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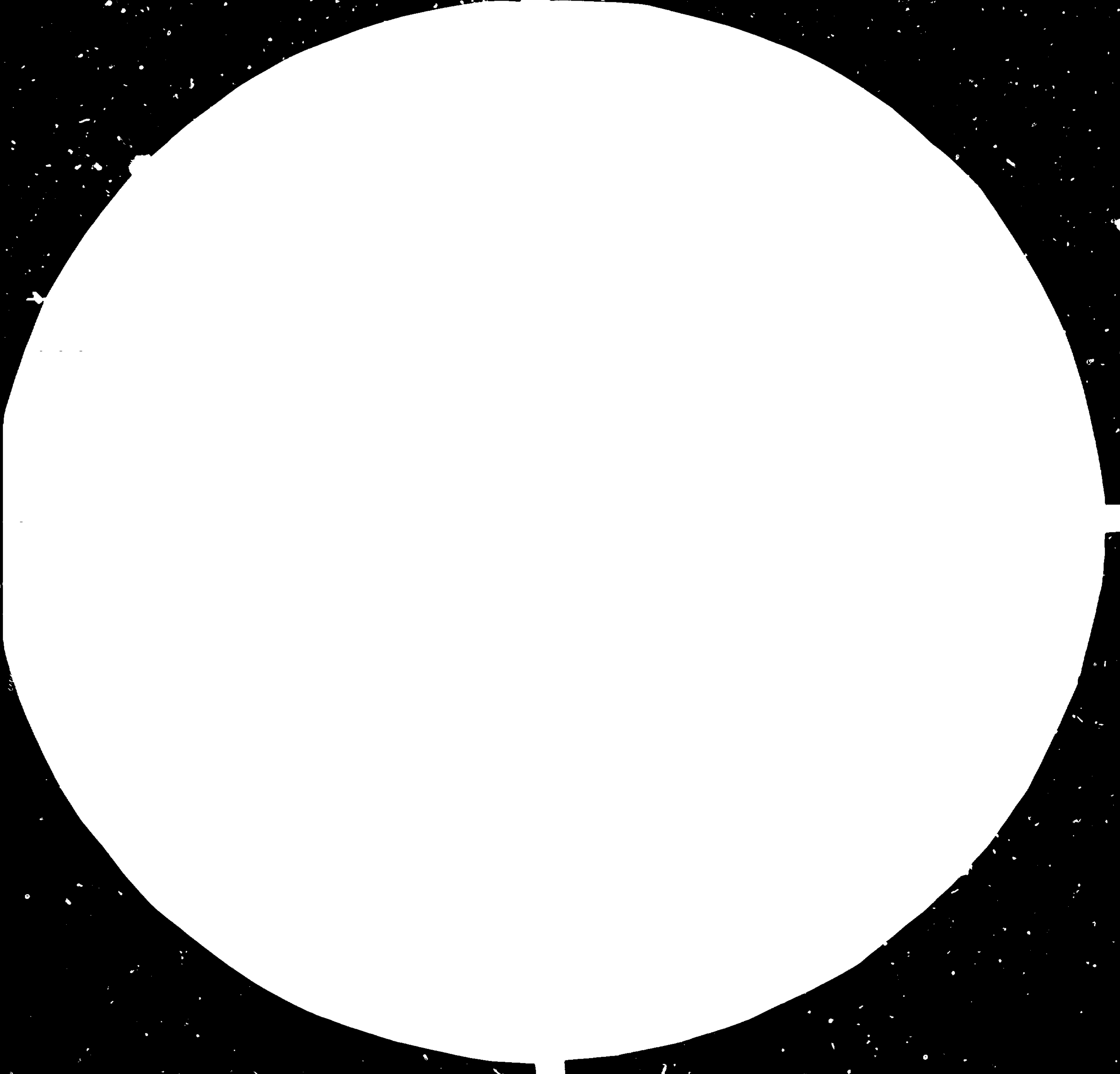

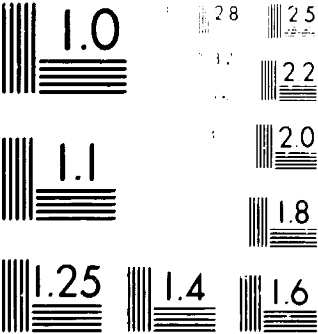

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Chile. ASSISTANCE TO THE
INSTITUTO DE INVESTIGACIONES TECNOLÓGICAS.
(INTEC)

SI/CHI/82/801

CHILE

Technical report *

Prepared for the Government of Chile
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of R.H. Westergaard,
industrial research organization expert

United Nations Industrial Development Organization
Vienna

* The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

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TABLE OF CONTENTS

1.0 INTRODUCTION

Over two weeks the consultant has been shown INTEC and has discussed the situation with its staff, visited clients, officials and CIMM as well as Foundation Chile and the University of Chile. In addition a good deal of documents have been studied. The program has been very fullpacked and there has not been much time to write a report. The present document consists of notes prepared in-between meetings, other activities and in the evenings. There has been no time to work them together to a coherent report or to weed out redundancies. The notes will be used in Vienna along with the contributions from the other consultant, to prepare the final report.

As certain decisions are in the process of being taken in Chile, these days, the notes may be of some use. It is emphasized that they do not yet have the status of a UN document and in the final discussions some of the views may be adjusted or taken out.

Each note has been given a number, which together with the list of content can facilitate the use of the notes. On the following pages is also a summary.

2.0 SUMMARY AND SOME SUGGESTIONS

INTEC CHILE is considered a successful multipurpose, multidiscipline institute, with a degree of self-financing which, even by the standard of industrialized countries, is impressive.

