Gunnar Eliasson
Ove Granstrand

The Financing of New Technological Investments

Booklet from IUI
No. 121

Reprint from

Technological and Industrial Policy in China and Europe.

Occasional Report Series No. 3
Research Policy Institute, Lund 1981

INDUSTRIENS UTREDNINGS-INSTITUT
STOCKHOLM

The Industrial Institute for Economic and Social Research

is an independent non-profit research institution, founded in 1939 by the Swedish Employers' Confederation and the Federation of Swedish Industries.

Objectives

To carry out research into economic and social conditions of importance for industrial development in Sweden.

Activities

The greater part of the Institute's work is devoted to long-term problems, especially to long-term changes in the structure of the Swedish economy particularly within manufacturing industry. This also includes continuous studies of the development of private consumption in Sweden and projections of demand for various products. Research results are published in the series issued by the Institute.
Along with the long-term research work the Institute carries out investigations concerning special problems and performs certain services to industrial enterprises, organizations, governmental agencies, etc.

Board

Address

Industriens Utredningsinstitut
Grevgatan 34, 5 tr, S-114 53 Stockholm, Sweden
Tel. 08-63 50 20

ISBN 91-7204-147-1

ABSTRACT

A long standing argument in economic literature is whether more efficient financial systems promote faster economic growth or whether a suitable financial side merely develops as a consequence of real economic growth. Formulated in such general terms the issue probably cannot be settled on empirical grounds.

This paper will approach a related issue from a more narrow angle. The financial system of an economy is the prime medium for the allocation of investment resources. Traditionally it has also been the prime target for government intervention and manipulation. It may hence be more or less developed (read efficient) as a market In determining which project gets financing at the expense of others and from what sources.

Large firms to some extent operate internally as financial institutions coordinating a number of "small forms" or production establishments. Hence the traditional argument that small firms live a more precarious financial life being less protected from the merciless forces of capitalist financial markets and unable to provide sustalned long term financing for large and risky investments. One particular aspect of this is the financing of new establishments.

High risk is the typical trait for new technological investments. A parallel argument is that the small firm is a better breeding ground for innovative activities than the large corporation. As a consequence, such is the argument, the financial system discriminates agalnst dynamic innovative behavior in industry.

This paper attempts to evaluate this hypothesis of financial discrimination by evaluating the arguments and carrying out a couple of case studies on how finance has in fact been organized for some typically high risk Investments in new technology.

THE FINANCING OF NEW TECHNOLOGICAL INVESTMENTS

by

Gunnar Eliasson
Industrial Institute for Economic and Social Research (IUI)
Stockholm, Sweden

Ove Granstrand
Dept. of Industrial Management
Chalmers University of Technology
Gothenburg, Sweden

1. THE ALLOCATION PROBLEM

AN ILLUSTRATION

The Swedish economy during the last few years has frequently been referred to as suffering from an allocation malaise. The full diagnosis of that illness is yet to be seen but a few illustrations of the symptoms will highlight the issue.

First, Figure 1 includes four diagrams. The left side shows that the raw materials producing sector — nowadays often recognized as a crisis sector — for the entire post war period has been drawing a constant fraction of total labor and investment resources allocated to all manufacturing. At the same time the raw materials producing sector has been providing the nation with a declining share of total manufacturing profits and value added (right hand part of Figure 1).

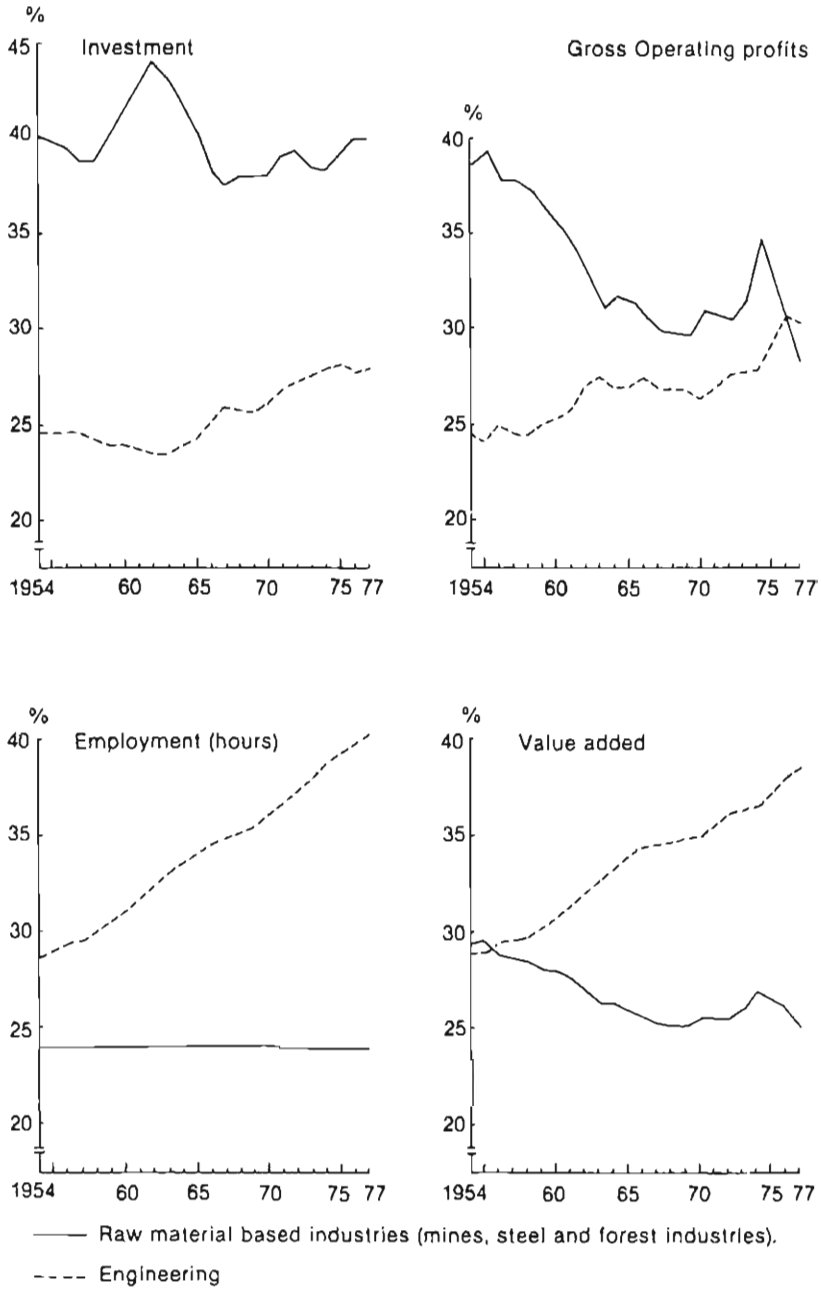
In more simple terms this means that a larger total manufacturing output should have been expected from a different allocation of resources (more to other industries) and more new resources (profits) for future investment and growth would have been generated if less resources had been made available to declining firms in the raw materials sector. The raw materials producers are predominantly of the large size, capital intensive, low product technology type that have fared less well in international markets during recent decades*. The decisive allocation variable is investment in a broad sense and those factors that guide financial resources to particular investments.

