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TECHNOLOGICAL COMPETITION AND TRADE IN THE EXPERIMENTALLY ORGANIZED ECONOMY

by
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THE INDUSTRIAL INSTITUTE FOR
ECONOMIC AND SOCIAL RESEARCH

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FOREWORD

In the experimentally organized economy introduced in this book the manufacturing firm is portrayed largely as an information processor. The implications for foreign trade, industrial policy and economic growth are explored. These issues have long been an important theme of research at the institute. This book includes three articles published during 1987. An introductory chapter has been added to link the articles together. This publication can be seen as an intermediate report from an ongoing study aimed at highlighting the nature of technological competition among multinational firms in international markets, and the basis of competitiveness of nations.

Stockholm in November 1987

Gunnar Eliasson

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CHAPTER I

Tehnological Competition and Trade in the Experimentally Organized Economy – The Themes

Technological Competition and Trade in the Experimentally Organized Economy – The Themes

Specialization requires technology and coordination

In Adam Smith's early conceptualization of the market economy, firms achieved local economies of scale through specialization and the application of technological know–how. Specialization, however, meant increased demands on coordination. To account for that Adam Smith introduced the invisible hand of the market and thus achieved complete specification of the market economy. In doing so he really made – as we shall see – the economics of information the foundation of economics.

This verbally presented model of Adam Smith (1776) is a dynamic one that has little to do with the refined general equilibrium models used in trade theory. However, both Adam Smith and, until very recently, most theorists tended to neglect or suppress the fact that technological improvement requires large investment in human capital and that coordination requires costly communication. Communication has a geographical and physical dimension (trade in goods), and an information dimension. The latter is carried out in the form of market coordination through prices and the use of coded information in administrative control systems. Continued specialization will have two effects: (1) trade will occur at finer and finer levels, making the nation and its given country-specific comparative advantages less and less relevant; and (2) the informational requirements for coordination will become more and more detailed, heterogenous, and intractable for central control.

Industrial knowledge matters

This book takes an unconventional approach in arguing that production, properly measured, largely consists of the transaction or use of information through the application of knowledge capital. It is the size, composition and quantity of this knowledge capital base, not machines and labor hours, that determine the competitive capacity of a firm or a nation. This was obvious to John Stuart Mill (1848) och Johan Westerman (1768) – an unknown Swedish economist – but has been more or less neglected since then (Abramowitz 1987). The most outstanding industrial knowledge and endogenously acquired comparative advantage characterizing an exclusive group of wealthy industrial nations is the ability to form and to manage large industrial organizations in an international market environment (see Chapter II and Eliasson 1987).

Recognizing knowledge capital and information processing as the key characteristics of economic activity, technological change associated with information processing becomes the driving force behind economic growth. Following Joseph Schumpeter's (1912) early conceptualization of the innovative and entrepreneurial process as targets whose outcomes are unpredictable, I introduce (in Chapter II) what I call the experimentally organized economy.

Immense business opportunities and very limited local knowledge

This notion is made credible through reference to the immense set of business opportunities residing among the industrial nations, coupled with the locally bounded competence (knowledge) base of firms. Together with unrestricted competitive entry, this introduces the (unpredictable) technological competition at the world level that is characteristic of the experimentally organized economy.

Technological competition is predominantly based on product improvements (see Chapter III), not process improvements as emphasized in the new mathematical literature of technological competition (Krugman 1981, 1983, Helpman–Krugman 1985, Spencer–Brander 1983, etc.).

The economics of information

Practically all economic activities can be classified under one of the four headings in Table I:1. Classical trade theory does not allow agents to come up with unexpected business solutions, that might succeed or fail. In contrast, the business opportunity set (item 1) in the experimentally organized economy is conceived to be so large, compared to the limited knowledge base of each agent (bounded rationality, item 4) that unexpected events, including mistakes – which are unexpected events by definition – constantly occur. A sufficiently large opportunity set, coupled with bounded rationality and tacit, incommunicable knowledge, will create the dynamic technological competition of the experimentally organized economy. This setting could be seen as a case of asymmetrically distributed information, were it not for the fact that most of the opportunity set is unknown, and that each agent possesses marginal, and often not even overlapping elements of know–how. The inability of agents to capture more than a small part of the total opportunity set in their business decisions, and the impossibility of communicating critical elements of their knowhow, is the key feature that makes an experimental organization of the economy efficient.

The nature of experimentation and search in this economy, therefore, has clear implications not only for the competitive success of firms (the filter item 3), but for the welfare outcomes of different ways of organizing trading in international markets, and for the potential of industrial policy making, or "industrial targeting".

In Chapter III the manufacturing firm is presented as an information processor, coping with its experimental economic environment. The limited local knowledge base ("bounded rationality"), incommunicable high level business know–how ("tacit knowledge") and an unlimited international business opportunity set ("state space") combine to make firms into deliberate experimentors, rather than planners. Under the free competitive entry conditions for technological competition of international markets, a fierce selection or filtering process (item 3 in Table I.1) occurs. The competitive edge of firms rests on their ability to bias their business

Table I.1 **The four productive activities in the information based industry**

1. **Taking advantage**	through – Technical information processing – Innovation – Entrepreneurship
2. **Coordination**	through – Competition in markets – Administration in hierarchies
3. **Filtering**	through – Selection, entry, exit and mobility
4. **Knowledge creation**	through – Education and knowledge transfer

experiments (selection of activities) towards a higher probability of successful outcomes than the industry average, an ability to identify mistakes fast and to take rapid effective correction. The international firm as an efficient intelligence organization – not only a product-developing producer and distributor – is described in Chapters II and III.[1]

Modeling the experimentally organized economy

Chapter IV simulates the experimental economy as it is represented in the Swedish Micro-to-Macro (M-M) model.[2]

[1] See further Eliasson, G., 1988, "The Knowledge Base of an Industrial Economy" to be published in The Human Factor in Economic and Technological Change by OECD and The Dynamics of Supply and Economic Growth – a matter of industrial knowledge, IUI Working Paper No. 182, 1987.

[2] See Eliasson (1978, 1985, 1986).

The model exhibits (a) multimarket interaction across agents. This generates a short-term disequilibrium process that affects the long-term growth path of the economy through (b) technological change (embodied in new investment), (c) ex ante profit guided investment, (d) income demand feed back, and (e) dynamic price, and quantity interaction through markets.

Firms in the model constitute systems for short-run and long-run learning, planning, and capital accumulation. Each quarter they interpret their economic environment and their interior capacity to make a profit. Each quarter they decide on their desired production, employment and investment. Armed with these plans they go into the labor market where the employment plans of all firms are confronted with one another and with labor supply. The labor force is treated as homogeneous in the model. Labor can be recruited from a common "pool" of unemployed and from other firms. The labor market search process allocates total employment over firms and determines the wage level, which is thus endogenous in the model. Even though the labor market is homogeneous, wages vary among both firms and industries, without any tendency to converge.

Domestic product prices and production volume in the four product markets are determined through a similar process. The export volume is also determined endogenously.

Three exogenous variables (besides government policies) drive the model: (1) the rate of technical change (which is specific to each sector and raises the labor productivity associated with new, best practice equipment in each firm), (2) the rate of change of prices in export markets, and (3) labor supply.

Technological diffusion through technological competition

There is also a capital market in the model where firms compete for investment resources and where the rate of interest is determined. As new best practice technologies are exogenously developed, they are made internationally available in the form of best practice investment vintages (the "opportunity set"). Profit opportunities are created and exploited by existing firms through their (endogenous) investment decisions or by new firms through competitive entry in markets. These opportunities lead to investment in the latest technologies, i.e., diffusion occurs. As the new technology is diffused, the profits earned by non–innovators are competed away, because the use of the new technology impact on prices in product and factor markets. Thus technological competition through entry of new firms and new technology in old firms controls size and concentration. Eventually non–innovators must either exit or change to the new technologies. As firms adopt the new technologies, or exit, productivity in the model economy increases.

The M–M model makes it possible to analyze the macroeconomic growth consequences of alternative modes of organizing dynamic market processes and trade (Chapter IV).

Trade and competition

The simulation experiments focus on the national competitiveness of an industry in an international trade perspective. Firms are assumed to be price takers in international markets and price and quantity setters in domestic markets. This small country asumption may not be the best one for a nation like Sweden, dominated by large, mature multinationals. But it has been conventionally applied, and for the particular analytical exercises of Chapter IV this restriction does not significantly affect the interpretation of results. However, for the record, one should keep in mind that Swedish multinationals frequently dominate their respective international market (see Chapter III) and together have more than half of their activities (measured by employment) abroad (see Eliasson-Bergholm-Horwitz-Jagrén 1985, p. 35).

The model is constructed so that by varying the assumptions about the characteristics of new technologies one can explore the impact of more or less labor–saving types of technological change. One may also consider variations in the rates at which markets adjust to disequilibria, and the impact of varying the elasticities of exports to foreign and domestic prices to investigate the importance of "rigidities" and "trade impacts" in the determination of the impact of new technologies. The organization of market processes and market regimes significantly affects the reliability of firms' learning mechanisms, the stability of market adjustments, and the efficiency of administrative coordination of the firm.

The comparative advantages behind foreign trade are not well defined ...

Because of technical change and endogenous investment, the classical notion of exogenously given comparative advantages has no meaning in this model, since comparative advantages, defining the competitive situation of the firm or a nation change as a consequence of the ongoing economic process (see Chapter II).

Therefore, industrial targeting will never be effective in the experimentally organized economy

For each occasion there is a proper optimal speed of price adjustment (and demand feed back) to a disturbance that achieves reasonable macro stability, normally at the cost of increased microeconomic instability (Chapter IV). This means (Chapter II) that industrial targeting aimed at selective control of the economy is liable to fail in the experimentally organized economy. The efficient–growth oriented industrial policy is to organize the economy such that it can cope with change.

The observation in Chapter III that technological change – through new information technologies – appears to move in a relatively more (hardware) capital saving direction, has no medium or long–term effects on unemployment, as long as a reasonable domestic factor price flexibility and labor mobility can be organized.

The importance of an optimal trade regime

The allocation effects of the effective introduction and exploitation of new technology (see Chapter IV) depend critically on the extent to which the (small, industrial) economy can participate in international specialization. The design of superior market trade regimes appears to be far more productive at the macroeconomic level than attempts to target industrial sectors or technologies. The latter will regularly fail (Chapter II) for the following reason: Competitive advantages of firms and sectors depend on the selective outcome of the allocation and knowledge accumulation process – which is analytically intractible to planners and observers – and is characteristic of the experimentally organized economy.

The organization of "optimal trade regimes" must strike a balance between macro stability, rapid market adjustment to higher static process efficiency, the introduction of new technology, and the shifting of trade patterns in response to new price signals.

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CHAPTER II

Industrial Targeting: Defensive or Offensive Strategies in a Neo–Schumpeterian Perspective

Industrial Targeting: Defensive or Offensive Strategies in a Neo-Schumpeterian Perspective

1. The Problem, Summary of Method and Conclusions

Two phenomena are characteristic of decision-making in general, and decision-making in business in particular; namely (i) what Simon [1955] called "bounded rationality", and (ii) what Polanyi [1967] has referred to as "tacit knowledge". Bounded rationality simply postulates that simplified, and normally biased, or erroneous perceptions of reality necessarily underlie decisions in complex situations. Hence, deliberate risk-taking and frequent mistakes are necessary characteristics of economic life. "Tacit knowledge" means that the competence to decide and take action is embodied in individuals, or teams of individuals. Advanced competence needed for many critical business decisions as a consequence cannot easily, or at all, be communicated to others. In particular, it cannot be traded in bits and pieces in markets.

This paper, hence, takes three observations as starting points: firstly, we observe that the commercial opportunities of modern manufacturing firms are defined internationally, while the competence to exploit the international opportunity set profitably is locally determined; secondly, the industrial nations are defined by their abundant local competence (1). Because of their superior industrial technologies, politicians of the

(1) It will become clear as we go along, why industrial knowledge is not

advanced industrial nations have usually been advocates of free trade; thirdly, international trade theory (from which economists derive advice on trade policies) is traditionally framed in a static time dimension, and is often based on the notion of a fixed endowment of factors of production and the absence of significant economies of scale. Even though a departure from the Walrasian tradition has begun in recent years, it really has not changed the static underpinnings of theory [see Dixit, 1983; and below]. Diminishing relevance has induced a recent change in emphasis [Krueger, 1968; Caves, 1985; Krugman, 1981; Dixit, 1983; 1986; Kierzkowski, 1984; Helpman, Krugman, 1985; Spence, 1984] away from static trade theory based on fixed comparative advantages to one based on internal economies of scale in order to explain intra-industry trade. This reformulation has shifted the conventional Stolper-Samuelson distributional results. In the new game of Chamberlinian monopolistic competition and imperfect markets, trade liberalization in manufactured goods characterized by internal economies of scale is optimal policy.

Even more "novel" in a trade theoretic context, however, is the notion of technological competition. Firm competitiveness now depends on its R&D spending and its ability to learn rapidly "by doing". In this "theory", R&D spending is assumed to depend on (foreign) competitors' spending on R&D and expectations about what competitors will do. Models (1) have been built which suggest that protection of domestic firms from import competition will allow them to learn from their own R&D spending and thereby establish a strong international competitive position. Such models make it possible to derive so-called *industrial targeting* as optimal trade policy. The government targets certain firms to be protected from import competition. This argument is very similar in content to both the "infant industry argument" and to the "socialization of innovative behavior" argument by Arrow [1962]. There is a host of traditional objections to this "modern" theory of protection; product competition concerns substitutes only, R&D investments concern process improvements

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an internationally very mobile resource that can be hired in markets, except within the (international) business organization.

(1) Most references go back to Spencer, Brander [1983] or Brander, Spencer [1984], or earlier versions of the published articles.

in a firm envisioned as a factory (1), informational requirements are impossible, foreign governments will retaliate, etc. [Krugman, 1984].

The main purpose of this paper, however, is not to criticize the "modern" theory of import protection. The objective is (i) to develop a comprehensive picture of dynamic market competition, which emphasizes the accumulation of industrial know-how and the growth of firms producing goods for specialized markets characterized by imperfect information and few producers, and (ii) to derive the implications for trade policy.

In developing this position, however, two additional arguments against the industrial-targeting proposal will be voiced. Firstly, it rests on traditional, static assumptions about markets. Firms are assumed to be competing for some monopoly rent in at best a two-period setting. This is enough to keep it a classroom exercise, and out of policy discussion. Secondly, the accumulation of technological know-how through R&D spending and learning by doing has been taken out of context, and been assumed to be efficient as a purely internal firm activity. The targeting argument also assumes that becoming technologically competitive is a once-and-for-all investment with a well defined payoff. In an empirical setting characteristic of manufacturing firms, this is completely wrong. The main argument against traditional targeting that emerges from this analysis is that the total rent firms are competing for is positively dependent upon the intensity of learning through competition.

If technological know-how could be developed as efficiently in a remote, isolated R&D laboratory as it can through active participation in competitive markets, both the industrial targeting, and Arrow's "socialization of innovative behavior" arguments would have a place in the real world. In the experimental economy that I will introduce, the dynamics of market interaction removes the empirical foundation of arguments for industrial targeting. It is also significant that the notion of dynamic competition of Clark [1961] is conspicuously absent from the industrial-targeting discussion.

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(1) This is the least important form of R&D investment [Eliasson, 1985b; 1985c; 1986c].

A growing part of the industrial world is basing its economic wealth on manufacturing knowledge, accumulated during decades of trial and error in the markets. Such knowledge is closely associated with the labor force and is very specialized. In such a situation, the competitive position of a country becomes increasingly precarious, since its knowledge superiority in certain fields is constantly threatened by innovative, competitive entry of business units of other countries. At the same time, we conclude that the only efficient way to accumulate industrial knowledge appears to be to participate aggressively in the same market game and to exploit the economies of specialization offered in global markets. Attempts to protect the value of old knowledge through the protection of a country's industries only slow knowledge accumulation and reduce the quality of industry. This leads to competition based on the cost-efficient production of simple products, which relies on low-factor prices, notably cheap labor. Once advanced and socially-spoiled industrial nations are especially badly organized for this type of competition (1).

The conclusion is that industrial targeting of sectors or firms, that offers protection to allow them time to develop into aggressive international competitors, not only poses impossible informational requirements and stimulates retaliation, but also generates sloppy performance. Above all, it keeps the protected firm "out of school"; the intense learning experience of market participation that is needed to become and remain a viable international competitor.

If the politicians of a nation are worried about increased foreign technological competition, the policy advice is as follows. Rather than attempting to take on impossible managerial tasks, they should stimulate a broadening of the domestic industrial knowledge base through increased internationalization of their firms. This is a form of "insurance arrangement" that makes a specialized industry less vulnerable to technological competition, by increasing the number of specialities.

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(1) In an economic political perspective, it is interesting to observe that in the first industrial nation, the deindustrialization argument has been voiced as an argument for general protection in order to save British manufacturing from going under [Singh, 1977].

Hence, the analysis of this paper comes out in favor of the old policy of free trade as the only viable long-run policy, but the underlying model, and the reasons for this support are different from those implicit in traditional, static trade theory.

2. The Experimental Market Economy

Any suggestion about international trade policy or industrial activity has to be based on a notion of the nature of the market process and the time horizon under which objectives are to be realized. I introduce my notion in two steps: the first is a presentation of the international business opportunity set; and the second has to do with the local - in this case national - ability or competence to exploit that set efficiently. Both presentations introduce the market process, the accumulation of industrial competence, the creation of new business opportunities and economic growth as essentially an experimental, learning activity.

a. The International Opportunity Set

Technical advance is traditionally introduced in macroeconomic theory as a shift in the production function. This measurement method has made technical change appear as something that occurs externally, and independently of the market processes, commonly at no application of costs. This notion is not only "mystic" [Denison, 1979], but, of course, wrong. Technically we have the problem of allocating costs for inputs to the same accounts where outputs are being recorded. If activities paid for in the public sector - like public education - make labor hours more productive in manufacturing, the manufacturing production function will shift, because costs for inputs have not been properly allocated [Eliasson, 1985c]. Furthermore, we have the problem of the proper pricing of factor inputs. Griliches and Jorgenson [1967] dealt with this in a general equilibrium framework and almost managed to eliminate the drift in the macroproduction function, called total-factor-productivity change.

These problems are serious economic issues for many reasons, and the theoretical glasses one chooses restrict the options for policy advice. Total-factor-productivity advance has been the focus of central industrial policy ambitions in several industrial countries. For policies to generate desired results, the nature of total-factor-productivity change has to be properly understood by politicians. Productivity change typically originates at the micro level, and requires a genuine understanding of micro-macro dynamics to be successfully understood and influenced by policy. Since such understanding is generally lacking, ambitious policies in most countries aimed at substituting central Government industrial policy judgement for high level business judgement have been failures, or extremely costly. But in some countries, such as Japan, the assessment remains open for the simple reason that we do not know exactly what is being done. I have seen no convincing explanation beyond an efficient macropolitical control of wages and a diligent, educated, and well-organized work force. This is a form of general industrial policies similar to the old Swedish policy model [see Eliasson, 1984a; 1986a; 1986d], which was also very effective in using the markets to control inflation and wages, and to facilitate structural adjustment.

The notion that industrial policymaking, in order to be informed, requires the central control, communication and use of impossibly large amounts of information belongs to a long tradition in economic analysis beginning at least with the Lange [1936] - von Hayek [1937; 1940; 1945] debate in the 1930s and 1940s. This information requirement, however, doesn't seem to have unduly deterred policy ambitions. The first argument of this paper is that lack of adequate information is necessarily as typical of industrial policy action as it is for any business decision. Since the scope of policy action is much larger than any single business decision, the potential damage of mistaken decisions is much larger. There are four distinct reasons for this. The first is that basic industrial knowledge is tacit, vested with a group of people or a business organization and largely incommunicable, except within the same business organization. The second - originally a Marxian notion - is that the potential pool of knowledge (the opportunity set) is for all practical purposes unlimited. The third (discussed in the next section) is that the ability to exploit the opportunity set is local and limited. Hence, both the process of exploiting this opportunity set and of accumulating local industrial knowledge - which is the most important element of the market process - is experimental in nature and not predictable at the levels of aggregation at which policy targets (e.g. on technology) are set.

The fourth reason is perhaps the most important. The experimentally organized economy has two sides. The first is to select a maximum number of potential winners for trial in the market. The second side is to identify and eliminate the bad draws as rapidly as possible. The political system, of which industrial policymakers are a part, is notoriously badly-organized for accepting and correcting erroneous decisions. The anonymous market place will always be the supreme performer when it comes to closing down badly-performing production activities.

The conclusion so far is that active experimentation is a necessary requirement for innovative activity and rapid economic growth, but it should be diffused and restricted to the micro level of firm behavior.

I will introduce technological change and total-factor-productivity advance in terms of the expansion, and the exploitation of the technological opportunity set. I will then discuss the opportunities set per se, its macroeconomic consequences in terms of the micro-to-macro model developed at the Industrial Institute for Economic and Social Research, and the supporting empirical inquiries into the nature of microeconomic dynamics.

This analysis will neither make use of the concept of shifts in a macroproduction function, nor the notion of free access to external, infrastructural resources - notions that are related, or even the same. I will rather introduce the idea that, under certain environmental conditions, and with sufficient local know-how, access to profitable business opportunities is very cheap, and the innovative activities of all actors in the market together constitute the fundamental "mover" of the opportunity set. If it can be demonstrated that the total action of all firms is the main infrastructure builder in industry, the policy problem is naturally reformulated as a concern for how to organize the right environmental conditions.

Technology per se, of course, plays a critical role in determining in each application the upper limit for productivity. However, as has been demonstrated in a large number of studies undertaken by the Industriens Utredningsinstitut (IUI), it is the way one particular technology is combined with other technologies and other factors of production that determines actual productivity. Large steps forward in productivity at the firm level are always associated with changes in the organization through which factors are combined. This has been demonstrated at the local shop-floor level [e.g. Eliasson, 1980a; 1982; Nilsson, 1981] as well as at the macroeconomic level [Carlsson, 1980]. In fact, the way microeconomic behavior is dynamically coordinated in product, capital and labor markets has been demonstrated (1) to account for up to two extra percent of growth in output per annum over long, historic periods, or about the differences in recorded growth rates among the industrial nations since the beginning of the century. This means, firstly, that the existing organization of factors of production is rarely the best way of organizing production, and secondly, that small improvements in technology may open up a whole new set of possible and more efficient combinations. The idea, or the knowledge how to achieve new business combinations is what Schumpeter probably meant by entrepreneurship. We are not only concerned with new configurations of machines in a workshop, or with the introduction of new materials in automobile engines, but also with the introduction of entirely new business concepts, for instance, emphasizing product development and marketing rather than factory production [Eliasson, 1985b].