2.1 Diagnosis

Still it is in serious trouble for the following reasons:

- The government wanted it to be self-financing to a degree which will either kill it or transform it to an institution which can hardly be called a Research Institute.

- The creation of Foundation Chile and its choice of activities, having invaded INTEC's market, Foundation Chile has created a redundant capacity for contract research in a very depressed market. With its superior financing Foundation Chile may soon kill INTEC and create severe problems for some other research institutes.

- The world economic crisis together with the national economic problems have (temporarily, we must hope) created a rather difficult climate for industrial research in Chile.

- INTEC's status as a government entity may create additional problems in an economy believing in private enterprise and the free market forces.

- INTEC has contracted so much in terms of staff that many of its activities are below the size which in the long, or even medium term, is optimal and are in danger of failing.

- INTEC has for too many years lived on the limits of starvation and has exhausted its resources in terms of people and equipment.

2.2 Does INTEC have a role to play in the short and long term?

In the short term, INTEC's role is important although it is difficult to sell all available capacity.

In the long term, if industrialization and the economy in general develops favourably, Chile will certainly need more research capacity than it has today. So there ought to be a future for INTEC.

To give up INTEC now would, for the government and for CORFO, be an act of defeat. It would signal lack of believe in being able to solve the economic problems of Chile.

The consultant's opinion is that there ought to be no reason for such pessimism. Chile has a very good potential. Well educated, dedicated people, plentiful natural resources and already a good infrastructure and a considerable industry.

2.3 Possible solutions for INTEC

Three alternatives are listed below. The sequence does not reflect priority.

1. A considerable financial support through CORFO or other sources to the tune of 50% of the present budget for a period of say 3 years.

2. If Foundation Chile would stop competing with INTEC, and other national research institutes and instead help them, INTEC could take over Foundation Chile's contract research and again become forceful enough not only to survive but to take on

new activities and gradually expand.

3. INTEC could be integrated with the University of Chile, which would also secure larger groups, more economic operation and access to more expertise and a less pressed competition.

Both alternatives 2 and 3 will require government money but less so than alternative 1.

Alternative 2 and 3 will need very careful evaluation. It'll necessarily take time to agree to and make effective. In the meantime alternative 1 must be resorted to.

2.4 Who should pay for INTEC and why?

CORFO is the owner of INTEC. But INTEC serves many other interests and as CORFO is operated as a profit-making enterprise, it is unreasonable that CORFO shall bear alone the burden of providing the economic platform for INTEC. It already contributes more than desirable, from CORFO point of view, by financing special projects not directly related to CORFO enterprises. It is impossible to increase the overhead charge on paid projects so much that it can secure a healthy development of INTEC.

It is a national obligation to secure adequate industrial research facilities in the country: partly because of the social benefit and partly as a stimulus for industrial development. Every country with ambitions, developed or under-developed, recognises this duty. A substantial fraction of the money needed to save and improve INTEC has to come directly from government or from government via the relevant government institution such as a research council.

3.0 INDUSTRIAL RESEARCH IN CHILE

As this report has Chilean institutions as its target, it has no purpose to elaborate on the research system and the various research institutes, nor on the economic/political situation, except when of consequence to INTEC.

In Chile there are some 8 branch institutes which seem to function well (have only seen CIMM which is handling mining and extractive metallurgy. It was well equipped and seemed to be efficient and well-balanced between short term services and more long-term research, 60% external, 40% in house).

Multibranch services are offered by INTEC and two Santiago universities and the Foundation Chile. There is considerable competition for projects and INTEC must press its prices.

The Universities have their existence secured and have resources to develop people of high professional standard without charging the cost to their clients.

Unless INTEC gets some economic subsidies and/or somehow is merged with the University, it has small chances of surviving. It has already contracted so much in staff that some of the work groups are below critical size and they spend so much time on projects, 78% that there is too litle time for self-renewal.

3.1 Sources of finance

Under the present economic system it is attempted to press the research institutes to be 100% self-financed. Actually they have been receiving some support but with the understanding that they must soonest be self-financed. This squeeze has done some good. It has forced them to rationalize and become more efficient, to use more subcontracting etc., but this policy is destructive if carried too far. There is in CORFO - the owner of INTEC - an understanding of the fact that INTEC is in serious trouble and hopefully the UNIDO team can contribute to finding an acceptable solution.

One move in this direction is the new Research Council which will fund research projects. For juridical reasons INTEC can not get money this way. One government body does not give money to another in Chile.

Because of the severe unemployment situation, government institutions have been told not to give staff. In order to comply economic assistance may have to be given.

The economic worldwide recession together with the sudden change of economic system in Chile has caused a difficult climate for industrial research. Gradually this climate must be expected to improve and it may be a good investment to keep INTEC alive until such time.

4.0 CRITICAL SIZE

In the UNDP/UNIDO IRSI evaluation the term critial mas (analogy from uranium reactors) was much used. As INTEC has been contracting the question has been raised if its size as such or of the various professional groups may have fallen below viable size.

4.1 Institute size

The question of critical size is difficult to answer in absolute terms, because so many parameters are involved.

Obviously an IRSI can be small if it exits in an environment where it can subcontract much of its work. Many viable institutes exist with less than 100 persons.

A general purpose, multibranch institute needs to be larger than a branch institute because it needs to have more groups, each of which must have viable size. The size also depends on the level of sophistication. The more sophisticated an institute is, the larger it must be because of the many instruments and specialities. In case of INTEC a staff of 200 would allow more stability and better services. It is thinkable that an INTEC with 100 people will have more problems finding a market than an INTEC with 200. because the larger institute could offer better and more diversified services.