The main role of financial institutions is to allocate capital resources from their sources (the savers) to various end uses. A much honored ques-

* See Eliasson-Carlsson-Ysander (1979, chapter 6) and Ohlsson (1980).

Figure 1

Shares of the Engineering Industry and the Raw Material Based industries in investment, employment output and profits in Swedish manufacturing 1954-1977. (Present, moving 5 years averages.)



Source: Eliasson-Carlsson-Ysander (1979)

tion in economic (historic) research is whether the industrial revolution was, or fast economic growth in general is caused by a particular financial organization of an economy or whether economic growth simply forces the needed complementary financial structure to develop. Anyhow, parallel industrial and financial structures tend to exist in different countries and the absence of organized capital markets normally witnesses the absence of industrial advance as well. But cause and effect are difficult to identify since we are concerned with long time periods during which many rounds of cause and effect have taken place. The general presumption of this paper is that the efficiency and organization of financial markets do affect the real side of the economy. The particular question raised is whether the finance of new, high technology investments should be of particular concern in this respect.

The role of efficient financial markets is not only to allocate resources to the best activities as judged in an ex post perspective but also to deny resources to bad investments. The importance of this resource screening process was illustrated already in Figure 1 and is further emphasised by the observation that *at least* 50 percent of total productivity performance of Swedish industry seems to be the result of structural change *between* firms, rather than technical change at the firm level.* Factor markets (labor, capital etc.) are the vehicles for structural change and the introduction of new and superior products and production techniques at the expense of less efficient alternatives.

NEW TECHNOLOGY VENTURES

The main allocation problem is to get finance to those activities that turn out successful *ex post*. This is, however, close to a trivial formulation. Success is the result of entrepreneurial competence and very often luck. Our problem is to identify the peculiarities of "new technology" venture finance.

There are two special features. *One*, new technologies are inherently risky. To be worthy of attention they should yield very high expected returns. This quality, however, they share with a much broader class of activities.

The logical conclusion would be that risky ventures in new technologies require a much deeper knowledge not only by the user but also by the supplier of funds to reduce the risk content of investments. Therefore,

* See Eliasson (1980) and Carlsson (1981).

and *second,* these kinds of investments are normally associated with a high degree of internal finance, either through internal profit plow back within firms, equity participation of outside investors or through the supply of ingenuity and work effort by a small group of daring entrepreneurs and inventors, all hoping to earn a large capital gain in the end. A common proposition from many quarters has been that particular, specialized credit institutions that can assess these risky projects and provide finance, need to be created.

It is, however, very important not to get overly fascinated with the romantic vision of the small scale innovative company as the prime mover of technological advance in industry. So far it is not even clear which entities are more inventive, the large managed high technology companies or small companies. Even if innovativeness in a restricted technological sense can be shown to be relatively more associated with smallness than with large scale, the massive technological advance (as we measure it) associated with a prosperous industrial nation is

1. predominantly the result of R&D and investments in *large* companies and
2. in not very sophisticated technologies as well. At that level one also has to recognize that technological advance
3. consist of a spectrum of factors, generally not thought of as "technical". The management of the company is one such factor and the "management" of the entire economy, (policy making, cultural system, incentives etc.) another.

The larger the "firm" and the more advanced the economy the more important is this third observation. The introductory illustration of the "allocation problem" was intended to emphasize this aspect.

