication patterns. A host of general environmental conditions are accelerating these advances, some of them technological, some political (such as increased government deregulation).

In this respect, Canada has some major challenges on the supply side. The Japanese openly discuss the covergence of the three "C" industries - computers, telecommunications, and consumer electronics. Only the Japanese have large, successful, and vertically integrated companies encompassing research, marketing, and production across all three industry boundaries. The absence of advanced companies in computers and consumer electronics removes most Canadian companies from direct development on the supply side of automated systems - except in the case of telecommunications.

Yet the future competitiveness of Canadian industry rests with the use and application of automation systems which provide a strategic advantage <u>and</u> a productivity enhancement potential.

From a management perspective, the impact of automation systems changes the relationship between strategic and operating decisions, and the manner in which the two are integrated. Under the traditional approach to automation, the real strategic decisions center on the choice of particular forms of hardware (go, no-go decisions) and the capital costs involved. Software decisions flowed directly from the configuration inherent in the hardware decisions. In the newer tradition of automation, involving much more complex decision patterns, the strategic pattern centers not on hardware decisions alone, but on the total pattern of hardware, software, and management systems. Whereas the traditional approach favoured a highly centralized approach to decisions, with data systems geared to bottom-up accounting flows and top-down commands, the newer tradition puts merit on the dispersed flow of both data and accounting systems and decisions. Coordination of decisions involving hardware, software and management systems takes place in the successful firm really at the middle management level, hence the importance of educated and continuously trained personnel.

A projection of Canada's economy over the next 20 years shows a clear shift away from agriculture, traditional raw material-intensive sectors, and smokestack manufacturing. The softnomization of the industrial structure around information, micro electronics, and service functions suggests a dramatic need to develop skills and processes capable of exploiting the competitive advantages inherent in automation triangle processes. Fears of job loss and technological displacement may be well placed if the emphasis is on short term productivity but with no sense of strategic advantage. Canada's historic shortage of management skills, combined with a weak record of technological diffusion, suggest the need for dramatic policies and programs to elevate the awareness levels of the competitive requirements of automation and the need to invest in automation which provides real strategic advantage. The impact of this issue is discussed later in this report.

3.5 ORGANIZATIONAL AND SOCIAL ASPECTS OF SLOW ADOPTION OF TECHNOLOGY IN CANADA

The last chapter summarized the evidence that many, but not all, of the new technologies tended to be adopted more slowly in Canada than in their closest competitors. This section will speculate on some of the possible reasons for that widespread tendency, and comment on any evidence relating to the possible factors. This section will start at the level of the firm, then move to aspects of the economic environment in Canada, and finally to the level of society.

One possible source of resistance to change is at the level of the individual firm, and the key role of management as a source of change. It is widely accepted that decision making in the private sector tends to be highly centralized at the senior managerial level in Canada, so their attitudes to change are key. Past studies of management in Canada show that the general level of formal education of managers is lower than in the United States. This partly reflects the fact that the proportion of the labour force with a university degree is lower in Canada than in the United States. This is also still true for those entering the labour force for the first time, as the proportion of the 18 to 25 year olds attending university in Canada is still half the comparable proportion in the United States. The contrast is even more marked for those taking undergraduate and graduate degrees in commerce and business administration, where the proportion in the U.S. is still four or five times the comparable Canadian proportion. It is widely assumed that more formal education increases the knowledge and awareness of alternative values and procedures, so that lower levels of formal education can be one of the factors contributing to slow adoption of new ideas.

A further dimension that can contribute to openness to change is the age of the manager, and the age when the manager first moved into the middle levels of management. In the United States, a series of studies have reflected a tendency for a move to younger managers over time. In Canada , on the other hand, the top managers in Canada moved into middle levels of management later in their working life than in comparable surveys in the United States. Many of the existing senior managers got their first exposure to management in the Second World War, and the armed services tended to have an authoritarian managerial style. Canadian senior levels have tended to be promoted to senior levels from within their firm, so there has been less exposure to alternative organizations, procedures and management styles.

There is also some evidence to indicate that a high proportion of the chief executive officers and directors in the private sector come from the upper classes (Porter, 1965, pp. 291-295) and a later study indicated that the proportion of the Canadian corporate elite that came from the upper classes was even higher in the early 1970's than it had been in the mid 1950's (Clement, 1975, pp. 172-223). For a fuller discussion of the evidence for the previous three paragraphs see Daly 1979.

If one combines the pieces of evidence that indicate senior business managers tend to be older, to have less formal education for management and to have a high representation from the elite, the evidence seems to reaffirm a pattern in which senior business managers would be less open to change than in the United States. There managers tend to be promoted earlier, with greater emphasis on their performance and ability, and a more open process of selection for management positions.

It is sometimes asked how the Japanese organizations are so fast in adopting new technologies and managerial practices when the average ages of managers are so high and promotions are heavily based on seniority with the company (frequently it is the only company with which they have been employed). A key contrast is that the Japanese organization operates on a much more participative basis, with the responsibility for initiating the proposals for change and their implementation coming from younger and more junior managers. Many suggestions come from members of the quality circles that operate in many Japanese organizations; they make many more suggestions per year than in North America, and the proportion of the suggestions that are implemented is also higher. Thus, older managers are not as large a source of resistance to change in Japan as can arise in Canada.

The previous pages of this section have identified a number of factors in the recruitment and promotion of managers in the private sector that can contribute to resistance to changes. At the same time, the last section discussed the likelihood that the pressures of international cost competitiveness and reductions in cost that can be achieved from the effective introduction of office automation over time, are likely to persist in the future. It is also likely that the younger managers with upward mobility will normally be more open to the introduction of such new technology than older managers (although it is recognized that some older professionals are just as willing to try new technology as younger professionals). An increased number of younger and more highly educated managers would like to have a greater degree of managerial responsibility earlier in their careers than the managers now approaching retirement, and they tend to favor more participative management styles than the more autocratic styles that still tend to predominate in Canada. There were some tendencies that a growing proportion of companies were beginning to move towards a more participative managerial style in the late 1970's, but this tendency was abruptly interrupted by the severity of the 1981-82 recession in Canada. As a part of corporate survival, many companies introduced aggressive steps to cut costs by reduced employment. As part of the process of becoming "leaner", many companies ended up truly becoming "meaner"; the possibility of moving in a more participative direction could very well have been set back by a decade.

The economic factors that are tending to encourage office automation, are still encountering resistances at the managerial and other levels. For the longer term, it is anticipated that the economic factors will dominate, but anything that can be done to increase the gains, and reduce the costs and the sources of resistance to change will contribute to a more effective functioning of the Canadian economy in an interdependent world economy, where producers in other countries are farther along in successful implementation of the new technologies.

It is also useful to speculate about the broader social factors affecting technological change and the growth of nations. One important recent look suggests that many societies historically have ended up introducing a variety of special interest groups that limit entry, increase incomes and prices, and end up stopping or resisting change and hindering economic growth. On the other hand, societies that experience social, political and economic upheavals end up with quite new elites emerging, and these societies are more open to change than societies with prolonged periods of peace and tranquility that permit sources of rigidity to develop (Olson, 1982). If this framework is applied to Canada compared to the United States and Japan, Canada has not had the same degree of upheaval as the United States (with the War of Independence and the Civil War and a relatively more open society for the recruitment and promotion of managers). Japan had the Meiji period of opening up to the west in the latter part of the 19th century, and then the political and economic reforms after the Second World War and a high social and political commitment to economic growth. Canada has put a high priority on gradual change and continuity, and such social values tend to put priority on the status quo rather than the gains from change. Those themes have been developed by both sociologists (Lipsett, 1965) and political scientists (Presthus, 1979) and these studies support the interpretations at the managerial level that show or even discourage change, even when economic and competitive forces suggest that change is necessary, desirable, and eventually almost inevitable if Canada is to achieve improved economic performance.

CHAPTER 4

ORGANIZATIONS AND THEIR TECHNOLOGICAL BASE

4.1 INTRODUCTION

The previous two chapters have examined the issues surrounding technological innovation and productivity, with particular emphasis being placed on the emerging technologies of the office. Chapter two focused on a macro-economic perspective, arguing that technological progress has not neccessarily led to large scale unemployment; there seems to be little hard evidence that this new development will as well. Rather it is Canada's slow adoption of newer technologies that reduces our ability to compete that is the greater threat. Chapter three then narrowed the focus to examine, at the firm level, adoption of new technology as a strategic condsideration, concluding with some arguments as to why Canadian firms appear to "technologize" at a slower pace than their foreign competitors. This chapter will narrow the focus even further by examining two issues - the nature of managerial work and the nature of information technology. However, rather than concentrate individually on each issue, our main thrust will be the interrelationships between the two. How can one examine what a manager does to understand how new technologies might affect him? How can one discover what technological gaps still exist in the "automated office", and how might those be filled? Why is it that in implementations of similar technologies, some succeed and some fail? We don't purport to answer these questions definitively, but we will present some frameworks from which the issues could be approached.

Communications is the essential building block of organization; many authors have stressed that coordination through communication is an absolute prerequisite for organizational survival (March and Simon, 1958; Thompson, 1967; Hage, Aiken and Marrett, 1971; Perrow, 1967). Probably the best statements on the importance of communications come from Chester Barnard, considered one of the fathers of modern organizational theory:

An organization comes into being when (1) there

> are persons able to communicate with each other (2) who are willing to contribute with each other (3) to accomplish a common purpose. ... [pg. 83] The possiblility of accomplishing a common purpose and the existence of persons whose desires might constitute motives for contributing twoard such a common purpose are the opposite poles of the system of cooperation. The process by which the potentialities become dynamic is that of communication. ... [pg. 89] In an exhaustive theory of organization, communication would occupy a central place, because the structure, extensiveness and scope of organization are entirely determined by communication techniques.... [pg. 88] (Barnard, 1964)

Indeed, since coordination is the key component that allows the totality of organizational effort to be greater than the sum of its parts, any study of individual productivity within an organization must include analysis of how any one person relates individual tasks to those of other workers. Any technological change that might affect the manner of relating or coordinating has the potential to affect individual, and thus organizational, productivity.

The various technologies that potentially could be included in the "office of the future" affect the way people communicate. Their effects can be seen not only in the manner in which they communicate, but also in the preparation to communicate. For example, electronic mail has been for some time the backbone of any office automation strategy. It has the capability of speeding up interpersonal communication by either replacing "telephone tag" or surface mail. And so, it is often quoted as a primary example of technology's potential for productivity inprovement in the office, through a basic cost-reduction argument. However, there is much more to the communication event than simply mailing a memo. Before that can happen, the sender must sit down, formulate exactly what should be included in the memo, get the message entered into an appropriate format for use in electronic mail, and then finally follow the steps to actually send the message to the appropriate mail-box. Thus, if there truly is productivity improvement in the use of electronic mail, it must be apparent in the whole of the communication event, not simply the transmission step.

Thus, there is a need to understand more of the total communication process and its relationship to managerial activity before one can begin to understand what the potential benefits of the various new technologies might be for office and managerial work. It is with this in mind that this section explores various models of managerial work. In fact, no one model is completely satisfactory, in the context of office automation, but there is some synergy

Exhibit 4-1 Model of the Communication Channel

among them that begins to point out the direction that future research should pursue.

4.2 MODEL OF THE COMMUNICATION PROCESS

The first model is a slight modification of the famous Shannon and Weaver feedback model of communications, which has become the basis for cybernetic theory. As can be seen in Exhibit 4-1, there are seven components in the model. The purpose of the model is to understand where "noise" can enter the process to upset the perfect communications act, and what actions might reduce the effect of noise.

Briefly, the sender wishes to communicate with the receiver, either to request information, to send information, or to change his behaviour (all of which are equivalent, in cybernetic theory). To do so, the sender first formulates a message that he believes is conceptually consistent with the receiver's "semantic space" to illicit the appropriate response. Once he has the message conceptually formed in his mind, he formats it into some appropriate language for communicating. He then chooses the medium over which he wishes to transmit the message, encodes the message into a coding scheme that the medium can accomodate, and transmits the message.

At the receiver's end, the process is reversed. On receipt of the coded message over the medium, the receiver decodes the transmission into a language, assimilates a message from the language, and reacts to the message according to the way he understands it. Inherent in the model is the assertion that the message received is never exactly the same as that intended, because of the effects of various types of "noise" on the communicating process (as shown in Exhibit 4-2). Various actions can increase the accuracy of the communications including feedback, cue redundancy, cue summation, and so on.

This model can be used to analyse the potential benefits of new communication technologies for improving productivity. Most of the early writings on office productivity (e.g. the work by Bair) focused on potential improvements from changing the transmission medium alone. For example, "telephone tag" is the ultimate engineering noise problem - if the receiver is not there, transmission cannot occur. By replacing the telephone medium with electronic mail, one improves the process, since the specific "tag" noise is eliminated; the claim is that the shift from real-time to delayed-time does not seriously affect the information flow itself. However, it is not only the medium that has been changed, but virtually the whole process from beginning to end. The sender will format the message differently, knowing that it is now going to be

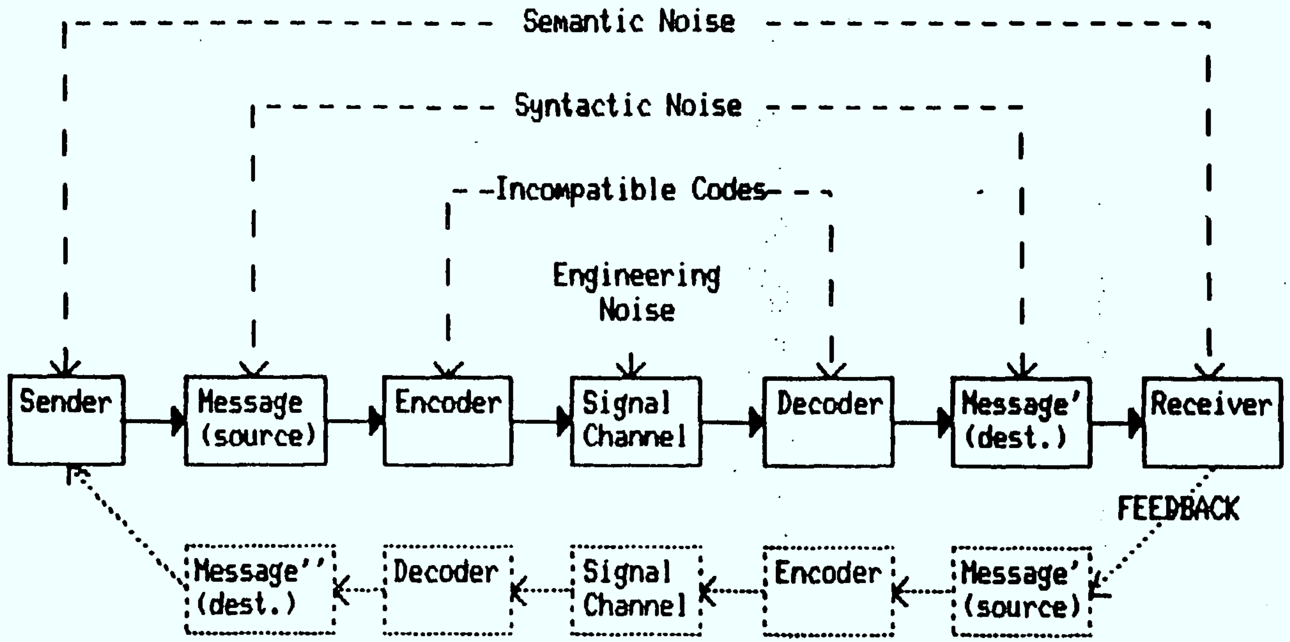


Exhibit 4-2 - Enhanced Communications Model read, with no immediate feedback, and then he must spend some time having the message coded for transmission - in this case, entering it using some type of computer input device. Thus, it is not enough merely to quote the savings in time spent in "telephone tag" to show improvements in communications productivity. The extra time spent formulating and enterring messages into mail must be compared with the total effort in using the telephone for the same communications purpose; in addition, the effectiveness of each process must be compared.

This small example shows the benefits of approaching productivity using a cybernetic model. The differences of efficiency and effectiveness quickly become apparent if one examine the tradeoffs inherent in choosing one medium over another. However, there can be no denying that the measurement problems involved in such comparisons are enormously complicated, as outlined in Chapter 2. As yet, the authors have seen no published research that has tackled these problems directly.

One might anticipate some of the potential research results. Cost benefit tradeoffs using the total communications model become easier. For example, there is no denying that voice messaging systems (sometimes known as voice store-and-forward systems) are a more attractive substitute for telephone tag, since the total process more closely resembles the original intended event; i.e. the particular "coding" used in voice messaging is not as different from real-time telephone conversation as is text messaging. However, currently the cost differentials (on a per byte storage and production basis) and potential coverage (in terms of reachable audience) vastly favour text messaging over voice messaging. Even when cost differences begin to shrink, there may be advantages to text messaging that are inherent in the nature of the communication event that we have not yet discovered. For these arguments alone, there are some great benefits to be obtained from research examining the nature of all communication events within an organization, not solely those that are elecronically mediated.

Another use of the general field of information theory, more commonly called cybernetics, is the strict definition of information that is provided by it. Information is defined to be realization of events (called "experiments") that reduce the overall uncertainty (called "entropy") of a finite, probabilistic set of outcomes. Thus, data about events become information when they shift the probability space of all likely outcomes so that the total measure of entropy is reduced - normally, when one outcome becomes more probable than others.