4.2 Group size

In many institutes one may find some very small specialities with one researcher and a technician. This may be O.K. when the speciality is the use of some special equipment, like electron microscopes and various analytical tools.

Groups which are covering broader aspects, such as projecting and engineering, automation, microbiology, operational analysis, electronics, need to be larger; maybe from 3 to 5 professionals or more depending uppon the level of ambition.

The electronic group at INTEC is doing fine work, but is obviously dangerously small. The loss of one senior researcher could have serious consequences.

Since it is imposible to give generally valid figures of critical size, this must be assessed from case to case, asking such questions as:

- Is the group too small to be flexible in terms of taking on projects?
- Is it so small that it must refrain from taking on large interesting project?
- Is it too small to have the needed specialist?
- Is it too small to provide an inspiring environment?

In case of the institute as such - provided each group is of adequate size - the main questions is: can it meet the market demand or must it reject interesting projects?

Another criteria is if it is large enough to be able to have good internal services taking care of such things as:

- Promotion and marketing
- Computer services
- Library and information
- Workshop facilities
- Printing and reproduction
- Stores and stocks
- Legal advices
- Health and other personnel benefits

Without having had enough time and oportunity to study the situation at INTEC, it is impossible to come up with a well-founded assessment. But the consultant's impression is that considering the multitude of activities covered, many of the groups are undersized. Further contraction will be dangerous. If INTEC could grow some 10 - 15% anually in the years to come it may become more viable and usefull in promoting industrial growth.

5.0 GOVERNMENTS ROLE IN RESEARCH POLICY IN A MARKET ORIENTED ECONOMY

One of the most important leasons learned in the recent UNDP/UNIDO evaluation of IRSIS was that the application of a stereotype IRSI model -disregarding local political, economical conditions a level of development as well as development potentials- can cause severe mistakes.

The UNIDO team is very much aware of this pitfall and tries to be as realistic as possible. It is necessary to assess the appropriate role of the Chilean government in shaping an efficient IRSI policy.

In what may be termed the social democratic countries of most of the industrial world, industry and market forces are responsibles for controling 70 to 80% of the research. Government controls the rest.

The reasons for needing government control are mainly to cater for the future (industry is rather cash-flow , short term oriented) and to cater for the needs of the society. Needs which do not represent a business opportunity for the private sector.

In a country with a liberal, market oriented economy,the business sector is likely to be even more cashflow,shortterm oriented and perhaps showing less social responsibility. The research policy in Chile has aimed at provoking the IRSI's to be effective and shed off activities for which there was no market. This has resulted in better management and efficiency, but also tended to force IRSI's like INTEC to do work which has little to do with research. It has also crippled the ability to develope new skills and do future oriented work.

It is difficult to find valid arguments for believing that there is less need for government subvention and control in Chile of a multibranch, multidicipline IRSI like INTEC than in the more developed countries. On the contrary, in a less developed a country it is more necessary for the government to support research as a means of promoting development.

5.1 Should the less developed countries spend more money on research than the more developed countries in order to catch up?

The answer is generally no. Much of the research money spent in eg. U. S. A. is used for space research, atomic energy, military purposes and on other sophisticated areas not relevant in developing countries. Developing new revolutionary technology in developing countries is, generally speaking, less profitable than in highly developed countries. The less developed countries are not able to promote introduction of sophisticated new technology and have a market which is too small to pay for the failures with occasional success, because of their limited profit possibility in a small country.

In developing and smaller countries, R & D is related to more conventional products and processes than in the U. S. A. and comparable countries. The project success rate needs to be higher. Costly high risk projects are seldom justified in developing countries.

5.2 The Potential of Chile

Compared to most other countries clasified as developing countries, Chile has many advantages:

- a relatively homogenous population.
- high level of education and many people with university education.
- better than average natural resources: mining, foresty, fishing, agriculture, oil, hydro electric power, good harbours, good climate.
- good infrastructure.

There is no reason to be so modest in terms of ambitions with respect to industrialization and ability to compete with other countries.

6.0 NEW FIELDS OF ACTIVITY FOR INTEC

Intec's role is to do technological work (research) for industry private and public, filling in the gaps not covered by the branch institutes. It competes for this work with Universities and sometimes branch institutes and Foundation Chile. With the small manufacturing industry, the present market is limited and INTEC has few specialities to offer which can not be found elsewhere.

If INTEC shall have a bright future it must, probably within the constraints just mentioned, develop some new skills which in the future have a growing market. Below some such activities are suggested.

1. Instrumentation, measurements and automation based on computerization.
This is probably the most promising field. It could serve all the branch institutes and the primary manufacturing companies and make them more competitive.

2. Microbiology has many aspects:
Industrial and public hygiene, various types of fermentation industries which can be foreseen to have a bright future because of the new processes based on genetic engineering.

3. Robotics. In manufacturing robots take over more and more. Chile should not (or only in a transition period) establish production based on cheap labour. It will be necessary to use modern technology and robotics is absolutely essential. It is a science related to # 1. It is important to have activities which mutually support one another.

4. Environmental protection. The most industry relevant activity relates to industrial effluent to the water and the atmosphere. Environmental impact studies, using computer modelling and sophisticated chemical analysis lends itself well to an institute like INTEC. Studies of purifying effluents and recovering by-products and recirculation of materials are other possible activities in this field. It relates very much to primary industries and

therefore a market should exist.

#5. Fish processing. It is understood that the fishing research institute is devoted mainly to biological and ecological studies and not to the use of fish. There may well be room in Chile for more local consumption of fish as well as export of iced, frozen, irradiated or canned fish and other seafood products. For INTEC this may be a natural activity.

6.1 How can new activities be created?

There may be many roads to this.