With this expanded notion of the international opportunity set it (i) becomes enormous in scope, offering a wide range of different business combinations. The set is so large that each actor in the market can be

(1) In the Swedish micro-to-macro model. See Carlsson [1980]; Eliasson [1980b].

familiar with only a small part of it (1), indicating that the nature of *innovative activity* has to be *experimental* and that the existing set of combinations is virtually inexhaustible within practical planning horizons [Eliasson, 1986c]. (ii) We also conclude that *innovative activity* to a significant extent is *imitative*. The bulk of R&D spending in corporations - even R-spending - is oriented towards learning what is going on among competitors and improving upon existing solutions. Discrete jumps in technology occur, but at the application level they nevertheless appear as piecemeal advances, since they always need additional improvements in complementary technologies. Hence, dynamic competition means that new features are added to a competitor's product, adding to the total number of new combinatorial possibilities. Upgrading a low performer to a high-performing technological competitor is definitely not - as presumed in the targeting literature - a once-and-for-all R&D effort to increase process performance in the factory, that then gradually matures into efficiency under the shield of import protection. R&D investments are predominantly in own product improvements, normally aimed at not making them substitutes. (iii) Hence, the international opportunity set tends to increase from *intensive use*. It not only comes back to life, as does the pig in the Nordic sagas - Särimner - after having been eaten the night before, it even grows in size.

With this presentation of the international opportunity set, total industrial innovative action becomes the most important industrial infrastructure builder, that makes additional, marginal innovative investments cheap, or very profitable. The process I have just described is familiar to everybody who has been in reasonably close contact with innovative activities within manufacturing firms.

The distinctive feature of the capitalist market organization is that the competitive exploitation of the international opportunity set and the competitive entry of firms and technologies is free [Pelikan, 1985]. This means predictability of outcomes at the micro level is very low, and, hence, the informational requirements of industrial targeting are impossible to fulfil.

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(1) This can be interpreted as an assumption of bounded rationality, in the sense of Herbert Simon.

b. The Nature of Local Industrial Competence

High profitability in the innovative exploitation of the international opportunities intensifies innovative Schumpeterian competition. However, the ability to exploit the opportunity set profitably depends on local industrial competence residing in the various firms. Pinpointing the nature of that local competence is extremely difficult, as we have found in several IUI research projects. Let me simply observe here that the competence to run large business organizations is probably the major, endogenously created factor endowment of the industrial nations.

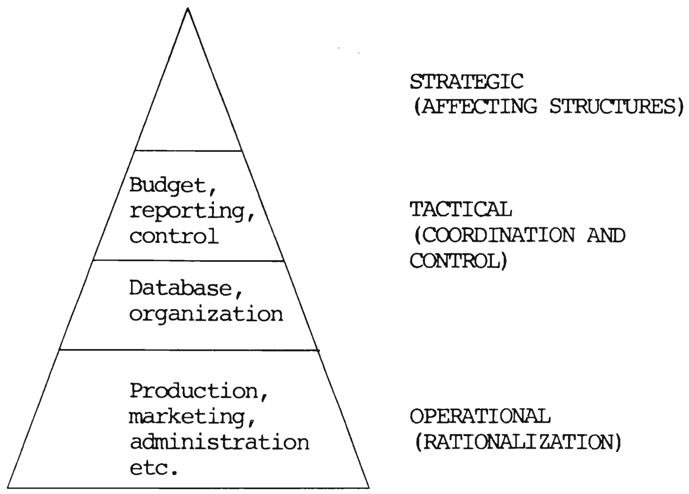
This competence can be identified very superficially in Figure 1. In this diagram three levels of competence are introduced in order of sophistication and macroeconomic consequences: (i) local, factor saving (rationalization); (ii) tactical, control (coordination); (iii) strategic (structural change).

The first two levels refer to a more efficient use of existing knowledge, even though the coordination of increasingly larger and complex business organizations requires industrial competence of a kind that no country outside the industrial world really possesses.

The ultimate criterion of industrial competence, however, is the ability to adjust to new technologies being created in the international opportunity set, to combine them with existing structures into a new, viable business activity. In small or large business organizations this competence corresponds most closely to the entrepreneurial function. When too many firms lack this ability, a whole industrial nation may get stuck with the wrong knowledge base and experience a dismal circle of worsening relative economic performance.

This observation points to a particular aspect of industrial competence directly related to the experimental nature of the market system. Since industrial decision makers can never predict with any accuracy and reliability at their operational levels, they try, gamble or experiment. The *critical competence* comes into play when *mistakes* are *to be identified* and *mistaken activities to be shut down*.

Figure 1 - Levels of Decision-Making within a Business Organization



Source: Eliasson [1985a, p. 14].

We have found that the top level reorganizational ability is the most important explanation of major advances in productivity at division or firm levels. Competitive forces, but also other forces related to attitudes and incentive systems in society play a critical role in keeping this economic process in motion. We have found that the ability to reorganize the firm early to emphasize product development and marketing has been an important determinant of success during the 1970s [Eliasson, 1985b]. This raises the interesting problem of whether large scale factory production - once the symbol of industrial competitiveness - is now a sign of industrial backwardness or whether the mature industrial countries for one reason or another are losing their competence to produce (1). We will come back to this issue in the next section. Before that we have to define clearly what is meant by an industrial knowledge base or industrial competitiveness.

(1) It is of interest to recall that the new theory of industrial targeting is still phrased in terms of the manufacturing firm as a goods-producing factory and that R&D spending is aimed at upgrading process performance.

c. *International Competitiveness - What Is It?*

For a *nation* [Eliasson, 1972, pp. 129 ff.], international competitiveness is best measured by the ability to sustain long-term growth in disposable real income (1). For a firm, it means the ability to sustain a high rate of return on capital. The two measures are interrelated. But they can also both be decomposed into two parts; one relating to relative prices, the other relating to productivity (2).

For the firm, productivity depends on its efficiency in organizing production and/or in increasing the quality of output. This technical proficiency is expressed, on the price side, in management's ability to choose the right product or to be in the right markets. For the nation as a whole, both abilities aggregate into a measure of productivity reflecting industrial skills to organize factors of production such that a great value of output in foreign currencies is achieved, and resources are created and efficiently reinvested in the economy such that rapid macroeconomic growth is generated. At the national level, however, the price problem consists in controlling domestic factor prices relative to foreign prices of output [Eliasson, 1985c]. If productivity growth at the macro level stagnates, then a higher burden in maintaining competitiveness of firms falls on domestic factor price control. However, domestic factor price control, including real wage control, does not produce rapid long-term growth in disposable real income, unless matched by productivity growth. The latter can only be maintained through the continued upgrading of industrial knowledge (3).

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(1) In fact, this is the same as to measure competitiveness by the *return to total wealth* of a nation. When seen in this perspective, the ways a nation organizes and uses all its resources, including those in the public sector, become a matter of concern, since the allocation and use of all resources determine factor prices to export industries and import competing industries. Short-term factors such as the trade balance are only pieces in this puzzle.

(2) The Swedish micro-to-macro model developed at IUI clearly illustrates the economic significance of this definition of competitiveness. In Eliasson [1985c] the relative importance of the various measures for competitiveness has been analyzed within an international trade framework.

(3) It is interesting to observe that the endogenous parameter that was adjusted to differences in competitive pressure on similar factory

d. Learning, Technological Upgrading and Economic Growth - The Endogenous Factor Endowment

The two earlier sections have presented the competitive situation of the firm as that of a competent and aggressive experimenter on an enormous stage with a large audience. There is really no practicable limit to what can be done. Competence has three dimensions; to have a sense for what the audience wants to see, to have the technical competence to carry out the performance, and to spot and understand at an early stage when you have chosen the wrong play. The enormous opportunity set creates uncertainty in the sense that competitors can "enter" in a multitude of unpredictable ways. Competence to compete successfully can only be achieved by active participation in the international market game. Participation makes it possible to understand what competitors are doing, initiating and implementing what they have done as fast as possible and - if possible - to be ahead in the innovative game.

This holds, more or less, for all actors in the markets of industrialized countries. A key notion for successful participation is a broad knowledge of what customers need and are willing to pay for; not only consumers in Burenstam Linder's [1961] sense, but also industrial customers.

This is the nature of the accumulation of industrial knowledge and the transfer of industrial tradition between generations. It is obvious that comparative advantages under such circumstances become endogenous and quite unstable. Developing countries have a decisive handicap in knowledge accumulation from the outset. A nation which cuts itself off from active participation in these markets through protective measures can very rapidly slide into a vicious circle, gradually destroying its industrial knowledge base. Once competitiveness can no longer be based on superior competence to organize factory production or to develop sophisticated products (1), cheap factors of production such as raw materials

production units in a large multinational firm was in fact productivity [Grufman, 1982].

(1) In view of this argument, it is interesting to observe Leamer's [1984] opposite conclusions, namely that physical and human capital reversed their roles as sources of comparative advantage between

and labor (1) is the only way to compete. Having entered a decline phase of economic development, the mature industrial nations appear to be the worst performers when it comes to controlling factor prices in order to achieve competitiveness.

The "tacit" nature of industrial knowledge, important aspects of it being vested with a team or a business organization, makes it wrong to treat it as a well-defined, and freely-movable "disembodied" resource that can be purchased in the international market at a price.

3. Deindustrialization

a. Is There a Deindustrialization Problem?

"Deindustrialization" has become a topic of public concern since the 1970s. As a rule, worries have been focussed on the relative decline in jobs in manufacturing, notably blue-collar jobs. In reality the situation in industrial countries is very different. For one thing, the manufacturing firm has become a major service producer [Pousette, Lindberg, 1985], to an increasing extent drawing on human capital outside the traditional pool of skilled workers. For another thing, the changing organization of manufacturing production means that a growing part of human-capital service production may or may not be carried out within

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1958 and 1975. In 1958, skilled workers were the source, in 1975, physical capital. This contradicts the results of both Ohlsson [1980], Bergholm and Jagrén [1985], and Swedenborg [1979] and of several additional IUI case studies. The problem is probably the one emphasized by Leamer himself, that a theory can only be evaluated with respect to alternative theories, and there is no comprehensive alternative theory to the Heckscher-Ohlin hypothesis yet in sight. Deficient measures of human-capital input in production is another probable source of error, and human capital - at least in the 1960s and 1970s, from which Leamer's data come - tends to be correlated with physical-capital installations. Data after 1975 will probably tell more about the dynamics of a market economy. Aggregate sector data, furthermore, are not so informative in this context.

(1) "Competence" then is of course just another word for a cheap factor input.

the manufacturing firm, or within the same country as the parent company. While a growing portion of technical services has been separated off as independent consulting firms statistically classified as private services, the large manufacturing firms are taking over an increasing part of marketing activities from previously independent agents. In small advanced countries, however, marketing activities of large companies are predominantly in foreign countries. On the whole, while blue-collar jobs in industry seem to be decreasing, total employment in (Swedish) manufacturing industry, abroad and indirectly in subcontracting work, has at least been constant. The problem is not at all a decline in manufacturing size, measured by resource use, but in value-added growth based on an unchanged or even growing resource base. This problem has to do with productivity and the quality of input resources, the most important quality aspect appearing to be the way resources are allocated, recombined and organized.

An inefficient organization of total industrial resources and an inability to adjust the organization ahead of the problems (cf. Figure 1), makes the industrial sector of a country vulnerable to competitive changes in other countries, where firms are more adept or more aggressive in exploiting the international opportunity set. One important question to ask here is whether the local inability of a country to keep up in such an economic race is economical or technological in nature, or is based on an inability of the socio-political system to accommodate change. Whatever the answer, if the ambition is to remain an advanced industrial nation, the long-term solution must be to participate openly in the international industrial market game, not to close off the economy, as has been suggested "[Singh, 1977; Spencer, Brander, 1983; Krugman, 1984].

b. The Destruction of the Industrial Knowledge Base

Deindustrialization may be regarded as one possible phase of industrial progress. Once the analysis takes the factor endowment of an economy as endogenous, the economic security traditionally associated with, for instance, a raw material source becomes illusory. Industrial knowledge has no absolute value. Its economic value depends on the knowledge of competing firms or countries. It becomes normal to expect that, in the long run, economies should lose their positions as relatively advanced "industrial" nations. Over historic time spans, it even becomes unclear what we mean by "industry". Developing countries are trying to develop industrial skills by imitating (learning) skills already developed in the advanced countries. Since prices in the advanced countries are based on the absence of these skills in the underdeveloped countries, returns to capital in such industries in the advanced countries will come down and capital will flow to developing countries in proportion to their success in imitating industrial skills and knowledge.

Industrial knowledge is, however, a very complex asset, its efficiency being dependent upon the way society is organized. It can rarely be hired in a market and it takes many decades to develop (1). Even though technology per se may be developing "successfully", other elements of the total industrial capital structure may deteriorate, resulting in industrial performance of the kind the U.K. economy is currently experiencing. As we concluded earlier, in an operational sense, the exact composition of the appropriate industrial knowledge is unpredictable and not communicable. It is accumulated through active participation in the market process, or through "on the job learning". Hence, a nation's problem of competitiveness cannot be solved through subsidizing "technology" [cf. the opposite argument in Arrow, 1962b] or through protecting targeted firms; the requisite central knowledge base of knowing what to do is absent at the policy level. The only way to accumulate the requisite knowledge is to participate actively in the market game to see which actors come out on top. This is tough politically and socially even for successful actors, and really difficult for those actors who have lagged behind. But competing with low-cost production of simple products with developing nations must be even worse socially for an once advanced and wealthy industrial nation.

However, if technology is changing rapidly among the advanced nations, a new picture again develops. For one thing profit opportunities may return to the industrial nations, reversing again the flow of international

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(1) Cf. the Norwegian transformation problem in Eliasson [1983].

capital away from the developing nations. Certain regions of the U.S. offer examples of this and the "electronics revolution" is often quoted as a technological breakthrough that will return economic initiative and high returns to the already mature industrials.

While this may have serious consequences for developing economies, the same events pose an even greater threat to the mature industrials that have been slack in attending to their industrial knowledge base, because more intensive competition now cuts in at a more advanced level, where they may earlier have been protected from competitive entry by a knowledge barrier. But blocking out such competition is suicidal in the long run because it hinders domestic producers from learning what is going on in the markets and, hence, prevents them from catching up.

4. Industrial Concentration

a. Inevitable or Desirable?

Economies of scale have often been emphasized as a source of industrial productivity. But economies of scale in static, general-equilibrium models - still the main intellectual structure of trade theory - cause concentration tendencies in industry, pose barriers to entry and remove standard equilibrium properties from the model. In general, they cause a lot of analytical trouble in the theoretical structures that underlie welfare analysis.

If economies of scale are the basis for comparative advantages and if economies of scale develop endogenously as a result of continuous, successful accumulation of industrial knowledge, not only problems of analysis occur. The same idea has been used as a rationale for protectionist interventionist policies. By protecting domestic markets from foreign competition, domestic economies of scale and comparative advantages in, say, chips manufacturing are said to develop. Hence, the government should target certain firms for protection until they have invested sufficiently in R&D to have accumulated the competence and built the scale needed to compete successfully in world markets [see e.g. Spencer, Brander, 1983; Krugman, 1984; Grossman, Richardson, 1985; Dixit, 1986]. This argument is similar to the old infant industry argument. In terms of our earlier analysis, it is wrong. It rests too strongly on the notion of the firm as a factory. It neglects the fact that in the modern firm industrial knowledge is created through active participation in a competitive market process and that such knowledge is more related to products than to processes. Without active participation, and without a persistent competitive threat from others, learning does not occur [cf. Business Week, 1986, p. 86].

U.S. antitrust policy is another form of intervention to protect small firms from the cut-throat competition of huge market leaders based on enormous economies of scale. This has never been regarded as a serious problem in small, open economies such as the Swedish or Dutch economies, where large firms always have to be based in foreign markets. Even though the value added of such international firms may be large in comparison with total domestic value added in manufacturing (the value added of global Volvo is more than 10 percent of total value added of Swedish manufacturing), it is still insignificant when compared to world automobile production and hence, unimportant from the point of view of market concentration. As U.S. domestic markets for manufactured products are being increasingly opened up to foreign competition, similar reasoning is beginning to shape also U.S. antitrust policies. In addition, the combination of bounded rationality and the unlimited opportunity set generates enough unanticipated technological competition to check unlimited firm growth through increasing economies of scale.

The efficiency of routinized innovative activities in large business corporations, which was observed by a worried Joseph Schumpeter [1942], was believed by him to be the source of unlimited economies of scale and of concentration that would eventually merge capitalists with the political system, and destroy democracy. Schumpeter formed his notion of the firm as a factory production process. Factory production appears to be of diminishing importance as a source of economies of scale in the advanced industrial nations. There are, however, other kinds of economies of scale that appear to matter in this context. They occur in finance, R&D, and product development, and in marketing, forcing a wedge between economies of scale associated with factory size and economies of scale associated with financial size. If this distinction is not made, we will observe an increasing degree of concentration in most countries by conventional measures and interpret the tendencies erroneously [see Eliasson, 1986b].

Economies of scale in technology, notably product development, coupled with the utilization of economies of scale and market knowledge in marketing and distribution undoubtedly matter for the competitiveness of firms. These will exhibit themselves as endogenously growing comparative advantages in international trade. In the small industrial countries, market investment is measured to a large degree by the extent of foreign subsidiary operations.

b. Vulnerability

The increased size of specialized producers of technologically advanced products for global markets causes new types of policy problems for the small industrial nations. For one thing, firms expand their administrative system across national boundaries and reduce policy autonomy of the national authorities. For another thing, the volume of manufacturing production activity will be concentrated to relatively few, major producers of mature products, the competitiveness of which depends heavily on the constant maintenance and upgrading of their knowledge base. In principle, the problem is similar to that of nations dependent on one, or a few raw material resources. If a major producer fails, the whole country will experience a significant economic problem (1). While the old Swedish engineering firms have succeeded in staying viable competitors for decades [see Eliasson, 1985c], this does not appear to be the general

(1) The ten largest firms in Swedish manufacturing account for: ca. 30 percent of Swedish exports; 47 percent of total manufacturing R&D spending; more than 70 percent of total foreign employment by Swedish manufacturing; and ca. 37 percent of total manufacturing employment (directly and indirectly) in Sweden.

experience in the old industrial nation. Dependence on a unique knowledge capital may increase international dependence in the sense that loss of a unique knowledge position might occur quite fast. On the other hand, the knowledge base of the advanced engineering firms we are talking about is broad. It can be applied to other activities. The ability of some old, large Swedish engineering firms established in the mature markets to "transform" themselves in the wake of the oil crisis in the 1970s is very illustrative in this respect. Skilled labor, in particular, can be used in other firms. And engineering industries basing their competitiveness on advanced product technologies tend to generate new industrial ideas ("the opportunity set") at a rate that one never finds in industrial environments dominated by basic industries, which build their competitive edge on cost-efficient, large-scale manufacturing of simple products.

While economic vulnerability of a developing nation normally falls back on a single, rich raw-material resource, advanced but small industrial nations will necessarily - through specialization - grow increasingly dependent on a specialized knowledge base. In a world economy subjected to rapid technological change, this is a precarious economic situation. The only means of "protection" is through a high savings ratio and an efficient insurance scheme. The most effective insurance scheme probably is the *increased internationalization* of domestic industries *to broaden* the *industrial knowledge base*. This development has occurred endogenously in Sweden and has been in the interest of both firms and their owners, on the one hand, and the country and its inhabitants, on the other. Without its broad knowledge base multinational engineering firms based in international markets would not have been able to replace the "slack" left by contracting basic industries in Sweden in the 1970s as fast as they did. An alternative insurance arrangement discussed in Norway before "vulnerability was realized" through the decrease in oil prices, was the creation of a huge funding arrangement to invest the cashflow from the oil fields in the international capital market (1). Since capital markets and insurance markets are not developed to handle huge and very long-

(1) Or, more adequately, also to create an institutional arrangement to keep public and private consumers off the oil income. See further Eliasson [1983].

term investments or such commitments, this is not really a permanent solution.

Again both the concentration and the vulnerability problem indicate the importance for a country of having a broadly-based innovative activity associated with the expansion of what we have called the international opportunity set. This has clear implications for the ways policies should be designed.

5. Industrial Policies

a. Policy Targeting or Systems Care

The aim of this paper has been to modify the theory of international comparative advantage to incorporate the typical endogeneity of important, knowledge-based factor endowments. The answer to what long-term policies should be appears clear, namely to make sure the industrial knowledge endowment is continuously updated. Since the nature of the future knowledge capital is inherently unpredictable, central targeting for capital accumulation does not appear to be a workable proposition. Large scale industrial policy programs have normally ended as failures [Eliasson, Ysander, 1981; Eliasson, 1984a] and the proposition voiced by many to subsidize innovative activity to preserve innovative output [Arrow, 1962b] appears to be a contradiction in itself [Eliasson, 1986c]. In fact, even large scale public educational programs may no longer appear as self-evident solutions to industrial advance if subjected to careful examination [Eliasson, 1986d]. The open participation in the experimental market game may turn out to be the most efficient industrial learning mechanism society can organize. This is an economic-systems care problem, not a targeting issue, and it is intimately associated with the ways the noneconomic activities of a country are organized.

b. Guidance and Coordination - To Run Industrial Policies through Large Firms

Large business corporations or even whole industrial nations, such as Japan, have often been referred to as examples of successful planning machines. Even if it is true that the knowledge to run these machines is tacit and noncommunicable to central bureaucracies, it should be possible - it has been argued - to combine the industrial knowledge residing in large business organizations with central political targeting, without explicitly centralizing all the knowledge necessary to achieve a complete overview and control [Bray, 1982; Heal, 1973]. After all, this is exactly the method used by large business corporations to coordinate sometimes extremely heterogeneous and complex activities [Eliasson, 1976]. Why not inject new savings resources into these large companies to make them innovate more, but require of them to meet specific social or political targets, in addition to profit objectives [Eliasson, Ysander, 1981]? Such policy suggestions are based on the 1942 Schumpeterian notion of efficient routinized innovative behavior. Indeed, the bulk of innovative activity in industry even appears to be of the routine type [Eliasson, Granstrand, 1982]. However, the whole suggestion is nullified by the nature of the international opportunity set. To run policies through (large) firms means concentrating resources on a smaller number of actors, and hence *restricting the variety of competitive, innovative entry* in markets. Why should a subset of large business organizations represent the variety of all potential new market entrants, when available evidence suggests that the large organizations are the most conservative ones, and that efficiency in innovative activity rather requires the broadest possible variety of market trials.

c. The Creation and Maintenance of a Productive Capitalistic Market Environment

Policy conclusions are always dependent upon the theory or model one adopts to study economic processes. However, when one starts from the notion that economic processes are experimental, ruling out the possibility of efficient central-information processing, the road of advice inevitably leads away from a dominant central influence on basic innovative processes in the economy. The reason is not only that economic action is too complex for deliberate central policy interference to be at all informed, but also requires a stable underlying production structure to be efficient [Eliasson 1984b, pp. 68 f.]. Central knowledge processing is a misconception of what goes on within a firm, that is not informative and definitely not a good guide for policy action.