One particular aspect of risk associated with large, international companies in intense rivalry with new product qualities rather than prices on standard products is the lengthening of development time (the gestation period) in combination with larger risks for product failure.* Even though actual costs incurred up to production and sales may be fairly small the indirect costs for the entire company to be left hanging in the air with an unsuccessful, major product can be enormous.

Finally, and importantly

* See Eliasson (1976, pp 243-249).

4. In small and large businesses alike the major financial requirements do not originate in R&D spending per se but in the overall growth process associated with the launching of a new technology (product, process etc.) Even though the case reports will concentrate on the R&D side, the relative magnitude of plant, equipment, inventory and trade credit finance has to be remembered.

THE LARGE FIRM AS AN INVESTMENT BANK

The large western firm can generally be seen as a bunch of small firms held together by a corporate headquarter that operates very much as a commercial and an investment bank* when it comes to obtaining an efficient *internal* allocation of available funds. This is where management techniques enter and by this formulation we can also discuss the differences between a small and a large company when it comes to financing high technology investments.

First, this means that much of new establishment activity in fact takes place *within* large firms.** Without the financing trouble said to be associated with independent new entry.

Second, one has to keep *financial scale* and *production scale* very clearly apart when discussing problems associated with "smallness". Production scale normally determines the size of the investment and the technology risks taken on. The financial scale of the company determines how much risk that can be absorbed. Production scale is a very relative concept that has to be seen in the context of a market. Generally speaking we can say that the twenty or so large and internationally known Swedish companies are large or very large in an international comparison when it comes to plant size but quite small in financial size. They are usually quite specialized producers that sometimes dominate the world markets in their product range (for instance Atlas Copco, Sandvik and to some extent LM Ericsson). Their high degree of specialization, however, also means that investments in new and superior technologies by the firms themselves or in a competitor firm poses extremely high risks for the firms.

Their relatively small financial size in an international market setting at the same time imposes narrow limits on the capacity to absorb such risks. LM Ericsson and ITT provide a very good case in point. ITT has so far missed out in technological competition with LM Ericsson in their common field, but its large financial size (some 10 times that of LM Ericsson in 1977 measured by sales) means that it can absorb a "mistake" internally and possibly finance a comeback as well. For this reason we have found it appropriate to choose two large Swedish companies to illustrate

* See Eliasson (1976, chapter VII:3).
** See Du Rietz (1980).

the problems associated with invest ments in new technologies, and in one case the new product technology cannot even be called sophisticated or very advanced. Part of the high technology investment for these companies in fact consists in obtaining an economically efficient combination of market size, product design, production scale and marketing organization. In addition to that both companies obviously strive hard to obtain as well an efficient internal allocation of resources that also allows for more spreading of risks than earlier so that an investment mistake in their increasingly competitive markets does not jeopardize the entire company and the efficiency associated with a high degree of specialization.

THE ORGANIZATION OF FINANCE

Internally generated finance can normally be allocated efficiently *within* the corporate entity, even though internal restrictions associated with labor-management relations etc. may sometimes slow down the process.

The credit market "manages" the allocation of funds *between* corporate entities and between firms and other sources of saving. A general and very complex problem has to do with the efficiency of the credit market mechanisms. We will only touch upon this matter here. Three problems will be discussed below. The first has to do with the locking in effect of internally generated funds for tax reasons, the second with the non-market availability of funds for other reasons than long-term efficiency (subsidies) and the third and final question, considering all this and other factors (next section) is whether the small innovator with no own funding is as bad off as it is often believed. This is perhaps where equity market finance really becomes important.

It has sometimes been advocated that the development shown in Figure 1 to some extent depends on a tax induced misallocation of resources between companies. Corporate income and personal income taxes place large wedges between the before tax rates of return available within the company and the after tax returns available to share owners when the company distributes profits as dividends. It is easy to demonstrate that highly profitable projects in company A become less attractive than low profit or even loss projects in company B when it comes to deciding on where to allocate internally generated finance in company B. This aspect is particularly important for R&D investments, most of which consist of wages that can be immediately written off. Such factors tend to favour waste and a lowering of internal rate of return requirements. At the same

time they make financial risks smaller; losses are immediately lowered by a reduced tax burden on profits from other sources. Hence a large diversified company should be more prone (for tax reasons) to engage in high risk technology ventures than a small company, provided other factors do not offset this inclination. Such factors are the much talked about difficulties in large companies of efficiently spotting future technologies or carrying them through due to conservative bureaucratic organisations. If these are the companies that are currently making the profits, waste and inefficiencies and less growth may follow, and especially so if markets turn against their products*.

One extreme form of such "waste" is the subsidy program for ailing industries enacted in Sweden during the second half of the 70ies. Massive resources** have been systematically channelled to some low performing companies with a very doubtful future through the public budget. This is the extreme opposite to an efficient long-term market allocation of resources. The important question is what the prerequisites are for an efficient market allocation of funds. Do the adverse allocation effects associated with i.e. the tax and subsidy schemes make less resources available for other, better investments?