- Persuade a company to take interest, or take advantage of an incidental opportunity to enter the field.
- Make a feasibility study.
- Send people abroad to learn what others are doing and acquire the skill needed to start up.
- Do inhouse projects and try to use the results to arouse a sponsor.

From case to case the resources and the time needed vary from case to case. Some of the areas mentioned could be entered without lengthy preparations, others may need substantial public funding over several years.

The main stumbling block is that Foundation Chile is already planning to be active in the fields proposed.

7.0 THE ROLE OF IRSI'S IN ESTABLISHING NEW INDUSTRY, NEW PRODUCTS OR PROCESSES OR IMPROVING EXISTING PRODUCTS AND PROCESSES.

An industrial project has several components or activities. If the project is relativily simple, the IRSI can be responsible for all these activities. This is often the case in the least developed countries and when the projects are small and simple.

If a project is large and sophisticated the IRSI is responsible only for a small fraction of the work and this fraction is highly research-oriented.

Below are listed some of the activities typical of an industrial project.

1. Compile information -state of the art,available technology.
2. Prefeasibility study: markets, inputs , business opportunity.
3. Research, laboratory experiments.
4. R & D,larger scale experiments, possibly pilot plant and preliminary design.
5. Final feasibility study.
6. Engineering and practical adaptation of R & D results.
7. Construction.
8. Start up, debugging.
9. Backstopping.
10. Operation.

The role of the IRSI varies with the size and nature of the projects. In case of an electronic device needed only in small numbers, the IRSI could be responsible for all phases from 1 to 10.

In case of a new large factory the role is limited to at the most 1 to 3 and participation in 4, and maybe only to one of many components of the factory.

In case of a single piece of equipment such as the fumigation chambers developed at INTEC, INTEC was responsible for all the 7 first steps.

An IRSI which concentrates on the most research intensive activity (no 3) can do much more for the industrial development in the country than one which covers also the more practical aspects. Activity 4 R & D should always be made jointly with industry in case of sophisticated projects in order to reduce the need for addaptation of IRSI results to industrial conditions and to secure realism.

8.0 INTEC'S PRESENT AND FUTURE ROLE

It is obvious that in order to survive and as a result of the stage of development at INTEC and in industry, INTEC is in most cases taking on activities far beyond 4 = R & D. In case of the fumigation plant they perform routine repeated projects involving no research.

This may be useful and profitable for INTEC and of value to the country, but is not the ideal role of an IRSI.

If INTEC shall be justified and have a significant national impact, it ought gradually to concentrate on the activities which have a research nature and which nobody else can do. But this transition can not come suddenly. It is a longterm goal. In order to reach it: INTEC must develop higher skills and must find some new specialities. This will take time and require input of government money. Success may not be possible without a change in the industrial climate. It requires that industry becomes more adventurous and shows more entepreneurship, and that more manufacturing is done in Chile.

If Chile will depend only on primary and to some extent secondary industries related to natural resources, the scope for R & D at Intec will be small, as the branch institutes can do most of the work.

Without manufacturing it will be impossible to find enough work for the people of Chile. Sooner or later, ways and means for encouraging local manufacturing must be found — until then INTEC may have to conserve itself in a survival modus of existence — hopefully given means not only to survive but also to prepare for a better future.

8.1 Is INTEC redundant to the other competing institutions and should it be maintained?

INTEC is in most respects redundant to other institutions, but one may as well say that they are redundant. Foundation Chile was created after INTEC and has invaded many of INTEC's fields of work. Both have working groups of similar (sub-optimum) size.

Competition is good as long as it does not either cause too much fractionation into small enterprises of low capability nor causes one enterprise to grow at the expense of the others until it has virtually a monopoly. If either of these extremes seem to develop,government may want to interfere. So far fractionation seems to be the most obvious danger. But there is also a danger that Foundation Chile with its financial superiority and international affiliations may get a monopoly in several fields.

It is the judgement of the consultant that INTEC under unfavorable competitive conditions has survived, not without glory! Each pesos spent at INTEC appears to produce more results, than in most of the competing institutions, but INTEC will lose out and deteriorate in a few years unless something is done to improve its situation. Much money and human effort has been invested in INTEC and it has payed off (as far as it is possible to judge after a short visit). To let the institute die would be a regrettable loss to the country.

On the other hand to keep it alive by artificial feeding and breathing can only be justified as an emergency procedure.

It is highly recommended to keep INTEC alive at least a few more years, hoping for better times. But to keep it alive on the starvation limits has little sense. It will only cause pain. It needs to recover and rebuild its strength in order to be able to prove its right to exist. A half-hearted help is no real help.

There is at present an overcapacity for services which can be sold at full price. In the future the demand may grow. The number of researchers in the country is quite low relative to the size and potential of the country in comparison to other countries.

Government in other countries has invested in building up research capabilities and doing research giving a contribution considerably in excess of what is used by industry for IRSI services. This investment has paved the way for fast industrial growth. Norway is a good example.

9.0 GOVERNMENT RESEARCH POLICY IN OTHER COUNTRIES

All governments have problems with creating a good policy with respect to its support and its influence on Industrial Research. One of the UNIDO consultants comes from Norway. This country in 1981 made a study (NOV. 1981: 30 A and B) titled in translation:

" Research, technical development and industrial innovation "

with the subtitle: " An evaluation of the public support of technical - industrial research and development in Norway ". Although Norway has a more developed national industry than Chile, the countries have many things in common. The report does, for comparison, also give some information on the policy in some other countries. The whole system of research institutes and research councils have been created after 1950. (with a few exceptions).