Optimal long-term policy means organizing the noneconomic factors such that the full potential of the economy can be exploited. This inevitably means organizing the economy to cope with change. A rule system has to be established that determines how costs and benefits associated with economic change are to be distributed, that is also accepted politically.

We concluded earlier that the factory production of simple products appears to be an economic activity subjected to intense competitive pressure in the advanced, high-wage industrial nations. At the same time, the organization of both the political system and the labor market of industrial nations is heavily biased towards the preservation of the "worker culture" associated with earlier industrial technologies. A steady change in that bias will have to take place if the production system is to be efficiently reorganized to cope with future competition. This is one of the noneconomic obstacles to economic change.

The regional consequences of economic change, which for small nations become national problems, is another problem. Knowledge-based industries do not develop in isolated regions. A certain critical knowledge mass, only associated with large cities, possibly related to a viable research environment appears to be needed to achieve the desired, innovative industrial activity. The population of a country sets clear limits as to how many such research environments can develop. So a successful solution to the industrial transformation problem of a national economy is probably going to worsen the regional problem, or at least increase the differences in wealth and knowledge endowment between the growing industrial city regions and the rest of the country.

It would be instructive to study how different nations have developed different choices in this respect. It is also important to understand how the political choice process is organized. A general conclusion seems to be that the countries that have best recognized the experimental nature of the capitalist market process, accepted it politically, and supported its functions, have displayed the best macroeconomic growth performance over the long time spans.

The experimental nature of technological advance means that failure should be a normal and frequent phenomenon. Industrial competence is very much related to spotting and accepting failures early. It is expected that investment money be lost now and then. Mistaken installations represent relatively small losses to the economy as long as one does not insist on carrying out production in them [Eliasson, Lindberg, 1981]. Hence, the perhaps most efficient organizational form is the one product, one division firm that is exposed to rapid failure and exit if it is not on top of the market. The experimental attitude represents the *offensive* side of industrial policies.

Finally, why shouldn't public bodies, like local government or even central government, be allowed to participate in the experimental market process? There are a couple of decisive reasons for not allowing that. Firstly, public bodies as a rule command one huge resource, and hence can make sizable policy mistakes with devastating macroeconomic effects. However, secondly, the most important cause for the public authorities to abstain from experimentation is their inherent inability to spot policy mistakes early, and to close down mistaken ventures fast. This inability is what makes them good democratic institutions, but, at the same time, it turns them into incompetent business organizations. The *defensive* part of industrial policies must be to minimize the delays in the "creative destruction" process at a minimum social cost. In fact, this is a typical efficiency problem.

The moral of this paper can now be summarized. Active experimentation in the markets and a broad-based social willingness to accept the adjustment process caused by frequent decision mistakes are necessary conditions for economic growth. However, experimentation should be strictly kept at the micro-agent level in order to limit the extent of single mistakes.

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CHAPTER III

Information Technology, Capital Structure and the Nature of Technical Change in the Firm

INFORMATION TECHNOLOGY, CAPITAL STRUCTURE AND THE NATURE OF TECHNICAL CHANGE IN THE FIRM

ABSTRACT

This paper presents statistical evidence on:

1) the importance of "soft" capital spending items like marketing and R&D investments, and

2) the dominant service content of production in the modern manufacturing firm.

It pictures the firm as a dominantly information processing entity that has been gradually shifting its competitive base from process cost efficiency toward a product technology. The paper argues:

3) that during the post-war period technical change has been gradually pivoting in a relatively more (hardware) capital saving direction.

The growing service content of manufacturing production consists of various forms of information gathering and using activities, product development, marketing and management being the most important items, using up more than half of the resources in the largest Swedish manufacturing firms. Rather than competing with simple products and lower prices the advanced manufacturing firms are based in sophisticated customer markets and compete with improved product qualities, to a large extent through extensive marketing networks located in foreign countries. Sometimes the information gathering and using activities take place within the administrative framework of the firm and are statistically measured as a manufacturing activity, sometimes the activities are run through separate agents, and are statistically observed as private services. The institutional delimitations are becoming increasingly unstable. (This development suggests that the current concern with the employment consequences of information technology in automation of factory production is a misdirection of attention. Far more significant developments are occurring in other dimensions. It also makes the notion of price elastic

export functions, commonly used in international trade models and macroeconomic models, somewhat suspect.)

I. FROM A PROCESS TOWARD A PRODUCT-BASED INDUSTRIAL TECHNOLOGY

A large body of literature conventionally assumes that technical change has been, and still is, predominantly labour saving. These results come out of standard production function analysis, the bulk of which is from econometric analysis of macro time series data. (This quality of technical change is sometimes thought to have permanent consequences for employment; see Eliasson, 1985c.)

The econometric studies practically always see capital as consisting of machinery and constructions to be used in factories. Occasionally, goods in process inventories are included. The notion of a firm from this (macro-economic) perspective is that of a factory.

The argument in this paper is that this kind of analysis fails to capture the evolution of the modern manufacturing firm. Statistical data as a rule do not exhibit the large "soft" part of investment spending, devoted to product development (almost all R&D), marketing and knowledge accumulation in general. Lacking, or disregarding, this information, we do not understand the change in the nature of technical progress that has taken place gradually, from a process efficiency ("cost cutting") based industry toward a product-based ("value added increasing") industrial technology oriented toward specialised customer markets.

Internal data on production activities in a modern firm used for analysis in several IUI studies suggest that technical change has been gradually shifting in the direction of relatively more capital saving technical change. With "capital" we then mean machinery, constructions and possibly inventories, or the data that usually enter macro production function analysis. New co-ordination and information management techniques work in that direction and the higher share of interest costs in total costs during the 70s has provided an economic incentive to adjust faster to what has been technically feasible.

This change in the nature of capital invested in industry also mirrors a parallel shift in technology in which economies of scale in processing is diminishing in importance, while significant economies of scale in marketing and finance are emerging, forcing the organisation and institutional delimination of the modern firm to change (Eliasson, 1985a, b).

This paper broadens the concept of capital to include all inventories, accounts receivable and all other assets appearing on the active side of a balance sheet, as well as a spectrum of debt categories directly linked to the ongoing production process. This is exactly where capital saving technology is predominantly applied in the non-hardware production process which appears to be a major part of value added creation within a modern business entity.

If the analysis is extended to cover all external, institutionalised information and distribution activities that are directly related to manufacturing goods production and the carrying of the goods to the final users, this conclusion as to technical change would no doubt be further reinforced and the notion of a shrinking "manufacturing sector" in a modern industrial society would most likely be falsified as a statistical artifact, based on badly designed statistical taxonomies.

The point of my argument is that if we continue to stick with the old notion of capital in industry as being machinery and construction capital directly linked to the process side of production, and think that this is all that matters, we are being deceptive to ourselves and our readers.

This paper will present some recent statistical and qualitative evidence on the nature of capital accumulation in Swedish manufacturing to support this view.

II. THE MODERN MANUFACTURING FIRM -- A KNOWLEDGE-USING AND INFORMATION PROCESSING ENTITY

Most of capital invested in a modern manufacturing firm applies to the non-hardware side of production. Take human capital away and the same conclusion probably still holds. Practically all non-hardware capital and much hardware capital (computers being a case in point) are related to the gathering, analysing and use of information in various forms, or information handling in general. The following set of Tables 2 (A to C), derived from Swedish firms, illustrate this. Sweden seems to be one of the few places where such data are systematically gathered (1). The data are neither representative for all Swedish manufacturing firms, nor for average industry in the advanced industrialised countries. However, the data should be indicative of the direction in which manufacturing in advanced industrial nations will eventually be heading.

The basic information technology in the sophisticated fringe of large Swedish firms is devoted to developing the right products and moving the products to the right customers around the world. In the early 80s these firms employed some 50 per cent of the industrial labour force in Sweden. Their product development and marketing competence have been the vehicle for making them competitive during the 70s, thus displacing basic industries to second rank in the hierarchy of size, performance and as competitive exporters. (Table 3 lists all large Swedish companies by size as exporters in 1965, 1978 and 1981) (2). Those firms are of special interest as indicators of the future structure of industry. The tables show that at least half of "measurable" capital spending has been invested in marketing and R&D. The bulk of marketing capital is invested abroad, and even if it is largely of a goodwill nature associated with the development of new markets, it is still "physically" or geographically tied to these markets. R&D capital has largely been invested domestically in Sweden as is also the case with the bulk of process installations.

Marketing and R&D capital are decisive for the competitive situation of the entire corporation. Capital for marketing and R&D defines the unique knowledge base of the firm, and explains whatever profitability that can be derived from process activities. A supplementary indication of this is that practically all statistically measured R&D spending in Swedish industry goes into new product development (see Table 4) and that new product changes usually initiate and carry major productivity advances in ongoing process activities (see section III).

With at least half of capital spending devoted to development and improvement of products for specialised customer-markets and to moving them to these customers across borders, within the internal distribution system of the firm, the bulk of the latter investment being located outside the country, the whole notion of estimating traditional macro export functions and export price elasticities for industrial sectors in advanced OECD countries is becoming increasingly irrelevant.

Since the competitive edge of these firms is only secondarily based on process knowledge one can safely conclude that further investment will shift capital structures in the direction of relatively more non-process, product and market investments, and away from plant and equipment installations. If any part of the entire operation perishes for economic and technical reasons it will be the manufacturing process part. This is already evident from a firm by firm and sector comparison. Hardware intensive firms, producing simple goods and selling them through external traders, like basic industries, iron and metal manufacturing and parts of intermediate goods and heavy engineering industries constitute a relatively declining industrial base. These firms live on process cost performance and cost efficient technology is relatively easy to imitate in, for instance, the newly developed industrial countries. Technical innovative activities are oriented toward process improvements, where the payoffs from R&D spending appear not to be as large as in R&D investments closer to the product. While R&D intensive production seems to be competitive through exports from Sweden, simpler process dependent production, like textiles, seems to be more prone to be allocated abroad, away from a high wage economy like Sweden.

The change in aggregate capital structures thus observed has mainly come about through a generally faster growth of those firms, whose competitive edge was based on new product creation to begin with, rather than on cost efficient production. Technological and market development, however, has made marketing and product development (R&D investment) relatively more profitable than new process installations (Eliasson, Bergholm, Horwitz and Jagrén, 1985). Hence, also within firms, one can observe a shifting in emphasis toward upgrading product qualities through R&D spending and marketing investments. This is typical of the industries in the upper left hand corner of Figure 1.

Swedish manufacturing industry was heavily based on process performance through skilled workers by the late 60s. For instance, internal budgeting and control procedures in Swedish firms appeared to be relatively more biased toward cost and process control than the pronounced product and market orientation of similar management procedures observed in the United States firms (Eliasson, 1976, p. 227). The process-based industries in Western industrialised countries suffered heavily in the post oil crisis years of the 70s. Perhaps as much as 20 per cent of manufacturing capacity in Sweden, almost all of it in the unsophisticated basic industry firms (3) in practice went bankrupt with little advanced notice, and the bulk of remaining industries went into a reshape period. Only some of the already R&D, product and marketing oriented firms weathered the 70s more or less unscathed. Some firms went for process rationalisation of existing lines, with not very successful outcomes. Others pulled ahead, restructuring their organisations, emphasizing product and knowledge-based activities, and closing unsophisticated product lines, emerging, if successful, at the top of Table 3. These reorganisations would probably not have been possible without a prior build up of the necessary knowledge and competence base. To understand the nature of, and the prerequisites for a successful reorganisation of a firm a much more profound and comprehensive knowledge is needed of the interior activities of an industrial firm than economics currently has. This in particular holds for the accumulation and transmission of knowledge within a firm (Item 10 in Table 1).

To serve as a systematic background for understanding the content of ongoing activities within a modern firm, Table 1 lists the important functions. The equation below is a breakdown of costs allocated on the functions in Table 1. They have been used to calculate Table 2B and 2C. The argument above is that the performance of the materials processing function is no longer the critically important one, and will be even less so in the future in the more advanced industrial economies. Non-processing [all other items than (6) in Table 1] activities are mainly oriented toward innovating and co-ordinating the entire business entity. Such stocks of knowledge we do not measure well, but the rough estimates presented in the table suggest that they are sizeable and at least comparable to machinery, equipment and buildings on a reproduction value basis. The co-ordination activities require sizable capital stocks to keep the flow performance of the firm efficient. Ingoing, intermediate and outgoing inventories of the process stage is one well-known example.

Table 1

MAIN OPERATIONAL TASKS OF A LARGE MANUFACTURING FIRM

1. Innovative
2. Internal reorganisation
3. Product development
4. Investment (bank) allocation
5. Commercial bank (cash management)
6. Insurance, risk reduction
7. Materials processing (the hardware function)
8. Purchasing
9. Marketing and distribution
10. Education and knowledge accumulation
11. Welfare and income redistribution.

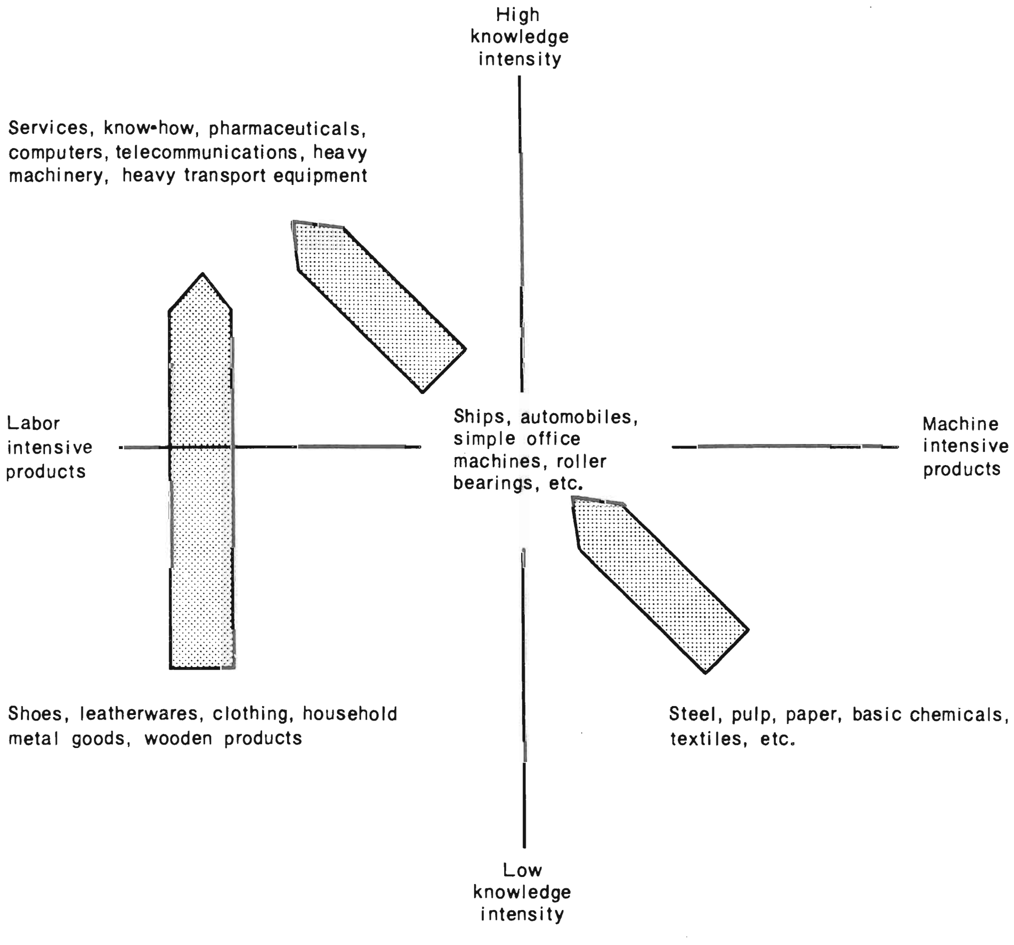
To measure the input content of total value added let us decompose total costs (TC) of a division or a firm into:

$$TC = \sum^{n} w.L + \sum^{n} p^{I}.I + \sum^{n} (r+\rho-\frac{\Delta p^{K}}{p})p^{K}.\bar{K} \qquad (1)$$

n lists the number of tasks or functions (i.e. n = 10 in Table 1).

The first item to the right is labour costs (w = wage, L = labour input). The second item adds up purchases [p^I(= price), times I (= volume)].

Figure 1. **FROM A PROCESS COST EFFICIENT TOWARD A PRODUCT-BASED INDUSTRIAL TECHNOLOGY**



The third item is the standard definition of capital costs associated with each function. The price of the service of a unit of capital is p^K (the price of a unit of capital) multiplied by the sum (within brackets) of the interest rate, the depreciation rate and the change (with negative sign) of the capital goods price index. The latter measures the capital gain on K, which has to be subtracted from the capital service charge.

Define

$\epsilon = R - r$

where R is the nominal rate of return on capital (K) and r is the nominal loan rate. Then the sales value (= S) of the firm can be expressed as

$S = TC + \epsilon . K$

If the return to capacity is equal to the loan rate then $\epsilon = 0$ and total sales equal total costs, if properly measured. From an analytical point of view it is interesting to know how the various functions n (that draw labour, materials and capital costs) contribute to the overall return to capital, measured by ϵ . We argue in this paper that the major contributions to a positive ϵ in the 70s have been R&D spending on product development (item 3) and marketing (item 9) in Table 1. We would also argue that items 1, 2 and 10 have been critical in developing the product and marketing skills although it is close to impossible to pinpoint these activities in statistical terms. In Tables 2B and 2C we have disregarded the ϵ item in dividing total costs, and in Table 2B we have disregarded all costs but labour costs when distributing costs on functions 3, 9 and everything else.

The internal structure of the modern firm is such that each function listed in Table 1 has its own departmental domain well defined within the firm and in its cost account classification. To some extent, most of these "internal" activities can be made both cost and profit responsive. Notably, in small firms the services of many of the non-processing activities are bought in the market. This highlights two important factors in productivity change, namely institutional or organisational change as a result of the changing importance of different activities within the firm. This can also take the form of acquisitions and through exits. We also observe that each of the ten operational tasks and departments has its own capital endowment, that can sometimes be measured and isolated on an investment accrual basis. We can now rephrase our previous argument by saying that much of total factor productivity growth or improved profit performance of a firm can be traced to a changed allocation of resources on the various items in Table 1, (Eliasson, 1985c).

III. FINANCE AND ORGANISATION

Finance in its various manifestations has a much more significant impact on the real side of the behaviour of firms than is generally recognised in the economic theory of the firm, a circumstance that makes it natural to view a firm as a financially defined entity. It is dominated and co-ordinated from the top down by the capital market and the owners, who set rate of return requirements, that also define the outer limits of the firm as an organisation, namely when, on the margin, it begins to attract and/or leak external funds (Eliasson, 1976, p. 256; 1984d).

Table 2A

INVESTMENTS (a) IN THE FIVE AND THE 37 LARGEST SWEDISH MANUFACTURING GROUPS, 1978

Firms have been ranked by foreign employment (percentages)

	The five largest groups		The 37 largest groups	
	All group	Foreign subsidiaries only	All group	Foreign subsidiaries only
R&D	25	10	21	6
Machinery and Buildings	45	41	52	42
Marketing	30	49	27	52
Total	100	100	100	100

(a) Investments in marketing and R&D have been estimated from cost data.

Table 2B

WAGE AND SALARY COSTS IN DIFFERENT SPENDING CATEGORIES IN THE FIVE AND 37 LARGEST SWEDISH GROUPS, 1978 (Percentages)

	The five largest groups		The 37 largest groups	
	All group	Foreign subsidiaries only	All group	Foreign subsidiaries only
R&D	7	3	7	2
Processing and other	63	52	70	58
Marketing and distribution	30	45	23	40
Total	100	100	100	100

Note: We have been unable to separate administrative costs,etc., from production process cost data, and wages and salaries in marketing and distribution are probably underestimated. The "other" item should be in the neighbourhood of 15 per cent of total costs according to preliminary data from an ongoing IUI study.

Source: Eliasson G., De intlandsetablerade företagen och den Svenska ekonomin, Research Report No 26, IUI, Stockholm, 1984.

Table 2C

TOTAL COSTS DISTRIBUTED OVER DIFFERENT ACTIVITIES IN A LARGE SWEDISH ENGINEERING FIRM, 1981 (SWEDISH OPERATIONS ONLY) (Percentages)

1. R&D, design and technical documentation	17
2. Work scheduling	15
3. Production	44
4. Marketing and distribution	9
5. Finance and administration	5
6. Other	10
Total	100

Source: Fries, H., "The Firm, Productivity and the Emerging Technology", in Microeconometrics, IUI Yearbook 1982/83, Stockholm, 1983.

Risk finance and ownership control is usually associated with decisions that fundamentally restructure the organisation of the firm and that appear to be the main vehicle for large and fast advances in productivity. Venture capital is a special form of risk finance. The term is usually associated with new innovative entry activities, often thought of as "high tech" innovative entry (see Granstrand, 1985). The long-run importance of such innovative entry activities for the macro economy appears to be very large. Much more theoretical and empirical research is, however, needed for this working hypothesis to be gainfully used in policy making (Eliasson, 1984a,e). In addition, the bulk of innovative activity seems to take place within the large firms, financed through internal cash flow, which is the quantitatively most important form of risk capital.

In addition to supplying risk finance aiming for long-run economic performance, owners also exercise a short-term cost and rate of return control function. This is operated indirectly through top level management. Either owners sell out (vote with their feet) or apply pressure on, or change top management. Efficient profit control is partly a matter of being informed, partly a matter of taking action on the basis of information. Modern information technology is rapidly increasing the transparency of large corporations for owners and top management in terms of cost and profit performance allowing, as a consequence, more "flat" hierarchical organisations. However, access to information, control and the ability to take effective action fast have much to do with how the firm is organised. Divisionalisation or the organisation of the firm as a group of separate corporate entitities owned and controlled by a financial holding company (the investment company function, item 4 in Table 1) began long ago, but is still in progress.