This definition can be usefully applied in a more general way to integrate various perspectives on the use of information itself. Information might be defined as data that are used in making a decision. The cybernetic definition and the one above are, in fact, totally consistent, in view of Herbert Simon's definition of decision making as making a choice among various alternatives. Each alternative will have associated with it some probability of achieving the decision maker's desirable outcome (albeit the probabilities may be totally subjective). When the decision maker chooses some particular alternative, he chooses the one that most probably leads to his desired outcome (or sets of outcomes) and that probably leads least to undesirable outcomes. Any data that he uses to assist him in choosing that alternative will be useful only if it increases his subjective assessment of these likelihoods, and thus are truly entropy reducing, again if only in a subjective sense.

From a behavioural perspective, information has been defined as "behaviour initiating stimuli in the form of signs". Again, this is not inconsistent with the cybernetic model. Any data that a person receives that change the probabilities of his performing certain actions, so that he in fact realizes an action, must reduce entropy, and therefore must be information. The difference is that the cybernetic model would allow information capture to occur without necessarily initiating behaviour immediately; rather, the probabilities of certain behaviours occurring in the future as a result of receiving various stimuli would be altered so that some behaviours are more probable than before, and others, less probable.

Nevertheless, this behavioural perspective raises some interesting issues. If one of the intentions of the communicator is to change the receiver's behaviour, then communication impact becomes critical; the importance of business graphics systems and decision modelling tools are obvious when seen in this context. They may permit the communicator to influence the receiver (in this case the decision-maker) more strongly. In addition, by building a "logical" decision model the communicator can explore more possibilities before finding the right "sign" (potential outcome) with which to attempt to influence.

Overall, the cybernetic model is useful for examining the potential improvements that can be expected from technologies that mostly affect the tranmission mechanism for communications. Thus, voice store-and-forward systems, graphics, electronic mail, perhaps even word processing itself, could be examined from this perspective. However, the model does not tell much about how messages are formed, or for what purpose, other than in a mathematical, entropic sense. Communications is a purposive event; so models are needed that can allow examination of both how and why a manager formulates messages for communicating. This model examines the ultimate means of communicating; the next section examines the stages that precede the communications event.

4.3 MODELS OF COMMUNICATION ROLES IN ORGANIZATIONS

Starting with the initial work of Jacobsen and Seashore in the 1950's, many researchers have attempted to model organization on the basis of communication roles. The basic roles that have been used are Group Member, Isolate, Liaison, Bridge, and Linking Pin (McClean, 1980). Unfortunately, most of the work has been fraught with mathematical and measurement difficulties, so that no comprehensive model of managerial activity directly based on these roles has yet appeared, at least one that can be measured unambiguously. However, certain conceptual models that are loosely based on these roles deserve some mention.

4.3.1 Mintzberg's Managerial Roles

The most important of these models is Henry Mintzberg's "Managerial Role" model. In it, he criticizes the typical "pigeon-holing" of management activity according to Fayol's classic categories of planning, organizing, staffing, directing and controlling. Instead, Mintzberg claims that management action falls loosely into three groups: one, the interpersonal roles that develop as a result of his status; two, the informational roles that naturally follow the development of his interpersonal roles; and three, decisional roles that are facilitated by his informational roles. Thus, there is a sequence of role development, shown below, with each specific role within three general classes.

1. Interpersonal Roles - As a <u>figurehead</u> the manager is the spokesman for the firm to its environmental members. The <u>leadership</u> role stresses the relationship of the manager with his staff, while the <u>liaison</u> role recognizes peer relationships. These interpersonal contacts make it possible for the manager to emerge as the "nerve center" of the organizational unit.

2. Informational Roles - The informational roles of <u>monitor</u>, <u>disseminator</u>, and <u>spokesman</u> are quite significant in Mintzberg's view. One of his studies revealed that chief executives spent 40% of their contact time on activities devoted exclusively to information transmission, and that 70% of their incoming mail was informational rather than requests for action.

3. Decisional Roles - The decisional roles cast the manager as an <u>entrepreneur</u>, seeking to improve the unit, as a <u>disturbance handler</u> who performs much as an orchestra conductor in keeping all of the resources in tune, as a <u>resource allocator</u>, and as a <u>negotiator</u>.

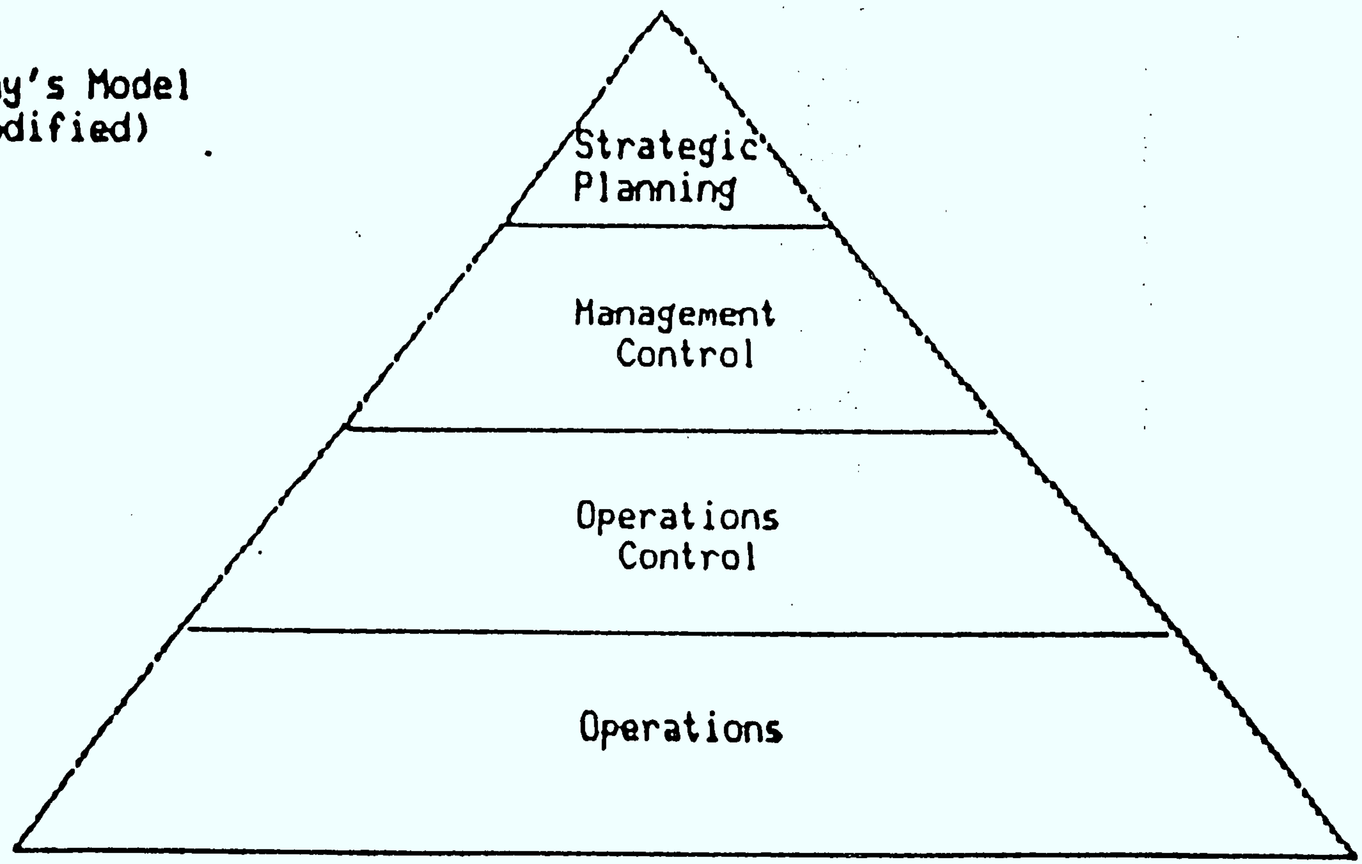
This model is attractive since it focuses not only on the roles a manager adopts in performing his job, but also on the relationship between information, communications, and decision making in his activities. In addition, his information-related activities are a prerequisite for any decision roles, and consume a great deal of his time. A fundamental implication is that if technological innovation can reduce the amount of time spent in informational roles, yet achieve the same, or greater, effectiveness, then managerial productivity will increase. Unfortunately, there are no published studies in the literature that directly show improvements in productivity through increased efficiency within information-related activities.

However, McLeod and Bender (1982) do use the theory to develop a complete plan to integrate word processing with an existing Management Information System. By focusing on the particular roles of <u>monitor</u>, <u>disseminator</u> and <u>spokesman</u>, and on the differences between "hard" information (output from a formalized computer-based system) and "soft" information (verbal contact, mail, telephone calls, gossip, and so on), they hoped to develop an implementation plan that would improve managerial performance within informational and decisional roles. Although they did not measure any performance levels to prove their point, their approach is nevertheless interesting because it raises for the first time the need to look "beyond" word processing itself to other information technologies, in particular existing M.I.S. that must interrelate with the new software and hardware technologies. They conclude by drawing out a development path that would eventually lead to a managerial, multi-function workstation that could integrate all data processing and word processing activities for managers involved in the long-range planning effort for the firm. The next section returns to this point because it is at the heart of any overall productivity improvement that can be realized with office automation technologies.

The importance of Mintzberg's model lies not so much in its categories, nor in its particular roles, but in its explicit recognition of the importance of information and communication to a manager's job. Unfortunately, it cannot distinguish well among managers. The model is an operative one; every manager fulfills all the roles, but each to more or lesser extent that others. There is no indication that one role is any more important than any other role, nor that relative importances change either with organizational

EXHIBIT 4-3

Anthony's Model
(modified)



level, with function, or with personality. Such knowledge would be very useful in deciding where office technology strategies should be focused within organizations to achieve the greatest benefit.

In its favour is the recognition that the activities that a manager carries out fall within the roles he is fullfilling. However, those roles interact quite heavily when one examines activities. For example, the process of sending a particular memo to your managerial peers does not simply fall within the role of liaison, but perhaps within disseminator, monitor, or spokesman as well, depending on the nature of the information contained in the message. It is possible that various types of managerial activity are better represented by a two-dimensional matrix of Interpersonal Roles by Informational Roles (and perhaps by a third dimension of Decisional Roles). However, the task of distinguishing activities within cells of such a matrix has not yet been attempted. But it would potentially have great benefit; if we could categorize a manager by how much of his time he should spend within each role, because of the nature of his job, then we would be better able to focus technological improvement on those activities within the matrix that have the greatest potential for overall impact. It would appear much like a contingency theory of implementation for various mixtures of office technology, rather than the overall panacea that manufacturers would have us believe.

4.3.2 Anthony's Model Of Organizations

One model that does try to distinguish among roles according to level and has been used very successfully within Management Information System research is the three-level management pyramid of R.A.Anthony (1965), which was later expanded to four levels by several writers (e.g. Davis (1974), Ein-dor and Segev (1978), and Ahituv and Neumann (1982)).

Basically, organizations resemble pyramids, broken into four levels (see Exhibit 4-3). At the top reside the senior executives of the firm, whose major activity consists of strategic planning - the "deciding on objectives of the organization, on changes in these objectives, on the resources used to attain these objectives, and on the policies that are to govern the acquisition, use and disposition of these resources." Middle managers exercise management control to "assure that resources are obtained and used effectively and efficiently in the accomplishment of the organization's objectives". Lower management provide operational control to assure "that specific tasks are carried out effectively and efficiently". And finally, operations carry out those tasks.

Specific managerial functions change quite dramatically as one traverses the pyramid. As Ahituv and Neumann conclude:

> "In summary, the scope of each function narrows as we go downward along the organizational hierarchy. At the bottom, managers deal with more detailed data referring to shorter periods. They have a shorter planning horizon and a smaller span of control. The effects of their decisions are detected earlier and more easily. The implication is that control in these levels is more concrete. In other words, adopting Simon's terms,... we may say that decisions at the upper level are completely unstructured, whereas at the bottom they are fairly close to being structured" (page 123).

These differences have had a major influence on those who have studied the use of formal information systems within organizations. The scope of Management Information Systems has been broadened during the last 10 years from its narrow perspective of capturing and processing basic organizational transactions to include new systems of hardware and software to support managerial decision making. This expansion will be covered in more detail in the next section on the technology base of organizations.

More relevant to the current discussion are the differences outlined in Anthony's model. These show that the information gathering and communicating activities of each manager differ substantially by level in the firm. Communications that flow down the firm will start out as general policy directives, and become more task specific and more concrete the further down they travel. Communications in the reverse direction will consist at the lowest levels of basic feedback on activities being carried out. These comunications will provide the basic material by which operational control can be effected. As one moves up the firm, upward communications become more aggregated and exception driven, as managers turn from a solely internal focus to more external information.

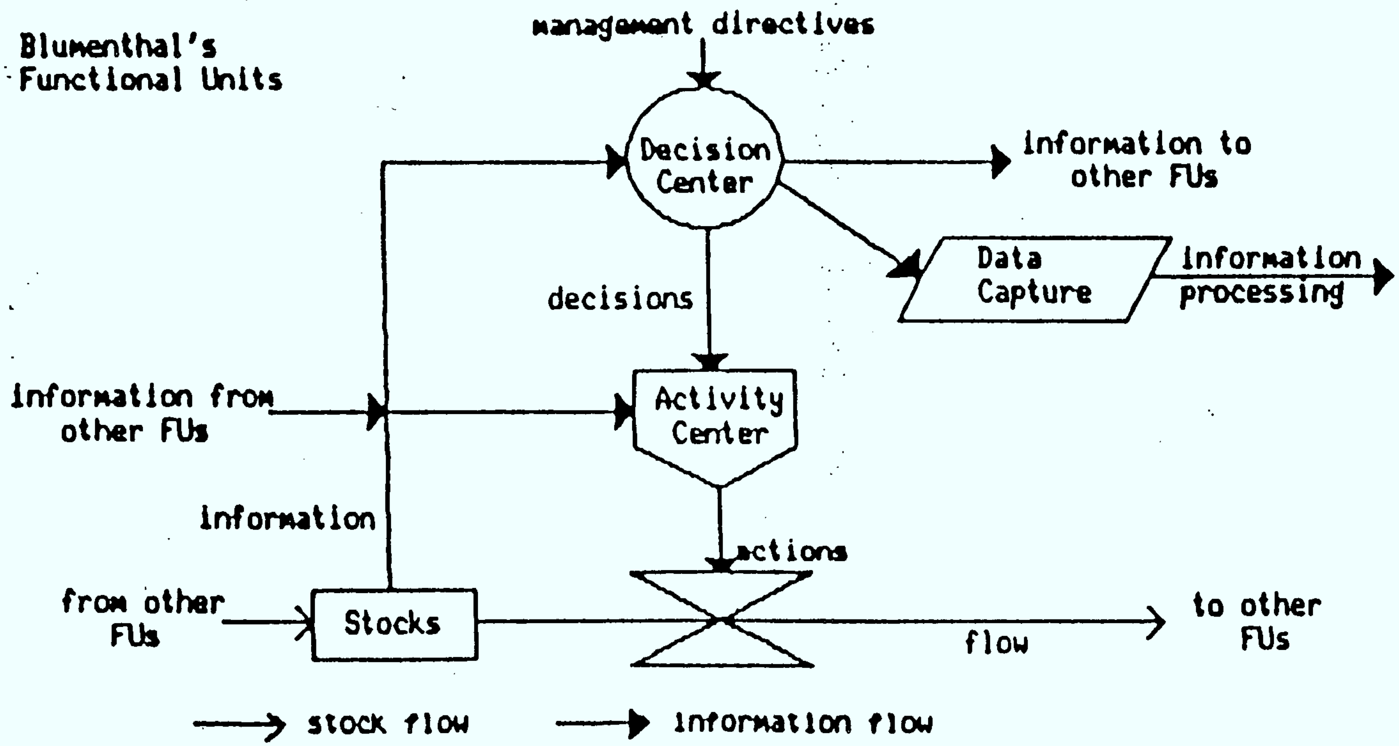
The decisions that are made also differ by level of the firm. In Simon's terms, the decisions that are made at the lowest levels of the firm are very routine in nature; managers can rely on set ways to handle problems, and gather the information to make the decision. However, at higher levels in the firm, more decisions tend to be non-routine in nature; managers cannot rely on standard practices to solve the problems. Instead, they must gather more information and follow much more complex problem-solving algorithms than they would normally do. More of the necessary data may be from external sources than would be the case lower down in the firm, so that information gathering may be more time consuming.

Anthony's model provides a strong basis for studying potential impacts of office technology. From a communications perspective alone, some interesting points arise. If managers at the higher levels of the hierarchy concentrate more and more on external data sources, does organization-wide electronic mail provide as much potential benefit for a president or a vice president as it might for a line manager, who is almost completely focussed on internal communications? Should organizations focus on interfacing managers into corporate databases to get summary reports tailored more to their needs, or should they focus on providing electronic mail systems to handle exception reports and directives? And further, given the integration possibilities outlined in the previous chapter across the automation triangle, between managerial systems requirements and hardware and software, how does the full potential of office automation impact on the information needs at different levels of the organization? Although Anthony's model provides a basic framework within which to study differences in information and communication needs by level, it is not rich enough to describe how data produced on organizational activities and management information interrelate, especially when it comes to determining how technology might affect that flow. It does warn us that information needs differ, so we should suspect that the mix of technologies that are introduced to the office, consisting of various hardware and software components, might differ in effectiveness with organizational level. This is consistent with arguments made earlier in the discussion of Mintzberg's Managerial Role model. Since the mix of roles filled by a manager will differ by his level, so too will his range of activities; then matching the technology most effectively against that particular range becomes the crucial issue. What appears to work for one, may not work for another. To further explore this issue of technology supporting managerial activity we must turn to a more dynamic model.