9.1 Research Councils

There are several research councils covering more or less separate fields such as:

- Technology and natural science (NTNF)
- Fishery
- Agriculture
- General sciences

The council for technology and natural sciences (NTNF) is the one responsible for most of the industrial research It has erected and more or less financed many IRSI (*). It receives its funds from the governmental

(*) IRSI = Industrial Research and Service Institute.

department for industry and from the profit made by the state football pool company.

9.2 Branch Institutes

Norway has many branch institutes such as: Herring meal,potato processing, (starch, glycose and alcohol), pulp and paper, concrete and cement, brewery, dental materials, wood processing and furniture, brick making, canning industry and many others related to agriculture, ships research, electricity distribution, building research.

9.3 Mono-purpose institutes

Oceanography, geological survey, continental shelf investigations, underwater technology, air pollution, water pollution, harbours and hydraulics, geotechnique, road research, transportation/economics, energy research (previously atomic energy), defence research.

The branch and mono purpose institutes are financed by the various branches, relevant departments and project money or direct subvention from one or more of the research councils. Most of them have project income as an important financial source. There is also a Branch Research Foundation giving out public money.

9.4 Multipurpose - multi branch - multi discipline institutes

SINTEF is based at the technical university in Trondheim and cooperates in various ways with most of the faculties and draws on university expertise. It has in addition full-time staff of 950 and is considered very successful.

SI (Central inst. for ind. research) in Oslo was erected by the research council for technology and natural science, NTNF in 1950. It has 350 staff and about 130 professionals.It works in a variety of fields, computersciences and electronics are the most successful.

CMI was established as a foundation donated by a wealthy person. It had relatively few fields of activities originally, but takes on more and more. It has some 250 persons.

9.5 Industries own research

The large industries, some of which are partly state owned, have research facilities and do more research than the institutes. They finance their own research, but can apply for partial financing from the research council and some other public sources of finance.

The Norwegian NOU report covers 173 pages and 336 pages in an addendum. Only a few figures from the many tables and graph can be mentioned here.

It may be most interesting to look at SI and SINTEF. SI is similar to INTEC today. If INTEC merges with the university, SINTEF will be the model.

Income sources in 1.000 Norwegian crowners, in crown = 10 pesos.

	NTNF Projects	Public Sector Projects	Other Research Councils	Industry	Other Business	Foreign Sources
SI	28.313	3.649	5.250	10.418	8.456	3.290
SINTEF	40.575	43.011	7.704	31.975	11.750	4.982

	General Subvention	Projects	Projects share	Special equipment
SI	10,6	19,92	2,4	2,85
SINTEF	8	40,8	3,1	1,54

It can be seen that SI is more expensive to operate than SINTEF as a result of SINTEF's affiliation with the university. SINTEF uses the money more efficiently.

9.6 Research Council Projects

Various policies have been tried over the years. in the beginning, SI got most of its budget directly from NTNF. This made life too easy and more and more money became ear-marked project money, until it was realized that NTNF should not try to exercise such detailed control. It has in the NOU report been suggested to let SI administer more money itself. NTNF will gradually discontinue handing out money for small projects and instead concentrate on broader programs.

Much of the success of the NTNF system is due to the policy of promoting industrial participation. NTNF tries not to give money to projects unless there is also an industrial participant who contributes with money. Larger projects and programs always have steering committees with industry representatives.

9.7 Why use so much money?

Norway spends 1,4% of BNP for research 26.750 billion pesos. Only 36% is paid by the enterprises. The answers are:

- By having high level IRSI's also smaller enterprises can have access to sophisticated services and technology.

- By subventing research the government hopes to stimulate the willingness to go into research based production (peak technology with high potential but also high risk).

- Many research needs relate to: health, protection of human life and environment and responsible use of natural resources. The private sector will not finance such activities. For this reason government must create research institutes and give them enough funding to secure the needed competence and stability.

The policy has paid off. Norway has since 10 years developed a large offshore petroleum industry. Because of the high competence and good laboratory facilities in the country, Norway can now be operator both for exploration and exploitation. It produces semisubmersible drilling platforms of own design, as well as production platforms , does most of the engineering and delivers 80% of the inputs to the oil industry in open competition, despite the very high labour cost in Norway.

All the institutes do well and have enough high level projects, despite the international economic crisis.

10.0 THE NORWEGIAN RESEARCH SYSTEM EVALUATION

Part of the addendum to the NOU report is produced by the British SPRU and is in English. On the following pages some of the tabulations are reproduced (the whole English section covers 137 pages and a copy is given to INTEC).

p. 195 presents the SPRU report.

p. 199 to 202 is a summary

204 and 205 shows in a block diagram the Norwegian system.

211 shows the government funding of industrial research in 9 developed countries. It can be seen that no country bases its research on institute self-financing. In developing countries the self-financing is much smaller often in the order of 10%.

p. 220 shows the sources of money used by NTNF, the council for industrial research.

p. 224 shows the sources of income at SI (the institute of the Norwegian consultant).

p. 231 shows how SINTEF is financed. SINTEF is located at the technical University in Trondheim. SINTEF has 950 people of its own and in addition draws on the professional staff of the University. It has a wide range of agreements with the various institutions and faculties of the university. It can be seen that SINTEF is a more economic model. It needs only half as much general funding as SI and is generally playing a more important role. This model is worth consideration in Chile (ELAB is an electronics institute).

Both SI and SINTEF get large projects from international companies operating in Norway. The small scale industry is helped by the STI, the states technological institute which is very practically oriented. It gives vocational training.

The report covers various fields of industries.

p. 247 shows how electronic services are used.

p. 257 indicates the rate of project success. RF is a new institute associated with a technical college. It does little experimental research. It is located in Stavauger - The oil capital of Norway. Again it appears that SINTEF is more successfull than SI because of size and facilities and expertise provided by the University.

p. 266 and 261 sheds light on the strengths and weaknesses of SI and SINTEF.