THE SMALL INNOVATOR AND THE EQIUTY MARKET

We have argued so far that no efficiency reasons can be advocated for large scale public subsidy interventions in stagnating businesses. At the same time such interventions, before they took place, have practically always been presented either as ventures for the future or attempts to give an obsolete company a new future. Let us reverse the argument and ask whether there is any need for public support of high technology investments. Does the small innovator need any new financial help from the public sector or rather, is there any evidence to show that new technologies have not succeeded because of lack of finance. Hence, is there any need for new institutions in the finance markets to cater for the high technology companies.

One characteristic of new technology investments is their high risk content. Hence such investments to a large extent tend to be internally financed within large companies. For any outside supplier of funds to be interested he will have to be both well informed and be offered the opportunity of a share in the possibly large profits, since he will run a higher risk than normal of not getting his money back if the project turns out a loser. The typical involvement then becomes equity participation or the

* Indeed that seems to be a likely outcome. See Eliasson & Lindberg (1981).

** Amounting to almost 16 percent of value added or at least twice the money spent on R&D in industry in 1979. See Carlsson-Bergholm-Lindberg (1981).

outside financier has to have an objective function that identifies with a larger collective interest. This can be the case for the government that is supposed to see to the interests of the entire nation, or for a large commercial bank serving the interests of a group of companies, with a large joint ownership, or a large business organization, where all financial arrangements are internal. A normal credit contract on the other side would have to carry a very high interest rate to cover the insurance premium for large possible losses. The creation of limited liability, joint stock companies in the 19th century was also characterized as a major "technological" innovation that made it possible to pool large resources for risk ventures in a fashion not possible before. Similarly, an unlimited number of case histories can be told about a "financier" (a privately wealthy person or a company) entering into an equity partnership with an invent or a small innovative company that needed an enlarged capital base. During the last 10-15 years a number of publicly supported institutions have been created in the Swedish credit market all with the explicit objective of catering for the needs of particular investors engaged in high risk activities. Contrary to our conclusions above, they have not typically been of the equity participation type but rather extend regular types of credits at normal rates of interest. In effect then credits have been given at a subsidized price.

The question asked was, do a number of new technologies, products or production processes lie unexplored because of lack of finance. The capitalist's answer would be that in a sufficiently "pluralistic" market economy, the culture of which places a premium on material wealth, some institution or person would soon pick up the idea or new institutions would automatically be created to do it for pure profit reasons. If this does not happen the presumption is that the "idea" wasn't really that good to begin with by *commercial criteria*. Besides risk content there are only two exceptions to consider. The first refers to *size*. Some projects may be so large that there exist no market solution. It is, however, difficult to give good and obvious examples that provide a good case for government intervention; Nuclear Power, the Space Shuttle and the Concorde are all cases where the economic rationale behind needs further clarification. The second has to do with the possibilities of establishing a *temporary monopoly* around the innovation. If the knowledge cannot be protected by patent, secrecy or rapid, continuous quality upgrading the incentives to incur development costs do not exist. Such externalities have normally been catered for by the creation of appropriate institutions;

schools, university or other research institutions, special R&D firms etc. The small scale venture capital institutions working directly with creative individuals as in Californian electronics industries during the last few years are a good example of a spontaneous market response for a financial need, expressed in terms of grand payoffs for the successful.

At least three conclusions follow from the above theoretical discussion.

First, large firms that have been successful in the past possess the necessary finance of the desired quality (risk capital). However, large firms may not in all respects be the most efficient managers of new technologies.

Second, small firms may be better organized to manage the first innovative stages of new technologies. They, however, often lack the necessary amount and quality of finance and management expertize, which is a form of technological competence.

Third, technology in the context of a modern business company is a broader concept than processes and products. An important part of the technology of successful firms, for instance, has to do with marketing and distribution.

As a consequence we conclude this paper with two case presentations of how new technologies were financed,

1. A large, high technology venture in a large company (AXE in LM Ericsson),
2. The financing of a new product in a large firm where technical sophistication is not the main innovative element (the new Volvo model).

2. THE FINANCING OF NEW TECHNOLOGICAL INVESTMENTS IN TWO LARGE COMPANIES

INTRODUCTION

Telephone exchanges at LM Ericsson and passenger cars at Volvo represent the two cases. The choice was motivated by:

— Both cases represent large scale investments, in one case in a very sophisticated technology

— Product development in both firms is characterized as major product generation shifts, intermittently straining the financial resources of the companies

— Both companies are multinationals. They are very large by Swedish standards but quite small in an international comparison when "financial size" is compared.

The following case reports concentrate on the funding of R&D work. The reader should keep in mind, however, that this is only part of the overall financing required to support a growing company.

THE DEVELOPMENT OF A NEW GENERATION OF PASSENGER CARS AT VOLVO

In the near future Volvo will introduce a new generation of passenger cars. A new generation has so far been launched each 10-15 years preceded by "terrible torment, not the least financially". While the new generation of passenger cars in the 50ies, the Amazon generation, took around 3 years to develop at the R&D cost of 50 MSEK (= Million Swedish Crowns) the new generation in the 80ies will have a R&D time of 4-5 years and the R&D cost will exceed 2000 MSEK. The annual R&D cost for passenger cars amounted to some 5% of the corresponding sales in 1978. In the years to come it is, however, estimated to rise to around 10%, including tooling. (See Table 1.)

Factors behind the increasing R&D costs are the cumulative effect of customer and governmental demands on safety, comfort, environmental protection, fuel economy and general performance. Also the need to control the rising costs in production increasingly require improvements in tooling. The tooling costs, amounting to 25-30% of R&D costs, have grown exponentially.