4.3.3 Blumenthal's Information Flow Model

One of the criticisms of Anthony's model is a lack of integration between the activities of the operations level of the firm and the managerial levels. In an attempt to integrate Anthony's description with Simon's classifications of decisions and Forrester's description of stock and information flows in operations (called the Industrial Dynamics Model - (Forrester, 1961)), Blumenthal (1969) developed a comprehensive model that aids in understanding the relationship between operations on stocks and information and data flows in an organization.

EXHIBIT 4-4



Blumenthal's
Functional Units
management directives
Decision
Center
information to
other FUs
Data
Capture
information
processing
decisions
information from
other FUs
Activity
Center
information
actions
from other
FUs
Stocks
flow
to other
FUs
stock flow
information flow

The basic unit of the model is called the <u>Functional Unit</u>, which can be loosely described as a point in the organization where a discernable operational action occurs. The functional unit is concerned with receiving, processing, and outputting two types of entities, "stocks" and "information". Exhibit 4-4 shows the relationships between the flow of stocks and the flow of information (data) into and out of the functional unit.

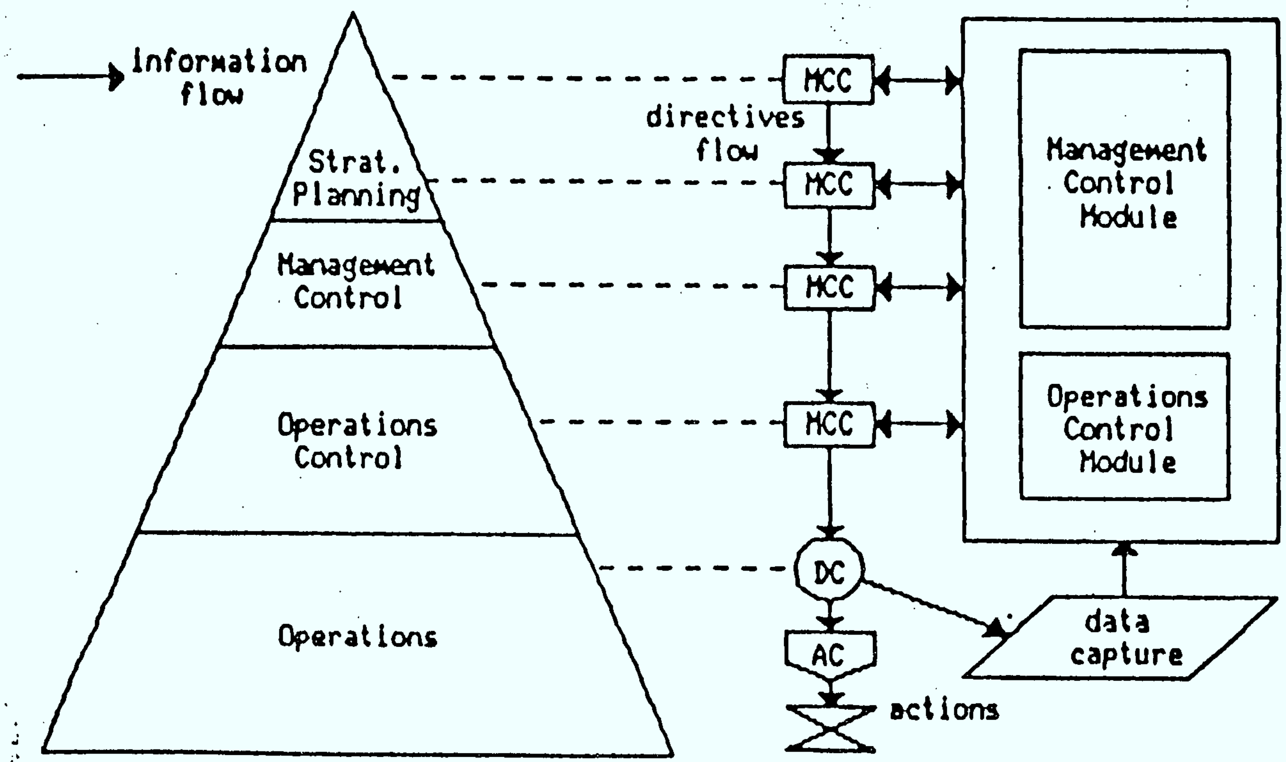
Fundamentally, information (more preferably termed data) is collected from other functional units, from the "stock" point within the functional unit, and from higher management and then is used to make decisions on the actions to be taken on the unit's stocks. That is, decisions are made at the <u>decision center</u> and passed to the <u>activity center</u> which carries out the directed actions on the stocks (processes them, distributes them, consumes them, etc.). Data concerning the directed activities and current stock levels are passed to other functional units; a certain portion of the data may be "captured" for further information processing at a later date.

The operations level of the organization then can be viewed as a collection of functional units, which are interconnected by physical stock flows, and by data flows that are used to regulate physical activities. The primary direction of physical flow is horizontal across the operations level; however, the nature of the information flow depends on the operating communication characteristics of the firm, and on the nature of the information. Part of the data will be used for operational control of the particular functional unit in question, part will be passed to other functional units to be used in their decisions, part will be captured for future processing.

Blumenthal distinguished between the <u>functional units</u>, which actually carried out the operational actions, and <u>control centers</u>, which directed those actions. Managerial control centers were points in the organization that either acted as a decision center for one or more functional units or for one or more subordinate managerial control centers. Thus the organization is a hierarchy of control centers, that fits naturally with the expanded Anthony model of control and operations levels. Operations are made up of functional units that take stocks from other functional units, perform some actions on them (note the close resemblance to the economist's and the accountant's "valued-added" concept), and then distributes them to other functional units. In so doing, the functional units generate data on their activities, which are fed either directly to their own operations control (or indirectly to other control points), directly to other functional units, or captured to be used later.

The nature of the organization will affect how data and information will actually be distributed within the operational levels of the firm. For example, in a highly formalized, bureaucratic organization, information flow may be highly vertical, according to the way Max Weber described. Data necessary for other functional units would move "up and down the hierarchy", possibly moving several levels before a common control center is found. In the process, the possibility of data distortion increases, of course, with the number of levels that have to be traversed. As a response, organizations adopt other means to distribute operational information, ranging from formalized Fayol gangplanks to highly individualized, informal networks. It is in this way that new office communication technologies may provide either a benefit or a disbenefit, depending on the nature of the change introduced and the level of integration according to the ideas of the automation triangle described in Chapter 3. Clearly, the new technologies can affect two specific parts of this model. First, the manner in which information is gathered on current "stock" levels, on the states of other functional units, and from upper management can be affected by technology. Directives and orders might be distributed through electronic mail systems, while data on stock levels and transfer states might be retrieved from on-line data bases. In addition, the manner in which decisions are made might be modified by the application of decision models, working with the more accessible on-line information. Thus the impacts might be seen in two distinct areas, again supporting arguments made previously. New office technologies will affect not only the way managers communicate, but what they communicate as well. Decisions that are made eventually become directives that are communicated to control the flow of resources within an organization. Thus any new system that improves decision modelling ultimately affects the communication system as well. But more importantly, this information flow model points out for the first time that new office technologies must fit into the information processing framework that already exists. Many firms capture data about activities of their various functional units. The promise of office automation is that communications regarding those activities and the decision processes affecting those units might be improved. In the next section, we will turn to an overall framework that attempts to bring all of these points to bear.

EXHIBIT 4-5



information flow
Strat. Planning
Management Control
Operations Control
Operations
directives flow
MCC
MCC
MCC
MCC
DC
AC
actions
Management Control Module
Operations Control Module
data capture

4.4 INFORMATION TECHNOLOGY BASE

To examine the potential impact of the new office technologies on managerial work, the nature of the information systems that are already in place must first be examined. The premise of this report is that ultimately to be accepted and integrated into the work environment, office technology must in some manner integrate into the structure of the organizational information system; it may either improve its overall performance, or it may hinder it. The next section turns to the overall productivity concerns of managing organizational data and information, and to the general structure of those systems.

All organizations process information; thus, all organizations have information systems. The structure of organizational information systems can be classified by two dimensions - the use to which the processed data is put and the extent that the process is automated. Before covering automation, the next section examines the kinds of data processing that organizations and managers utilize.

4.4.1 The Framework For Information Systems

The framework in this section is based on an excellent discussion in Ahituv and Neumann (1982). To start, the Blumenthal model presented in the last section is extended to include information systems, as shown in Exhibit 4-5. The extension involves adding two different "model bases" that share the same bottom-level, operational data base within an information system, in an attempt to explain what happens to the data generated by functional units. The data enter an "information system" where they encounter an "operational control module". Within that module, they are processed using certain models to provide information for operational control (note the output to a management control center) and to provide data for a higher management control module, which services the Management Control and Strategic Planning levels of the organization.

The point that is stressed throughout current MIS literature is that information requirements of various management levels are different; therefore, the data bases and model bases also differ with each organizational level, and with functional differences. Generally, operational information:

- is more routine
- must be current and up-to-date

- must be highly accurate

- is based on internal data from operations

- is highly repetitive and fixed in format

- is historically oriented (what has happened ?)

By contrast, managerial information (for levels above operations control):

- is determined by individual managerial needs

- is older and more aggregated

- may not be very accurate

- is based on more external data and summarized internal data

- is customized to individual requirements, often on a one-time basis

- is more future oriented (what might happen ?)

These differences are said to arise because of differences in the mix of decision types that information consumers face.

Following Simon's classification of decisions into structured (all the decisions steps are known and highly repeatable), unstructured (not all the steps are known, nor are they structured), and semistructured (a mix of the two extremes), many MIS writers (including Keen, Scott-Morton, Gorry, Sprague, etc.) have concluded that organizational information systems can provide different levels of support for managers, depending on what kind of models are provided in the MIS modules. Their general thrust is that information systems could be built that would support managerial decision making in various ways. Thus, through the judicious design of databases, model bases, and the tools to bring the two together, Decision Support Systems could assist the manager in making semistructured and unstructured decisions, by allowing exploration of more alternatives, use of more data, use of different explanatory models, and so on, than would normally be the case owing to restrictions of time, cost and ignorance.

Thus, a Decision Support System can be viewed as a complex set of tools, provided by an information system, that assists managers in making decisions. Generally, the argument has been that DSS are provided by designing computer systems in appropriate ways, although on a conceptual level, one can always think of "decision support systems" that exist without computer assistance (e.g.

commercial graphics support). What of the other facets that information systems in general provide?

Another set of differentiated systems is called Structured Decision Systems by Neumann and Hadass (1980). In general, Structured Decision Systems differ from DSS in that the problem is well understood, the data is easily captured and repeatable, the decision process is algorithmic and well-understood, and the problem is very routine and localized. Even without computer assistance, most managers use forms of Structured Decision Systems when they apply routine procedures from policy manuals (in fact, Weber's classical bureaucracy can be thought of as an attempt to force all organizational decisions to be structured in similar ways). With computer asssistance, the decision is solved by applying the appropriate model from the model base to the appropriate data from the data base, which is simply a difference in procedure, rather than in kind. How are the models and the data enterred into their appropriate bases?

The internal data that the Structured Decision System will utilize is provided by the Transaction Processing System of the organization. The role of the TPS is to capture data regarding the activities of the operational level of the organization - in other words, it is the data capture module for the functional units described previously. The TPS then processes this captured data in predetermined ways to provide the information which the operational control levels utilize. In addition, some of the data may be processed in other ways to be utilized at higher levels of the organization, in addition to external data. The external data is captured by managers playing "boundary spanning" roles (as described in Tushman, 1977).

How the models are placed in the model base, especially for Structured Decision Systems, is not so straightforward. Ahituv and Neuman (1982) argue that likely Transaction Processing Systems precede all other forms of information systems. Organizations first develop batch-oriented computer systems that handle the five stages of the "transaction processing cycle":

1. recording and data collection

2. data conversion and verification

3. data validation

4. file updating and processing

5. reporting

As organizations gain familiarity with these systems, they proceed to develop on-line versions to improve performance and responsiveness.

Once the TPS is running well, the next stage of development is not so clear. Ahituv and Neumann suggest that organizations will then develop some Structured Decision Systems based on the files that are generated by the TPS. The argument seems to rely on the fact that such systems do not require much external information and are very routine and repetitive. A good example of such a system is an inventory management system, which automatically reorders materials based on the levels of inventories found in the files, the known lead times required by known suppliers, and the known inventory model that is being applied.

However, this development assumes that the appropriate inventory model is already known; perhaps it is not. In that case, the development will more likely parallel Simon's concept of non-programmed decision making, where various alternatives are analysed, an appropriate one applied, and the results monitored to improve the process the next time. Once the process begins to stabilize, that is once one model seems to give "satisficing" results, then the model can be added to the model base of the SDS. The decision maker thus follows more of a semistructured process before the implementation of the final system; he may even use a formal Decision Support System to assist him in choosing alternatives, and monitoring the results.

Therefore, there seems to be two development paths that may construct Structured Decision Systems. The first is the automation of known structured decision processes using files maintained by the TPS. The second is development of routine through the use of semistructured decision techniques, perhaps with the actual aid of computerized Decision Support Systems. There are no known empirical studies that have examined this issue. Yet it is a crucial one. At the heart lay fundamental questions regarding the nature of managerial decision making. On the one hand, the management scientists argue that well-researched and complex decision models can be made available to managers only through complex Decision Support Systems, and then only as "black boxes" to optimize payoffs. On the other hand stand the micro-enthusiasts who believe that spreadsheets are the only tool a manager needs; heuristics and "gut-feel" drawn from continually massaging data and graphs will eventually build some routine processes.

The development of Decision Support Systems themselves hinges on three different components - the data, the decision models, and perhaps most importantly, the decision maker himself. Since Decision Support Systems are used to support mainly middle and upper level managers, the development of the actual data and model bases will be highly individual, as the particular decision and information requirements differ from manager to manager. Certainly, some of the data must be generated by internal sources; in this case both the TPS and SDS will have input. But, some of the data will also be external in nature. Some may be captured by formal boundary-spanning and environmental scanning roles, but much will be captured by the manager himself (or by his support staff). In addition, although certain general models can be provided in the decision model base, the use of these models and their tailoring to a manager's particular problem will be up to the manager. Thus, the key component in the successful use of Decision Support Systems is the end-user himself. This has led researchers and practitioners to focus on design issues that revolve around ease-of-use, flexibility, and adaptability, issues to which we will return later.

The purpose of the above discussion is to identify the information system environment into which office automation technologies will be introduced. Organizations generally have a good deal of experience with basic information processing technologies, particularly Transaction Processing Systems and Structured Decision Systems. Although Decision Support Systems have represented an identifiably separate development in the past ten years, it is only recently that such systems are becoming widely available, as the price-performance ratios of hardware have decreased and the powers of software have increased. However, it is not sufficient to simply install the requisite hardware and software in order to reap the performance benefits of automating information systems; the key success factor must remain the control system that integrates all the components together. Complete utilization of whole of the Automation Triangle (introduced in the preceeding chapter) is a requisite for successful implementation of new office technologies.

4.5 THE AUTOMATION TRIANGLE AND ORGANIZATIONAL INFORMATION SYSTEMS

Successful automation of any process requires three components:

1. Hardware which provides mechanical advantage over other means of performing the task

2. Software which provides the instructions to apply that mechanical advantage

3. Management or Control Systems which link the proper software to hardware for the specific task, monitor the application, direct the software in response to this feedback - in short, provide the "regulator" or "steersman" function for automation.

The complexity of the automated system depends directly on the complexity of the control systems in place. As an example, consider two different kinds of robotized arms. Each has the same mechanical hardware (the ability to move in, out, up and down, the ability to rotate the hand in two planes, and the ability to grasp), each has the same software (instructions to move in a specified distance, to rotate in a certain plane a fixed arc, to close the hand a certain amount and the like). However, each has a completely different form of control system. In the first, control is exercised by a human monitoring the arm's movements, and then directing the software to move the arm in certain ways to perform some task. In the second, control is exercised by "teaching" the arm the sets of moves to perform for some repetitive task (usually, a person will take the arm on a walk-through of the whole procedure). In each case, performance is increased by the application of mechanical advantage, directed by software instructions, which are controlled by some system. However, the nature of control is different, and thus the nature of the automation is different. These same concepts can be applied to the components of organizational information systems.

The automation of information systems occurred primarily because of the immense "mechanical" advantage afforded by computers. At the simplest level, a computer is only capable of recognizing "on" or "off". However, by developing ingenious coding schemes and harnessing the fundamental binary capability of a computer, humans have been able to give the computer an enormous mechanical advantage over man (although it is realized through complicated electronics). Computers are capable of performing simple arithmetical calculations at many times the speed at which humans can do them. By coupling that ability with addressable logic and large amounts of short term and long term memory, computers are now infinitely superior to humans in those tasks that require such capabilities, normally situations with enormous amounts of repetitive logic and even larger amounts of data.