Vedlegg 4

Government Support for Industrial Research in Norway: A SPRU Report

John Irvine, Ben R. Martin, and Michiel Schwarz
with Keith Pavitt and Roy Rothwell

A Report Prepared for the Industriforskningsutvalget by the Science Policy Research Unit

University of Sussex, Brighton, U.K.

July 1981

Executive Summary

1. The establishment and operation of a collective research system is only one of a number of measures governments can take to encourage and support industrial innovation. Norwegian research institutes should thus be viewed as representing only a single, albeit a key, component in this broader scheme for stimulating technological change.
2. This implies that collective industrial research can only be fully effective if broadly integrated within a wider government strategy towards technological change and industrial development. This is difficult if there is no clearly formulated, explicit national industrial strategy. Perhaps this accounts for the present lack of co-ordination in Norway between the various government measures for the support of technological change and innovation, and for the relative neglect of some of the measures for encouraging innovation that are available to governments (such as an innovation-conscious procurement policy).
3. One of the principal components of any national industrial strategy must be an integrated research and development (R&D) policy. To help draw this up, NTNF and the research institutes would be required to generate forward-looking policies involving both plans for their longer-term research interests, as well as efforts to improve the services they offer to firms.
4. All this would clearly require careful co-ordination and collaboration between all the interested parties. The formulation of an overall strategy for R&D, innovation, and industry should involve representatives from government, industry, trade unions, the research councils, and institutes, as well as from various interest groups in society (in the fields of education, health care, environmental issues, etc). Ultimate responsibility for the construction of this overall strategy and in particular for ensuring coherence between its constituent components should presumably rest with the Ministry of Industry.
5. Periodic reassessment and updating of the industrial and technological strategy would be essential. It should be flexible with respect to changing societal and market needs, and to emerging technological opportunities and threats. It should not be amenable to change according to the whims of party politics.
6. The adoption of such a strategy would greatly facilitate the selection of areas of technological research on which resources were to be concentrated. Institutes would then be invited to submit to NTNF proposals for l o n g - t e r m (3 to 5 years) r e s e a r c h p r o g r a m m e s in those areas. This would help overcome the fragmentation and discontinuity in research efforts discussed in section 13.2.2, and enable institutes to achieve a «critical threshold» of resources in each chosen area of technology. It would also permit greater decentralization and even a formal separation between NTNF and the institutes (see 15 below), with stronger institute boards being made responsible for planning and monitoring research activities at each of the institutes.
7. For each area in which proposals for longterm research programmes were sought, NTNF would appoint an ad hoc committee of experts containing strong industrial representation. This committee would decide which of the proposals submitted by institutes was to be supported.
8. In order to overcome the danger of the programmes resulting in «research for its own sake», their implementation should be carefully monitored by the ad hoc committees in close association with the boards of the institutes concerned. Furthermore, gradually increasing industrial involvement could be built into the funding of each programme.
9. Besides supporting long-term strategic research at institutes, NTNF would also fund i n d u s t r i a l R&D p r o j e c t s initiated by firms and carried out by them alone or in collaboration with institutes.
10. To prevent the use of this «industrial R&D» support from being dominated by a few large firms in each sector, positive

steps should be taken to ensure wider involvement. For example, the number of applications accepted by NTNF from any one firm could be limited, and the procedure for applying simplified (see 34 below).

11. While it is extremely important to encourage proposals of high quality from firms, care must be taken to ensure that overemphasis of this point does not militate against small firms' applications.

12. While high quality proposals are clearly essential, of even greater importance is the quality and utility of the R&D carried out, and particularly its transfer into industrial application. It is clear from this report that assessment in this area has been rather lacking (section 13.2.3).

13. This implies the need for more careful monitoring of on-going research programmes and projects, and for mechanisms to assess the degree of success in implementing research results in industry. This «quality control» function could be carried out by NTNF committees and by institute boards. Perhaps some of the techniques utilized in this study might be adopted.

14. The establishment of a coherent strategy within the research institutes (and by NTNF with respect to the institutes) should go some way towards resolving the confusion that currently exists concerning the role and functions of instututes (section 13.3.1). In particular, it should clarify their function with respect to long-term «strategic» research.

15. It is suggested in this report that the above function, along with those of «industrial research and development» and «special help for small firms», should be administratively separated, with each receiving separately designated funding. Institutes and firms would then no longer compete directly for funds, as they do at present, often to the disadvantage of the firms (particularly smaller ones). Moreover to avoid the potential conflicts of interest currently associated with NTNF trying to fulfill two roles at the same time — that is, funding R&D, and being responsible for NTNF institutes — a formal legal separation between NTNF and the institutes should perhaps be considered.

16. The present rather unwieldy system of 20 NTNF committees could be greatly reduced to a small number of «industrial R&D committees» so chosen that they correspond more closely with today's (and tomorrow's) technological needs. Since these committees would only consider applications from firms and not institutes, and since the number of applications accepted from each firm might be limited (see 10 above), their workload would be considerably less than that for the present committees. The membership of these new committees could therefore be kept very small. In addition, the use of overseas experts might be considered in order to avoid possible conflicts of interest.

17. In selecting between projects submitted to NTNF industrial R&D committes, the key criterion should be the likely industrial benefit of the proposed work, rather than whether it is technologically «interesting».

18. For those firms successful in obtaining project grants, the choice as to whether or not to use the institutes for carrying out some of the work would remain with them.