Table 3

THE LARGEST SWEDISH (MANUFACTURING) EXPORTERS, 1965, 1978 AND 1981

Name of firm	Rank by size of exports 1981	1978	1965	1965 Exports from Sweden in percent of total Swedish goods exports	1965 Percentage of total employment in foreign subsidiaries	1978 Exports from Sweden in percent of total Swedish goods exports	1978 Percentage of total employment in foreign subsidiaries	1981 Exports from Sweden in percent of total Swedish goods exports	Year of establishment	Type of activity
Volvo	1	1	1	5.0	Percentage	9.2	Percentage	10.6	1926	Automobiles, trucks, etc
ASEA	2	4	5	2.6	share for	3.4	share for	5.2	1883	Heavy electrical, robots
Saab-Scania	3	3	13	1.6	group 1-5:	3.8	group 1-5:	4.2	1937/1891	Trucks, automobiles, aircraft
Electrolux (a)	4	6	25	0.8	13.0	2.3	29.3	3.6	1910	Whitewares, etc.
Sandvik	5	5	9	2.2		2.6		2.6	1862	Hardcore metal, tools
Ericsson	6	2	8	2.3	Percentage	4.0	Percentage	2.5	1876	Telecommunications
SCA	7	8	3	3.0	share for	2.1	Share for	2.3	1929	Paper & pulp
Boliden (b)	8	19	18	1.4	group 6-10:	1.2	group 6-10:	1.8	1925	Metal & mining
SKF (a)	9	15	6	2.5	48.8	1.5	31.3	1.6	1907	Ball bearings, etc.
Alfa Laval	10	11	20	1.1		1.6		1.5	1878	Dairy systems, centrifugal equipment
LKAB	11	10	2	4.6		1.8		1.5	1890	Iron ore
Stora Kopparberg	12	14	12	1.7		1.5		1.5	13th cent	Copper mining, steel
Svenska Vary	13	7	-	-		2.1		1.5	(1977)	Shipbuilding
Södra Skogsägarna	14	16	-	0.6		1.5		1.5	1943	Pulp & paper
SSAB	15	13	-	-	Percentage	1.5	Percentage	1.5	(1978)	Pulp & paper
MoDo	16	18	7	2.4	share for	1.3	share for	1.3	1873	Pulp & Paper
Bofors	17	17	21	1.0	group 11-20:	1.3	group 11-20:	1.2	1873	Weapons, steel, electronics
Holmen	18	21	23	1.0	0.9	1.2	2.2	1.2	1609	Paper
Billerud	19	-	19	1.2		(1.0)		1.2	1883	Paper
Papyrus	20	-	-	0.3		0.9		1.1	1895	Paper

a. Including large parts of Facit (1978) and, for 1981, also Gränges.
b. The reason for the large advance of Boliden in the export ranking is partly the rapid increase in relative raw materials prices 1978 to 1981, and partly an increase in trade activities.

Source: Eliasson, G., De utlandsetablerade företagen och den svenska ekonomin, op. cit.

Table 4

ORIENTATION OF R&D INVESTMENTS IN SWEDISH MANUFACTURING, 1981
(Percentages)

1.	On general increases in knowledge	4
2.	On new product	19
3.	On products already in market but new to firm	26
4.	On improvements of existing products	36
5.	On improvements of existing processes	8
6.	On development of new processes	7
	TOTAL	100

Source: Swedish Central Bureau of Statistics, 1984:20.

Finance buffers, furthermore, operate as a risk reducer that makes it possible to plan ahead and to smooth other activities over time, something that has been demonstrated over and over again to be productivity enhancing.

Of course, any firm that cannot efficiently finance its own trade is placed at a disadvantage, when it comes to the planning of production, distribution and marketing. The advantage of a large investment capital becomes even more important when allocating investment and in the carrying out of long-term, risky investment programmes.

In addition to this -- of growing significance because of the high interest rates during the 70s -- large, idle financial balances, that are not profitably invested, are costly. That is one of the reasons why both the investment allocation, the commercial bank and the insurance function have been increasingly internalised and centralised in large firms in an effort to economise on the costs of finance, while preserving financial independence. Arguments resembling these have been used to include a "real balance" variable in macro production function analysis, [for instance Fisher (1974), You (1981)]. In principle, there is a good point here, even though I doubt these are the effects that show up in macroeconometric production function analysis. [Jagrén (1984) demonstrates how productivity on the construction side of the OIII nuclear reactor in Sweden was deliberately lowered to complete the project ahead of schedule in order to reduce total costs and start an income stream earlier. Toward the completion of the project accumulated interest costs were much larger than total construction costs.]

Financial strength on the margin of course also defines the outer limits of the firm seen as a financial entity. If rates of return on some marginal activity within a firm are consistently below the market loan rate or the rate of return on some alternative interior activities, strong pressures build up to sell off or close down that activity, or at least to deprive it of new resources. There are few factors that hold back efficient long-term planning as much as insufficient financial size and strength. It reduces the ability to take on risks. If management knows what it wants, inefficiency breeds if they cannot launch ahead on full scale, but have to take one cautious step at a time. This is particularly emphasized by the shifting of economies of scale during the post-war period, between the items in Table 1, away from factory production toward marketing in particular. The ten largest firms in Table 3 have been devoting a rapidly growing share of their capital spending on international marketing efforts, investments that are extremely risky.

Pratten (1976) reports another intriguing and related result. In his comparison of matched Swedish and British firms he notices that Swedish firms were much smaller in financial size but larger if compared by process/factory scale of operations. Productivity in the latter sense in Swedish firms was much above the same measures in British firms, that also invested less and grew much more slowly, even though they exhibited a somewhat higher return to capital according to the three definitions used. These are data from the late 60s. They do, however, suggest that there may be financial factors at work both on the formation of firms as institutions and on the real, GNP contributing performance of manufacturing activities. Financial durability is critical for longer-term innovative ventures, where a positive cash flow may take years to show. A large and somewhat "over-sized" financial base is therefore instrumental in running a large modern firm efficiently. The larger and more heterogeneous the firm, however, the more complex it is to operate and the more easily internal inefficiencies develop. The firms may simply be too large to be efficiently run, or the technology and competence to run them may be lacking. Rigidities and inefficiencies associated with big corporate bureaucracies have been increasingly discussed in the last decade (Dearden, 1972; Eliasson, 1976; Hayes-Abernathy, 1982). As an introduction to the next section I venture to say that this competence (vested in items 1 through 6 and 10 in Table 1) may be a most fundamental industrial technology that defines the comparative advantages of firms in the advanced OECD nations. The efficient use of information is the critical matter.

IV. TECHNICAL CHANGE IN A MODERN FIRM

From the macro-econometrics of production technology, the residual "after labour and capital", for a long time "explained" most of output growth among the industrialised countries as a measured time trend, or in a "mystic way". Technical change so measured faded away in the 70s (Åberg, 1984). Denison (1967) removed part of the shift by redefining input volumes through ad hoc adjustments for quality. Griliches-Jorgensen removed much of the United States residual in the 50s and the 60s through appropriate adjustments of prices on factor inputs. Why the residual came in the 50s and the 60s and why it went in the 70s, however, still remains a mystery to paraphrase Denison (1979).

When seen from a macro-economic point of view, technical change can occur at roughly three levels of aggregation in the production process, and at a fourth level in terms of the market environment.

Items 3 and 4 separate the firm from its environment, or the market. It is significant in my view that much of the measured productivity improvement at the macro production function level appears to lie in the intersection between 3 and 4, notably between the firm on the one hand, and the capital and equity markets on the other.

Table 5

STAGES OF TECHNICAL CHANGE

1. Process 2. Product (normally establishment level) 3. Management (firm level) 4. Economic policy (macro level).

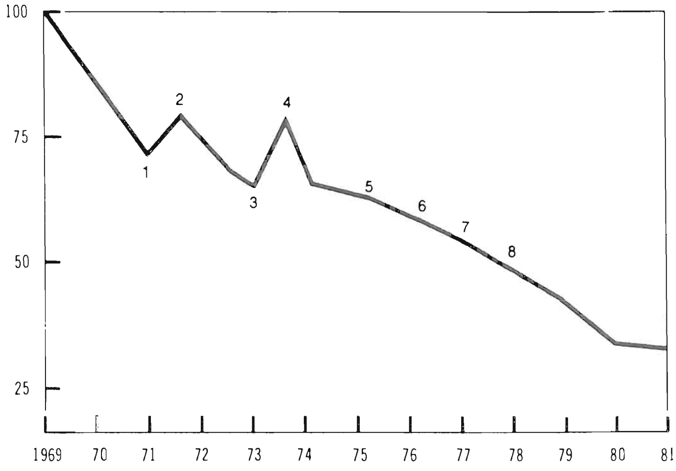
The most widely "acknowledged level" of technical change on the other hand, again, is at the process stage, where process techniques are improved so that the same products can be manufactured by the application of smaller inputs of one, several or all factors, or rather more interesting from the economic point of view, at lower total unit costs. In some industries, notably capital intensive, basic process industries, technical change oriented toward a more cost efficient production of simple products undoubtedly is very important. However, such improvements as a rule occur as a consequence of a redesign of production process flows associated with the installation of new capital goods (new products). In engineering industries, however, technical improvements of existing production lines appear to be the least important of the four types of technological improvement, even though it can be large and rapid at small, well-defined segments of the production process (Figure 2A illustrates this).

Major shifts in productivity at a production line in engineering industries normally occur simultaneously with a redefinition, or a redesign of a product, like a new automobile model, or the high speed printer in Figure 2B. This redesign of the product and a simultaneous redesign of the production line, after the initial shift, often leaves ample scope for further piecemeal improvements. The major initial shift seems to be dependent upon a reorganisation of process activities that have been planned and thought of when designing the product, not necessarily with the installation of new, faster and more sophisticated machinery. The research carried out by the Swedish Computers and Electronics Committee includes many examples of how a reorganisation of existing machines, to obtain a new flow pattern, significantly improved aggregate productivity performance. It is not by accident that recent engineering literature is so occupied with the optimal factory design and that the availability of engineers trained in "systems thinking" has been found to be insufficient in advanced industrial nations.

In fact, improved overview and better co-ordination of the entire factory process appear to be the major simple notion that is extremely conducive to productivity increase in a general sense. I will begin at the production line level and move upwards through the product design and process levels, including also distribution. Finally it will reach stage 3 in Table 5. With regard to the art of holding the firm together financially and optimising productivity performance at that level, non-process equipment begins to dominate and to become a large cost item in total costs. The technological possibility to overview of the entire system can significantly cut stock requirements and significantly increase flow efficiency.

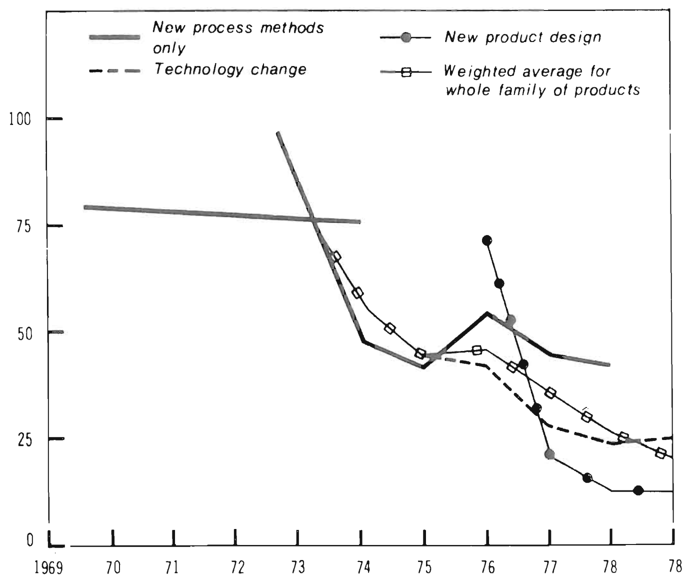
Figure 2. **CHANGE IN PRODUCTIVITY, 1969-81**
Percent

A. LABOUR PRODUCTIVITY IN THE PRODUCTION OF A PARTICULAR PART WHICH REMAINS IDENTICAL OVER TIME



1. Learning phase, hours for supervision and quality control gradually reduced.
2. Subcontractor takes over, new learning phase.
3. Production moved back to own factory.
4. New subcontractor.
5. Pick and place robot installed.
6. Automatic engraving + multiple machine servicing begins.
7. Electrochemical + extra robot, etc.
8. Automatic grading begins.

B. TOTAL FACTOR PRODUCTIVITY FOR A FAMILY OF SOPHISTICATED ENGINEERING PRODUCTS



Note : The figures show the use of factor inputs (labour hours in A and a weighted index of all factors in B) per unit of output. Index = 100 initial year.

Source : Gunnar Eliasson, "Electronics, Economic Growth and Employment – Revolution or Evolution", in Giersch (ed.) *Emerging Technologies, Consequences for Economic Growth, Structural Change and Employment*, Tübingen, 1982.

It is clear from much of the analysis carried out at IUI that the productivity potential of the so-called new information technology lies in making the business organisation more transparent and in the more efficient co-ordination that becomes possible. Improved, central profit control makes it technically possible to decentralise operational decisions and responsibilities (Eliasson, 1984c, Fries, 1984). Improvements begin to show already at the parts production stage where better overview and a faster flow allow savings in inventories at all stages. Positive systems effects, however, expand rapidly from there to financial control at the firm level. Labour saving improvements may dominate at the lower process stages of production (numerically controlled machines, robots), but capital (costs) saving improvements escalate from there on.

Let us begin by seeing a product as a particular constellation of parts. Some parts may be standard parts while others are uniquely fashioned for the particular product. Competitiveness of a product of a particular producer lies in:

i) the manufacture of parts (or purchasing of parts);

ii) the design of the combination of parts (product design);

iii) the design of new parts and new combinations of parts (and new product design);

iv) the assembling of parts to a product.

Competitiveness under i) and iv) is normally based on process cost efficiency, under ii) and iii) on unique human skill endowments. Parts production employs most of the heavy machinery in a firm. (In the extreme case, where a bulk commodity like pulp or steel is the output and little assembling or combinating activity is needed, the entire process can be seen as "parts production".) Numerically guided machine tools, robots and automation (in process industries) have become increasingly important at this stage. The smaller the part the more labour saving such installations appear to be. The longer the parts production process, with several sequences of machine installations like in Figure 2A, or complete automation of a line (see Nilsson, 1981), the more of machine capital saving is achieved through faster flows but also, and more importantly, the more savings on stocks of goods in process are achieved.

It should be remembered, however, that a part in a product, is a product in itself, that may be the main (final) product of a subcontractor (for instance ball bearings in an automobile). The earlier in the production stage the simpler the product as a rule, and the more process-oriented production (steel, parts, automobile) the more of automated processes we find. However, also at this stage major innovative product design activity has been taking place recently. New materials are entering engineering industries making it possible to integrate, or rather cut across several production stages, using different technologies, i.e., to "shape" materials (casting and gluing rather than turning and grinding). It was noted already by Hicks (1977, p. 147 ff) that the basic functions of machine tools used in engineering production are the same as those about 150 years ago. Plastics and composite materials are becoming increasingly superior to steel in standard products and -- above all -- as basic materials, in the new, advancing industries (aircraft, etc). Entirely new tools to cut (for instance lasers) and to form and fasten are used, and costs are coming down rapidly. It is no wonder that the traditional machine tool makers are finding themselves in a competitive squeeze from two ends, new materials and distressed customers. (The frequent worries about robots and distressed machine tool manufacturers by industrial policy authorities may simply be beside the point. It is the combination of new materials and new types of tools that will reshape factory processing of goods in the advanced industrial countries and rapidly shift performance upwards.)

Capital costs increase in relative importance as we approach the later assembly stages of a given combination of parts (a given automobile). Automated equipment is still relatively rare at this stage, but technology is improving fast. The more comprehensive the production process, the more stocks are needed to handle flow interruptions in order to keep up flow speeds. Information techniques, and designs to monitor the production flows to achieve overview of the production line become instrumental in the capital savings process. Hence, what we are observing is the substitution of one form of capital for the other used in the co-ordination of production and all activities of the firm. In the old type of decentralised operations, inventories are needed to prevent flow interruption. Particular designs of flows and feedback adjustments cut stock, and also machine capacity requirements even further. The more in this direction we move, the more of information technology and accumulated human capital is, however, needed to achieve the observable capital savings.

The design and change of the product itself is the third competitive factor, and the decisive one in advanced industries. It is quite resource using in itself (see Tables 2 and 4). Electronics enter into the product, replacing mechanical techniques. Major advances are currently on the way in design (service) production in the form of CAD and (even) CAD/CAM techniques linking parts inventory and parts production directly to product design. This is inventory saving, while labour inputs in the design stage may even increase. The important technical improvements, however, come with the interaction of product design with process organisation and techniques. (In saying so I am thinking more of designing the product with the requirements of the process technique in mind than of actually integrating design work with work preparation and processing. The latter is the idea of CAD/CAM which is still (1985) in its embryonic stages, with few applications outside specific industries like chip manufacturing. The former is probably the major instrument behind currently observed productivity advances.)

Standard parts in the manufacturing of increasingly complex and variable product designs are becoming common. The automobile is a case in point, and the relative competitive superiority of small producers of design-based manufacturing is a double case in point.

CAD technologies coupled with flexible process designs make it possible to achieve more frequent product changes using standard parts all the time and without fundamentally new investments in factory equipment. All this is dominantly capital saving technical change. In addition to this the major advances in total factor productivity performance (see Figure 2B) are normally associated with major product design changes. Robotisation, for instance, to be profitable normally requires a minimum product life. Hence, existing production lines for old products are not automated if the remaining lifelength of the product is short. When a new product is introduced and a new production line designed, new techniques, like robotisation, can normally be planned in advance.

A division or a profit centre of a firm can be seen as a bundle of products of the above type. At this stage the combination of products is truly what matters for competitiveness, and in some firms a division may be buying semi-manufactured products or the whole product, simply applying its own brand label, or maybe adding some design features to the product.

This is the situation in important areas for many of the world's leading firms, notably several in Table 3. The design, marketing, distributing and financing activities increase in importance. Overview, often global overview, becomes important and technical change at this level operates significantly on the capital (stock) requirement side. Global inventory control systems are easily recognisable illustrations of this, where large technological steps forward have already been taken, but these are not necessarily the potentially most important areas.

A firm, finally (we are now reaching stage 3 in Table 5), can be seen as a bundle of divisions. Technology now is almost entirely management or its various forms of co-ordination. We can distinguish between four different categories:

i) Cost control.

ii) Profit control (short term).

iii) Investment allocation (medium term).

iv) Organisational change (long term).

Cost control dominates the interior activities of the firm. Profit control enters at a level of aggregation when the firm opens up to both product and input markets, for instance, the division level. It is normally associated with the budgeting process (see Eliasson, 1976a). In practice, this process is concerned with improving cost performance over a given divisional product structure, eliminating cyclical slack. Hence, budget profit control is closely related to the economists notion of static efficiency. The comprehensive budget process in a large firm means co-ordination through total cost control through the application of advanced, predominantly capital-saving information technology.

The problem of comprehensive profit control of course becomes even more important and difficult at higher decisions levels in the firm. Investment allocation was closely related to the long-term planning process which was very popular during the late 60s. As a formal management procedure, however, it has not been successful (see Eliasson, 1976a). Investment allocation is a typical corporate headquarter task. It means changing the composition of output through remixing a given bundle of products, through the varying of investment. Efficiency, here in the sense of equating the marginal product of capital to some chosen interest rate, is closely associated with the neoclassical notion of dynamic efficiency. Reweighting of output composition has been demonstrated to be a significant factor behind shifts in the macro production function (see Eliasson, 1985c). Again, short-term profit control in the budget appears to be the important information technique currently used in achieving such results.

What I prefer to call Schumpeterian dynamics (see Dahmén, 1984) is dominated by the entrepreneurial, or the capitalist, ownership function. It enters under category 4. This time we are concerned with institutional change or reorganisation within a firm defined as a financial entity (a group, a conglomerate) through entry, exit and internal changes at all levels. (Entry corresponds to the use of new, unique parts in a new product design.) Large step improvements in competitiveness and productivity, as we measure them at the firm level, are normally associated with such internal reorganisations.

This is not the place to present quantitative evidence on such structural changes. Very little, in fact, exists and research in that area has recently been started in IUI. However, a few observations can illustrate this. Over the past seven-year period, for instance, Swedish Match has bought 40 subsidiary companies and sold off 45 companies. Electrolux has acquired ca 325 producing units and sold off ca 30 firms since 1967. This is the kind of structural change that can be observed rather easily. But if one looks deeper into the aggregates a much more lively recombinatorial activity appears. Parts of subsidiaries or divisions are purchased or sold. So far, we have only impressionistic evidence of this, even though IUI is currently doing a detailed study on a group of firms.

These changes are geared to concentrate and reduce the number of activities to a few rather than many knowledge bases and to achieve economies of scale both in product development, marketing and production. Interestingly enough the patterns we have observed point in one direction. Economies of scale in increasingly costly R&D spending require larger and larger volume shipments. To achieve larger volume shipments either new markets have to be developed or -- which is more typical of mature product firms -- market shares have to be increased, notably through increased marketing efforts in customer markets. Investments in marketing are both long term and expensive and increased competitiveness does harm to competitors. Marketing skills draw on a rather homogeneous, product-related knowledge base and a specific, market-dependent knowledge base that relates to many products in that same market. Furthermore, it is often less expensive -- and much faster -- to buy an existing market network than build it from scratch. Hence, one observes firms, in particular in the mature product markets, that expand their administrative control system to internalise also the significant value added created through marketing services, that was earlier often run through independent agents or sales agencies.

At least for Swedish firms, the bulk of foreign direct investments is related directly or indirectly to such extensions of directly (controlled) marketing networks in foreign markets.

Larger volumes bring larger production and economies of scale. Most firms want to concentrate processing of hardware production in a few places. It is typical and most economical for most Swedish multinational companies, as in all activities of any degree of sophistication, requiring skilled or educated workers, to concentrate goods processing to Sweden. Local markets, national trade policies and existing production facilities in purchased companies, however, do not always make this homeward production possible, practical or economical.

However, at the other end, service production at earlier stages of production and R&D development demand a much larger variety of very specialised service activities.

As a rule it is not economical even for large firms to keep all these activities inhouse, at least as long as they are not vital for commercial product innovations or for reasons of commercial secrecy.

Hence, while manufacturing firms are integrating vertically downstream, closer and closer to the final consumer, the need for more and more specialised services at earlier stages of production has been spinning off a varied, institutional fragmentation and specialisation. In countries where taxes are high and labour markets are regulated, the economic incentives for this are also strong, since skilled, specialised and valuable talent normally does not fetch its right remuneration within a large organisation. The employee does not want to take on responsibility for a very expressive and specialised service that is needed now and then. The specialist wants to be compensated at a level comparable to his value for the user of his service. Hence, there is a mutual interest for institutional separation. These tendencies are difficult to measure statistically, but they can be observed to occur abundantly around high-tech industries like electronics. This development will clearly put pressure on the unintentional welfare and income redistribution arrangements that have always been typical within large "teams", like large factory installations. With high productivity "workers" separated off in self-employment or small consulting firms the remaining factory operation will lose some of its potential internal generosity.