The application of the mechanical advantage afforded by computer processor and memory circuits is due solely to the software that controls the functioning of those circuits. As software has progressed over the last three decades, managers have discovered ways of providing mechanical advantage in a whole host of different situations, using the same hardware, responding to different sets of instructions. As long as the situations requiring this mechanical advantage were separable, the control systems needed for this form of automation were quite simple (generally, an operator handling switch panels and card decks, one at a time).

However, as organizational situations became more complex, and the need arose to handle more than one situation at a time, the control systems became more and more complicated, leading, in part, to the great variety of operating systems now available. The function of the operating system is to load each program, when required, along with each program's separate data files, to complete the processing, and distribute the results to the appropriate user. But as organizational information systems have become more complex, with the separation into Transaction Processing, Structured Decision, and Decision Support Systems, the requirements placed on the control systems become even more complicated and their role becomes more critical.

Each of the three major components of organizational information systems is a form of automation, providing "mechanical advantage" for different situations. Thus, each has different requirements of hardware, software and control systems. Transaction processing systems are typified by large amounts of data, low processing complexity and well-established control procedures. Their hardware components have not changed much in complexity, only in performance (they need to be bigger, faster, etc.). Software is data-base focussed, with related reporting support for operational control. Their control systems, then, are relatively simple; their only "worry" is linking the various data files together at the right time, and securing access to them. Typically, in the early seventies, these systems were batch-oriented, as discussed in Chapter 3. Nonetheless, as the hardware and software have advanced, interactive versions appeared. Thus, the control systems grew in complexity to allow interactive data access (e.g. data entry, query). However, reporting programs are still run mainly in a batch mode.

Structured Decision Systems represent more complicated systems. Although at first glance the hardware requirements may appear the same as for TPS, after a closer look the increased complexity becomes apparent. SDS require not only the "mechanical advantage" in the same sense as TPS, but they require more of it. In addition, they require monitoring components to provide ongoing data on which to base decisions. Software is definitely more complicated; the decision steps follow more complex algorithms and/or heuristics. The rules are generally implemented in higher level languages than in TPS. But most importantly, the control systems are more complicated. They must provide the monitoring control that "awakens" SDS; they must link the appropriate decision software to the correct data files; they must output the decisions to the proper targets. In the latter case, the control system may actually implement the decision (e.g. automatic ordering in a computerized MRP system). The types of output devices may vary from CRTs to plotters to servo-controlled machines. Each output device requires different control "drivers" for the results of SDS software.

Decision Support Systems again represent another level in complication. The hardware components generally require higher levels of interaction; the forms of interaction may vary from one user to another. For example, one manager may prefer "mouse-driven" interaction modes, while another may prefer "key-boarding"; some situations may require full-colour, interactive, high-resolution graphics, while for others, line-printer graphics will suffice. The software, too, is more complex; it differs from SDS software, in that it is more flexible, supports many different algorithms and heuristics (rather than a few dictated by the decision), and generally attempts to be "easier to use", meaning that the implementation is more complex. The control systems are called upon to link many different forms of software to many different types of hardware, for different situations and different users. They must be more interactive, easier to use, quicker in response, more robust; in short, they are very complex.

To this point, the report has described each of the systems types as if they exist in isolation when, of course, they do not. Successful implementations rely not only on recognizing the increasing complexity of each component of the automation triangle for each of TPS, SDS, and DSS (in increasing order), but in also realizing that the more complex systems rely heavily on the successful operations of the simpler levels. The successful running of any system relies mainly on its control subsystem, once the hardware and appropriate software are in place. Structured Decision Systems use data files provided by transaction systems in their algorithms; for example, Material Requirements Planning systems require up-to-date inventory and parts-explosion files, etc. which are produced and maintained by the Transaction Processing System. Decision Support Systems potentially can use data from both SDS and TPS; for example, a budgeting system may project profit margins using price data from a structured pricing algorithm and cost data from production transaction files. Our conjecture is that the more productive Decision Support and Structured Decision Systems rely more heavily on the control subsystems of the systems that exist below them in the hierarchy of organizational information systems; in doing so the information produced is broader in scope, more accurate, more organizationally representative, in short more useful and more believable than information produced by stand-alone systems.

4.5.1 The Automation Triangle And Office Automation Systems

An Office Automation System must be similar in nature to the three systems described above, in that it must consist of the three components, hardware, software, and control systems. At first glance, the hardware components would seem to be the same as those required for Structured Decision and Decision Support Systems. However, on closer inspection, the fact that enhanced communications is a core component of OA systems renders the hardware more complex. Where DSS and SDS may rely on terminals, printers, plotters, etc. normally directly connected to mainframe computers (or perhaps distributed mainframes), OA systems may involve numerous micro-computers, terminals, and so on, interconnected by numerous network architectures, including the many flavours of Local Area Networks, which in turn connect to a wide variety of mini-computers, super-mini computers, and so on. This difference is clearly due to the basic intention of OA systems, that is to enhance interpersonal communications. Standardization across computer systems and architectures, and across communication network architectures, will certainly render the task of implementing office systems easier than a situation where communications and common protocols have to be established among competing architectures. One suspects that one of the reasons that OA systems have not gained the acceptance in Canada that was trumpeted several years ago is that most potential installations resemble the latter case, more than the former, so that a single vendor's solution could not be applied across all systems. However, there is absolutely no data available to support such a conjecture on implementation failures.

Software is also more complex than is apparent at first. The nature of the software that is needed is wholly reliant on the mix of hardware systems that will be faced. It is a relatively simple matter to construct electronic mail software, complete with "file drawers" and mailing lists, if all parties involved will utilize a single mainframe through similar terminals. The software becomes more complex if one moves to communicating mainframes of a similar architecture. Complexity increases again if the mainframes are dissimilar; which communication protocol should be used? As we move to micro-computers, LAN's, PBX's and so on, the software problems become enormous. Ever if one refers to the ISO/OSI data communications model (Tannenbaum, 1982), which attempts to lay out layers of standardization for communication protocol, one finds that standards do not yet exist at the uppermost layers, which are the main application and presentation layers of interest. So the designer is forced to adapt some protocol, and attempt to implement it on as many machines as possible. Again it is clear why successful implementations tend to favour single vendor solutions.

If other software systems are added, such as calendaring, tickler files, the complexities increase, since now system "breakthroughs" are required to compare calendars, which may involve different file structures, different presentation protocols, different protection standards, and so on. For example, consider implementing a calendaring system involving micro-computers. Manager A wishes to schedule a meeting with Manager B; he would like to avail himself of one of the attractive features of electronic sheduling - the ability to check B's calendar for conflicts. If their two micros are only connected by a simple LAN, with no central computing power, then for A to check B's calendar, he must "breakthrough" to B's system, take control for some period of time, and check his calendar file. If B is also working on his micro at the same time, he loses control for some period of time. If the micros utilize "multi-tasking" operating systems, then that problem can be minimized, but now A must worry whether the right calendar file is online at the other end; if not, some message must go to B to "change floppies". So one adds a hard disk to each micro to ensure that the calendar file is available. Now B worries about the security of his other files, and about having to leave the computer on so that others can access his calendar. So a central file server is added to the LAN to ensure each manager's access to all calendars, even when the other micros are not on-line. One could continue to increase the hardware complexity as each problem was explored (such as security, privacy, access to other networks, etc.). However, the lesson remains that as software requirements increase, and the number of differing hardware components also increases, the nature of the control systems in place become much more complex.

The control systems for OA systems permit the various hardware and software components to function together. Even with a solution involving a single mainframe and a single type of terminal, the control system is the critical component that allows messages to be routed to the correct user, that ensures file integrity for calendaring, and provides various levels of file security to differing groups of users, depending solely on the intentions of the file's author. Clearly, the more software functions that are provided, and the more diverse the hardware components, the more complex the control systems must be. Then, file integrity across multiple systems must be ensured, conversions among protocols must be fast and accurate to allow data to flow among different machines, users must be easily identified on each of the many systems, authorizations for file access at various security levels must be consistently enforced across the whole system; in short, the control system requirements become almost unmanagable.

There is another aspect of control systems that probably becomes evident for the first time only with Office Automation Systems, and that is the nature of organizational control over these systems. The control systems side of the automation triangle includes the management systems that are constructed to ensure system viablility and proper operation. Although each of the information systems that were discussed earlier also must have management systems, their visibility is not so pronounced. The procedures for control of Transaction Processing Systems are clear, tending to follow known rules established for audit and accountability. The management systems that surround Structured Decision Systems again tend to be well understood, and relatively simple, since they rely heavily on output from the TPS to function, and are generally imposed on particular areas of an organization (such as inventory control in a warehouse). It is true that control systems for Decision Support Systems are more complex, since to be most effective, the systems want access to data within the other two systems. However, Decision Support Systems tend not to be that easy to use, at least those that are more robust (such as financial planning systems) and support access to large corporate databases; those that are, such as simple spreadsheet packages, generally require little or no access, and are considered much more suitable for managerial use. Thus, the management control systems that are implemented around Decision Support Systems tend to follow the pattern already established within TPS and SDS - only technically competent support personnel will be allowed access to the large and powerful DSS "generators"; the manager can rely on highly controlled, "turn-keyed" systems and on micro packages with data coming mainly from known reports.

OA systems are obviously different. The fact that the nature of OA software is deceiving (it appears to the user as simple to use, but is indeed very complex) only reinforces the wide-spread belief that every manager can benefit from participating in Office Automation Systems. This raises very serious management control issues. Assuming that an organization cannot afford to automate every manager, which managers should receive the benefits? Should we implement a system where managers of a certain rank receive their own terminals or micros, but others at lower ranks share? Perhaps the criteria is better justified by function, rather than by rank. Which basic communications architecture should be implemented - terminals talking to a strong, centralized, mainframe hub, micros sharing files around a ring, or a hybird of the two? The point is not that these issues have not arisen before within the other information systems, but that OA has democratized the impact of technology. There is a strong belief among developers that one may never get certain managers to use Decision Support Systems, but practically every manager will use messaging systems. Thus questions surrounding the control of OA systems are being raised from a much broader potential base of users.

The above discussion emphasizes that OA systems are the most complex of information systems on all three sides of the automation triangle. Such a conclusion raises some interesting questions regarding the factors that might surround successful implementation of OA systems. Can one successfully implement a large complex OA system, in the absence of the other information systems, successfully operating? Or should one pursue a partitioned strategy, where each system was implemented in turn, starting from the simpler TPS and ending with the most complex OAS? As the question has not been asked before, there is no evidence one way or the other. However, the authors believe that the latter approach will most likely lead to significant performance improvements in the long run.

4.6 DISCUSSION

4.6.1 Broaden The Scope

There are several conclusions that one can draw from this investigation of the technological bases of information systems in organizations and of their importance to the "automated office". First, and probably foremost, is that one cannot afford to view the "automated office" as an electronically enhanced communication system alone. Claims for productivity improvement tend to rest on too narrow a definition of communications i.e. the transmission of messages, rather than on the broader process of communication as presented in the communication model above. There is no empirical research that has examined the impacts of automated communication systems from that broader perspective, so that we are still left wondering whether there is any potential for positive productivity impacts in the application of the new communication technologies (such as digital PBX's, electronic mail, voice messaging) beyond the standard claim of reduction of "shadow functions". So the first need is to broaden the scope of both laboratory and field research to include the broader process.

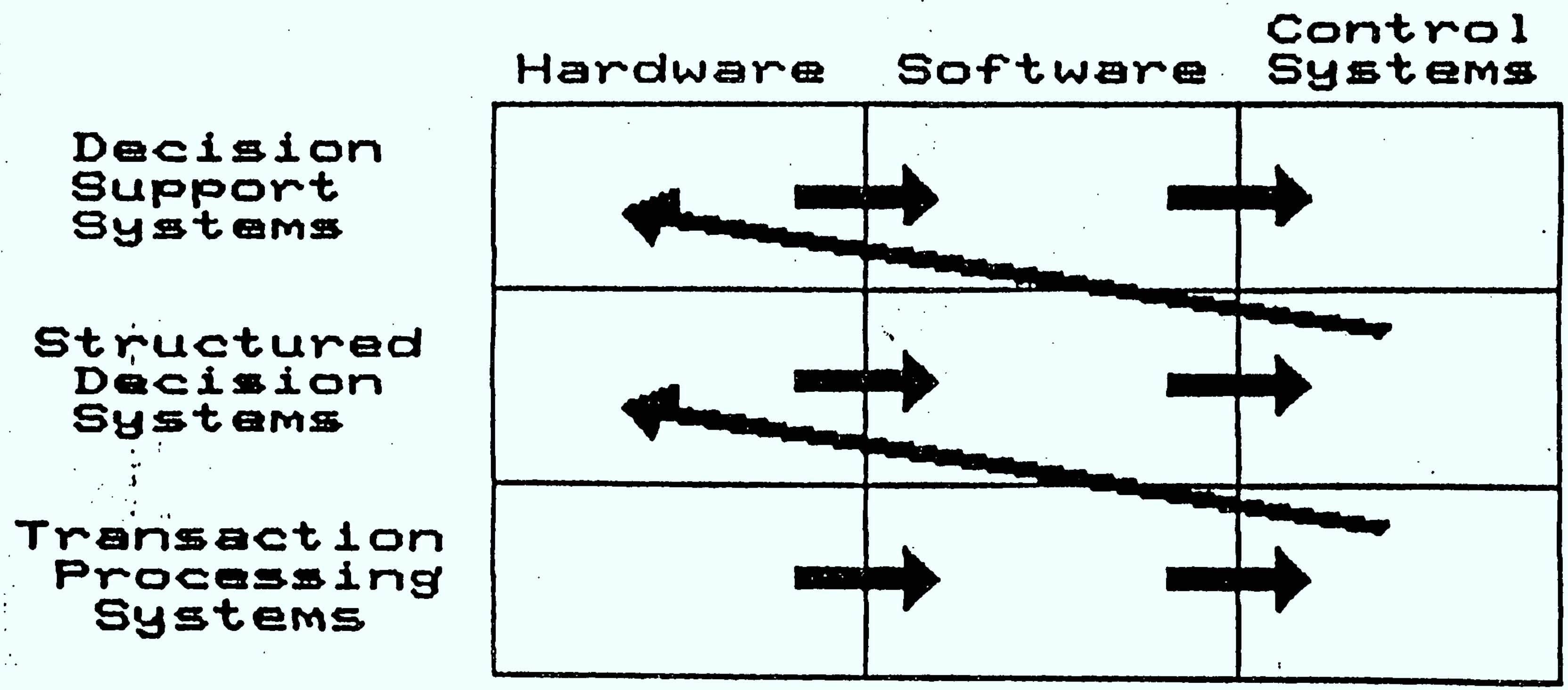
Secondly, the processes of communications and managerial decision making are inherently intertwined to such an extent that it seems difficult to distinguish between the two. Many organizational authors beginning with Chester Barnard, through Herbert Simon and Henry Mintzberg have basically argued the same point - that decision making is one of the fundamental managerial activities and that communications is the process that links decision activities together, and thus provides the "glue" for organizations. Indeed Mintzberg has provided a role model that attempts to delineate managerial functions along those lines. However, it has not led to the kinds of research that would support its claims, perhaps because it is more normative rather than empirical in derivation and is thus difficult to measure. It does underline the need once again to broaden the sphere of investigation to include how managers make decisions, based on what data they collect from where, how that data is gathered, and how the decisions are disseminated, implemented, and monitored, most of which is through communication activities.

4.6.2 Focus On Integration And Control Systems

Once the scope of investigation is broadened to include information gathering activities, one finds a large body of literature related to Management Information Systems that examines the interplay between data processing technology and organizations. By examining Anthony's model of managerial levels and Blumenthal's flow model, arguments were presented as to how Management Information Systems seem to have naturally delineated themselves into three fundamental types: Transaction Processing Systems, that capture and summarize data regarding the fundamental activities of an organization; Structured Decision Systems, that make routine decisions based on that data; and Decision Support Systems, that assist managers in making the more complex decisions that are less routine in nature, involve more managerial judgement, and involve external and/or subjective information that cannot be captured by the automated information system. It then seems natural to attempt to place the "automated office" within that context, since fundamentally the technologies related to office automation are data processing technologies coupled with electronic communication technologies. The questions remain where and how.

In an attempt to answer those questions, the Automation Triangle was employed to examine more carefully the relationships among the three types of information systems. Basically, the systems differed in the level of complexity of each point in the triangle i.e. hardware, software, and control systems. In addition, it was argued that each system relied on the establishment of the controls of the systems of lesser complexity before they could achieve their full potential. Thus, Structured Decision Systems could only be successfully implemented once the Transactions Systems were fully established, complete with control systems necessary to gather and interrelate the data needed by the SDS. A natural evolutionary path for information systems within organizations then appears to be to install the required hardware, obtain or create the necessary analysis software, and then to develop the control systems for each type of information system in turn, as shown in figure 4-6. Again, no research has directly approached that

EXHIBIT 4-6


Hardware
Software
Control Systems
Decision Support Systems
Structured Decision Systems
Transaction Processing Systems

process.