19. If a firm did choose to sponsor work at an institute, financial provision could be made in the grant to encourage the transfer of technology through the movement of people. For example, the firm might be encouraged to send some of its staff to work at the institute in the early stages of the project, helping to specify exactly what was required. In addition, towards the end of the project, institute staff might be required to spend some time at the firm implementing the project results (see 28 below).

20. However, the present scale of NTNF support for R&D carried out in industry is so small that its effects are little more than marginal. One ultimate aim of a national industrial strategy would be to move away from providing large subsidies for declining industries, and towards backing potentially important new industries on the one hand, and encouraging (for example, through retraining schemes) moves away from industrial sectors that are likely to be threatened in the future before firms run into financial difficulties on the other. In short, there would be more of a «preventative medicine» approach, with procurement policy again playing a key role.

21. In order to fulfill the increased strategic role assigned to them, several institutes might require considerable reorienta-

tion. Institutes incapable of adapting themselves sufficiently might have to be phased out, or at least encouraged to perform different, less research-oriented functions (such as organizing training courses, providing assistance to small firms, and carrying out development work), while staff were being retrained to work in more strategically important areas of technology.

22. This raises the question of the need for constant regeneration of institute staff. Skills and attitudes geared to solving yesterday's problems may be inappropriate to the implementation of forward-looking strategies, particularly if they involve new areas of technology and new markets.

23. As part of this regeneration process, the institutes will need two main types of recruits: new graduates, and engineers or researchers with industrial experience. The first of these can best be provided through the very close association and perhaps physical integration of an institute with a local university or regional college. (Involvement in teaching would also stimulate institute staff, helping them to maintain their research creativity and to develop new skills.) The second might be achieved through the introduction of a more flexible salary structure to attract experienced industrial researchers, even on a short-term basis.

24. The prime function of the technical collective research infrastructure is that of technology transfer, and, in the Norwegian context, there are three aspects to this. First Norway, being a small country, and performing less than 1% of the total world R&D, clearly needs to import ideas and technologies from abroad. In order to facilitate this process, much greater funds need to be provided for financing institute staff to work overseas for temporary periods in universities and advanced technology firms.

25. Secondly, there is the aspect of the transfer of technology between institutes, a process which, this report suggests, is highly unsatisfactory (Section 13.3.3). Although it might prove difficult to arrange, there is no doubt that the transfer of individuals between institutes (even on a temporary basis) could greatly improve this process. Mechanisms to facilitate such transfers should therefore be actively sought (for example, through the secondment of staff from one institute to another to build up teams for carrying out strategic research programmes).

26. Thirdly, there is the all-important transfer of technology from the institutes into industrial use. At present, no very effective mechanisms appear to operate in Norway to facilitate, or even to monitor, this process. This major weakness in the system might be alleviated through a combination of measures.

27. In the first case, with strategic research programmes, institutes should be encouraged to recruit, on secondment for one or several years, research staff from user industries. These individuals would, in turn, be actively involved in the later industrial implementation of the research results.

28. A second mechanism involves the transfer of industry-sponsored R&D undertaken at institutes. The institute might be required to submit a report not at the end but 80% of the way through the project, after which institute staff would spend the remaining 20%. of the time working to implement the results within industry.

29. A third mechanism involves the State Technology Institute (STI). At present, there appears to be little contact between NTNF and the institutes on the one hand and STI on the other, thus restricting the possibilities for diffusing new industrial methods and techniques into industry. Consideration should perhaps be given to the establishment of a formal body within the Ministry of Industry linking and co-ordinating the activities of NTNF, the research institutes, and STI.

30. A final mechanism is the encouragement of long-serving institute staff to undertake «industrial sabbaticals» perhaps once every 5 or 6 years. This would increase their awareness of industry's problems. They might, in particular, spend their time on projects involving the implementation of previous research at their institute. Firms would then be able to use institutes as a «library of skills», temporarily borrowing researchers on sabbaticals.

31. The collective research system, as currently constituted, is being abused by certain firms, some of whom fail to put in their share of the costs of a project for which they have received NTNF support. Such abuses could be discouraged

by taking more care to ensure that grants are awarded only for projects to which firms are genuinely committed. By removing the need for firms and institutes to compete directly for the same funds, one would end the current bargaining process in which institutes «solicit» industrial partners, a process that often results in firms entering projects to which they are only half committed.

32. Another questionable use of the system concerns those firms receiving grants for work that they themselves can afford without NTNF help. Greater consideration should therefore be given by NTNF committees to the ability of firms to carry out R&D without help.
33. Some firms, particularly smaller ones, are unable to use the existing collective research system very effectively. In the competition for funds with institutes and large firms, they are at a severe disadvantage. They need special help.
34. This might be provided by a more technically-oriented STI, although this would probably require better co-ordination between NTNF and STI than there is at present (see 29 above). In addition, the institutes might provide subsidized services for small firms. Finally, NTNF could make the procedures involved in applying for help more simple (with a less complicated application form for small firms) and more flexible (by having more than one application date each year). It could also provide a «sign-posting» service to inform firms of all the . ities and types of help available.
35. Successful innovation depends as much on non-technical factors (such as good management, forecasting of user-needs, and marketing) as it does on technical ones. At present, NTNF, when deciding which projects to fund, rather neglects these non-technical considerations. The ability of the firm concerned to supply the necessary non-technical skills should be incorporated as one of the criteria in the selection precedure for projects.
36. In addition, institutes could begin to build up non-technical support services, perhaps through co-operation with a university or college, or through «swap» arrangements with firms.
37. By virtue of the unique opportunity afforded by North Sea oil, Norway has the resources required to implement these various measures. With a strengthened and evolving R&D capability, Norwegian industry and indeed the country as a whole could enter the 21st century with optimism.