It is clear that the organisational and internal institutional changes that we are discussing are decided at the very top of companies, at the highest executive level, at the board of directors and by the dominant owners.

Very little systematic research on the importance of the capitalist ownership function has been published. IUI has recently began a large scale project with this intention.

As it emerges from our analysis the major advances of productivity at the firm level seem to be associated with structural changes of the kind mentioned at the product and higher levels that are closely linked to the ownership function of a firm where risk finance and industrial competence enter a form of symbiosis. The next important step in the shifting of the macro production function appears to be the capital market allocation function between firms.

Technical change currently appears to be working against traditional economies of scale in factory production while, at the same time, an often neglected scale function has been on the advance for decades, and increasingly so during the disorderly 70s (see Eliasson, Sharefkin, Ysander, 1983), i.e., financial scale, financial risk reduction being the key factor at work. Figure 3 summarises these tendencies.

In the first place, the international market environment has become increasingly less predictable.

Secondly, product technologies and continuous innovative product change have become key competitive edges for the advanced manufacturing firm.

Figure 3

TENDENCIES

From cost efficient production of simple goods toward a product-based industrial technology

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1. Uncertainty up and predictability down in the international business environment.

2. Product technology is becoming relatively more important for competitiveness than cost efficiency.

3. Products are characterised by:

   -- more complex technology and design;
   -- longer development periods;
   -- larger development costs;
   -- larger demand for risk capital;
   -- shorter life lengths; and hence,
   -- higher risks.

4. Competing technological development and higher business uncertainty together places a premium (ceteris paribus) on financial size.

New products, however, are characterised by longer gestation periods, larger development costs, larger requirements of internal risk finance. But once in the market product life cycles have shortened.

Together, this means a higher level of risk taking on the part of the firm. Disorderly market behaviour and reduced environmental predictability mean that the larger financial commitments receive a premium. Risks can be spread over a larger number of activities, and most importantly by concentrating cash flows from many operations to one point at a time. The financing of high risk product developments can be internalised.

However, the larger and the more heterogeneous the financial organisations under which all these activities are gathered, the more complex and the more information demanding the task of managing the system. This becomes obvious when we look again at for instance, Electrolux Corporation, headquartered in Stockholm, with approximately 89 000 employees, approximately 270 subsidiaries and operating in approximately 50 countries. The typical characteristics of such a company is that top level management has far from complete knowledge of what goes on below them. This is particularly true for how things are done. On the other hand, the top managerial staff of a well managed large company has a clear view of its objectives and a quite clear view of what, in terms of performance, can be demanded of the various subsidiary operations of the company.

The top level is to set the right targets and to devise a reliable reporting and control system against these targets. Targets have to be close to what is feasible; only slightly above, to be taken seriously and to stimulate increased efforts. But if targets are set too low, performance invariably adjusts downwards. The art of remote control and guidance of a large business organisation affects productivity performance of the entire organisation and clearly is a matter of how to design an efficient information system (4).

There is a trend toward the delegation of operations (how to do things) and increased centralised control (what to do). This is exactly the opposite to automation which involves centralising process knowledge (how) in enough detail to run a production process centrally. This orientation of modern business information and management systems also runs contrary to the "old" idea of scientific management, which was based on the naive idea of centralised management. The reason for the the changed orientation was the clash with reality. Complexity of top management decisions and built-in inconsistencies (see Table 1) between various functions make centralised management techniques impracticable.

Table 6 illustrates that important parts of key elements of operations knowledge simply are not available at the top. The resolution of top level routine access to information rarely goes below the product group level [item (3) in Table 6] and the reasons are entirely practical, namely costs of designing and updating the database.

V. WHY IS TECHNICAL CHANGE SHIFTING IN A CAPITAL SAVING DIRECTION?

A typical development of the modern firm that accompanied the post-war advancement of industrial technology in the Western world, has been the increased emphasis on product technology and a relative decrease in the importance of process techniques and cost efficiency as a basis for competitiveness. This development is witnessed by the emerging importance of engineering industries, while basic industries have been in relative decline. The relative growth of a white-collar, educated labour force in manufacturing tells a similar story.

Perhaps even more important in a future perspective is the so far neglected emergence of service production and information handling as the dominant production activity of a manufacturing firm. It is often more important to know how to design the product and the production process and to know where the right customers are, than to manufacture the product. A consequence of this has been a rapid institutional change -- also in typically non-manufacturing sectors -- and a growing dependence of the manufacturing firm on human knowledge and skills.

A side effect of this development has been a rapid deterioration in the quality and relevance of official statistics, that so far has not been adequately taken into account in economic analysis. Above all, the delimitations of statistically defined sectors have become shifty and dependent upon the organisation of firms. With a signficiant part of total resources in manufacturing devoted to service production that can be administered within the firm as a manufacturing activity or in a separate

Table 6

ORGANISATIONAL AND INFORMATION HIERARCHIES IN A LARGE FIRM

Level of Aggregation (1)	Organisational Unit (2)	Activity (3)	Objective (Criterion) (4)	Database (Measurement System) (5)	Market Contract (a) (6)
1.	Group	Financial guidance and control	Return to equity	Profit and loss statement and balance sheet	I, L, P, K
2A.	Division	Financial & profit control	Return to total capital	Profit and loss statement and partial balance sheet	I, L, P
2B.	Subsidiary	Profit control	Return to total	Ditto	I, L, P
3.	Product Group	Factory Production	Profit margin	Profit and loss statement	I, L, P
4.	Product	Process	Sum of cost elements	Cost accounts	I, L
5.	Component (part)	Process-stage	Cost element	Cost accounts	I, L

a) I = Market for components, etc. (purchasing).
L = Labour market (hiring).
P = Product market (selling).
K = Credit market (borrowing).

Source: Eliasson, 1984c.

business unit (a consulting firm, a distribution or a sales agent, a firm devoted to technological innovative development work, etc.) statistically classified as private service, the information content of official national accounts statistics is on the decline. A traditional economic analysis of standard aggregates may make us believe in "de-industrialisation", while a careful analysis may suggest that this is all nonsense.

Industrial technology will probably push further in the direction of using relatively less hardware than software capital. And at least to judge from Swedish experience, the locus of manufacturing competence has already shifted toward product technology, where most of R&D spending goes, and marketing and distribution, which also -- in fact -- means a broadening of the product concept. The enhanced product orientation has already demonstrated itself in:

i) more diversity and complexity in product offerings;

ii) longer product gestation periods;

iii) shorter product life cycles;

iv) that successful manufacturing firms have their base in competitive customer markets in advanced industrial economies.

A direct consequence of the growing product orientation of manufacturing industry and the longer gestation period between product initiation and final delivery is:

i) The growing importance in total value added of service production of various kinds and the increasing share of both;

ii) Information and transaction costs;

iii) Capital costs in total costs.

The accumulation and application of information is a common denominator of those activities. The development of a new product, preparing for its production, perhaps in a different country, making it known to customers, marketing it, distributing it and servicing it, etc., are all reflections of the increased role of information use in manufacturing production.

These activities are not hardware capital intensive. They are based on people and human skills (5). This development, however, at the same time increases the total risk exposure of the entire business entity. It takes longer before investments begin to generate a positive cash flow, and if mistakes are made, product lives in the market will be short and the whole firm may be in jeopardy. Such technical, commercial and market risks are normally carried within the company as a financial unit and by the owners, risk carrying being an important production activity of the modern firm. The increased exposure has already induced, and will continue to induce, the formation of larger multiproduct, multinational firms seen as financial units, that can absorb greater mistakes internally.

We have already observed from a number of studies that better co-ordination of factory processes and distribution networks has been a typical capital-saving technology based on new information techniques. This above mentioned development, hence, means that these monitoring and control techniques are now becoming even more important in co-ordinating the entire set of activities in even larger business units.

Better co-ordination of the entire organisation means a faster flow of products (cf. global inventory control) and is a typical capital-saving technological change.

VI. SUMMING UP

This paper does not present a strict econometric test of some well-defined hypotheses. We have rather brought together a wealth of scattered facts. This fragmented evidence has been merged with some reasonable guesswork into a rather complex working hypothesis about the nature of, and change in technological progress in modern manufacturing industries. The following five statements make up our main conclusions.

First, total factor productivity as observed at sector or macro levels is mainly economic in nature, rather than technical; the dynamics of allocation of resources within firms ("management") and through markets, between firms being the vehicle for advance.

Second, the focus of technical change, and the application of R&D spending are shifting from achievement of cost efficient processing towards product quality upgrading. This shifting of emphasis reflects the orientation towards customer markets and large and elaborate resource applications in marketing.

Third, points 1 and 2 highlight the modern manufacturing firm as a predominant "information processor". Exploiting new, emerging technologies for sophisticated product designs and intense marketing to find the right "paying" customers globally is a more profitable focussing of resource use than efficient production of simple hardware. The not very successful idea of a world car compared with the successful performance of specialised, customer-oriented automobile designs is a good example. This development will probably knit the advanced industrial OECD nations together economically even more, further alienating the group from the not so developed economies.

Fourth, this shifting of activities from hardware processing towards various forms of information processing appears to be pivoting the nature of technical change in a relatively more capital saving direction than was earlier the case.

Fifth, finally, even though the service content of manufacturing production may dominate, the services are still linked to a product that can be traded (Lindberg-Pousette, 1985). The changing nature of manufacturing production and institutional reorganisation brought about by both technological advance and other economic factors are blurring our statistical observation instruments. We may wrongly believe that we are observing a process of "de-industrialisation".

A proper scientific foundation of these results requires much more empirical research. The evidence so far accumulated suggests that industrial policy-makers should take careful note of this movement of the industrial locus away from blue-collar factory production.

NOTES AND REFERENCES

1. At the Industrial Institute for Economic and Social research (IUI) as part of the database project associated with the micro-to-macro model project (see Eliasson, 1978, 1984; Lindberg-Pousette, 1985) codenamed MOSES Database.

2. A supplementary conclusion of this paper is that the existence of this technology washes away the importance for medium-term employment of the crisis industries (accounting for more than 10 per cent of manufacturing employment in the mid-70s) and the enormous industrial subsidies during the crisis years of the 70s, spent to save employment. In the longer term, the effects of these subsidies appear insignificant or perhaps even worthless. I would even argue for a sizeable negative value, since industrial subsidies probably stimulated substantial domestic factor cost overshooting and retarded output growth in the frontier firms: see Eliasson-Lindberg, 1981; Eliasson, 1984; and Carlsson-Bergholm-Lindberg, 1982.

3. This figure comes on top of a normal share of distressed industries. See Chapter 10, Section 6.6 in Eliasson-Carlsson-Ysander et al, 1979.

4. See again Eliasson, 1976, on MIP targetting (op.cit., pp. 236 ff., 258 ff.). MIP targetting characterises the firm in the micro-to-macro model used for simulation experiments in Eliasson, 1985c.

5. Information processing has also become more hardware intensive (see Barras' paper), for the simple reason that computers are replacing clerks with pens at desks.

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CHAPTER IV

Dynamic Micro–Macro Market Co–ordination, Technical Change and Trade

Dynamic Micro-Macro Market Co-ordination, Technical Change and Trade

ABSTRACT

This paper discusses the nature of macro productivity change from the perspective of a Schumpeterian micro-to-macro (M-M) model. It emphasizes the dynamics of resource allocation through markets (firms) where agents are both price and quantity setters. We find that the organisation of market processes (the market regime) is important for the rate of total factor productivity change at aggregate levels. This is especially so when relative prices shift as a consequence of the ongoing market process, and markets, notably the capital markets, are in disequilibrium.

Illustrative simulations on the M-M model of the Swedish economy are presented. The effects of shifts in the nature of technical change from a labour saving toward a capital saving bias are investigated in a semi-closed economy and in a fully open economy. In the latter exports adjust to the relative profitability of foreign and domestic deliveries and price transmission across borders occurs. We find that the allocation effects of effective exploitation of technical change through international specialisation matter significantly for productivity growth. If the economy is kept semi-closed the same (exogenous) technical advance generates significantly smaller productivity expansion. The analysis suggests that the "mystic" residual shift factor in macro production function analysis that persisted for such a long time and then disappeared in a "mystic" way may partly or wholly be explained by a shift into a different "market regime" in the 70s.

In all scenarios reasonable price and quantity flexibility prevent long-term technological unemployment from occurring. A change in the bias of technical change makes little difference.

1. Dieter Kimbel at OECD, Paul Stoneman at Warwick University and Ken Hanson, Thomas Lindberg, Erik Mellander and Tomas Nordström at IUI have been very helpful in commenting upon and suggesting improvements in earlier drafts of this manuscript. All remaining errors are, however, entirely of my own making.

1. THE MICRO DYNAMICS OF ALLOCATION -- INTRODUCTION

Economic theory lacks a comprehensive theory of dynamic market processes. Received theory analyses how existing resources are allocated among existing economic structures in a one period context and with exogenously given prices. The interesting problem is how markets influence the behaviour of both prices and quantities over time. According to the structure and the adjustment process characterising a market regime, relative prices are derived which bias the rate and direction of capital investment. We are interested in this latter influence of changing relative prices in a disequilibrium market adjustment process upon the allocation of capital and the production decisions. Such a dynamic economic framework is necessary to analyse a macroeconomic growth process.

Shifts in the macro production function has long been the key notion of technical change in economic growth. Empirical enquiries into the nature of this macroeconomic shift leave most of the growth generating factors to be explained as a mystic residual, to paraphrase Denison. The residual is either represented by an exogenous trend, or by exogenous quality improvement in factors of production.

In my first paper (E 1985b)[1] I investigated the nature of accumulated capital. I found that much capital accumulation -- and probably the most important part -- was of a "soft", non-process oriented kind. This finding led me to express doubts about the usefulness of the traditional macro production function analysis.

In this paper we study the quantitative importance of the allocation of capital through a dynamic market process. We abstract from the non-process capital and concentrate on the hardware factory production capital. We do, however, apply two observations from the earlier paper. The first observation is the tendency toward a relatively more capital saving technological change. The second observation is that R & D spending, an "investment" charged on current account, drives this shift in technological change. In addition the average character of capital installed is changing through the exit of obsolete activities. We study the implications of this observation in a micro-based macro (M-M) model of the Swedish economy.

We carry on the analysis in three steps. First, we present a simple, semi-analytical version of the model where the rates of return and the capital market interaction of individual firms are made analytically explicit and related to the components of total factor productivity change. We draw on earlier empirical studies with the M-M model to clarify the mechanisms of the market system.

Second (in Section 5), we carry out one set of simulation experiments where technical change is pivoted in a relatively more capital saving direction. In those experiments domestic markets are kept partly isolated from foreign markets (through exogenisation of exports), thus depriving the firms in the economy of the possibilities of exploiting their technical advantages through international specialisation. We then make domestic and international markets fully interactive.

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[1] Chapter III in this book.

We finally conclude with a section on policy-making in the non-equilibrium market environment that we investigate.

In attempting to explain total factor productivity growth we have applied micro simulation analysis with the M-M model of the Swedish economy. In the M-M model analysis, relevant factor and product prices are endogenised and dependent on the factor and investment allocation process itself. There is a feedback relationship between relative prices and capital investment which determines the dynamic patterns of output growth.

The hypothesis is that the dynamics of relative price adjustment matters significantly as an explanation of residual total factor productivity (TFP) change at industry levels. At least 50 per cent of measured growth in all industry TFP appears to originate in the market induced resource allocation between firms and between divisions (or profit centres) in large firms. Hence, variations in market conditions, pure technical change at the micro level held constant, significantly influence long-term economic growth. (Fifty year macroeconomic growth trajectories differing by 1 or 2 per cent per annum have, in fact, been generated by simply manipulating the market conditions and adjustment speed determining parameters of the M-M model.)

The M-M approach makes the dynamic market processes the moving force behind the rate of change in total factor productivity at the macro level. Manipulation of market regime controlling parameters can eliminate the macro growth effects of pure technical change at the micro level, or enhance them. Pure technical change at the micro level sets the upper limits at each point in time for what can be achieved at the macro level through efficient economising and, hence, is a necessary (and as a rule internationally available) condition. Given the technical parameters of the model and prices, maximum outputs could be calculated over a period. However, even though this would be the technical maximum of a static optimisation exercise, it will never be reached, since the closer to the "technical optimum" you get, the stronger and speedier multi-market price feedbacks from further quantity approaches to the technical optimum, and the more jittery prices, and the less predictable both short-term and long-term price development. Reduced predictability and increased economic uncertainty moves the economy away from the technical optimum.

Hence, total factor productivity change or the "technical residual" seems to be a typically economic phenomenon. As a consequence, this paper also underscores the detrimental effects on economic growth of a disturbed or unpredictable market price system.

2. MARKET REGIME AND TOTAL FACTOR PRODUCTIVITY GROWTH

a) Technological and Market Regimes -- the Problem

Three aspects of the macroeconomic process have to be made explicit to understand the nature of dynamic resource allocation and the economic growth process.

1) Technology;

2) Macro demand management;

3) Market regime.

Technology is decisive for long-run cost developments. The marginally best producers in an economy bring market prices down toward their marginal costs through competition.

Macro demand management is the Keynesian, income generated, demand feedback loop in a macroeconomy, through which the public sector may exercise its influence via intervention in both the income formation process (taxes), demand formation (government spending) and price formation (regulation). The market regime defines all other characteristics of the economy, institutional facts, the rules of the market game, and above all, the adjustment speeds of various actors to economic stimuli, notably prices.

The public sector through its legislative power exercises an influence on the market regime.

It is clear from this presentation that to discriminate between the impact on total factor productivity change of the market and of technology is not all that easy.

The macro demand feedback influences the short-term cyclical efficiency characteristics of the economy. Market regime together with the cyclical factors determine the long-run equilibrium characteristics of the economy. In the simulation experiments on the M-M model of the Swedish economy to follow, the nature of the divergence between long-run technology dependent costs and prices will be seen to be decisive for economic growth. In fact, we will find that technology, productivity and costs -- as the latter determine long-run price developments -- cannot be studied separately from the price mechanism itself.

In this paper we will attempt a complete micro-macro approach to the determinants of technical change and growth in which the dynamic market process and technical change are interdependent.

Of course, as one moves up in levels of aggregation eventually everything will have to be endogenously determined. We stop at the Swedish national borders. We make the doubtful assumption that the world is in long-run price-cost equilibrium. This assumption is implemented by adjusting exogenous foreign prices, the foreign interest rate and internationally available technology (best practice plants) in such a fashion that investments in such plants operating at full (normal) capacity will earn a return to investment equal to the foreign interest. While the world is continously in perfect equilibrium we study the dynamics and growth of a domestic M-M economy that is dynamically interacting with this "calibrated" world economy.

We investigate the effects of a) faster and slower rates of labour saving technical change through endogenous investments in existing firms (using different assumptions on the speed of agent responses in the markets) and b) a more or less open economy. Technical change takes place in one firm, in one sector, or throughout the entire industry, or abroad only. We shift the character of technical change from a labour saving bias toward a technical saving bias (relative to a reference case).

We will begin by briefly outlining the model, and making the capital market interaction and total factor productivity change explicit and related.

b) The M-M Model Economy (1)

<u>Model Overview</u> (2)

The M-M model is oriented mainly toward analysing industrial growth. Therefore, the manufacturing sector is the most detailed in the model. Manufacturing is divided into four industries (raw material processing, semi-manufactures, durable goods manufacturing, and manufacture of consumer non-durables). Each industry consists of a number of firms, some of which are real (with data supplied mainly through an annual survey) and some of which are synthetic. Together, the synthetic firms in each industry make up the differences between the consolidated real firms and the industry totals in the national accounts. The 150 real firms in the model cover 70-75 per cent of industrial employment and production in the base year, 1976. The model is based on a quarterly time specification.

Firms in the model constitute short and long-run planning systems for production and investment. Each quarter they decide on their desired production, employment and investment. Armed with these plans they go into the labour market where their employment plans confront those of other firms as well as labour supply. The labour force is treated as homogeneous in the model, i.e. labour is recruited from a common "pool". However, labour can also be recruited from other firms. This process determines the wage level, which is thus endogenous in the model. Even though the labour market is homogeneous, wages vary among both firms and industries without any tendency to converge. Since the labour market is only subdivided into industries, not regions, mobility in the labour market is probably overestimated. This is important in interpreting the results.

The micro-to-macro model features an endogenous firm exit device. It is activated when net worth of a firm goes below a certain minimum level in per cent of total assets (bankruptcy) and/or when the firm runs out of cash (liquidity crisis). The firm, of course, gradually fades away through lack of investment if its cash flow diminishes and if it cannot borrow in the capital market at the going interest rate.

Domestic product prices and the production volume in the four product markets are determined through a similar process. The export volume is determined endogenously in the following way.

Each quarter the firms determine their production volume in two steps. First, they determine their desired production volume, taking into account desired changes in their inventories of finished goods, based on their expected total sales (including exports) which are in turn based on the firms' historical experience. This first production plan is revised by the firms with regard to profit targets, capacity utilisation, and the expected labour market situation. After this revision, the production plan is executed. The production volume is distributed to the export and domestic markets according to an export share, which is dependent on that for the previous quarter, but which also depends on the difference during the previous quarter between the export price and the domestic price. If this export price (which is exogenous) was higher than the domestic price, the firms try to increase their export share during the present quarter. However, the adjustment takes place over several quarters, not instantly. If the export price is lower than the domestic price, the firms do not try to lower their export share but rather maintain it at a constant level. In spite of this asymmetry concerning the effect of positive or negative price differences between exports and the domestic market, it turns out that the export shares in the various markets can both increase and decrease. This depends on whether firms with high export shares fare better or worse than other firms in the market. The import share in the four markets is also determined by the difference between the export and domestic prices with a certain time delay. High domestic prices relative to foreign prices lead to increasing import shares.

There is also a capital market in the model where firms compete for investment resources and where the rate of interest is determined. However, in the present runs the rate of interest has been determined exogenously. At this given interest rate firms invest as much as they find it profitable to invest, given their profit targets.

Public sector employment is determined exogenously, and the rate of wage increase in the public sector has been set equal to the average wage change in manufacturing, preserving the relative, average salary and wage differential between the two sectors.

The exogenous variables (besides government policies) which drive the model are the rate of technical change (which is specific to each sector and raises the labour productivity associated with new, best practice investment in each firm), the rate of change of prices in the export markets, and the labour supply.