The question of where to place office automation within that context then becomes one of belief in its potentiality. If office automation consists solely of electronic communication systems linking word processors, messaging systems, and text systems, then it would appear to be less complex than even transaction systems, and could be placed either below TPS, or perhaps on the same level. (This argument has in fact been recently forwarded by Kroeber and Watson, 1984). Then, the problem of productivity impacts at the managerial level afforded by such systems do indeed rest solely on their communication aspects, perhaps with the broader perspective of the full communication process taken into account. Most of their impact will be felt at the clerical level, in the same way as Transaction Processing Systems tend to improve the processes of data input and retrieval at the same level.

However, if one views office automation systems as being the culmination of twenty years of information systems development, then it more probably is the apex of complexity of systems that are available today, and as such should sit on the top of figure 4-6. That view seems to be supported by the growing complexity of hardware and software related to the office. Complex managerial workstations are being developed that include graphics, integrated voice and data, "user friendly" interfaces such as "mice", complete telephone functionality and so on. Software manufacturers are pursuing multi-function, easy-to-use interfaces through such concepts as "windowing" and "tailorable menus". Although they may appear less complex to the user, they are indeed much more complex to develop.

The current industry offerings of complete OA systems seem to bear out not only this view of complexity, but the fundamental nature of the automation triangle at work. Older systems such as IBM's PROFS, DEC's All-in-1, Data General's CEO are basically control shells that attempt to integrate each vendor's older product offerings or hastily constructed new ones. They all have electronic mail systems and calendaring systems, some more elaborate than others, and some form of information query system that is usually far from "user friendly". Each will have some document preparation facility, usually an editor and text formatter combination, rather than a more easily used word processing package. They may include a "spread-sheet" that is one or two generations behind what is commonly available on micros. The better ones are "tailorable" in that systems developers can add other packages to the OA shells. However, there is little guarantee of common file protocols among applications. The manufacturers are beginning to recognize that it is not enough simply to integrate applications within an overall shell; the applications must be capable of exchanging information easily and transparently. Thus the range of applications that are available, and the variety of computer equipment on which they can run, must initially be very narrow. The amount of software engineering involved in interfacing among various file and communications protocols is very large indeed. Slowly we are beginning to see the range expand; IBM, DEC, and Data General have announced the migration of their OA systems to their micro lines, with complete file exchange. This will obviously continue in both software and hardware lines.

If one moves away from the large computer manufacturers to the smaller OA systems developers and vendors, two trends are apparent. The first trend is to build a complete system from the ground up. To ensure integration among applications, and portability among various machines, most developers are employing UNIX (or a variation) as the operating system under which to run. The hope is that UNIX provides a more powerful set of tools with which to integrate applications. Unfortunately, the end result may not be that attractive to potential clients. Such systems require implementation in a stand-alone manner; they are not meant to be placed around existing applications. Many clients will already have existing systems and applications that will then only be approachable through communication links in a distributed fashion. This trend ignores the necessary integration with the lower level systems (TPS, SDS, and DSS) that was argued above, and so is likely to have very little long term impact.

The other trend is best exemplified by Lincoln National's OPT system. The major thrust of that development was integration among various hardware and software products. Their view of OA systems was that there were two systems, one for communications, and one for decision support. For decision support, an elaborate cost/benefit analysis was performed on various software systems for different applications (such as information retrieval, graphics, spread-sheets, financial modelling, etc.) and the best system chosen. Part of the criteria for choice included the ability to run on various types and sizes of machines. Once they had settled on certain products, they then proceeded to write an overall control system, that included an electronic communication and calendaring system, and that also guaranteed easy exchange of information among the various applications. The resulting system (which is being marketed in Canada by Prime Computers) supports a wide variety of "managerial workstations", from simple, dumb terminals through all variations of micros, including several "lap size" models, and provides a very rich set of tools to managers and staff alike. This trend focuses right on the control system side of the automation triangle, accepting the fact that there are already many powerful hardware and software components available for the office; the trick is in integrating them, and the OPT system is a good example of what can be accomplished. The fact that OPT currently is controlled by a PRIME computer is immaterial, since the same approach could be taken with any main computer and any operating system.

4.6.3 Conclusions

If these views are correct, then several substantial conclusions can be drawn. First, the full impact of the automated office on managerial performance will not be realized until it is fully integrated into existing information systems, whether they be the simpler transaction processing systems, or the more sophisticated decision support systems. Indeed, if one agrees with the evolutionary argument, OA systems may not achieve full potentiality until such time as all three MIS systems are fully implemented within the organization. It can be argued that OA systems only deal with communications technologies, but where do the decisions to be communicated come from? Where are the data on which decisions are based gathered? If we are considering the potential impact of OA systems, we should consider the support systems that lie underneath, feeding the decisions and communications with which OA systems deal.

There are strategic considerations as well. Should an organization even attempt to implement a "fully integrated office automation" system before the other information systems have been implemented and stabilized? If not, what implementation strategy should they pursue to ensure that each system is sufficiently integratable, without having to continually back up within each system's life cycle for reevaluation and "patching"? These questions are only now beginning to appear, and have yet to be researched, so that no conclusions can be drawn. More fundamentally, are researchers even asking the right questions when examining the potential impacts of the new technologies on managerial functions?

As an example, consider the implementation of micro-computers within an organization. A fully developed strategy would examine the nature of the control systems that need to be constructed that would allow micro-computers to integrate into the existing information systems and indeed expand their capabilities. These systems must provide the basis for further distribution of CPU power, while maintaining the necessary data integrity afforded by centralized information systems. Furthermore, these systems must integrate the plethora of text processing systems that are cheaply available for those micros, yet maintain the necessary editting and formatting flexibility that allows for all stations to use the various forms of text generated by an organization in an effective manner. One hears too many tales of organizations either severely restricting data access from micros, or forbidding it entirely to believe that they have any coherent strategy for reaping the benefits of these types of systems. Or one hears of systems being implemented to integrate micro-computers that do not allow editting of received text files because of the technical limitations imposed by different file structures. In each case organizations have not approached OA systems from an evolutionary, integrated view, focusing on which control systems have to be installed to ensure integration and migration among the various information systems that are in place. Rather they have focussed on the local hardware and software problems, ignoring the more important vertex of the automation triangle.

In conclusion, the problem of the impact of office automation systems on managerial productivity appears once again to be one of strategic choice. If an organization is only prepared to take the narrower view of OA systems as slightly more complicated communication systems, then the potential impacts are narrow, probably less impacting on the "bottom line" than implementing standard transaction processing systems, depending on the nature of the business. However, if an organization views office automation as the ultimate in information system development, as the "capstone" of a concerted thrust into information management in all its aspects, then the potential benefits include all of the benefits of automating information systems themselves, with the additional benefits afforded by those control systems that must be implemented for OA systems to be supported successfully by the information systems below them. Clearly, the argument involves a view of management information that transends the traditional boundaries of Electronic Data Processing, Telecommunications, and Printing into one that views it as a strategic resource, complete with tactics that will improve the efficiency and effectiveness of the organization as a whole. It is a broad view, but one that is clearly needed, faced with the rapidly changing technological environment that all organizations face. As such, office automation is only the tip of the information iceberg that must be understood before true managerial productivity gains can be ensured.

CHAPTER 5

CONCLUSIONS

5.1 INTRODUCTION

This study has reviewed productivity trends and issues in the context of employment, technological applications and organizational development, and the impact of office technology on organizational functioning. Clearly, the general topic of office automation has not been well or adequately addressed in Canada. Much of the literature is anecdotal, descriptive, overly generalized, and lacking an empirical base. Yet the importance of office automation needs to be addressed in a much more comprehensive and, indeed, urgent fashion by policy makers, whether in government, business, labour or the universities.

A major contribution of this study is a comprehensive literature review, a conceptual framework to link office automation to other aspects of technology in the organization, and the impact of technology on information flow for truly effective productivity enhancement.

There can be little doubt that real output improvements in the economy are dependent directly on increased productivity and the quantity and quality of resources used, including technology. Yet the absence of detailed studies on information technology, and the limited awareness of the true impact of office automation on organizational performance, must become priorities in Canada if the country's weak productivity performance is to be improved. This concluding chapter puts forward some ideas in this direction.

5.2 RECOMMENDATIONS

The overall recommendations in this report fall under three headings: educational awareness programs, automation utilization schemes, and improved data systems on automation.

5.2.1 Educational Awareness Scheme

There is clearly a need to greatly improve the awareness among managers and workers of the advantages of using office automation, not only to improve productivity, but to gain competitive advantage against competitors abroad. Canada has little choice but to compete. Our dependence on export trade dictates it.

The government can take a major leadership role. It can undertake empirical studies of the effects of office automation within its own departments. It can commission studies of office automation by outside consultants and academics. It can encourage the dissemination of information on both the benefits and the costs of office automation in the literature. It can serve as a catalyst to bring together informed policy makers about the trends and issues in hardware development and their linkage to software developments through seminars, films, exhibitions, media coverage and the like. It can consider new incentives to productivity enhancement, including important symbolic gestures such as a Canadian Award for Productivity Enhancement, for high standards of productivity improvement to public and private organizations.

The government can also take a lead in attempting to broaden the view of office automation, by commissioning studies and reports that explore the interrelationships among all forms of information systems, and that attempt to discover any productive synergies that must exist. It is only through the construction of comprehensive information systems, from transaction through to office automation, that permanent and wide-spread productivity gains in an organization will be promoted. Electronic communication systems might provide some quick improvements, but only through the more comprehensive forms of automation, including Decision Support and the like, will be groundwork for further improvements be laid. The government can provide some very strong incentives in this area.

5.2.2 Automation Utilization Schemes

Canada needs, as an urgent priority, a comprehensive program to study, monitor and enhance the uses, not only of office automation, but micro- electronics of all descriptions in industry. Britain's MAP scheme - Micro-Processor Application Project - might serve as a prototype. It had as its objective four aims: 1) raising knowledge levels of the potential for micro-electronics; 2) increasing substantially the supply of people trained in microelectronic skills; 3) helping firms to establish the relevance of microelectronics through grants for studies on feasibility; and 4) improve the rate of microelectronics applications.

The obvious reason for caution in adopting automation utilization schemes is fear of rising unemployment and technological displacement, particularly of women. Yet the cautions raised by the British experience should be kept in mind. The point is made in the useful study, Microelectronics In Industry: What's Happening in Britain:

> It is not, however, entirely up to managers alone - trade unionists also have an important part to play. It is essential for the well meaning general principles of the official policy statements to be translated into constructive behaviour on the shopfloor - for example, in flexibility over demarcation lines and restrictive practices and willingness to consider changes in jobs, training and retraining.
>
> The extent to which trade unionists can play their part will depend to an important degree, however, on whether managers meet two necessary conditions. The first is to bring the workforce and trade unions into the discussions as early as they possibly can. There are plenty of case histories of firms where everyone was brought in right from the beginning, where all quickly came to think of it as 'their' project, and where allthe little human difficulties got swept aside in the ferment of ideas and enthusiasm from all directions. At the same time the projects which have run into major shopfloor opposition have nearly all been ones which were hatched in great secrecy and sprung suddenly on the workforce in the hope they could be rushed through before those affected had time to think or raise objections.
>
> The other condition is, as far as possible, to make it worthwhile for all affected. Trade union leaders (and their members who vote for them and pay their salaries), however sympathetic they may personally be to various wider ideals, normally see their primary role as improving the welfare of their members. It is therefore neither reasonable nor realistic to expect them to go overboard in pushing for the introduction of new technology for the sake of some wider general good if the immediate and specific effect is to worsen their members' work conditions, reduce their earnings, or even throw them out of a job altogether in a climate where they remain unemployed for a very long time to come.

> If the proprietors run the enterprise (and introduce the new technology) primarily for what they can get out of it, they canot expect the workers to be motivated wholly by loftier considerations. It is hence only natural and proper for trade unionists to seek to negotiate ways of ensuring that the introduction of the new technology is consistent with the welfare of their members, for example by trying to secure protection against any health or safety hazards, and to get job enrichment and better working conditions, redeployment and retraining rather than job losses, job shedding by natural wastage or voluntary arrangements rather than by compulsory redundancies and, of course, more take home pay. Sometimes these things will be incapable of achievement and the best that can be hoped for is to make the establishment more competitive and thereby secure its survival, albeit with fewer or worse jobs, rather than have it go under altogether with the loss of all jobs. Normally, however, there will be much more room for manoeuvre than this. After all, the main reason for introducing the new technology in the first place is that it will be a superior system and so will raise productivity in one way or another (if it does not, its introduction is probably ill-advised anyway); so it will usually be possible (and sooner or later necessary) to use part of the gain to make it worthwhile for the workers affected.

The government should also foster a willingness to adopt proven technologies more quickly, and to utilize them more effectively. There is a great deal of doubt whether Canada can compete effectively in the production of all the pieces of the automated office, particularly those components of the supporting information systems, at least across the whole of the competitive battleground. It may be able to target certain specific segments, but it is unlikely that strong government incentives will improve upon private industry's success in targetted fields. Rather it should encourage firms to import and implement proven technologies, and not to wait for the Canadian "version". It is the successful management of the new technologies that will be of most benefit to our international competitiveness in the long run. Part of this recommendation also requires government to develop better education and training of our managers in the successful implementation and application of the older information technologies, and the newer office systems, particularly in the small to medium sized business sector.

This is not to say that the government should not promote system development, but it should narrow its focus to particular kinds of systems. What is lacking generally in most office automation systems, that have been constructed from many vendors, are good overall control systems. The other sides of the automation triangle are readily available. There are a myriad of small and large computer systems, terminals, and the like. As well there are numerous versions of "spreadsheets", more powerful decision support systems, databases, applications generators, fourth generation languages, graphics systems, and so on to be bought for a price. What is missing is an overall integration, or control, system, that allows these various products to communicate with one another. It is therefore the control side of the automation triangle, both specific technical control systems and overall management systems, that the government should promote.

5.2.3 Improved Data Bases

Canada does not have adequate data systems on how well or how poorly the country is performing in the area not just of office automation but microelectronics applications. Only government can collect and disseminate this information on an internationally standardized basis, at least initially.

International comparisons of automation performance are an extremely effective way of enhancing the general understanding of productivity and its uses - the Japanese example is the best illustration of that. Comparative data become essential tools to monitor gaps in productivity performance, both in terms of process and in terms of product. Moreover, productivity enhancement criteria can be developed and improved on the basis of comparative data. Comparative data also greatly improve the country's capacity to make informed judgements on productivity trends, and to develop better criteria against which both public and corporate policy can be assessed.

There also has been no adequate data collected on the nature of adoption of information systems within Canada, both on the various types that are in place and on the implementation paths that were followed. There is even less material available on the information systems characteristics of firms that have implemented various forms of office automation, either successfully or unsuccessfully. It is often thought by MIS practitioners that Canada lags the U.S. by as much as three or four years in information system implementation, but there is no hard evidence to support the claim. If the same, or worse, is true in office automation, our competitiveness might be severely hampered.

5.3 CONCLUSION

This study is the first of its kind relating directly to office automation. Further studies are needed.

For instance, the Department of Communications should promote further analysis in the following areas:

1. impact of office automation in small business;
2. leasing programs for office automation enhancement;
3. promotion of low cost feasibility studies for office automation;
4. longitudinal studies of office automation on workplace attitudes, politics, and organizational design;
5. improving office automation technology for Canada's service sector;
6. integrating office automation skills with traditional work norms;
7. cross sectional studies comparing Canada's performance in office automation with other countries;
8. developing teaching manuals, along the lines of Ontario's Automotive Parts Technology Centre, on adopting office automation techniques into Canadian-owned companies.
9. Studies outlining Canada's competitive needs in software development for the new technologies, including public sector and voluntary organizations.
10. conceptual studies forecasting Canada's microelectronic needs in both traditional economic sectors (e.g. resource industries), energy process technologies in manufacturing, and applications in service sectors where Canada's comparative advantage can be exploited (e.g. libraries, universities, state-owned corporations, isolated communities and the like).