The intermittent product generations amplify the financial problems of rising R&D costs. They are typical for passenger cars and are also becoming increasingly pronounced. The development of trucks, on the other hand, is more gradual, although there is in this case a trend towards the creation of model generations as well. Both technical and market factors lie behind the product generations. Technically the so called packaging of the components in the system of a passenger car has become very efficient and the geometry of the self-supporting body makes gradual changes difficult and uneconomical.* Thus, a polarized pattern of introducing minor changes in yearly models and major changes in connection with generation shifts are favored as economical. Technical solutions to smooth out generation changes are not explored.

Scale economies in the serial production of passenger cars are con-

* This is also true in other engineering industries, where the major productivity improvements in production are simultaneous with new product designs. Cf Eliasson (1980).

sidered dominant, although the realization of such scale economies is not totally dependent on the formation of product generations at the level of the entire system of a passenger car. Finally some market factors also favor intermittent product generation. Customers demand substantial renewals of models after a while and it is also very risky in a basically conservative mass consumer market to deviate markedly from the behavior or established competitors. Even though the marketability of a product may be enhanced by intermittent model generation formation, some gradual adjustments of model designs seem possible at the image level, opening up possibilities to smooth out R&D costs. Nevertheless Volvo management believes that the pattern of generation formation will prevail in the decades to come. The exponential trend of rising R&D costs, however, is believed to be curbed.

Given the patterns of rising R&D costs and product generation formation and also the 50% sales dependence of Volvo on its passenger car business, — what are the resulting financial problems for Volvo? Three dimensions of the financing problem stand out. Development (investment) costs are considerable. The bulk of the financing has to do with tooling, hardware investments and sales finance and hence applies at a fairly late stage in the development cycle. The early R&D stages (the gestation period) are becoming longer and the indirect consequences of a less successful new product generation for the entire company are increasing. Hence, total risks tend to increase well. The awareness of these problems has been acute in Volvo and the history of Volvo from the mid 70ies shows a variety of spectacular initiatives to overcome them, many of which have been motivated by the need to spread risks and reduce the heavy dependence on passenger cars. Several important steps may be distinguished in this context.

Table 1
Economic Data for LM Ericsson and Volvo

	LM Ericsson	Volvo
Sales 1975 (MSEK)	7 240	13 692
Sales 1980 (MSEK)	12 174	23 803
Growth (Sales 1980/Sales1975)	1.68	1.74
Average annual growth 1975-80	10.9%	11.7%
Internationalization[1]	0.58	0.28
Diversification[2]	0.64	0.50
Pre-tax profit after depreciation 1980 (MSEK)	935	1 007
— as % of sales (profit margin)	7.7%	4.2%
Cumulated profit 1976-80 as % of cumulated sales	7.5%	4.0%
Main Product area	Telephone and telex stations	Passenger cars
Sales in main product area (MSEK)	4 442	11 980
Sales in domestic market (Sweden)	22%	25%
R&D cost 1980 (MSEK)	1 013	n.a.[3]
— as % of sales	8%	n.a.
— as % of investments in machinery and equipment	141%	n.a.
R&D cost 1975 (MSEK)	510	n.a.
— as % of sales	7%	
— as % of investment in machinery and equipment	78%	
Average annual growth of R&D cost 1975-80	14.7%	n.a.
Capital turnover 1976[4]	0.7	1.06
Capital turnover 1980	0.7	1.08

1.Employees abroad/total number of employees.
2.Sales outside largest product area/total sales
3. R&D for passenger cars amounted to ca 600 MSEK or 5% of corresponding sales in 1978.
4.Total sales/total assets (according to the balance sheet)

Source: Annual reports

A giant merger with Saab-Scania, the other Swedish automobile manufacturer, was proposed in 1977 but never realized, mainly due to managerial resistance at the top level in Saab-Scania. This merger was never considered a direct solution to the financing problem of a new model. Rather benefits of rationalization and the pooling of resources were sought.

Secondly, some years after the aborted attempt to merge with Saab-Scania, a spectacular move was announced in May 1979. Volvo announced intentions to enter a joint venture with Norway. In exchange for Volvo shares and industrial know-how, Volvo would get access to Norwegian oil money as well as Norwegian oil business opportunities. Although "the Norway deal" according to the official discussion was a solution to the financing of the new automobile the joint venture according to Volvo management was rather sought in order to give Volvo another risk profile. After heated, public discussions, not lacking in drama, the proposed joint venture was finally blocked by a group of main share holders in Volvo.

Thirdly, a new giant merger between Volvo and a large Swedish conglomerate, Beijerinvest, was recently announced in late 1980. This merger will again give Volvo its desired new risk profile and new business opportunities. The prospects for financing the new automobile generation have also improved. The Swedish stock market seems to have recovered and stock investors have displayed a trust in the Beijerinvest management that it did not show to Volvo management alone. During the 70ies Volvo has turned to the stock market several times for new capital, including special direct emissions to the public complementary pension (the AP) funds. But the gloomy prospects of investing in stocks in automobile business, especially after the oil crisis and the general recession in industry, have made the Swedish stock market appear very reluctant vis-à-vis Volvo. The devaluation of the Volvo share has also been an inhibiting factor in trying out foreign stock markets. Apart from legal obstacles, the additional risk for take overs was considered too great.