In contrast to most econometric macro models, domestic prices and wages are determined endogenously in MOSES. These in turn influence the firms' profits and therefore their production plans, the allocation of sales to the domestic and export markets, their investments, and therefore their productivity. This is the main mechanism through which resource allocation is determined in the model. These features make the model especially suited for analysing the effects of policy measures, which can be expected to influence the expectations and plans of firms and which influence the development of prices and wages. The advantage of a micro-based simulation model is, that one can introduce various policy measures affecting individual firms, rather than industries, and analyse the effects. In a more traditional macro model one is usually forced to make assumptions regarding the resource allocation effects, i.e. one has to assume a large portion of the results.

Profits and the Allocation of Capital in the M-M Economy

To outline the capital market dynamics of the M-M economy we derive the profit targetting and profit monitoring formulae used for both production and investment decisions. It guides the firm in its gradient search for a rate of return in excess of the market loan rate. To derive these formulae we decompose total costs of a business firm, over a one year planning horizon, into:

$$TC = wL + p^{I} \cdot I + (r + \rho - \frac{\Delta p^{k}}{p^{k}})\, p^{k} \cdot \bar{K} \qquad (1)$$

w = wage cost per unit of L

L = unit of labour input

p^{I} = input price (other than w and p^{k}) per unit of I

I = units of input

r = interest rate

= depreciation factor on $K = p^{k}\,\bar{K}$

p^{k} = capital goods price, market or cost

$\bar{K}$ = units of capital installed

In principle the various factors (L, I, $\bar{K}$) <u>within</u> a firm can be organised differently, yet achieve the same total output (3). Depending upon the nature of this allocation the firm experiences higher or lower capital and labour productivity, as defined and measured below. In what follows we investigate the capital-labour mix as it is achieved through the dynamic market allocation of resources <u>between</u> firms.

The firm is selling a volume of products ($\bar{S}$) at a price p^{x} ($S = p^{x}.\bar{S}$) so that there is a surplus revenue, ϵ , over costs, or profit:

$$\epsilon = p^{*}.\bar{S} - TC \qquad (2)$$

The profit per unit of capital is the rate of return (4) on capital in excess of the loan rate:

$$\frac{\epsilon}{K} = R^{N} - r \qquad (3)$$

In this formal exercise K has been valued at current reproduction costs, meaning that ϵ/K expresses a real, excess return over the loan rate, but that r is a nominal interest rate.

In the MOSES M-M model firm owners and top management control the firm by applying targets on R^{EN}, the return on equity-capital. This is the same as saying that they apply profit targets in terms of ϵ . Hence, we have established a direct connection between the goal (target) structure of the firm and its operating characteristics in terms of its various cost items.

Using (1), (2), and (3) the fundamental control function of a MOSES firm then can be derived as (5):

$$R^{EN} = M.\alpha - \rho + \frac{p^k}{p^k} + \varepsilon \cdot \Phi = R^N + \varepsilon \circ \Phi \qquad (4)$$

$$M = 1 - \frac{w}{p^x} \cdot \frac{1}{\beta} \qquad (5)$$

M = the gross profit margin, i.e., value added less wage costs in per cent of S

R^{EN} = $(P*\bar{S}-TC)/E$ the nominal return to net worth (E = K-debt)

α = $\bar{S}/\bar{K}$

β = $\bar{S}/L$

Φ = Debt/E = K-E/E

ε = $(R^N-r)K$

Management of the firm delegates responsibility over the operating departments through (4) and appropriate short-term targets on M (production control) and long-term targets on ε, that control the investment decision.

defines the contribution to overall firm profit performance from the financing department.

At any given set of expectations on (w, p^x) in (4) determined through individual firm adaptive error_learning functions, a target on M means a labour productivity target on $\bar{S}/L$. Hence, the profit margin can be viewed as a price weighted and "inverted" labour productivity measure.

The of an individual firm is generated through innovative technical improvements at the firm level (Schumpeterian innovative rents) that constitute Wicksellian type capital market disequilibria defined at the micro level. The drives the rate of investment spending of the individual firm. The standard notion of a capital market equilibrium is that of all $\varepsilon_i=0$.

A new investment vintage can be regarded as a "new firm" with exogenous capital productivity (α = $\bar{S}/\bar{K}$) and labour productivity (β = S/L) characteristics. A new investment can be seen as a new vintage of capital with its particular (α, β, ρ) characteristics in the profit control function (4) that mixes with existing capital installations in existing firms (6).

Actual prices (p^x, p^I, p^k, w, r), which are distinguished from those expected by a firm in planning, are determined through the dynamic interaction of all agents in product, labour and capital markets (7).

Foreign prices in the four manufacturing product markets, technical change in new investment vintages and the foreign interest rate are set exogenously.

Firms set prices and quantities and compete freely in all markets, thereby taking Schumpeterian innovative rents away for each other through competition, if they cannot be maintained through some innovative process, that generates new ε:s all the time. Part of competition takes place in the capital market, where high ε performers attract relatively more funds than low performers. This process can be said to be a long-term micro version of Wicksell's (1898) "cumulative process".

A firm exits permanently when it has suffered losses to the extent that its net worth $E \leq 0$. Firms also compete with each other and with other sectors for a given pool of labour. In the process individual firm wage levels and unemployment are determined and labour is distributed over firms. There is a similar short-term production and product price determining market mechanism. This more or less outlines the capital market dynamics of the MOSES M-M model. The dynamically ordered micro market economy that we are investigating is an economic system "with memory" which makes all states achieved "path dependent". [A system like this possesses an equilibrium if and only if all feasible future paths can be foreseen and the best chosen. This, however, requires an objective (welfare) function, that translates all feasible futures into the present, or that the capital market stays in equilibrium all the time. A capital market in equilibrium with all $\varepsilon_i=0$, however, reduces the choice, at best, to (see below) a no growth economy.

When "monopolistic competition" is a natural market regime characteristic, and prices and quantities are set in an interactive fashion as a part of an ongoing market process, a number of questions arise as to the nature of macro productivity change, and especially the relationship between profitability and total factor productivity growth. These will now be investigated.

c) The Derivation of Changes in Total Factor Productivity

The change in total factor productivity (TFP) is defined as the shift factor in a macro production function. Its behaviour at the macro level has been studied extensively. In this paragraph we define TFP in terms of the profit control function of a firm in the Swedish M-M model. In the next section we carry on certain simulations to study the behaviour of TFP under various assumptions as to technical change that enter as changes in the productivity parameters (α, β) in (4) and (5) of new investment vintages (8).

This section is theoretical. The next section is empirical in the sense that the same problem -- the effects on output and productivity of the dynamics of factor allocation -- is investigated on the M-M model of the Swedish economy. This section aims at introducing the dynamics of the model in the sense of neoclassical macro production function analysis. Before we do that a few explanatory words of why we do it are needed. The heart of the matter is that a model based on exogenous prices and equilibrium conditions -- to my mind -- gives an erroneous representation of macro production activity and productivity change. It is not even an acceptable approximation in this context because there is no room for the dynamic long-run productivity effects of price-quantity interaction over time. Since the macro production function passes standard econometric tests on its own merits the only way to challenge it is to present an alternative theory that is compatible with a standard macro production function under certain circumstances. We will demonstrate that the other circumstances are the normal state of the economy and that they give rise to very different interpretations of productivity change. This is enough to present our case, even though we have not been able to do all the illustrative simulations and estimations that we might have wished.

We argue that the M-M model is richer in empirical content than the macro model, and contains reasonable behavioural specifications. If small modifications in the M-M model -- that are prior and concealed assumptions in the macro model -- give rise to widely diverging macro interpretations, we have a case against the macro analysis in at least the particular cases to be expounded below. The key objection has to do with the aggregation assumptions of exogenous, equilibrium prices, which remove the productivity effects of dynamic factor market allocation. There is so to speak no dual because there is no equilibrium. We will illustrate this in the next section through inter alia closing and opening up the productivity potential of international specialisation.

<u>Definition of change in macro TFP -- where does technology enter?</u>

Define TFP as deflated value added (Q) divided by deflated total cost:

$$TFP = \frac{Q}{\text{Deflated TC}} \tag{6}$$

Not included are all purchases of intermediate goods and services and fluctuations in finished goods inventories. Hence, deflated value added is identical to sales volume:

$$Q = \bar{S}$$

Introduce the implicit factor price deflator such that (from 1):

$$TC = \varepsilon X$$

and

$$\text{Deflated TC} = X$$

Then introduce:

$$\frac{\Delta TFP}{TFP} = \frac{\Delta Q}{Q} - \frac{\Delta X}{X}$$

It follows:

$$\frac{\Delta TFP}{TFP} = \frac{\Delta Q}{Q} - \left(v_1 . \frac{\Delta L}{L} + v_2 . \frac{\Delta \bar{K}}{\bar{K}}\right) \qquad (7)$$

where: $v_1 + v_2 = 1$

$$v_1 = \frac{wL}{\varepsilon X}$$

$$v_2 \quad \frac{(r+p^k-\Delta p^k/p^k)p^k . \bar{K}}{\varepsilon . X}$$

Output growth can now be expressed as:

$$\frac{\Delta Q}{Q} = s_1 . \frac{\Delta L}{L} + s_2 \frac{\bar{K}}{\bar{K}} + s_3 . \frac{\Delta \bar{\varepsilon}}{\bar{\varepsilon}} \qquad (8)$$

where $s_1 + s_2 + s_3 = 1$

$$s_1 = \frac{wL}{p^q . Q}$$

$$s_2 = \frac{(r+p^k - \Delta p^k/p^k)p^k K}{p^q . Q}$$

$$s_3 = \frac{\bar{\varepsilon}}{p^q . Q}$$

(v_i) and (s_i) are weights in the price indices (ε, p^q) used to deflate TC in (1) and value added. $\bar{\varepsilon}$ is the deflated ε in (2). $\bar{\varepsilon}$ is again the dynamic factor that represents the capital market disequilibrium and that moves the investment of the individual firm. If (s_i) can be assumed to be constants, the integral of (8) is:

$$Q = AL^{s_1} \cdot \bar{K}^{s_2} \cdot \bar{\varepsilon}^{s_3} \qquad (8B)$$

For this integral to exist we have to assume $\bar{\varepsilon} \neq 0$ which is the same as to assume that the capital market has to be in disequilibrium in a Wicksellian sense. If we can assume that R^N and r in (3) should be corrected by the same deflator then monetary equilibrium means real equilibrium and vice versa. However, deflation is decisive for the measurement of productivity change.

TFP and Stability of Relative Prices

The existence of a capital market disequilibrium as defined above is partly a matter of accounting principles and partly a question of how factors are paid. If product and labour markets are in equilibrium and if the capital market is continuously in equilibrium in the Wicksellian sense of all $\varepsilon_i=0$, there can be no technical change except for accounting reasons.

Relationships such as (8B) have frequently been estimated under the name of production functions. To explain this let met repeat the earlier argument backwards. A macro production function usually assumes labour and investment goods markets to be in equilibrium. L and K are assumed to fetch their marginal product at each point in time. Expectations are static, so at each point in time the steady technical shift comes as a complete surprise, that nevertheless does not disturb prices (by assumption) and the continuing equilibria in capital and investment goods markets.

Who makes the production function shift? Suppose it is the owners of the production function outfit (8B). Then they pick up the residual value generated which per definition defines their marginal contribution. All markets, including the equity market, are in static equilibrium. This is alright as long as you don't attempt to measure the owners' contribution with the   in (2), or to correct the K value with   , and then estimate the production function. You then have an identity and your estimation is likely to break down. However, my argument has been that if you estimate such type production function on data for a world where (L,K) markets are in equilibrium then the estimated shift factor picks up the value added contributions of non (L,K) factors, and this contribution is equal to what non (L,K) factors get paid, presumably "the owners". However, again if (L,K) markets are not in equilibrium then the shift factor in fact picks up whatever factors (L,K) have been over or underpaid relative to their marginal productivities. If this is the normal state, which we argue is the case, then the estimated shift factor is only partly technological. It in fact averages exactly to what we have demonstrated, namely the residual remuneration to owners. Even worse, suppose labour is in a strong bargaining position and anticipates the steady, value added contribution from technical change in the form of higher wages, then much, or all of the technical shift factor may disappear as statistically estimated.

Sometimes these underlying "financial assumptions" have been discussed or even been made explicit. Thus, for instance, Aberg (1984) in estimating such a type production functions on data from OECD countries assumes a constant loan rate and a constant rate of return at the macro level for his various industries, when they are operating at normal capacity. This is the same as assuming that the aggregate   for an industry is constant over-time, which has also been true for Swedish manufacturing at a sufficiently high level of aggregation for the postwar period up to the mid-80s.

There is, however, also the matter of micro and macro. If relative prices are changing then instabilities (s_i) should be expected together with a continuous turnover of ε over time and across firms. We obviously have a problem with the macro production function when the supply side of the economy is subjected to reallocation of resources induced by relative price changes, as during the 70s. Indeed, in the MOSES M-M economy such dynamic resource reallocation is the main vehicle for productivity change. Furthermore, $\bar{\varepsilon}$ is also unstable, and different across firms, due to changes in interest rates in the financial market contributing to changes in TFP.

We know that for one firm:

$$s_1 = v_1 . \frac{\mathcal{E}.X}{p^q.}$$

$$s_2 = v_2 . \frac{\mathcal{E}.X}{p^q.}$$

It follows that:

$$\frac{\Delta TFP}{TFP} = \frac{\Delta Q}{Q} - \frac{\Delta X}{X} = [1 - \frac{p^q Q}{\mathcal{E}.X}]\frac{Q}{Q} + s_3 \frac{p^q Q}{\mathcal{E}.X} . \frac{\Delta \bar{\mathcal{E}}}{\bar{\mathcal{E}}} \qquad (9)$$

or, slightly rewritten as:

$$\frac{\Delta TFP}{TFP} = \frac{\Delta Q}{Q} - TFP . \frac{p^q}{\mathcal{E}} (s_3 . \frac{\Delta \bar{\mathcal{E}}}{\bar{\mathcal{E}}} - \frac{\Delta Q}{Q}) \qquad (9B)$$

Consequently, total factor productivity change depends critically on how we have defined our price index ($p^q, \mathcal{E}$).

Using the M-M model it is possible to simulate the dynamics of TFP change and assess the impact of different price deflators, market conditions, and rates of technical change in new investment vintages.

Before exploring these model experiments we will discuss further some implications of TFP change as defined above.

Since ΔTFP/TFP will mainly reflect the movements of average and the stability of the $\bar{\mathcal{E}}$ distribution over time and over firms, it would be more in keeping with the MOSES M-M concept to relate distributional $\bar{\mathcal{E}}$ properties and output growth. This has been done to some extent and the results strongly emphasize the importance for long-term, stable growth in output, of a continuous turnover of Schumpeterian rents, through innovative entry, innovations within firms and a steady exit flow of low performers, i.e., of a maintained capital market disequilibrium.

The shifting of the production function, defined by

$$\frac{\Delta TFP}{TFP}$$

partly reflects how the relative price vector (p, p^I, w, r, p^k) has been defined and calculated, most notably the interest rate r, and partly on how the weights v_i and s_i have been chosen.

A direct relationship between total factor productivity change and (the difference between the return to capital and the loan rate) has been established, when $\mathcal{E}$ has been deflated (to $\bar{\mathcal{E}}$) by some chosen price index. The profit minded entrepreneur is, however, interested in the current value of $\mathcal{E}$, and the current and constant price ϵ and $\bar{\epsilon}$, respectively, will move apart if prices change.

If v_i and s_i are fixed to a given base period, then the type of price index has been chosen. Only shifts in real factor use coefficients ($\overline{S/L}$, $\overline{S/I}$, $\overline{S/K}$) will affect total factor productivity change.

If the base period for the price indexes, on the other hand, is changed we lose conceptual control of TFP-change. If we use a continuously adjusted base period for the deflators, relative price change affects the size of TFP-change. It is easy to understand that a considerable literature on the index problem in production function analysis exists (see e.g. Diewert 1976, Fisher 1965, 1969, 1982, Griliches-Jorgenson 1967 or Brown-Greenberg 1983). Such analysis, however, has only been done under the assumption of static, equilibrium conditions when prices can be thought of as exogenous.

In the context of a dynamic market economy where resource allocation is guided by endogenous market price signals, however, the (s_1,s_2) as well as the ϵ become jittery and aggregation functions begin to shift, because of shifting relative prices and mistaken expectations. This instability in the price weights of the aggregation functions surfaces "technically" in the form of total factor productivity change. This poses problems for statistical estimation of a production function, unless the change is random and stationary or with a definite trend.

In the first round of model experiments we will investigate what happens when the economy experiences a pivoting in the relative size of (α,β) as it appears in new investment vintages that are endogenously entered into existing firm capital structures through micro investment functions dependent upon ϵ.

Capital Market Equilibrium

An equally interesting question, however, relates to the setting of the capital market loan rates and how this affects both investment through , and TFP/TFP directly through the accounting relationship (9B). In our experiments the market loan rates will be set exogenously. But in a fully market integrated simulation the possibility of departing from the foreign interest rate through domestic policies is severely limited. Even so the rate of return on total assets R^N in (4) is not independent on the rate of interest in the capital market, since variations in the interest rate affect all other domestic prices (p^q, $w,p^I,\ldots$) in the economy, and hence the level and dispersion of rates of return across the firm population.

We observe from (9) that TFP/TFP is defined if, and only if, $\bar{\epsilon}\neq 0$. For ΔTFP/TFP to be not only well defined but non-zero it must further hold that $\Delta\bar{\epsilon}=0$.

A dispersion of $\bar{\epsilon}_i\neq 0$ across the micro population of firms is a normal state in a dynamic market process. The position of individual firms in the distribution of ϵ should also change over time. [This "technically" means that total factor productivity change becomes an erratic phenomenon at the micro level.]

At the macro level total factor productivity change occurs as long as average $\bar{\varepsilon}>0$ across the firm population, assuming a given index pair $(\bar{\varepsilon}, pq)$. We ask what happens when all agents in the market adjust so that $\bar{\varepsilon}_i \rightarrow 0$, $i=1,2,\ldots,n$. This is a puzzling question that we have not been able to explore analytically. Simulation experiments, however, indicate that the macroeconomy gets unstable and that collapse becomes likely as the $\bar{\varepsilon}_i$ converge toward 0.

In the micro setting of our model economy the capital market should be in equilibrium where the marginally best producer with the highest $\bar{\varepsilon}$ determines the loan rate, making his $\bar{\varepsilon}=0$ and all other $\bar{\varepsilon}<0$. As a consequence, all other producers will adjust their output through the investment process (guided by $\bar{\varepsilon}$) until their $\bar{\varepsilon}$ become = 0 and/or the corresponding adjustment of investment, labour demand and output will affect all prices to the same extent. However, then (8B) will not be defined.

Either a state where all $\bar{\varepsilon}_i=0$ does not exist, or it is impossible to reach even as a momentary state. In short, a steady state solution appears not feasible in a dynamic micro-to-macro economy.

The Combination of Schumpeterian and Wicksellian Accumulative Processes

Following the tradition of Schumpeter, assume that the initial position is one of Walrasian equilibrium. Assume, furthermore, that some "entrepreneurs" invent production methods that make it possible for them, at prices given by the previous technological state to earn a return $\bar{\varepsilon}>0$, and, hence make them willing to invest.

A distribution with some positive $\bar{\varepsilon}_i$ then appears, that normally generates an aggregate

$$\frac{\Delta TFP}{TFP} > 0$$

because of the equilibrium disturbing, "costless" innovations.

The positive $\bar{\varepsilon}_i$ sets economic forces in motion. Investment takes place. Demand for factors of production increases and factor prices increase making the $\bar{\varepsilon}$ of all non-innovating firms negative. Eventually these actors will exit or improve again through "costless" innovations, etc. This is in principle how the M-M model currently operates.

The interesting question for an evaluation of total factor productivity change observed at the macroeconomic level, is therefore whether such a positive change depends on a constantly maintained disequilibrium in factor markets, with constantly underpaid factors, including savers, and/or whether the growth process occurs because "costless" innovations keep generating positive $\bar{\varepsilon}$ at the micro level, that are constantly eroded through market induced factor price adjustments.

In what follows we will therefore concentrate on studying the output effects of changes in the nature of technical advance at the micro level and/or the international market conditions.

3. THE MACROECONOMIC EFFECTS OF TECHNICAL CHANGE AT THE MICROECONOMIC LEVEL

Earlier technology experiments on the MOSES model economy have been concerned with exogenous advances in labour saving techniques through changes in β (5), proportionally across all firms, in a sector or in one large firm only. Three results from these experiments should be noted here. First, exogenous technical advances embodied in all new investment goods and brought into the production system through endogenous investment have to be activated by economic mechanisms to affect the macro economy. For instance, if firms keep investing because they have a large enough cash flow, they upgrade both the quality and the quantity of installed capacity. But there may be no output effects if demand is slack, or if competition from other producers is slack. Hence, the lags between technological advances available in capital goods offered in the market and capacity or output growth may be short, long or very long depending upon the market conditions prevailing.

Second, for a given set of such exogenous, technological conditions (a "technical regime") we have been able to generate a wide spread of long growth cycles by simply varying the specifications of the "market regime", notably the speed of price-quantity adjustments. In particular, if we somehow manage to keep a wide margin between R^N and r in (3) or a large ε, by exogenously lowering r, assuming that savers willingly let themselves be fooled to supplying funds at a low interest rate, a Wicksellian inflationary process accompanied by an investment boom is set in motion (E 1984a).

Over 50 year quarterly simulation experiments we have generated industrial output expansion paths -- holding technological regimes constant -- diverging as much as those between the industrial nations during the past 50 years.

Third, finally, in a model economy where individual agents are both price and quantity setters simultaneously, long-term or permanent technological unemployment is not a feasible phenomenon. Wages will eventually adjust to new technological circumstances, labour will move and unemployment will return to "normal". Permanent technological unemployment requires a Keynesian type fix price model. In a dynamic free market setting, the unemployment problem of interest is the time dimension and the stability of the employment adjustment process. A very fast market regime (E 1983) after a technological change generates continued unemployment through instabilities. A very slow market regime -- even though stable -- takes its time to reduce significiant disequilibria. In particular, if initial "disequilibria" created are large enough the adjustment process may be erratic for quite a while.

In the model market regime that generates the best "macro fits" in historic simulations domestic technological changes, whether local or universal, only generate minor, local unemployment situations that disappear after a 2 to 5 year period. Major disturbances associated, for instance, with clumsy economic policy making, that generate cost overshooting in export industries are more prone to create significant unemployment situations -- rarely, however, of long duration because prices, notably real wages, adjust. Similarly, technological changes abroad, manifested through intense price competition in foreign markets, in combination with a rigid wage and mobility structure in the domestic labour market easily creates serious unemployment spells in the entire export sector. The micro-to-macro market regime can be "enriched" by various kinds of price regulation arrangements that slow down or bias the adjustment response to technological competition, such that seemingly persistent unemployment and slow growth may follow. This is a hypothesis about the properties of the model economy that we have not analysed further in this paper.