APPENDIX A

TOPIC BIBLIOGRAPHY

Productivity, Economics and Policy

1. Aho, C. Michael: Rosen, Howard F.: Trends in Technology-Intensive Trade, US Dept. of Labor, 1980, October

2. Arrow, K. J.: "The Economic Implications of Learning by Doing", Review of Econ Studies, 1962, 29

3. Arrow, K. J.: Chenery, H.: Minhas, B.: Solow, R.: "Capital-Labor Substitution and Economic Efficiency", Review of Econ & Stats, 1961, August

4. Asian Prod. Org.: Profiles of the National Productivity Organizations in APO Member Countries, Asian Prod Org, 1980

5. Asian Prod. Org.: Factors which Hinder or Help Productivity Improvement in the Asian Region, Asian Prod Org, 1980

6. Bergsten, C. Fred: "The United States and the World Economy", Rosary College, 1978, April 21

7. Birch, John A.: Nichols, George C.: Enhancement Programs in Five Foreign Countries, US Dept of Commerce, 1972

8. Block, Herbert: The Planetary Product in 1980: A Creative Pause?, US Dept of State, 1981, August

9. Bowen, William: "How to Regain Our Competitive Edge", Fortune, 1981, March 9,p74-78+

10. Bronfenbrenner, Martin: Japanese Productivity Experience, Duke Univ Econ Dept, 1982

11. Brown, M.: On the Theory and Measurement of Technical Change, University Press, 1966

12. Burggraf, Shirley: "The Case of the Missing Productivity", US Dept of Com, 1980, January

13. Catto, Vladi: "Productivity and Growth: A Graphical Approach", Business Economics, 1979, May,p54-58

14. Chilton, W. L.: Labor Costs and International Competitiveness in Manufacturing Industry, Citibank NA Econ Dept, 1981, November 10

15. Comm for Econ Devel: Productivity Policy: Key to the Nation's Economic Future, Comm for Econ Devel, 1982, December

16. Coun of Econ Adv: Economic Report of the President and Annual Report of the Council of Economic Advisors, US Govt Printing Office, 1982

17. Denison, E. F.: "Accounting for U.S. Economic Growth 1929-1969", The Brookings Instit, 1974

18. Denny, Michael: Fuss, Melvyn: Productivity: A Selective Survey of Recent Developments, Ontario Economic Council, 1982

19. Dunn, Robert M.: Economic Growth Among Industrialized Countries: Why the United States Lags, Natl Planning Assoc, 1980

20. Ehrenhalt, Samuel M. (1983), "No Golden Age for college Graduates," Challenge, July-August, pp. 42-50.

21. Fabricant, S.: Basic Facts on Productivity Change, Columbia Univ Press, 1959

22. Fischer, David Hackett: "Chronic Inflation: The Long View", Jour Instit Soc-econ Stud, 1980, AutV-VN3,82-103

23. Freund, William C.,etc.: Building a Better Future: Economic Choices for the 1980s, NYSE, 1980

24. Freund, William C.: Reaching a Higher Standard of Living, NYSE, 1979

25. Freund, William C.: Manchester, Paul B.: U.S. Performance in a Global Perspective, NYSE, 1981

26. Gen Actg Office: Study of U.S. Competitiveness, US Govt Printing Office, 1980

27. Grayson, C. Jackson, Jr.: National Economic Growth and US Status in an Increasingly Competitive World: Realities and Policy Options, Center for Internatl Bus, 1980

28. Grayson, C. Jackson, Jr.: Lee, L. D.: Christiansen, G. B.: Productivity: The Foundation of Growth, US Govt Printing Office, 1980, December

29. Grayson, C. Jackson, Jr.: "The US Economy and Productivity: Where Do We Go From Here?", JointEconCommCongress, 1980, December

30. Hein, John: From Summit to Summit: Policymaking in an Interdependent World, The Conference Board, 1980, Report No. 774

31. Hogan, John, ed.: Craig, Anna, ed.: Dimensions of Productivity Research, Amer Prod Center, 1980, April

32. Hudson, E. A.: Jorgenson, Dale W.: "The Economic Impact of Policies to Reduce U.S. Energy Growth", Resources and Energy, 1978

33. Hunter, Nicholas. "Japan Fights Local Content Auto Rules," Globe & Mail, May 19, 1983 p. Bl.

34. IMF: World Economic Outlook, IMF, 1982, April

35. Japan-USEconRelGroup: Supplemental Report of the Japan-United States Economic Group, Natl Tech Info Service, 1981, October

36. Japan-USEconRelGroup: Report of the Japan-United States Economic Group, Natl Tech Info Service, 1981, January

37. Jorgenson, Dale W.: "Energy Prices and Sectoral Productivity Growth", US Dept of Commerce, 1980, May

38. Jorgenson, Dale W.: "The Answer is Energy", Challenge, 1980, Nov-Dec,p16-25

39. Kendrick, John W.: "Policies to Promote Productivity Growth", Amer Council on Educ, 1980

40. Kendrick, John W.: Grossman, Elliot S.: Trends and Cycles in Productivity in the United States, Johns Hopkins Univ Press, 1980

41. Kendrick, John W.: Grossman, Elliot S.: Productivity in the United States: Trends and Cycles, Johns Hopkins Univ Press, 1980

42. Kendrick, John W.: Thurow, Lester C., et al.: "The Decline in Productivity Growth", Fed Res Bank of Boston, 1980, June

43. Kendrick, John W.: Understanding Productivity; An Intro to Dynamics of Productivity Change, John Hopkins Univ Press, 1977

44. Kendrick, John W.: Curriculum for Economics 1981: Productivity and Economic Growth, Amer Enterprise Instit, 1980, November

45. Kendrick, John W.: Understanding Productivity; An Intro to Dynamics of Productivity Change, John Hopkins Univ Press, 1977

46. Kendrick, John W.: Essays in Contemporary Economic Problems: Demand, Productivity and Population, Amer Enterprise Instit, 1981

47. Kravis, Irving B.: Heston, Alan: Summers, Robert: World Product and Income: International Comparisons of Real Gross Product, Johns Hopkins Univ Press, 1982

48. LeMay, Tracey. "Much of Province's Planning Tied to High Technology," Globe & Mail, April 18, 1983 p. R6.

49. Lindsay, Franklin A.: Vanderslice, Thomas A., et al.: Stimulating Technological Progress: A Statement by the Research and Policy Committee, Comm for Econ Devel, 1981

50. List, Wilfred. "Unemployment, Technology May Create Demand for Less Working Time," Globe & Mail, September 6, 1983 p. B13.

51. Maddison, Angus: Phases of Capitalist Development, Oxford Univ Press, 1982

52. McGraw-HillEconDept: "America in the World Economy", McGraw-Hill, 1980, November

53. Mohr, Michael: Correia, Joseph: "The Bus Cycle & Prodity Growth in Total Private Bus Econ:1947-1977", Soc of Govt Economists, 1979, March 14

54. Nadiri, M. I.: "Some Approaches to the Theory and Meas. of Total Factor Prod: A Survey", Jour of Econ Literature, 1970, December

55. Natl Govs' Assoc: Utilizing America's Technological Resources: New Challenges to the States, Natl Governors' Assoc, 1982

56. Natl Res Coun: A National Strategy for Improving Productivity in Building and Construction, Natl Acdy of Sciences, 1980

57. Natl Sci Board: Science Indicators 1980, Natl Sci Foun, 1981

58. Norman, Colin: "The New Ind Revol: How Microelectronics May Change the Workplace", The Futurist, 1981, Feb,p30-42

59. OECD: Tech Change and Econ Plcy: Sci and Tech in New Econ and Soc Context, Paris, 1980

60. Ohara, Susumu, ed.: Industrial Review of Japan/1981, Japan Econ Jour, 1981, March

61. Olson, Mancur: The Rise and Decline of Nations (New Haven, Conn.: Yale University Press, 1982).

62. Peterson, Peter G.: The US Competitive Position in the 1980s - And Some Things We Might Do About It, Center for Inter Bus, 1981, March

63. Pres's Comm for 80s: The American Economy: Employment, Productivity, and Inflation in the Eighties, US Govt Printing Office, 1980

64. Ramo, Simon: America's Technology Slip, Wiley, 1980

65. Rasmussend, Wayne D. (1982), "The Mechanization of Agriculture," Scientific American, September.

66. Rice, Jame W. & Yoshiicawa, Takeo. "A Comparison of Kanban and MRP Concepts for the Control of Repetitive Manufacturing Systems," Production and Inventory Management, Volume 23, (First quarter 1982). pp. 1-13.

67. Sadler, George E.: Grossman, Elliot S.: Comparative Productivity Dynamics, Japan and the United States, Amer Prod Center, 1982

68. Sadler, George E.: Productivity Perspectives, Amer Prod Center, 1981, also 1982

69. Salter, W.: Productivity and Technical Change, Cambridge Univ Press, 1960

70. Salter, W.E.G., Productivity and Technical Change, Second edition, Cambridge: Cambridge University Press, 1966

71. Sentry Insurance Co.: Perspectives on Productivity: A Global View, Sentry Insurance Co., 1981

72. Terleckyj, Nestor E.: Levy, David M.: "Highlights of NPA's National Economic Projections to 1990", Looking Ahead, 1980, Winter

73. U.S. Congress: Government Regulation: Achieving Social and Economic Balance, Govt Printing Office, 1980, Vol. 5

74. U.S. Congress: Japanese Productivity: Lessons for America, Govt Printing Office, 1981, November

75. U.S. Congress: Research and Innovation: Developing a Dynamic Economy, Govt Printing Office, 1980, December

76. U.S. Congress: Robotics and the Economy, Govt Printing Office, 1982

77. U.S. Congress: The 1981 Joint Economic Report: Report of the Joint Economic Committee on the January 1981 Report of the President, US Govt Printing Office, 1981

78. U.S. Congress: The Productivity Problem: Alternatives for Action, US Govt Printing Office, 1981, January

79. US Congress.Bud.Off: The Productivity Slowdown: Causes and Policy Response, Congress. Budget Office, 1981, June

80. US Gen Actg Office: Unites States-Japan Trade: Issues and Problems, US Gen Actg Office, 1979, Sept 21

81. US Gen Actg Office: Stronger Federal Effort Needed to Foster Private Sector Productivity, US Gen Actg Office, 1981, Feb 18

82. US Gen Actg Office: Advances in Automation Prompt Concern Over Increased US Unemployment, US Gen Actg Office, 1982

83. US House of Rep: The Federal Role in Private Sector Productivity, Govt Printing Office, 1982, January

84. Ullman, John E., ed.: The Improvement of Productivity: Myths and Realities, Praeger, 1980

85. Vaccara, Beatrice: McAuley, Patrick: "Evaluating the Economic Performance of U.S. Manufacturing Industries", Industrial Econ Review, 1980, Summer,p6-19

86. Vanderslice, Thomas A.: "Closing the Technology Gap", _Jr Inst Soc-Econ Stud_, 1980, Summer,p22-31

87. Wishard, William Van Dusen: "Productivity and American World Competitiveness", _Vital Speeches of Day_, 1982, Mar1,p316-320

88. Young, James N.: _Productivity Over the Business Cycle_, Amer Coun of Life Insur, 1980, December

89. _Economic Growth in the Future-II_, Edison Electric Instit, 1981

Productivity in Manufacturing

1. "Introduction to Group Technology", Amer Prod Center, 1982, Source unknown

2. Abernathy, William J. and Wayne, Kenneth. "Limits of the Learning Curve," Harvard Business Review, September/October 1974. pp. 109-119.

3. Abraham, Richard G.: "Computer Integrated Manufacturing", Manuf Prod Frontiers, 1982, Feb,p17-22

4. Adam, Everett E.,Jr.,etc.: Productivity and Quality: Measurement as a Basis for Improvement, Prentice-Hall, 1981

5. Anderson, Ronald. "Protection for Auto Industry No Substitute for Competition," Globe & Mail, May 19, 1984 p. B2.

6. AmerAssocEngSoc: Innovative Manufacturing Technology, AmerAssocEngSoc, 1982

7. AmerAssocEngSoc: Research & Development for Increased Productivity - Where We Must Go, AmerAssocEngSoc, 1982

8. AmerMetalStampAssoc: "Japanese Automotive Stamping", Manuf Prod Frontiers, 1982, August,p1-5

9. Ashburn, Anderson, etc.: "Solving the Productivity Puzzle", American Machinist, 1981, June,p181-196

10. Baxter, John D. "Kanban Works Wonders, But Will it Work in U.S. industry?" Iron Age, June 7, 1982. pp. 44-48.

11. Burck, Charles, G. "Will Success Spoil General Motors?" Fortune, August 1983. pp. 94-104.

12. Bylinsky, Gene. "The Race to the Automatic Factory," Fortune, February 21, 1983. pp. 52-64.

13. Ehner, William J.: Bax, F. R.: "Evaluating the Factory of the Future: The Factory in Three Dimensions", Manuf Prod Frontiers, 1982, April,p1-9

14. Engelberger, Joseph F.: Robotics in Practice: Management and Applications of Industrial Robots, AMACOM, 1980

15. Fagenbaum, Joel: "Manufacturing - Industrial Control", IEEE Spectrum, 1981, Jan,p70-73

16. Flax, Steven. "How Detroit is Reforming the Steel Makers," Fortune, May 1983, pp. 126-129.

17. Fox, Robert E. "MRP, Kanban or Opt: What's Best?" Inventories and Production, Volume 2, July/August 1982. p. 4.

18. Groover, Mikell P.: "Industrial Robots: A Primer on the Present Technology", Industrial Engineering, 1981, Nov,p54-61

19. Hayes, Robert H.: "Why Japanese Factories Work", Harvard Business Review, 1981, J/A, p. 56-66

20. Hall, Robert W. "Stockless Production for the United States," APICS 25th Annual Conference Proceedings, 1982, pp. 314-318.

21. Hunter, Nicholas. "Analysts, Economists Predict Milk Recovery in Auto Sector," Globe & Mail, April 18, 1983 p. R4.

22. Hunter, Nicholas. "GM, Chrysler Cut Financial Costs on Cars, Trucks," Globe & Mail, August 5, 1983 p. Bl.

23. Ingram, Frederick B. "Group Technology," Production and Inventory Management, Volume 23 (Fourth quarter 1982). pp. 19-34.

24. Lardner, James F.: "Implementing CAD-CAM Technology in Industry", Manuf Prod Frontiers, 1982, April,p10-14

25. List, Wilfred. "No Concessions to the Auto Industry, New UAW Head Vows," Globe & Mail, May 20, 1983 p. Pl.

26. Nelleman, David O. "MRP vs. Kanban? Combining the Best of East and West," APICS 25th Annual Conference Proceedings, 1982, pp. 124-128.

27. Nelleman, David O. and Leighton, F. Smith. "Just-In-Time vs. Just-In-Case Production/Inventory Systems: Concepts Borrowed Back from Japan," Production and Inventory Management, Volume 23 (Second quarter 1982). pp. 12-21.

28. Nakane, Jinichiro and Hall, Robert W. "Management Specs for Stockless Production," Harvard Business Review, May/June 1983. p. 84-91.

29. Quantz, Paul A.: "CAD/CAM - Threat or Opportunity", Manuf Prod Frontiers, 1982, October,p9-12

30. Rosenbrock, H. H.: "Engineers and the Work that People Do", IEEE ControlSysMag, 1981, Sept,p4-8

31. Schonberger, Richard J.: Japanese Manufacturing Techniques: Nine Hidden Lessons in Simplicity, The Free Press, 1982

32. Schonberger, R., Sutton, D. and Claunch, J. "Kanban (Just-In-Time) Applications at Kawasaki U.S.A.," APICS 24th Annual Conference Proceedings, 1981, pp. 188-191.

33. Schonberger, Richard J. "A Revolutionary Way to Streamline the Factory," The Wall Street Journal November 15, 1982, p. 15.

34. Schonberger, Richard J. "Selecting the Right Manufacturing Inventory System: Western and Japanese Approaches," Production and Inventory Management, Volume 24 (Second quarter 1983). pp. 33-34.

35. Shingo, Shigeo: Study of 'Toyota' Production System from Industrial Engineering Viewpoint, Jpse Mgmt Assoc, 1982

36. Skinner, Wickham: Manufacturing in the Corporate Strategy, John Wiley & Sons, 1978

37. Soc of Manuf Eng: Manufacturing Engineering SME Golden Anniversary Issue, Soc of Manuf Eng, 1982, January

38. Staffer, Robert N.: "Automating for Greater Gains in Productivity", Manuf Engineering, 1981, Nov,p58-59

39. Stewart-Patterson, David. "Auto Sector Faces Wait on Content Requirement," Globe & Mail, May 26, 1983 p. 18.

40. U.S. Congress: Social Impacts of Robotics: Summary and Issues, US Govt Printing Office, 1982

White-Collar Productivity

1. "The Challenge of 'Increased Productivity'", EDP Analyzer, 1981, V19,N4,Ap,p1-15

2. Bistline, Susan: "Participative Management", Association Mgmt, 1980, August,p95-101

3. Boehm, Barry W.: "Keeping a Lid on Software Costs", Computerworld, 1982, Jan18,p1-22

4. Brooks, Julie K.: "Improving Managerial Productivity", Computer Weekly, 1981, Nov 23,pp5-10

5. Clare, Richard: "Bank's Mgmt Reporting System Sets Workloads & the Utilization of People", Industrial Engineering, 1981, Feb.,p78-82

6. Davis, J.: A Skills Building Approach to Management Development, NatlSocPerfInstrucJr, 1981, Spring

7. Delbecq, A.: Van de Ven, A.: Gustafson, D.: Group Techniques for Program Planning, Scott Foresman, 1975

8. Dickinson, R. E.: "How a Major Corp is Coping with the Pressure of an Office Automation Program", Industrial Engineering, 1980, July,pp50-55

9. Edwards, Nancy MacLellan,ed.: Office Automation: A Glossary and Guide, Knowledge Ind Publ, 1982

10. Forester, Tom: The Microelectronics Revolution: The Complete Guide to the New Technology and its Impact on Society, MIT Press, 1981

11. Gregerman, Ira B.: Knowledge Worker Productivity, AMACOM, 1981

12. Hackman, J. Richard: Oldham, Greg R.: Work Redesign, Addison-Wesley, 1980

13. Johansen, Robert, etc.: Electronic Meetings: Technical Alternatives and Social Choices, Addison-Wesley, 1979

14. Keen, Peter G.: Scott-Morton, Michael S.: Decision Support Systems: An Organizational Perspective, Addison-Wesley, 1980

15. Lehrer, Robert, ed.: White-Collar Productivity, McGraw-Hill Book Co., 1982

16. McIntosh, Lowrie W.: "Prepare for the Office of the Future - With Paper", Industrial Engineering, 1980, July,pp.40-45

17. Mertes, Louis H.: "Doing Your Office Over - Electronically", Harvard Business Review, 1981, M-A,p.127-135

18. Miller, Donald B.: "How to Improve The Performance and Productivity of the Knowledge Worker", Organizational Dynamics, 1977, Winter, pp62-80