The credit rating of Volvo has increased internationally. Because of its size and its introduction on the London stock market Volvo now has good opportunities to borrow abroad. Another factor improving the financing situation is the improvement in capital turnover (see Table 1.). An increase of 0.1 in capital turnover would reduce financing requirements by about 2 000 MSEK, which is roughly the estimated total amount for developing the new automobile generation in 1980. Finally and fore-

most the heavy vehicle sector (trucks, buses) has generated a steady cash flow during the 70ies, amounting to roughly one billion SEK in 1980.* It now seems as if the new automobile model generation can be self-financed through profits from heavy vehicles. These in turn are not typical "cash cows" in the sense that product and market development has stagnated. They are rather outstanding profit generators subjected to continued development. In this way the problem with financing the new generation seems to be solved in the traditional way through internal profit generation. The question is rather why the cash flows are not planned to be reinvested in heavy vehicles instead. Incidentally, the new organizational design in conjunction with the Beijerinvest merger has put the passenger car division on a joint stock limited liability basis. The opportunity will exist to introduce the division on the stock exchange as a separate corporate entity. In connection with transforming the passenger car division into a joint stock company, French state owned Reault bought a 10% minority interest in the Volvo Passenger Car company in 1979 with option of another 10%. (Together with Peugeot and Renault Volvo had formed a joint company in 1971 for the development and production of passenger car engines.) Recently the Renault minority share has passed the 10% level. This means that the Volvo Passenger Car company will no longer be eligible for taxfree intra group contributions to cover losses, e.g. contributions from the profitable truck division. All in all Volvo has created links with several financially strong partners - Renault, the Dutch state, which in 1980 owned 45% in a joint company with Volvo for the Dutch car DAF, and the Swedish supplementary pension fund, which is the largest shareholder in Volvo with more than 5% of Volvo shares in 1979.

THE DEVELOPMENT OF THE TELEPHONE EXCHANGE SYSTEM AXE AT LM ERICSSON

Beginnings and ends of large R&D projects are difficut to pin point but with reasonable definitions the development of the public telephone exchange system AXE at LM Ericsson took place between 1969 and 1976. The R&D cost amounted to roughly 500 MSEK. The system clearly marked the transition of LM Ericsson from an electro-mechanical to an electronic systems producer. The earlier product generation, the so called cross bar system, had been developed during and after World War II and

* Net after tax profits from heavy vehicles in fact amounted to 1 010 MSEK in 1980 while, the passenger car division showed a loss of 195 MSEK. The Volvo Group as a whole reported a 1 007 MSEK profit.

was introduced in the market in the late 1940ies with a subsequent market expansion in the 50ies and 60ies.

The history of AXE does not involve financial problems and spectacular responses to them of the same magnitude as has been the case for the new passenger car generation in Volvo. However, the history of AXE with respect to technolgical and market factors is interesting. In the early 1960ies prestudies of new telephone exchanges were initiated with the primary focus on computerization. The computer people in the 60ies had little understanding of the special application of computers in telecommunications and the LM Ericsson people, consisting of "telephone people" and newly graduated engineers, had but minor contact with the established computer world. At the same time top management in LM Ericsson was not acquainted with electronics and computer technology. The result was that most of the work on computerization was self-development, often along unconventional lines. Competence in computer technology was built up internally during the 60ies, especially about computer architecture, systems reliability, multi-processing and structured programming. The latter experience then paved the way for systems modularization, an important feature of the AXE system. Thus the transition into a new technology for an old application was achieved through self-development and the creation of design concepts which were new also to the new technology.

Around 1970 there were many internal discussions whether to continue development along the lines of a centralized telephone exchange, AKE, or develop a new system, AXE, based on modularized software and reed selectors. For a few years AXE and AKE were developed in parallel, although AKE development became more geared towards market adaptation. A strategic decision was taken in the early 1970ies about full scale development of AXE. At that time Ellemtel had been created, a jointly (50/50) owned company between LM Ericsson and its Swedish customer, the state telephone administration Televerket. This company was to do the development work of the new telephone exchange. Economic calculations for AKE and AXE were presented, giving estimates of some 100 man years of R&D for AKE, and some 1 000 man years for AXE, with several years longer R&D time. However, there was almost a tie between AKE and AXE. The managing director of LM Ericsson, then asked people at Ellemtel which way they believed the economically optimal technology would go and their choice was the technically more advanced system, AXE, — a likely choice by technical development

people.

The first pilot plant of AXE was ready 1976. Then things have happened rapidly. Technologically the system has been updated in several steps. An important step has been to digitalize the system in the second AXE-generation. The coming transition from analog to digital voice transmission was recognized and decided upon in 1973-74 and a fully digitalized version was introduced in 1978-79. A third AXE-generation is roughly scheduled for the mid 1980ies, providing integrated services in the transmission of data, speech, texts, and pictures.

The market development of AXE involves some spectacular events. The market break-through, apart from the Swedish market, came when the competent Australian telephone administration decided upon AXE in 1977. France decided upon AXE in 1976, but in this case LM Ericsson had to give up majority ownership of its French subsidiary. Nationalistic pressures have forced LM Ericsson to sell out stock in other foreign subsidiaries as well in order to get contracts. Thus not only products are sold but also parts of the LM Ericsson international organization, — not as a response to financial problems but as a response to the increased bargaining leverage of nation states and their strive for technology sharing.