With these results in mind it is interesting to see if differences in outcome occur if we change the nature of technical advance. The popular notion would be that labour saving technical change creates unemployment, while capital saving technical change of the same "size" does not. I have found in my earlier paper that technical change currently may be shifting in a relatively more capital saving direction. Does the popularistic notion that we then have to worry less about technological unemployment hold up?

To begin with we have set two different technological scenarios against each other. In one scenario (the capital saving scenario) the capital output ratio in new investment vintages [INVEFF = α in (4)] increases 1 per cent per year, compared to 0 per cent in the reference case. Labour productivity on the margin in new investment vintages [MTEC = β in (5)] expands at the same rate as in the reference case. In the second, labour saving scenario, the capital output ratio in new investment vintages is the same as in the reference case (i.e., zero rate of change) while labour productivity associated with new investment vintages expands 1 per cent faster per year than in the reference case. Everything else that can be controlled, including policy parameters, is kept unchanged.

In the first round of experiments (running 30 years by quarter) the foreign trade setting is "Keynesian". Individual firm exports are price inelastic, or exogenous and tied to a perceived market growth projection. In the second round of experiments the foreign trade setting will be classical and dynamic and more true to the MOSES idea. Relative competitive forces as reflected by domestic and foreign price and cost differentials will regulate the relative proportion of individual firm total supplies of goods in export markets. In this way market-induced international specialisation made possible by the introduction of new techniques will define the differences between the two rounds of experiments.

The output effects on the margin of a "unit of technical change" are roughly comparable in the first years of the simulation. After a few years the experiment cannot be controlled in that respect. (This is a typical feature of a dynamic simulation on MOSES with path dependent states, primarily because relative product and factor prices change endogenously.)

a) Nature of Technical Change and Elasticity of Export Supplies -- a Comparison

The first thing to notice is that the two experiments with price inelastic foreign supplies spin off different cyclical waves in output. (See Figure 1.) After some 20 years, however, output in the capital saving technical scenario starts declining relatively, while the opposite happens in the price elastic export scenario. Relative wages (Figure 3) follow relative output growth, while total unemployment, or the unemployment rate (Figure 2) moves the opposite way. In the price elastic foreign trade regime, capital saving technical change (eventually) yields more output growth, higher wages and less unemployment. In the Keynesian (price inelastic) regime, the results are the opposite. Labour saving technical change generates superior results.

On the whole, however, the longer-run (30 years) differences are not that large. In the two Keynesian price inelastic scenarios less people work in manufacturing in the capital savings scenario because capital saving technical change has generated a larger cash flow, more investment, faster income and demand growth, and hence both more efficient production and a faster growth in overall capacity. (If the Government had opted for faster expansion most of the unemployed could have been absorbed by the public sector without jeopardising economic growth.)

Terminal labour productivity in manufacturing is roughly the same in both Keynesian scenarios. A somewhat higher profitability has stimulated somewhat more investment in the capital savings scenario. Capacity to produce is larger but the result by the end of the simulation is slacker, in the form of unused labour and machinery capacity, rather than more output.

The M-M economic system does not recognise the existence of aggregate capital in the production process, but it can generate all kinds of capital aggregates according to desired specifications. All deflated aggregate capital output measures decrease, whether installed machine capacity (used in Figure 4B), actually used machine capacity or all assets are used in the numerator (9). The same measures show no trend, if computed in current prices, signifying a relative price trend "in favour of" investment goods manufacturers. It is interesting to note that the fall is most significant in the price inelastic (Keynesian) export cases. For each market regime capital or labour saving technical change makes little difference. The reason appears to be that the Keynesian market regime is less favourable to all firms and force more frequent exits and contractions of large, hardware capital intensive firms, while in the capital saving scenario rates of return improve and even basic industries survive and/or grow.

b) Total Factor Productivity Effects from International Specialisation

Things began to happen when we released the effects of international specialisation through opening up the economy to foreign competition. In the model technological knowledge is available as an exogenous resource vested in new investment goods. Innovative technical change at the micro level may be potentially favourable to the economy but the economy may be unable to respond by faster economic growth. The main transmission mechanism is the investment decision of individual firms. Absence of positive economic systems' responses is typical of the "Keynesian" (export price inelastic) experiments which exclude a rapid exploitation of the new export opportunities through factor reallocations (labour and capital) within the domestic economy. The reason is the assumed price inelasticity of export supplies. The firms cannot expand profitable shipments abroad beyond what has been assumed about exogenous world income growth. Domestic performance, nevertheless, is fine, since firms are being subjected to free import competition. The internationally specialised Swedish model economy cannot, however, compensate for lack of access to profitable foreign markets through a shift in the direction of more volume production for the home market. Competition holds down domestic prices and growth, and domestic and foreign costs grow apart. This is reflected in a growing differential between foreign (assumed) and domestic (endogenous) prices (10). With price and profit guided individual export shipments we expect to observe larger export shipments, and also a faster transmission of foreign prices into the Swedish economy. Compared to the price inelastic (Keynesian) case investment and labour resources should now be allocated (mixed) differently, and -- we also expect -- slack reduced. When seen from the aggregate industry level more economic growth should occur through faster TFP growth, or a shifting of the macro production function. Let us now switch on the price elastic export supply functions.

The simulation results are those expected. Manufacturing output growth is increased because of a more efficient resource use by between 1/2 and 1 per cent per annum over the 30 year scenario, depending upon which experiments we compute. For each technical change scenario the enhancement of TFP growth through trade specialisation is reflected approximately by the differences in output growth curves. In Figure 1 (C and D curves) the index minus 100 approximates the cumulated size of the TFP effect from international specialisation (11). As in earlier runs the difference is small to begin with but then the capital savings technical change scenario appears to yield the largest output effects from international trade specialisation. In the beginning the direct effects of "technical change" are almost equivalent. Then indirect feedback influences begin to cumulate and apparently these indirect effects are larger in the capital savings scenario.

The relatively faster growth in output and in TFP through trade specialisation in the capital savings scenario is reflected also in a relatively faster increase in wages. The wage cost increases are, however, relatively smaller than the corresponding output and productivity effects (this can be seen from a comparison of Figures 1 and 2). There is, however (Figure 3) virtually no difference in employment effects because of the differences in technical change. This is what we would expect from an economy characterised by a reasonably flexible price system, even though wage costs are (nominally) sticky downwards. However, openness to international trade specialisation pays off in both technical scenarios in the form of faster employment growth and less unemployment. The reason is further output growth and wages lagging productivity growth.

It is interesting to note that the investment cycles generated are quite different (Figure 4) even though average investment volume is approximately the same. Opening up the economy to trade specialisation generates one type of investment cycle (C & D) regardless of technical change. Changing from one kind of technical change to another generates another investment cycle (A & B) regardless of export regime.

Price flexibility seems to matter significantly for unemployment

(Figure 3). When we move from a price inelastic to a price elastic export supply function, and participation in international trade increases, unemployment diminishes significantly.

With capital saving technical change price inelastic export supplies take unemployment on a long upward drift (Figure 3). With price elastic exports capital saving technical change brings unemployment down. The market regime seems to be what matters for employment, not the technological regime.

Exogenous public sector demand has been e[illegible]ly the same in all simulations. Hence, this set of experiments for one thing illustrates the growth effects of more efficient resource use because of international production and trade specialisation, and secondly that endogenously generated income and private demand growth through increased trade specialisation can solve "the unemployment" problem alone, irrespective of the technical change characteristics assumed and without any support from tax or deficit finance of public demand expansion.

As a consequence of the foreign-domestic market interaction, the relatively higher fraction of supplies combined with import competition has forced up domestic prices closer to foreign prices. Consequently, output runs signficiantly higher than in the "closed" alternative, and machinery slack and labour hoarding much below.

The effects on output and employment of a pivoting of the direction of technical change comes out even more clearly in a more narrowly controlled experiment. In the reference case with price elastic (endogenous) individual firm export determination, that tracks actual macro behaviour over a historic reference period quite well, capital saving technical change is zero, while labour saving technical change is set at 2.5 per cent per annum on the average (at the firm level).

We now assume that each firm experiences a 1 per cent increase in   in new investment, while labour productivity in new investment vintages (β) increases at a rate 1 per cent lower than in the reference case. All other specifications are ceteris paribus. The reader should, however, note that the direct relative output effects on the margin of the change in (α,β) approximately cancel out during the first few years of the simulation. Very soon, however, the dynamics of micro-macro market interaction makes it impossible to control the experiment in such a way that the output effects of the pivoting of technical change are zero.

The simulation results (Figures 5A through D) are quite interesting. For ten years aggregate manufacturing output is the same even though it follows different cycles. By the middle of the simulation a strong export boom sets in. Toward the end of the simulation, however, the reference case has partly caught up with the expansion. Employment is considerably higher, and unemployment very low during the last decade of the simulation, wages are higher, but total investment spending over the 30 year period has been significantly lower than in the reference case. Obviously the relative improvement of "capital productivity" over labour productivity has caused a substitution of labour for capital over the 30 year period studied, which corresponds to the popular notion of the employment consequences of technical change. Two observations should, however, be made. First, the effects are very slow in coming, second, and most important, they are by no means a

Figure 1. **MANUFACTURING OUTPUT**

Experiments with shift toward capital saving technical change (23, 27) or labor saving technical change (24, 28).
Keynesian (A) and price elastic (B) exports.
(C) Exhibits output in capital savings technical change scenario ; price elastic exports in percent of price inelastic exports.
(D) Same for labor saving technical change.

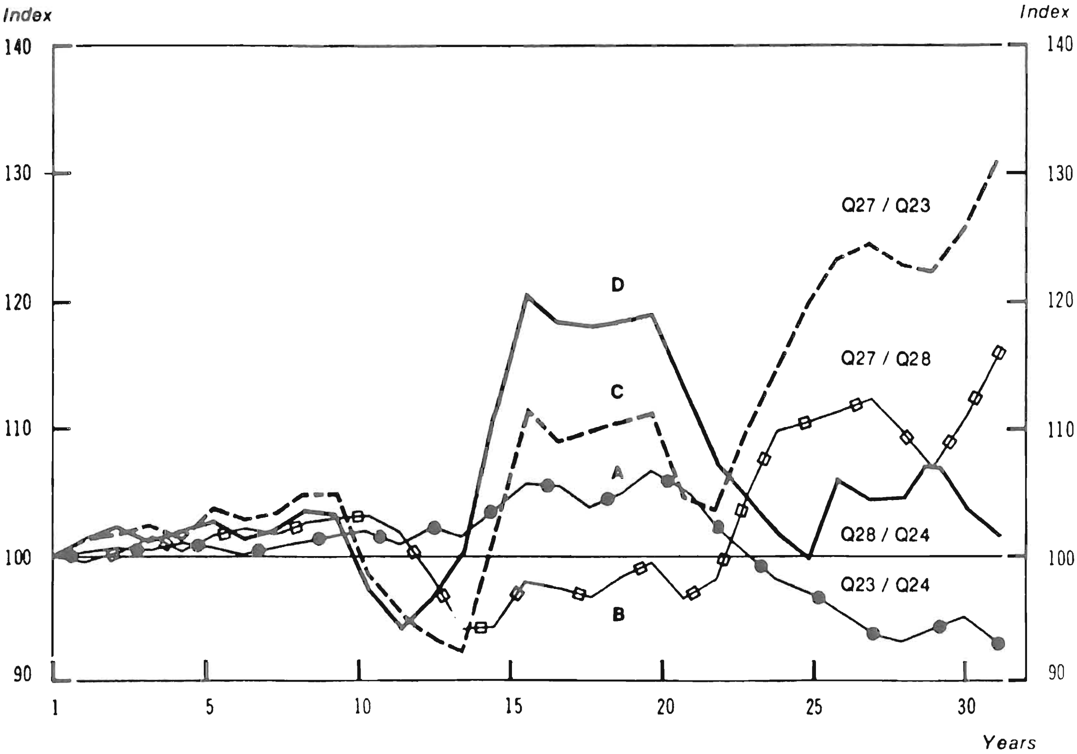


Figure 2. **WAGE COSTS**

Experiment with shift toward capital saving technical change (23, 27) over labor saving technical change (24, 28). Keynesian (A) and price elastic (B) exports.
(C) Exhibits wage costs in capital savings technical change scenario ; price elastic exports in percent of price inelastic exports.
(D) Same for labor savings technical change scenarios.

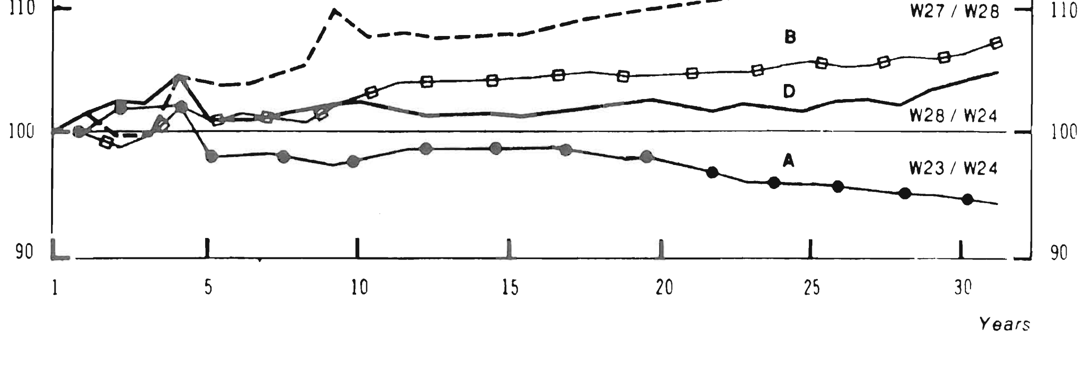


Figure 3. **MANUFACTURING UNEMPLOYMENT**

Experiments with shift towards capital saving technical change (23, 27) over labor saving technical change (24, 28). Keynesian (A) and price elastic (B) exports.
(C) Exhibits unemployment in capital savings technical change scenarios ; price elastic exports in percent of price inelastic exports.
(D) Same in labor savings technical change scenarios.

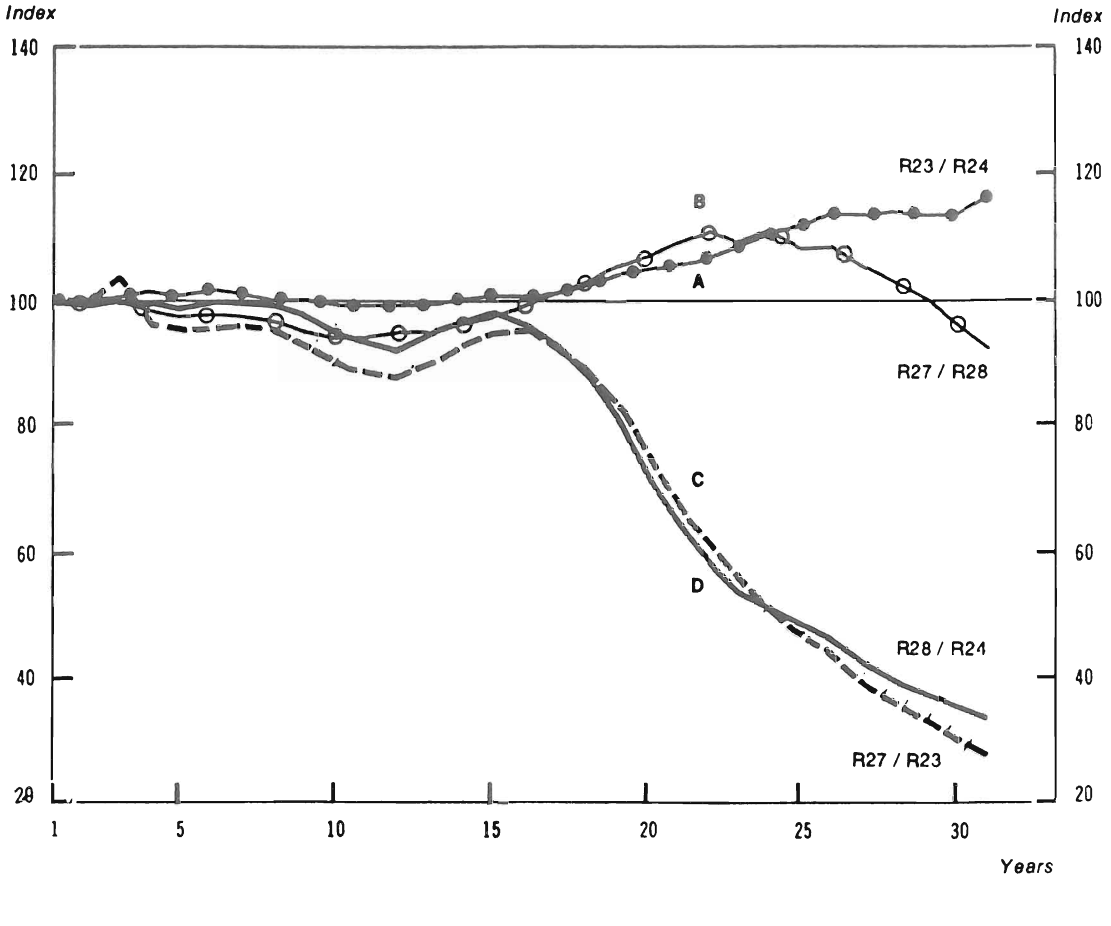


Figure 4A. **MANUFACTURING INVESTMENT**

Experiments with shift toward capital saving technical change (23, 27) over labor saving technical change (24, 28). Keynesian (A) and price elastic (B) exports.
(C) Exhibits investment in capital savings technical change scenarios ; price elastic exports in percent of price inelastic exports.
(D) Same for labor saving technical change scenarios.

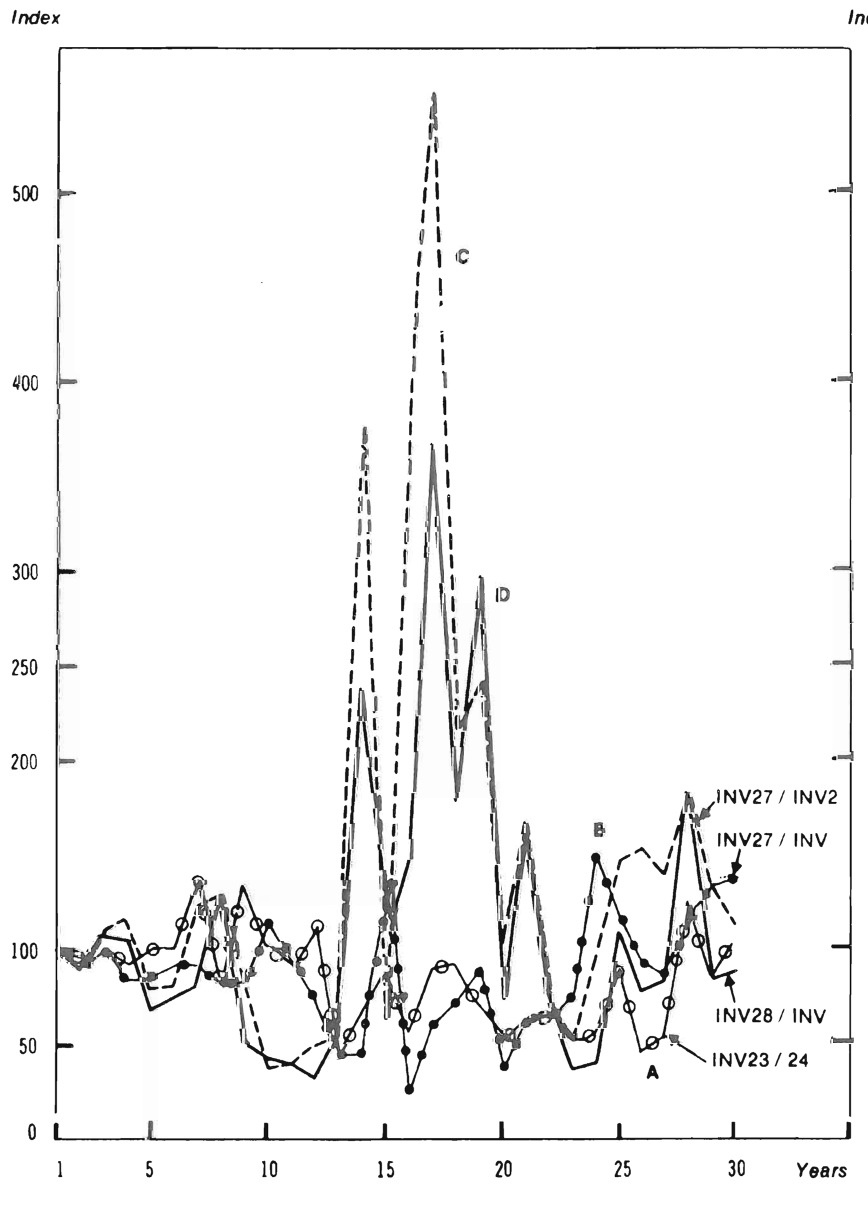
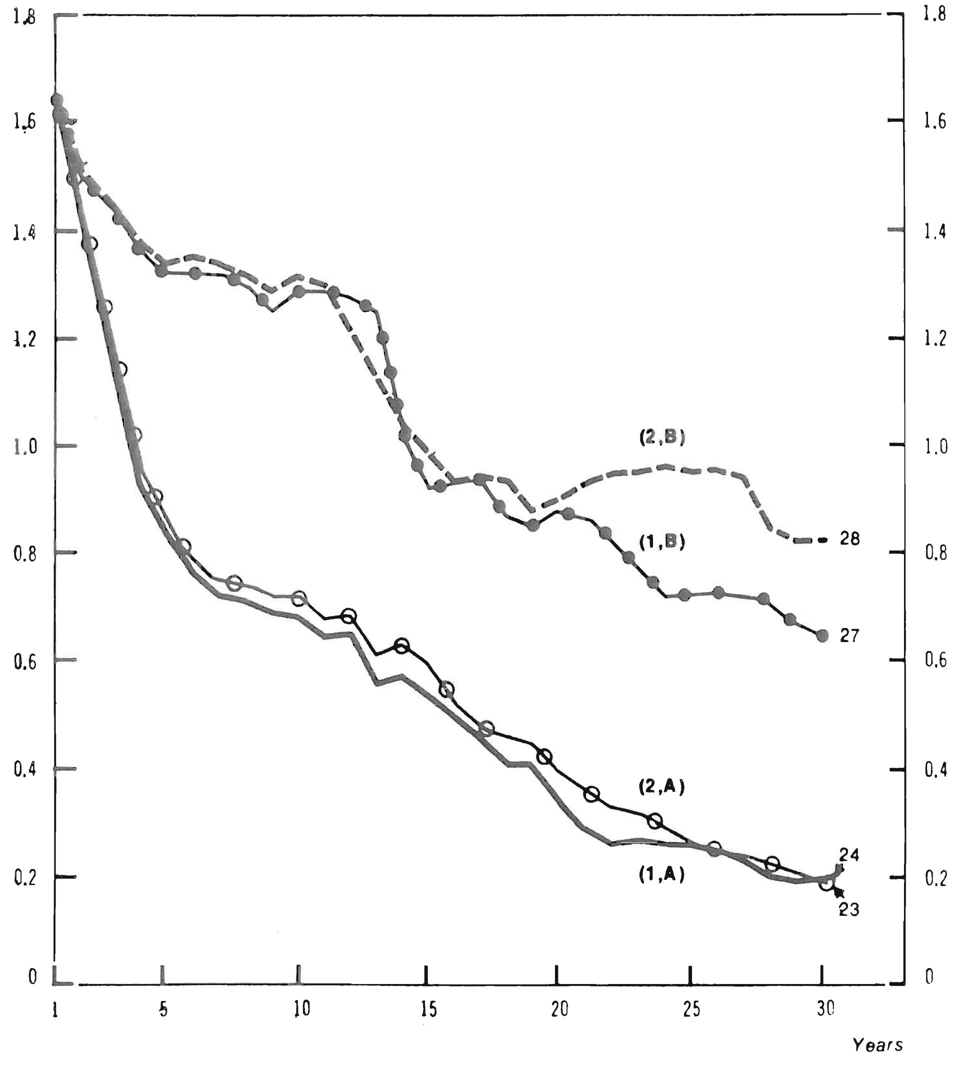


Figure 4B. **CAPITAL OUTPUT RATIOS**

(1) Capital saving technical change
(2) Labor saving technical change

(A) Price inelastic exports
(B) Price elastic exports



Note : Capital has been computed by cumulating net price adjustment capital stocks, adding them across firms, and deflating by the implicit price deflator simulated for the investment goods market.

consequence of the change in the nature of technical progress per se. Substitution of labour for capital has been caused by the relative price and cost consequences of technical change. The reason for the positive employment effects toward the end of the simulation experiment was a controlled wage development (see Figure 5C). The relative increase in output more or less stayed with the capital owners and higher profits did not cause extra wage drift. That higher profits do not necessarily generate faster wage increases also appears consistent with empirical evidence (Schager, 1985). The small wage response, this time, appears to have depended on the bad unemployment development in the labour saving technical change scenario. That the employment consequences are ruled by the relative price, cost development and not by the technical change development -- if the two diverge -- is quite neatly illustrated by the experiments in Figure 3.

c) Speed of Adjustment

Each variation in the technical change assumptions forces structural adaptation on the M-M model economy and results in a different set of final relative prices. The adjustment process is engineered through competitive market processes, the speed of which can be varied.