19. Moss, Mitchell L., ed.: Telecommunications and Productivity, Addison-Wesley, 1981

20. Nolan, Robert E. et. al.: Improving Productivity Through Advanced Office Controls, AMACOM, 1980

21. Norman, Colin: "Microelectronics at Work: Productivity and Jobs in the World Economy", Worldwatch Institute, 1980, October

22. Ohio State Univ., Research Foun.: Productivity Measurement Systems for Administrative, Computing and Information, Natl Science Foun., 1977, PB-292 698

23. Rowe, David L.: "How Westinghouse Measures White Collar Productivity", Management Review, 1981, Nov., p.42-47

24. Ruch, William A.: Measuring Knowledge Worker Productivity, amer Prod Center, 1980

25. Smith, Harold T.: "Who Will Manage Information - The Generalist or The Specialist?", Management World, 1980, March, pp8-10+

26. Stevens, Chandler Harrison: "Many-to-Many Communication Through Inquiry Networking", World Future Soc Bull, 1981, N-D, pp31-34

27. Stibic, V.: Personal Documentation for Professionals: Means and Methods, North-Holland, 1980

28. Uhlig, Ronald: The Office of the Future: Communication and Computers, North-Holland, 1979

29. Information, Organization and Power: Effective Mgmt in the Knowledge Society, McGraw-Hill Book Co., 1981

Productivity and Labor-management Issues

1. "A serendipitous training ground for managers", Business Week, 1982, F15,p52T-52DD

2. Anderson, Ronald. "Labour Focuses on Job Security as Companies Eye Productivity," Globe & Mail, May 9, 1983 p. B2.

3. Bass, Bernard M.: "Team Productivity and Individual Member Competence", Small Group Behavior, 1980, Nov.,p.431-504

4. Bass, Bernard M.: Barrett, Gerald V.: People, Work, and Organizations: An Introduction to Industrial, Allyn and Bacon, 1981

5. Bennett, Dudley: Successful Team Building Through TA, AMACOM, 1980

6. Bried, Hank: "Participative Management Program Presentation", Manuf.Prod.Frontiers, 1982, August p.20-26

7. Christman, Jesse: "Union-Management Cooperation", PIMA Magazine, 1982, August p.27-30

8. Clark, Kim B.: "Unionization and Productivity: Micro-Econometric Evidence", Quart. Jour. of Econ., 1980, Dec.p.613-639

9. Cohen, Deborah Shaw: "Why Quality of Work Life Doesn't Always Mean Quality", Training/HRD, 1981, Oct. p.54-60

10. Cole, Robert E.: "Made in Japan - Quality-Control Circles", Across the Board, 1979, Nov. p.72-78

11. Cook, Daniel D.: "Labor Faces the Productivity Challenge", Industry Week, 1981, March 9,p.61-65

12. Davidson, William H.: "Small Group Activity at Musashi Semiconductor Works", Sloan Management Review, 1982, Spring

13. Donaldson, Les: Behavioural Supervision: Practical Ways to Change Unsatisfactory Behaviour and Increase Productivity, Addison-Wesley, 1980

14. Doud, Ernest A.: "First-Line Supervisors: The Key to Improved Performance", Management Review, 1980, Dec.,p.18-24

15. Dyer, William G.: Team Building: Issues and Alternatives, Addison-Wesley, 1977

16. Francis, Dave: Improving Work Groups: A Practical Manual for Team Building, University Associates, 1979

17. Freund, William C.,etc.: People and Productivity: A Challenge to Corporate America, NYSE, 1983

18. Frieden, Karl: Workplace Democracy and Productivity, Nat'l Cen. Econ. Alter., 1980

19. Graham, Ben S.: Titus, Parvin S.: The Amazing Oversight, AMACOM, 1979

20. Greenberg, Paul D.: Glaser, Edward M.: Some Issues in Joint Union-Management Quality of Worklife Improvement Efforts, W.E.Upjohn Instit.Emp., 1980

21. Jain, Hem C.: Worker Participation: Success and Problems, Praeger, 1980

22. Jenkins, David: QWL - Current Trends and Directions, Ont. Min. of Lab., 1981

23. Levitan, Sar A.: Johnson, Clifford M.: Second Thoughts on Work, W.E.Upjohn Instit.Emp., 1982

24. Loftus, Joseph A., ed.: Walfish, Beatrice,ed.: Breakthroughs in Union-Management Cooperation, Work in Amer. Instit., 1977

25. McConkey, Dale D.: "Participative Management: What it Really Means in Practice", Business Horizons, 1980, Oct.,p.66-73

26. Metz, Edward J.: "Caution: Quality Circles Ahead", Train.Devel.Journal, 1981, Aug.,p.71-76

27. Mills, Ted: Quality of Work Life II, ACQWL, 1981

28. Myers, M. Scott: Managing with Unions, Addison-Wesley, 1978

29. Rosenberg, Richard D.: Rosenstein, Eliezer: "Participation and Productivity: An Empirical Study", Ind.Lab.Rel.Review, 1980, April,p.355-367

30. Rubin, Irwin M.: Plovnick, Mark S.: Fry, Ronald E.: Task-Oriented Team Development, McGraw-Hill, 1978

31. Savoie, Ernest J.: "The New Ford-UAW Agreement: Its Work Life Aspects", Work Life Review, 1982, V1,Issue1,p.2-9

32. Scobel, Donald N.: Creative Worklife, Gulf Publ. Co., 1981

33. Siegel, Irving H.: Weinberg, Edgar: Labor-Management Cooperation: The American Experience, W.E.UpjohnInstEmpRes, 1982

34. Turney, John R.: Cohen, Stanley L.: "Participative Management: What is the Right Level?", Management Review, 1980, Oct.,p.66-69

35. U.S.Dept.Lab., Lab-Mgmt.Serv.Admin.: The Operation of Area Labor-Management Committees, Govt.PrintingOffice, 1982

36. U.S.Dept.Lab., Lab-Mgmt.Serv.Admin.: Resource Guide to Labor-Management Cooperation, U.S.Govt.Print.Office, 1982, September

37. VanGundy, Arthur B. Jr.: Techniques of Structured Problem Solving, Van Nostrand Reinhold, 1981

38. Walton, Richard E.: Schlesinger, Leonard A.: "Do Supervisors Thrive in Participative Work Systems?", Organizational Dynamics, 1979, Winter,p.25-38

39. Werther, William B., Jr.: "Quality Circles and Corporate Culture", Natl.Prod.Review, 1982, Sum.,p.301-310

40. Werther, William B., Jr.: "Quality Circles: Key Executive Issues", Jour.Contemp.Bus., 1982, V11N2p.17-26

Managing Productivity

1. "IEs Gauge State of U.S. Work Ethic, Effectiveness of Productivity Activities", Industrial Engineering, 1982, Nov.,p.26-32

2. "Organizing for Productivity", Industry Week, 1981, F9,p.55-60

3. "Productivity Improvement Programs", Jour.Contemp.Bus., 1982, V11,No. 2

4. "Productivity: The Personnel Challenge", Prentice-Hall, 1973

5. "The Coming Industrial Miracle", U.S.News&WorldReport, 1981, N30,p.52-60

6. Beatrice Foods Co.: Productivity Sourcebook, Beatrice Foods Co., 1982

7. Belcher, John G., Jr.: The Productivity Management Process, PlanExecInstit., 1983

8. Benkler, Gordon: Productivity: A Managerial Perspective, Cont.Ill.Bank&Trust, 1982

9. Bennis, Warren: "Leadership Transforms Vision into Action", Industry Week, 1982, My31,p.54-56

10. Crosby, Philip B.: Quality is Free: The Art of Making Quality Certain, McGraw-Hill, 1979

11. Deming, J. Edwards: Management of Statistical Techniques for Quality and Productivity, M.I.T.CenterAdvdEngStud, 1982

12. Drucker, Peter F.: "The Shape of Industry to Come", Industry Week, 1982, Ja11,p.55-59

13. Fusfeld, Herbert I.: Langlois, Richard N.: Understanding R & D Productivity, Pergamon Press, 1982

14. Gold, Bela: Productivity, Technology, and Capital: Economic Analysis, Managerial, Lexington Books, 1979

15. Halverson, Robert A. "Productivity Management: The Zero Option," APICS 25th Annual Conference Proceedings, 1982, pp. 427-429.

16. Hayes, Robert H.: Abernathy, William J.: "Managing our Way to Economic Decline", Harvard Business Review, 1980, J-A,p.67-77

17. Hickey, James J.: Employee Productivity: How to Improve and Measure Your Company's Performance, InstAdvmtScificMgmtCont, 1974

18. Hughes Aircraft Co., : R & D Productivity, Hughes Aircraft Co., 1978, 2nd ed.

19. Hunter, Nicholas. "Pep Talks Spur Hayes-Dana Workers," Globe & Mail, August 18, 1983 p. B1.

20. Judson, Arnold S.: "The Awkward Truth About Productivity", Harvard Business Review, 1982, Oct., p.93-97

21. Kanawaty, George, ed.: Managing and Developing New Forms of Work Organization, Internatl Labour Office, 1980

22. LeBoeuf, Michael: The Productivity Challenge: How to Make It Work for America and You, McGraw-Hill, 1982

23. McBeath, Gordon: Productivity Through People, John Wiley and Sons, 1974

24. McConnell, J. Douglas: "Productivity Improvement in Research and Development and Engineering in the United States", SRA Journal, 1980, Fall,p.5-14

25. Mooney, Marta: "Organizing for Productivity Management", Natl Productivity Review, 1982, Spr,p.141-150

26. Murrin, Thomas J.: "Productivity and Quality Improvement", Westinghouse Elec. Corp., 1982, May 13

27. Ohmae, Kenichi: The Mind of the Strategist: The Art of Japanese Business, McGraw-Hill, 1982

28. Ouchi, William G.: Theory Z: How American Business can Meet the Japanese Challenge, Addison-Wesley, 1981

29. Pascale, Richard: Athos, Tony: The Art of Japanese Management: Applications for American Executives, Simon & Schuster, 1981

30. Peters, Thomas J.: "Stamp Out Risk Taking and Creativity", Forum: JAWH, 1981, M-J,p.9-17

31. Peters, Thomas J.: "Building Unassailable Skills: Lessons from Top-Performing American Companies", McKinsey & Co., 1981

32. Peters, Thomas J.: Waterman, Robert H., Jr.: In Search of Excellence: Lessons from America's Best Run Companies, Harper & Row, 1982

33. Phillips, Julien R.: "Management of Human Resources in the Excellent Companies", McKinsey & Co., 1982

34. Rolland, Ian: "The Human Equation in the New Corporation", Vital Speeches, 1982, VXLIXN1p.22-25

35. Rolland, Ian: Janson, Robert: "Total Involvement as a Productivity Strategy", Cal.Mgmt.Review, 1981, WinXXIVN2p40-48

36. Ross, Joel E.: Managing Productivity, Reston Publ. Co., 1977

37. Schleicher, William F.: "12 Common Sense Steps to Productivity Improvement", Natl.Prod.Report, 1978

38. Shaw, John C.: "The Quality-Productivity Connection", Van Nostrand Reinhold, 1978

39. Silberstein, Ross L.: "The New American Factory", Chemical Times & Trends, 1982, July,p.15-19

40. Tregoe, Benjamin B.: Zimmerman, John W.: Management Strategy: What it is and How to Make it Work, Simon & Schuster, 1980

41. U.S.Cham.Com.: "Management Attitudes Toward Productivity", U.S.Cham.Com., 1981, Publ.No.6505

42. USNCPQWL: "Improving Productivity, a Description of Selected Company Programs", U.S.Govt.Print.Office, 1975

43. Waterman, Robert H., Jr.: "The Seven Elements of Strategic Fit", Jour.Bus.Strategy, 1982, Win.,p.69-73

44. Wayne, Leslie: "Management Gospel Gone Wrong", New York Times, 1982, May30,Sect.3

45. Werther, William B., Jr.: "Out of the Productivity Box", Business Horizons, 1982, S-O,p.51-59

46. Wheelwright, Steven C.: "Japan - Where Operations Really are Strategic", Harvard Business Review, 1981, J/A,p.67-74

47. Key to Retailing Success and Survival in the '80s, Building Supply News, 1982, V-IIMerchSupp

Measuring Productivity

1. "The new, broader gauges of productivity", Business Week, 1982, Ap19,p.44B-44L

2. Arthur Young & Co.: "Productivity: A Study of Productivity Programs and Practices in General Merchandise Chains", Assoc.Gen.Merch.Chains, 1981, May

3. Bailey, David: Hubert, Tony: Productivity Measurement, Gower Publ. Co., 1980

4. Bank Admin. Instit.: Total Bank Productivity Measurement, A Conceptual Framework, Bank Admin. Instit., 1982

5. Craig, Charles E.: Harris, R. Clark: "Total Productivity Measurement at the Firm Level", Sloan Management Review, 1973, V14,N3,Spring

6. Daly, D.J. (1972), "Combining Inputs to Secure a Measure of Total Factor Input," Review of Income and Wealth, March, pp. 27-53.

7. Davis, Hiram: Productivity Accounting, Univ.Penn.Press, 1954

8. Dogramaci, Ali: Productivity Analysis, A Range of Perspectives, Martinus Nijhoff, 1981, :

9. Gold, Bela: "Practical Productivity Analysis for Management Accountants", Management Accounting, 1980, May,p.31-44

10. Greenberg, Leon: A Practical Guide to Productivity Measurement, Bureau Natl Affairs, 1973

11. Hatry, Harry P.: "Performance Measurement Principles and Techniques: An Overview for Local Government", Public Prod. Review, 1980, Dec.,p.312-339

12. Kendrick, John W.: Staff, Amer.Prod.Center: Measuring and Promoting Company Productivity: Handbook with Case Studies, Johns Hopkins Univ. Press, 1983

13. Lehrer, Robert, ed.: White-Collar Productivity, McGraw-Hill Book Co., 1982

14. Mundel, Marvin E.: Improving Productivity and Effectiveness, Prentice-Hall/APOrg, 1983

15. Mundel, Marvin E.: Measuring and Enhancing the Productivity of Service and Government Organizations, Asian Productivity Organi, 1980

16. Natl Res. Council: Measurement and Interpretation of Productivity, Natl Academy of Sciences, 1979

17. Nolan, Robert E. et. al.: Improving Productivity Through Advanced Office Controls, AMACOM, 1980

18. Ohio State Univ., Research Foun.: Productivity Measurement Systems for Administrative, Computing and Information, Natl Science Foun., 1977, PB-292 698

19. Parker, V. L.: "Measuring Productivity of the Airline Maintenance Function", Amer.Instit.Ind.Eng., 1980

20. Rowe, David L.: "How Westinghouse Measures White Collar Productivity", Management Review, 1981, Nov.,p.42-47

21. Sadler, George E.: "Measuring Your Productivity: How to Do It", Plastics Technology, 1982, Jan.,p.74-81

22. Schainblatt, Alfred H.: Measuring Productivity of Scientists and Engineers in R & D, The Urban Institute, 1981

23. Siegel, Irving H.: Productivity Measurement: An Evolving Art, Work in Amer.Instit., 1980

24. Siegel, Irving H.: Company Productivity: Measurement for Improvement, W.E.UpjohnInstEmpRes, 1980

25. Statistics Canada (1982), Aggregate Productivity Measures, 1981 (Ottawa: Supply and Services).

26. Steele, Charles G.: "Measuring Productivity, A New Challenge", Deloitte,Haskins&Sells, 1982, Vol.19,No.1

27. Stenger, Alan J.: "Productivity Improvement in Physical Distribution:The NCPDM Study and Beyond", Transportation Journal, 1980, Fall,p.19-32

28. Stewart, William: Performance Measurement and Improvements in Common Carriers, Purdue Univ.Intdis.Stud., 1980

29. Strom, John S.: "Bank Profitability: A Function of Productivity and Price Recovery", American Banker, 1980, February 29

30. Sumanth, David J.: Hassan, M. Zia: "Productivity Measurement in Manufacturing Companies by using a Product-oriented Total Productivity Model", Amer.Instit.Ind.Eng., 1980, AIIE/SpringConf

31. Thor, Carl G.: "Productivity Measurement", Corporate Cont.' Manual, 1982

32. Yanisiew, William: "Productivity Index Factors in Effects of Energy Use and Conservation", IE, 1982, Feb.,pp.50-54

33. van Loggerenberg, Bazil: Cucchiaro, Stephen J.: "Productivity Measurement and the Bottom Line", Natl. Prod. Review, 1981, Win.,p.87-99

Organizational Change & Development

1. Ackoff, Russell L.: Redesigning the Future: A Systems Approach to Societal Problems, John Wiley & Sons, 1974.

2. Adizes, Ichak: "Organizational Passages - Diagnosing and Treating Lifecycle Problems of Organizations", Organizational Dynamics, 1979, Sum.,p.3-25

3. Arai, Joji: "Human Resources", USSConLandHRes, 1982, April 2

4. Arai, Joji: "Productivity - The Japanese Experience", USHofRConS&T, 1983

5. Arai, Joji: "Small Business and Productivity", U.S.House of Rep, 1982, March 23

6. Beer, Michael: Organizational Change and Development: A Systems View, Goodyear Pub. Co., 1980

7. Cherns, Albert B.: "The Principles of Sociotechnical Design", Human Relations, 1976, V29N8p.783-792

8. Cherns, Albert B.: "Can Behavioral Science Help Design Organizations?", Organizational Dynamics, 1977, Spr.,p.44-64

9. Davis, Louis: "Optimizing Organization-Plant Design: A Complementart Structure for Technical and Social Systems", Organizational Dynamics, 1979, Aut.,p.3-15