The most important commercial success for AXE was the huge contract signed with Saudi Arabia in 1978 and jointly won together with Philips in fierce competition, among others with the old time competitor to LM Ericsson, ITT. The contract totalled about 15 000 MSEK with roughly a third falling on each of LM Ericsson and Philips, managing the installation, and Bell Canada, managing operations and education for 5 years. About 2 000 MSEK will be exported by LM Ericsson from Sweden. This contract has established LM Ericsson as the technological leader in its field. The contract also proves the company's organizational capability and at the same time strengthens its financial basis. The market development has been rapid since 1978. By 1980 the AXE-system had been introduced in 25 countries. The old systems have been forced out of the market much faster than initially anticipated by LM Ericsson. One result has been the accumulation of large stocks of old systems parts during some periods and strains on the ability to speed up conversion of the production and marketing organizations to the new product and production technologies.

On the financial side, a strong trend towards increasing R&D costs in telecommunication industry is seen. (However, one has to keep in mind that companies have an interest in showing high R&D costs.) About

80-85% of R&D costs are costs related to personnel and software development like programming. However, there is also a trend towards incorporating software functions in the hardware components. In order to counter the risk of technological dependence, especially on US component manufacturers, LM Ericsson may eventually have to become more self-supporting on the component side, in turn adding more R&D costs. A main factor in favor of integration backwards in the short run is the risk of disseminating knowledge to suppliers.

The formation of product generations is not so pronounced in telecommunications as in passenger cars. Rather, there are technological substitutes at the component and subsystem levels. Even identical systems are not mass produced. Computerization of course meant a pronounced generation shift, but generation shifts tend to be smoothed out, at least for LM Ericsson. This is due to the modular design of AXE, permitting the introduction of new technologies without having to change the whole system. Another factor behind the smoothing out of generation shifts, as claimed by an LM Ericsson representative, is the improvements in R&D decision making, based on technological and market forecasts. Naturally, new product will have to be introduced in the future and the creation of product generations is still likely to take place in the future, not the least for marketability reasons.

The development of AXE has essentially been self-financed through profits at the division level of telephone exchanges. Until the early 1960ies the technology development part or R&D (in contrast to product development) was centralized in LM Ericssson and financed through taxation of the different businesses according to a percentage of turnover. When divisionalization was introduced in the early 1960ies each division had to carry its own R&D costs. A certain corporate R&D fund has also existed but it has not been of any importance for the financing of AXE. The R&D costs in Ellemtel have been carried to roughly 75% by LM Ericsson. Televerket has had no financing part of development and market adaptation of AXE since 1976. The most important financing factor is the traditionally high profitability in telecommunications industry. LM Ericsson is a typically specialized company with small possibilities to re-allocate capital between different businesses. The company is also highly internationalized and sells its products to a few, very competent national customers. This involves political risks. The financing side of the AXE development hence has had a very different quality than was the case for Volvo.

However, LM Ericsson is likely to experience financial problems ahead. Not only R&D costs rise but demands for customer credits are also increasing. At the same time the unanticipated rapid transition in the market to the new system results in large stocks of old products, that tie up working capital (capital turnover is only 0.7, see Table 1.) Finally and foremost, the company is now diversifying into office automation and business communication, which will require much finance of high risk quality. At the same time profit margins in the traditional telecommunication business are shrinking.

3.CONCLUSIONS AND COMPARISONS

The cases of Volvo and LM Ericsson may look like success stories with no associated problems of finance at all. LM Ericsson has managed to develop and finance a new generation of telephone exchanges. Telephone exchanges have turned out to be one of the most successful of Swedish products in international trade since World War II. Volvo has succeeded in transforming itself from a predominantly passenger car company into a highly successful truck manufacturer as well. High profits from truck manufacturing have bolstered the financial consequences both of a new product failure (the small size DAF model) and of the period of sagging automobile demand of the 70ies.

R&D for the new passenger car model will require roughly the profits from the heavy vehicle sector during 2 years. Self-financing was relied upon in LM Ericsson but was not possible at all to the same extent in Volvo. Volvo was forced to take several initiatives in the direction of shared financing joint ventures.

Both companies have engaged themselves to a minor extent in joint development ventures to spread large R&D costs; LM Ericsson with its domestic customer Televerket in Ellemtel and Volvo with a competitor, Renault to develop a new engine. Similarly, Saab-Scania (the other Swedish car company and the once proposed partner to Volvo) has reached an agreement with Lancia (Fiat) to jointly develop the next generation of passenger cars. Joint venturism is generally growing among car manufacturers as a response to a rapid upscaling of new product development investments.

Both Volvo and LM Ericsson depend to some 50% (of sales) on passenger cars and telephone equipment respectively. The acute problem is to

lower this dependence through a planned program of diversification; Volvo into energy and LM Ericsson into office automation and business communication. This has been a major force behind the Volvo moves since 1975. The major strategy for these diversifications in both cases seem to be acquisitions.

The case descriptions of Volvo and LM Ericsson do not support the idea that in the development of new high technology product generations financing is the major problem, calling for government intervention, joint ventures, or new financial institutions. The problems are rather what will happen if the high risk venture fails and at what stage of the development program that the whole burden of risk is taken on.