On this score we note from earlier experimentation on the M-M economy that efficient quantity adjustment of the economy to an exogenous force requires some minimum stability of the corresponding (interactive) adjustment of relative prices. If price and quantity adjustments are too rapid, markets get disorderly, and relative prices jittery. Relative price signals then lose informational content as predictors of future prices, and quantities tend to be less efficiently allocated. If exogenous changes are large enough and market responses fast enough major output collapses can occur.

The market regime specifications in our simulation experiments are the normal ones of the reference case that track historic macro performance reasonably well.

Many of the results observed, however, relate to the micro specifications used. An important, necessary requisite for long-term stable macro development appears to be that micro diversity in the supply structure of the economy is maintained. This is the same as to say that a minimum variation in the (t_i) in (2) across the firm population is needed each period. The current model set up is particularly sensitive in this respect since it has an endogenous firm exit function regime where too fast competition forces too many firms to exit, while the remaining firms are "forced" through factor costs and (endogenous) productivity development to look very much (and too much for stability) alike. The (ε) distributions become flat. As the economy moves closer to a capital market micro equilibrium, the economy grows potentially unstable.

Figure 5A. **MANUFACTURING OUTPUT, UNEMPLOYMENT, WAGES AND INVESTMENT**

Output neutral (on the margin) pivoting of technical change in a relatively more capital saving direction assumed. Only price elastic export supply behavior exhibited.

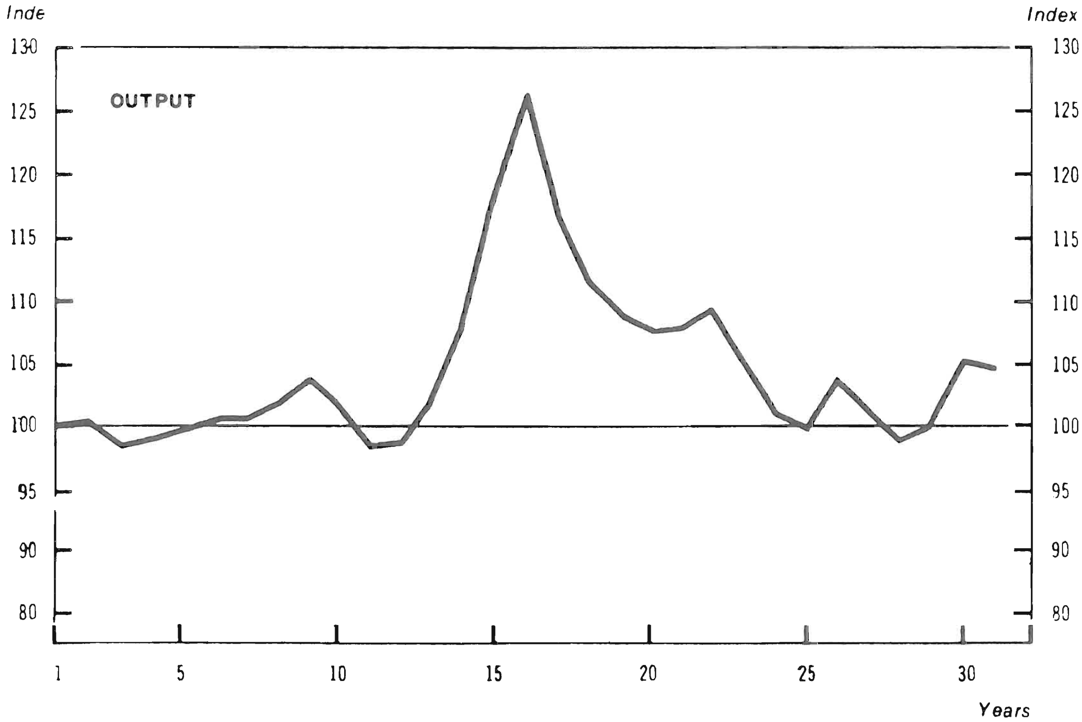


Figure 5B. **UNEMPLOYMENT**

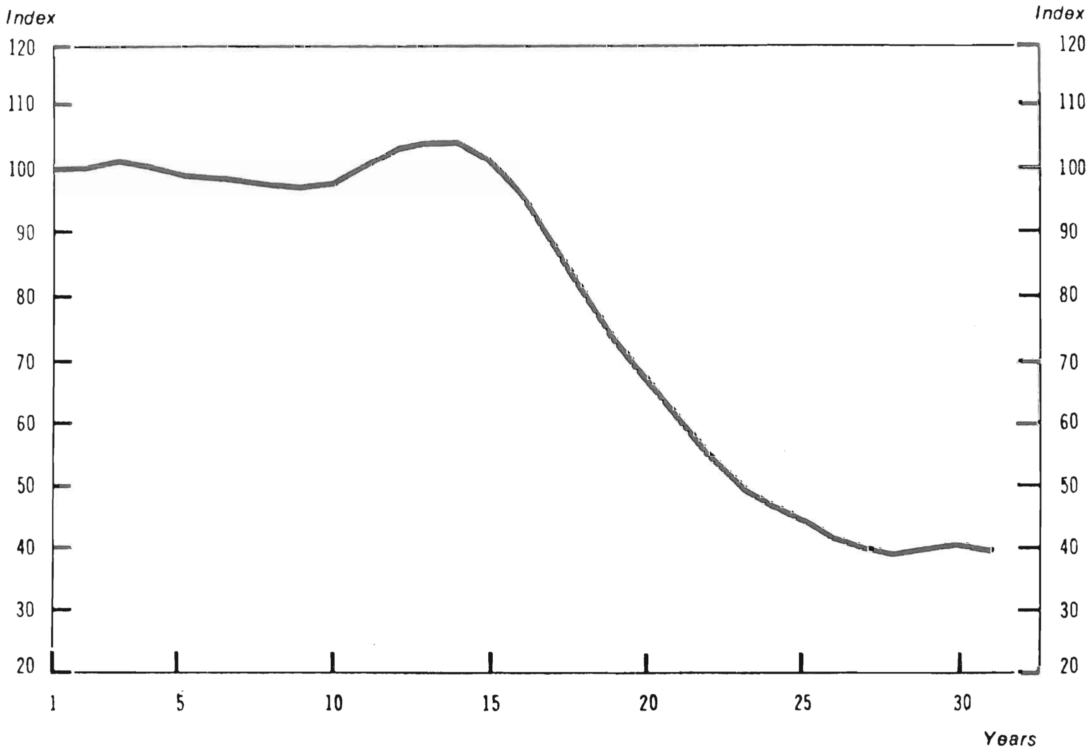


Figure 5C. **WAGES**

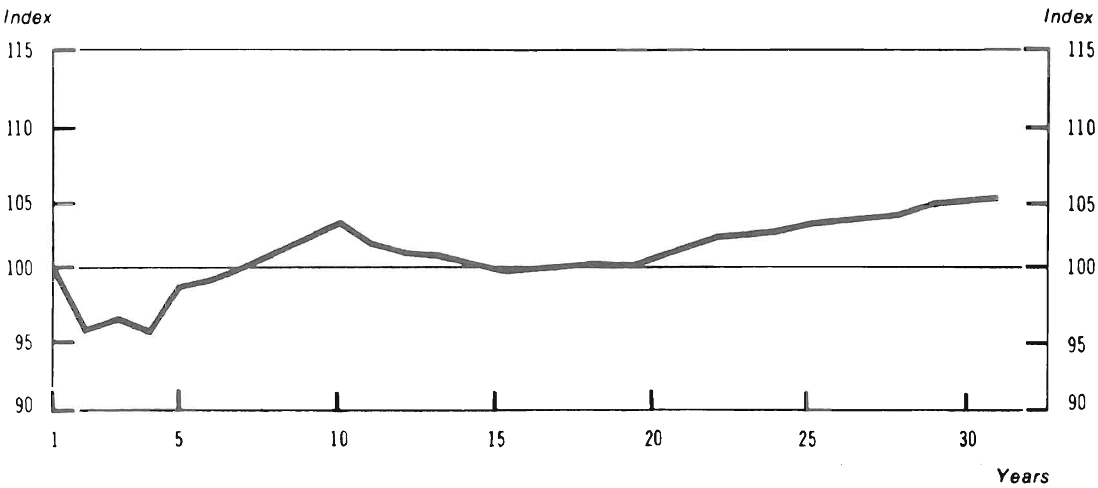
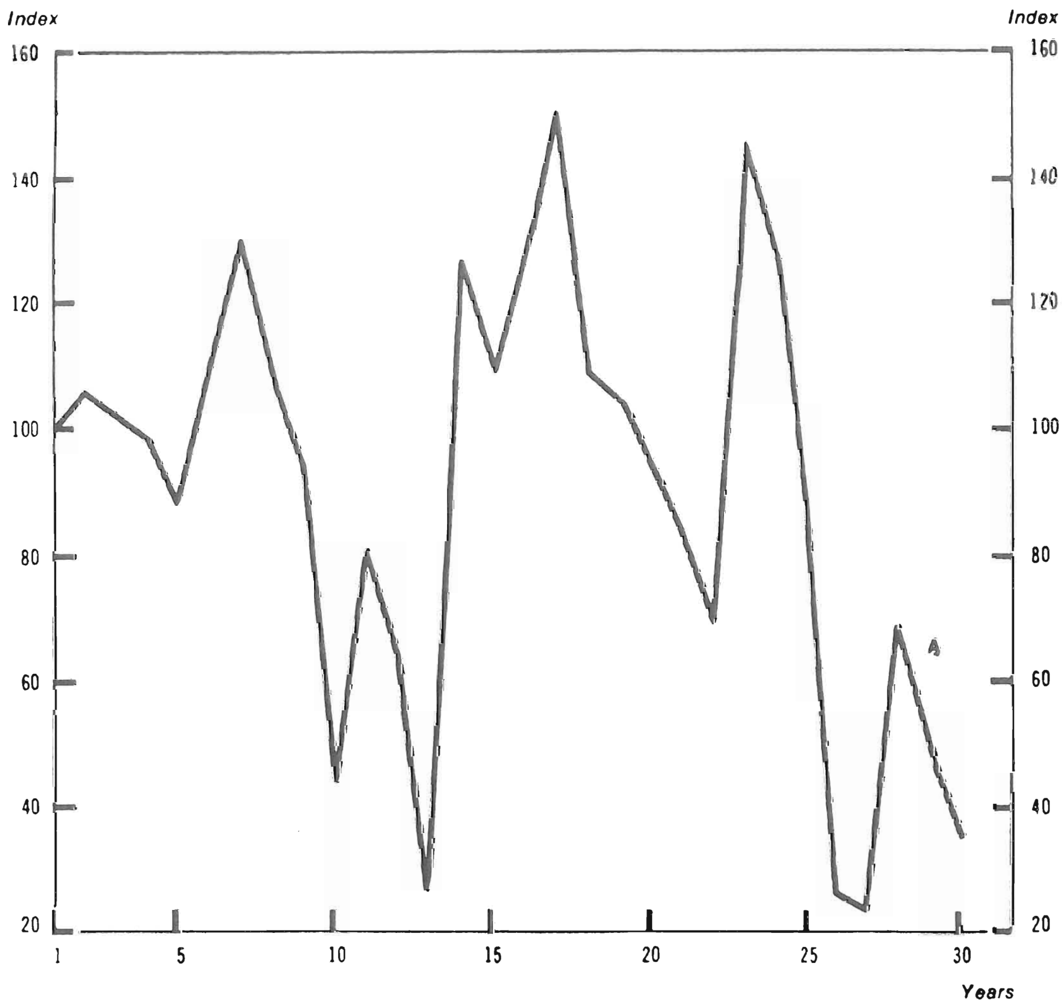


Figure 5D. **INVESTMENT**



4. CONCLUDING REMARKS ON THE ROLE FOR GOVERNMENT AND OTHER COLLECTIVE BODIES

Practically all theoretical "results" on the role of the Government in the economy rest on particularly designed economic models that either give an overwhelming role to politicians in office (Keynesian economics) or close to no role at all (pure monetary economics) except a perceived control of money supply. Normative welfare economies, framed as it is in static comparative equilibrium theory, is quite another matter. It has been designed so that within its logical framework there is no way of demonstrating that a privately organised market economy produces more economic welfare than a centrally planned economy (Pelikan 1985). These results and normative welfare economics in general rest on an axiomatic foundation of theory that imposes simple equilibrium properties on the economic system. On the whole, therefore, standard economic theory lacks a theory of dynamic markets. Once we introduce simultaneous price and quantity setting by agents -- as in the M-M model -- all the technically nice and for policy-makers straightforward and appealing results disappear. The policy-makers have had a much more demanding job than they ever believed they had in the rosy 60s.

The Schumpeterian-Wicksellian connection explored in this paper is a step in the direction Arrow (1959) asked for. The few, small revisions of received theory, however, both confuse and obscure the standard role of Government in the economic process. When we shift from macro Keynesian, or competitive equilibrium models to M-M dynamics, all of a sudden the economic machine becomes too complex for macro demand fine tuning, regulation or redistributional policies, if the objective is to achieve certain, detailed welfare results. A dynamic disequilibrium economic process responds dynamically to policies, and such responses frequently refute original objectives as predicted by received economic theory. The policy conflict lies in the dependence of economic growth on a persistent turnover of monopoly rents in the economy at the micro level. The latter runs counter to the aims of redistributional policies. The interesting thing is, that when such policies are pursued with some success -- as apparently was the case in the 60s of Western welfare economics -- a measure of instability -- released in the 70s -- was introduced by moving the micro structures of the economies closer to static equilibrium conditions, or in simpler words, by reducing all forms of slack in the economies, including cyclical slack.

One conclusion of this paper is that macro productivity change in all its statistical manifestations is a typical economic phenomenon. Pure technical factors may set the upper limits. But the economy is always operating at a significant distance from its potential. Economic and social factors determine how far away they operate at the micro market levels. Market dynamics and the ability and willingness of market participants to adjust to change, determine the efficiency of resource allocation and, hence, productivity advance.

Three roles for Government remain after this discourse. The first is close to -- but not as extreme as -- the monetarist credo, namely to serve as a guardian of an orderly market process. We recognise that between laissez-faire and extreme intervention there is an optimal degree and form of intervention in the organisation of the rules of the market game that enhances the information content of the market process to achieve steady and more rapid macroeconomic growth. We note that this role is not that of contracyclical policies. Part of the policy task must be to remove tax wedges in the price system (King-Fullerton, 1984, Södersten-Lindberg, 1984) to remove regulation and union practices etc. that make prices, notably domestic factor prices inflexible and misleading signals for decision-makers. This is a form of reversed incomes policy, and the dynamic rationale is that prices cannot be locked in place through incomes policies -- except very temporarily -- without causing significant negative allocation effects in the longer run.

The second role of Government is that of designing an efficient incentive system. I am thinking not so much in terms of reducing marginal income tax rates to achieve a larger supply of labour hours, but in affecting all the factors that are involved in the creation of new structures -- or innovative rents -- and that force exit of inferior agents. Economic research has been closing its eyes to these matters since the days of the early Schumpeter -- so we simply do not know much about what can be done here. But if I were responsible for an industrial policy arm of a Government, I would feel very uncomfortable with a number of standard bureaucratic procedures, especially those concerned with taking over the jobs of business leaders, and -- of course -- the subsidy department and would concentrate on establishing a lively and competent experimental base for industry. This issue is partly a matter of attitudes and ideologies of individuals and bureaucrats, and it is fundamentally a matter of education. For an industrial growth engine to function efficiently it must be rewarding in all dimensions of life to engage in the industrial market game. However, even at bureaucratic levels the attitudes have to be properly biased. Curious, risky and experimental purchasing by Government agencies with a view to achieving learning experience in industry is probably the most important form of industrial policy. There must be more innovative ways of spending a significant fraction of GNP than on defunct shipyards, standard steel producers and mines.

The third role of Government is technically related to the innovation process. We may imagine that an almost costless redesign of the innovative system may create a tremendous burst of innovative rents, . Innovative rents then arise because they are cheap to produce, and they spin off beneficial macro effects in the economy. Something like this appears to have been the case in Swedish industry during the past 10 to 15 years in the sense that the profitability of investing in R & D spending relative to process expansion has increased. To a large extent, however, this is the result of previously accumulated knowledge within industry and of a rapidly growing supply of well educated engineers. In both ways costs have not been properly charged to the innovative account and technically, shifts in total factor productivity (TFP) are observed.

The classical example of this (third) role is when the Government foots the bill for large infrastructure developments, while output effects are recorded in the private sector. Technically this means that the Government, through its right to tax, deprives labour of part of its income, and sends it back to industry "in kind". However, the Government could of course also organise the labour market in a way that wage overshooting is prevented, or that labour is systematically underpaid compared to what they might earn under a different labour market regime (see for instance Chen on Hyper Growth in Asian Economies). The Old Swedish policy model included typical elements of this, in the sense that centralised bargaining achieved a rather even domestic wage level, such that bad performers could hardly survive and tended to exit, while the high performers in industry paid labour less than they could afford on the margin. This tilted all more in favour of the best performers. The success of policy models like this -- for a while -- rests on their simplicity (no elaborate intervention on the part of Government in the market processes) and non-transparency to those who are in some sense "exploited".

The Swedish model included an even more subtle parallel element that generated the same positive growth effects -- for a while -- but that also illustrates how fragile such a policy or price distribution system may be, even though it helps to promote investment and growth. If savers can be fooled into accepting a low return on their deposits a generally higher average $\bar{\varepsilon}$ is created in industry at least for a while. A Wicksellian capital market disequilibrium has been created. We have demonstrated that this directly increases TFP change as we measure it.

Low interest rate policies were typical of European economies in the 50s and early 60s, when domestic credit systems were isolated from one another and could be efficiently regulated. Cheap financing appeared to have lured firms into faster investment expansion than they would otherwise have opted for and possibly more sloppy profitability requirements. This situation all of a sudden turned sour when the Western economies found themselves integrated into an international credit market, when interest rates were bid up across the line by the internationally best performers; reducing the "beneficial" ε effects all over the industrial world. The consequence was that the world capital markets moved close to what can perhaps be called equilibrium conditions, that capital suppliers (savers) were rewarded at a rate closer to their "just values", that average $\bar{\varepsilon}$ were reduced and -- as we have demonstrated above -- that total factor productivity growth -- as we measure it -- vanished.

NOTES AND REFERENCES

1. Also called the MOSES model. Both the micro-macro model used and the experimental designs are too complex to be fully described in this paper. For more detail, we have to refer the reader to other publications (E 1976b, 1978a, 1983c, 1985a, Albrecht-Lindberg 1982, Bergholm 1983).

2. This "Model overview" paragraph is a slightly modified version of Bo Carlsson's presentation in "Industrial Subsidies in Sweden: Simulations on a Micro-to-Macro Model", in Microeconometrics, IUI Yearbook 1982-1983, Stockholm, 1983.

3. Note that the same formula appeared as (1) in my first paper (E 1985) when discussing resource allocation and use within one firm.

4. The nominal rate of return is then defined as

$$R^N = \frac{p^x.\bar{S} - TC+r.K}{K}$$

5. For proof of (4) and (5), see Eliasson (1976a, 1984c).

6. In a fashion described in Eliasson (1978, p. 63 ff).

7. Only manufacturing firms are modelled in micro. The rest of the economy is closed through an eleven sector Leontief-Keynesian macro model.

8. In the standard MOSES description α = INVEFF, β = MTEC. See E 1978a, Sections 4.3 and 4.4.

9. The rapid initial drop in capital output ratios in Figure 4B, and particularly in the Keynesian experiments, depend on numerous exits of low profit, high capital output firms during the first few years of the simulation.

10. The reader should observe that the specialisation effect only occurs among the marginally best producers in the micro-to-macro economy. The Keynesian assumptions mean protection from foreign competition. Firms can raise prices and increase profits while at the same time slack (or a deterioration in productive performance) accumulates. The marginally best producers in each sector take advantage of this.

11. This is only approximately true since factor (labour and capital) use differs somewhat in the two scenarios.

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