10. Deal, Terrence E.: Kennedy, Allan A.: Corporate Cultures: The Rites and Rituals of Corporate Life, Addison-Wesley, 1982

11. Ferguson, Marilyn: The Aquarian Conspiracy, J. P. Tarcher, 1980

12. Greiner, Larry E.: "Patterns of Organizational Change", Harvard Business Review, 1967, M-J,p.119-130

13. Lawler, Edward E.: Pay and Organization Development, Addison-Wesley, 1981

14. Lawrence, Paul: Dyer, Davis: Renewing American Industry, Free Press, 1983, March

15. O'Dell, Carla S.: Gainsharing: Incentives, Involvements, and Productivity, AMACOM, 1981

16. Oborne, David J.: Ergonomics at Work, John Wiley & Sons, 1982

17. Pasmore, William A., Ed.: Sherwood, John J., Ed.: Sociotechnical Systems: A Sourcebook, University Associates, 1978

18. Ronen, Simcha: Flexible Working Hours: An Innovation in the Quality of Work Life, McGraw-Hill, 1981

19. Simon, H. A.: Models of Man, Wiley, 1957

20. Trist, Eric: The Evolution of Socio-Technical Systems, Ont. Min. Lab., 1981

21. Vaill, Peter B.: "The Purposing of High Performing Systems", Organizational Dynamics, 1982, Aut.,p.23-39

22. Vough, Clair F.: Asbell, Bernard: Tapping the Human Resource: A Strategy for Productivity, AMA, 1975

23. Woodstock, Mike: Unblocking Your Organization, University Associates, 1979

Productivity/Management in Japan

1. "Can Japan Keep It Up?", Technology Review, 1982, Aug/Sept

2. "Japan's High-Tech Challenge", Newsweek, 1982, Aug8,p.48-60

3. "Japanese Management and White Collars", USOff of PersonnelMgmt, 1982, Winter

4. "Quality and Productivity", Quality, 1981, June

5. "The Success of the Japanese", Prod&InvenMgmtRev, 1982, January

6. "Tomorrow's Leaders: Survey of Japanese Technology", Economist, 1982, June

7. Anon. "Japan's Edge in Auto Costs," Business Week, September 14, 1981. p. 92-93.

8. Aonuma, Yoshimatsu: "A Japanese Explains Japan's Business Style", Across the Board, 1981, Feb.,p.41-50

9. Arai, Joji: "Development of Robotic System and its Impact on Japan", USHofRConSandT, 1983, Robotics/Ju2

10. Asian Prod. Org.: Technology Development for Small Industry in Selected Asian Countries, Asian Prod. Org., 1982

11. Asian Prod. Org.: Productivity, Quality of Working Life and Labour-Management Relations, Asian Prod. Org., 1976

12. Asian Prod. Org.: Quality and Quality Control, Asian Prod. Org., 1976

13. Asian Prod. Org.: Quality Control and Quality Assurance: The Asian Experience, Asian Prod. Center, 1980

14. Asian Prod. Org.: Productivity Agreements, Worker Motivation and Sharing the Gains of Productivity, Asian Prod. Org., 1976

15. Daly, D. J.: "Corporate Strategies and Productivity Performance in Japan's Manuf Ind", IRPP, 1980, pp 317-336

16. Denison, E. F.: Chung, W. K.: How Japan's Economy Grew So Fast, The Brookings Instit, 1976

17. Drucker, Peter F.: "Behind Japan's Success", Harvard Business Review, 1981, J-F,p.83-90

18. Hall, Robert W. "Production Control & Japanese Productivity, Parts I and II," Inventories & Production, September-October 1981, p. 6 and November-December 1981, p. 6.

19. Harmon, Roy. "UPDATE 1982: U.S. Adaption of Japanese Techniques," APICS 25th Annual Conference Proceedings, 1982, pp. 179-182.

20. Hayes, Robert H. "Why Japanese Factories Work," Harvard Business Review, July-August 1981, p. 56.

21. Hongo, Takanohu: Management by Objectives: A Japanese Experience, Asian Prod. Org., 1980

22. Ishikawa, Kaoru: Guide to Quality Control, Asian Prod. Org., 1982, 2nd rev. ed.

23. Iwata, Ryushi: Japanese Style Management: Its Foundations and Prospects, Asian Prod. Org., 1982

24. Japan Prod. Center: Micro-electronic Revolution and Labor-Management Relations, Japan Prod. Center, 1982, May

25. Matsumoto, Koji: Organizing for Higher Productivity: An Analysis of Japanese Systems and Practices, Asian Prod. Org., 1982

26. McMillan, Charles J. "Production Planning and Organization Design at Toyota," Business Quarterly, Volume 46, Winter 1981. pp. 22-30.

27. McMillan, Charles J. "From Quality Control to Quality Management: Lessons from Japan," Business Quarterly, Volume 47, May 1982, pp. 31-38.

28. Meyer, C. Randolph. "Japanese vs. U.S.A. -- How Materials Management Differ," APICS 23rd Annual Conference Proceedings, 1980, pp. 219-221.

29. Monden, Yasuhiro: "What Makes the Toyota Production System Really Tick?", Industrial Engineering, 1981, Jan.,p.36-46

30. Monden, Yasuhiro. "How Toyota Shortened Supply Lot Production Time, Waiting Time and Conveyance Time," Industrial Engineering, September 1981. pp. 22-30.

31. Monden, Yasuhiro. "Adaptable Kanban System Helps Toyota Maintain Just-In-Time Production," Industrial Engineering, May 1981, pp. 29-46.

32. Monden, Yashiro. "Smoothed Production Lets Toyota Adapt to Demand Changes and Reduce Inventory Time," Industrial Engineering, August 1981. pp. 42-51.

33. Nakane, J. and Hall, Robert. "Transferring Production Control Methods Between Japan and the United States," APICS 24th Annual Conference Proceedings, 1981, pp. 192-194.

34. Nakane, Jinichiro. "Production Management in Japanese Industry," Bulletin of the Systems Science Institute, Waseda University, March 25, 1981, p. 92.

35. Nayudamma, Y.: Factors which Hinder or Help Productivity Improvement in Asian Region, Asian Prod. Org., 1980

36. O'Connor, Brian J. "How Do the Japanese Get Higher Productivity Than We do?" APICS 25th Annual Conference Proceedings, 1982, pp. 477-481.

37. Ohara, Susumu, ed.: Industrial Review of Japan, Japan Econ. Journal, 1981, March

38. Patrick, Hugh, ed.: Rosovsky: Asia's New Giant: How the Japanese Economy Works, Brookings Institution, 1976

39. Smith, Leighton F. and Harmon, Roy L. "Closed Loop Systems in Japan: Techniques of World-Wide Applicability," APICS 24th Annual Conference Proceedings, 1981, pp. 105-108.

40. USGenActgOffice: Industrial Policy: Japan's Flexible Approach, Joint Econ. Comm., 1982, June

41. Wantuck, Kenneth A. "The Japanese Approach to Productivity," Inventories & Production, January-February 1983, p. 4.

42. Wheelwright, Steven C. "Japan -- Where Operations Really Are Strategic," July-August 1981, p. 67.

43. Yukizawa, Kenzo: "Relative Prod in Amer and Japanese Ind and Its Change, 1958-1972", InternatlEconAssocCong, 1977, September

Productivity & Management in Canada

1. Auer, L.: Canadian Agricultural Productivity, Queen's Printer, 1970

2. Auer, L.: Regional Disparities of Productivity and Growth in Canada, Min of Sup Serv Can, 1970

3. Britton, John: Gilmour, James M.: Murphy, Mark G., asst.: The Weakest Link - Technological Prespective on Canadian Industrial Underdevelopment, Science Coun of Can, 1978

4. Clement, Wallace:The Canadian Corporate Elite (Toronto: McClelland and Stewart, 1975), esp. Chapter Five, pp. 172-223.

5. Daly, D.J. (1955), "The Long Term Decline in Employment in Canadian Agriculture," Canadian Journal of Farm Economics, pp. 19-31.

6. Daly, D. J.: "Canadian Productivity Performance: Some Guides for Business Decisions", Business Quarterly, 1983

7. Daly, D. J.: "Factors in Canada-United States Real Income Differences", InterReviewIncomeWealth, 1967, Dec.,pp285-309

8. Daly, D.J.: "Canadian Management: Past Recruitment Practices and Future Training Needs," in Max von Zur Muchlen, ed., Highlights and Background Studies (Ottawa: Federation of Deans of Management and Administrative Studies, 1979), pp. 178-200.

9. Daly, D. J.: "Further Improving Manufacturing Productivity in Canada", Cost and Management, 1980, J-A,pp14-20

10. Daly, D. J.: "Weak Links in 'The Weakest Link'", Cdn Public Policy, 1979, Summerp307-317

11. Daly, D. J.: MacCharles, Donald C.: Altwasser, Wendy: "Corporate Profit Drop is Worst since 1930s", Canadian Business Review, 1982, Autumn,pp6-12

12. Daly, D. J.: Canada's Comparative Advantage, ECC, 1979, pvii,92,12,10,1

13. Daly, D.J. (1983), Research on productivity of relevance to Canada, Current problems and perspective (Ottawa: Social Science Federation of Canada).

14. Daly, D.J.: "Technology Transfer and Canada's Competitive Performance," in Robert M. Stern, ed. Current Issues in Trade and Investment in Service Industries: U.S.-Canadian Bilateral and Multilateral Perspectives (Toronto: University of Toronto Press, forthcoming).

15. Denny, Michael: May, J. D.: "Postwar Productivity in Canadian Manufacturing", Cdn Jour of Econ, 1979, February

16. Economic Council of Canada (1983), The Bottom Line: Technology, Trade and Income Growth (Ottawa: Supply and Services).

17. Frank, James G.: Assessing Trends in Canada's Competitive Position: The Case of Canada and the U.S., Conf Board in Can, 1977

18. Lipsett, Seymour Martin: "Revolution and Counter-Revolution - The United States and Canada," in Thomas R. Ford, ed. The Revolutionary Theme in Contemporary America (Lexington: University of Kentucky Press , 1965), pp. 21-64, esp. pp. 38-43.

19. Porter,John: The Vertical Mosaic (Toronto: University of Toronto Press, 1965).

20. Presthus, Robert H.: "Evolution in Canadian Political Culture: Politics of Accommodation," Richard Preston, ed., Perspectives on Revolution and Evolution (Durham, N.C.: Duke University Press, 1979). Arthur Lower and J.M.S. Careless have reached similar conclusions earlier.

21. Strauss, Stephen. "Finding Niches Canada's Aim in Robotics Sector," Globe & Mail, May 13, 1983 p. B13.

22. Walters, D.: Canadian Income Levels and Growth: An International Perspective, Queen's Printer, 1968

23. Towards the Electronic Office, O.C.S., 1982

International Comparisons in Productivity

1. Daly, D. J.: "Declining Productivity Growth: An International Perspective", Canadian Business Review, 1981, Winter,pp2-6

2. Daly, D. J.: "Why Growth Rates Differ-A Summary and Appraisal", InterReviewIncomeWealth, 1968, March,pp75-93

3. Daly, D. J.: Canada's Comparative Advantage, ECC, 1979, pvii,92,12,10,1

4. Denison, E. F.: "Why growth rates differ: Postwar Experience in Nine Western Countries", The Brookings Instit, 1967

5. Denison, E. F.: Poullier: Why Growth Rates Differ: Postwar Experiences in Nine Western Countries, The Brookings Instit., 1967

6. Jorgenson, Dale W.: Christensen, L.: Cummings, D.: "Productivity Growth, 1947-73: An International Comparison", Govt Printing Office, 1978

7. Kravis, Irving B.: "A Survey of International Comparisons of Productivity", Economic Journal, 1976, March

8. Kravis, Irving B.: Summers, Robert: Alan, Kenessy: "Real GDP Per Capita for More than One Hundred Countries", Economic Journal, 1978, 88 June

9. Maital, Shlomo: Meltz, Noah M.: Lagging Productivity Growth, Ballinger Publ Co, 1980

10. Nadiri, M. I.: "International Studies of Factor Inputs and Total Factor Prod: A Brief Survey", Review of Income Wealth, 1972, 2

11. Scherer, F. M.: Beckenstein, A.: Kaufer, E.: Murphy, R. D.: The Economics of Multi-Plant Operation: An International Comparisons Study, Harvard Univ Press, 1975

Organizations and Information Systems

1. Ahituv, Niv: Neumann, Seev: Principles of Information Systems for Management, Dubuque: Wm. C. Brown, 1982

2. Alavi, Maryanne: Henderson, John: "An evolutionary Strategy for Implementing a Decision Support System", Management Science, vol 27 no 11, 1981

3. Anthony, R.A.: Planning and Control Systems: A Framework for Analysis, Boston: Harvard University, 1965

4. Barnard, Chester: The Functions of the Executive, Cambridge, Mass: Harvard University Press, 1964.

5. Blumenthal, S.C.: Management Information Systems: A Framework for Planning and Development, Englewood Cliffs: Prentice-Hall, 1969

6. Bowman, Marinus J.: "Human Diagnostic Reasoning by Computer: An Illustration from Financial Analysis", Management Sciences, vol 29 no 6, 1983

7. Buller, C.V.: Bennett, J.L.: Carlson, E.D.: "A case study of office workstation use", IBM Systems Journal, vol 21 no 3, 1982

8. Davis, G.B.: Management Information Systems: Conceptual Foundations, Structure, and Development, New York: McGraw-Hill, 1974

9. Edelman, Franz: "Managers, Computer Systems and Productivity", MIS Quarterly, vol 5 no 3, 1981

10. Ein-Dor, P.: Segev, E.: Managing Management Information Systems, Lexington: D.C. Heath, 1978

11. Forrester, J.W.: Industrial Dynamics, Cambridge: M.I.T. Press, 1961

12. Gardner, P.C. Jr.: "A system for the automated office environment", IBM Systems Journal, vol 20 no 3, 1981

13. Hackathorn, Richard D.: Keen, Peter G.W.: "Organizational Strategies for Personal Computing in Decision Support Systems", MIS Quarterly, vol 5 no 3, 1981

14. Hage, J.: Aiken, M: Marrett, C.B.: "Organizational Interdepenence and Intra-organizational Structure", American Sociological Review, 33(1968).

15. Helander, G.A.: "Improving system usability for business professionals", IBM Systems Journal, vol 20 no 3, 1981

16. Huber, George P.: "Cognitive Style as a Basis for MIS and DSS Designs: Much Ado About Nothing?", Management Science, vol 29 no 5, 1983

17. Huber, George P.: "The nature of Organizational Decision Making and the Design of Decision Support Systems", MIS Quarterly, vol 5 no 2, 1981

18. Jacobsen, Eugene: Seashore, Stanley: "Communication Patterns in Complex Organizations", Journal of Social Issues, vol 7, 1951

19. Kroeber, Donald W.: Watson, Hugh J.: Computer-Based Information Systems - A Management Approach, New York: Macmillan, 1984

20. Lucas, Henry C.: "An Experimental Investigation of the use of Computer-based Graphics in Decision Making", Management Science, vol 27 no 1, 1981

21. Lum, V.Y.: Choy, D.M.: Shu, N.C.: "OPAS: An office procedure automation system", IBM Systems Journal, vol 21 no 3, 1982

22. March, J.: H.A.Simon, Organizations, New York: John Wiley, 1958

23. McClean, Ronald J.: Organizational Structure as Viewed by Intra-organizational Communication Patterns, unpublished Ph.D. dissertation, University of Waterloo, 1980

24. McLeod, Raymond Jr.: Bender, Donald H.: "The Integration of Word Processing into a Management Information System", MIS Quarterly, December, 1982

25. Neumann, Seev: Hadass, M.: "On Decision-Support Systems", California Management Review, vol 22 no. 3, 1980

26. Perrow, C.: "A Framework for the Comparative Analysis of Organizations", American Sociological Review, 32(1967), April.

27. Randles, F., "On the diffusion of Computer Terminals in an Established Engineering Environment", Management Sciences, vol 29 no 4, 1983

28. Roby, Daniel: "Cognitive Style and DSS Design: A Comment on Huber's Paper", Management Science, vol 29 no 5, 1983

29. Roby, Daniel: Taggart, William: "Human Information Processing in Information and Decision Support Systems", MIS Quarterly, vol 6 no 2, 1982

30. Shannon, C.E.: Weaver, W: The Mathematical Theory of Communication, Urbana, University of Illinois Press, 1949

31. Simon, H.A.: The New Science of Decision Making, New York: Harper & Row, 1960

32. Thadhandi, A.: "Interactive User Productivity", IBM Systems Journal, vol 20 no 3, 1981

33. Thompson, J.: Organizations in Action, New York: McGraw-Hill, 1967.

34. Tushman, Michael L.: Romanelli, Elaine: "Uncertainty, Social Location and Influence in Decision Making", Management Science, vol 29 no 1, 1983

35. Zloof, M.M.: "Office-By-Example: A business language that unifies data and word processing and electronic mail", IBM Systems Journal, vol 21 no 3, 1982