In a sense the kind and the availability of financing may force a company into a less than optimal decision making situation, that rather increases the degree of overall risktaking. Furthermore, a good portion of luck is characteristic of most successful companies or at least an aptitude to spot and exploit lucky circumstances. But if the absence of a steady flow of internal finance, or a cumbersome procedure to obtain external finance makes the firm too cautious and slow in its development program and in its willingness to take on risks it may loose out altogether in the long run.

Neither of the two companies consistently handle the development of new product generations as investments. One aspect of this mentioned in the interviews is that decision-making has typically been piece-meal, let be that strategic decisions about what business areas to operate in and so on surround the decision-making concerning new product generations. This is not so because of lack of risk awareness but because of risk awareness. The risks involved, both at the corporate headquarter level and the level of individual top managers, are so large that one prefers to move cautiously, one step at the time. In a sense this also creates a possibility to diffuse potential blame for a failure, although a high rate of technological change, as in LM Ericsson, may rightly justify caution an flexibility. The technological pioneering and market timing of AXE may seem skilful but there were small margins between success and failure. Too much caution and a wait and see attitude because of the financial risks involved might be all that is needed for a clever or lucky competitor to take the lead and cream off the market. It is not likely that LM Ericsson would have gone bankrupt or would have become technologically obsolete, given its good communication channels with both the science and technology community and the advanced customers, but the company could have fallen

behind for a decade or so and could have lost its ability to self-finance future development. The risks involved in a failure of the new passenger car in Volvo are of a similar nature. The technical and market possibilities to smooth out future generation shifts are moreover limited, at least in Volvo, and the chances for a slowing down of growth in R&D costs are slim.

REFERENCES

Carlsson, B, 1981 "The Content of Productivity Growth in Manufacturing", in *The Firms in the Market Economy — IUI 40 Years,* Stockholm.

Carlsson, B Bergholm, F Lindberg, T, 1981 *Industristödspolitiken och dess inverkan på samhällsekonomin,* IUI Working Paper nr 39, Stockholm.

Du Rietz, G, 1980 *Företagsetableringarna i Sverige under efterkrigstiden,* IUI, Stockholm.

Eliasson, G, 1976 *Business Economic Planning — Theory, Practice and Comparison,* John Wiley & Sons.

Eliasson, G, 1980 *Electronics, Technical Change and Total Economic Performance,* IUI Research Report nr 9, Stockholm.

Eliasson, G Carlsson, B, Ysander, B-C. 1979 *Att välja 80-tal,* IUI, Stockholm.

Eliasson, G Lindberg, T, 1981 "Allocation and Growth Effects of Corporate Income Taxes" in Eliasson-Södersten (eds) *Business Taxation Finance, and Firm Behavior,* IUI Conference Reports 1981:1.

Eliasson, G Ysander, B-C, 1981 *Picking Winners or Bailing out Losers,* IUI Working Paper nr 37.

Ohlsson, L, 1980 *Engineering Trade Specialization of Sweden and Other Industrial Countries,* IUI and North-Holland, Amsterdam.

Pratten, C, 1976 *A Comparison of the Performance of Swedish and UK Companies,* Cambridge University Press, London.

Publications in English

1981

The Financing of New Technological Investments. Gunnar Eliasson and Ove Granstrand. Booklet No. 121. 23 pp.

Business Taxation, Finance and Firm Behavior. Proceedings of a Symposium at IUI, August 28–29, 1978. IUI Conference Reports 1981:1. 435 p.

The Use of Time and Technology by Households in the United States. Frank Stafford and Greg J. Duncan. Booklet No. 120. 41 pp.

The Duration of Unemployment and Unexpected Inflation: An Empirical Analysis. Anders Björklund, Bertil Holmlund, Booklet No. 119. 11 pp.

Structure and Performance in the West European Steel Industry: A Historical Perspective. Bo Carlsson. Booklet No. 118. 33 pp.

The Effects of Taxation on the Firm's Investment and Financial Behavior. Göran Eriksson. Booklet No. 113. 16 pp.

Publications in Swedish*

1981

Industrin inför 80-talet (Swedish Industry facing the 80's). Bo Carlsson, Johan Örtengren, Petra Lantz, Tomas Pousette, Lars Jagrén, Fredrik Bergholm. 495 pp.

Strukturproblem och rationaliseringsuppgifter på 80-talet. (Structural Problems and Rationalization Tasks for the 80's). Bengt-Christer Ysander. Booklet No. 117. 15 pp.

Industristödspolitiken och dess inverkan på samhällsekonomin. (Industrial Subsidies and Their Macro-Economic Impact). Bo Carlsson, Fredrik Bergholm, Thomas Lindberg. 153 pp.

Offentlig ekonomi i tillväxt. (Growth of the Public Sector). Bengt-Christer Ysander. Booklet No 116. 79 pp.

***Almost all studies in Swedish are published with a short summary in English. A list of all books published with titles in English can be obtained from the Institute on request.**

All the publications can be ordered from Industriens Utredningsinstitut, Grevgatan 34, 5 tr, S-114 53 Stockholm, Sweden.

ISBN 91-7204-147-1

CityPrint AB

ISSN 0443-0409