1. INTRODUCTION

The crucial and increasing importance of research and development (R&D) and of innovation in general in strengthening and maintaining the international competitiveness of a nation's industry is by now firmly established. Although the need to develop an industrial R&D capability had been recognized in Norway for some time, it was only at the end of the Second World War that the first steps were taken in this direction. The Royal Norwegian Council for Scientific and Industrial Research (NTNF) was set up shortly afterwards in 1946. Of the various mechanisms available for state support of R&D, Norway has chosen to concentrate particularly on that of «collective research», with centralized facilities funded by the government at institutes carrying out research for the benefit of (and partly paid for by) industry and public agencies.

Over the 35 years of its existence, NTNF has grown significantly in both size and complexity, establishing a large network of committees to determine and administer the distribution of research resources, as well as running its own research institutes. In addition, various other mechanisms for the support of R&D have been set up outside NTNF. The total system for the support of R&D has, however, become rather complex and inflexible, and one apparent consequence of this is that many firms are increasingly experiencing difficulty in using the system. This is one important reason for assessing NTNF and its relationship to other mechanisms for the support of R&D.

A second main reason for carrying out such a study concerns the changes in the structure of the Norwegian economy, and in the nature of firms, many of which now have their own R&D capability. This gives rise to the question of whether the NTNF system as presently constituted is still appropriate to current industrial needs.

Thirdly, the retirement of Robert Major, NTNF's Director for the first 34 years, and the question of who should succeed him, gave rise to a debate over the aims of NTNF — for example, over the relative emphasis that should be given to long-term research compared with shorter-term development work, and whether it was wise for NTNF to operate both as a funding agency and an

FIGURE 1

MAIN CHANNELS OF FUNDING FOR GOVERNMENT SUPPORT OF R & D

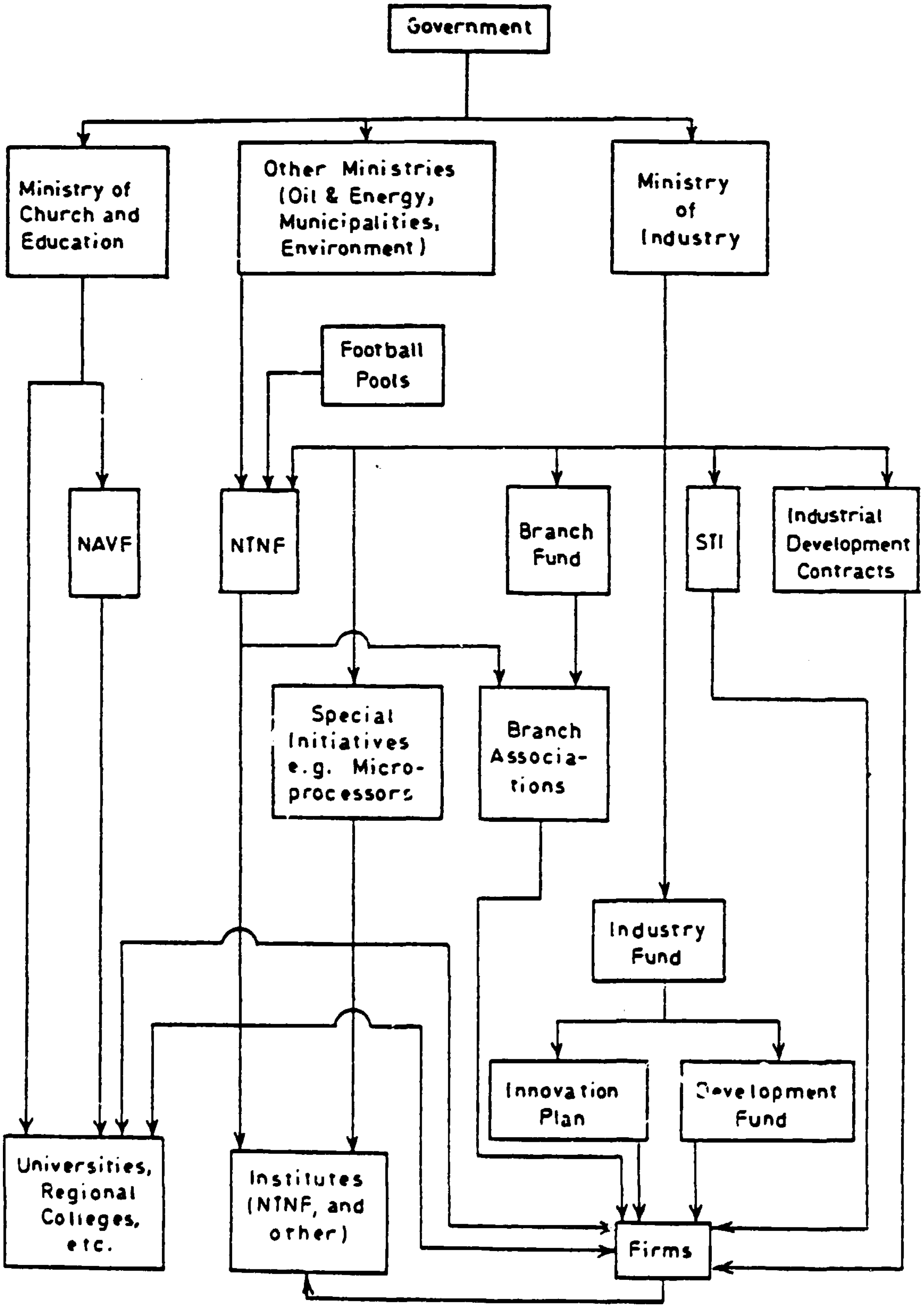

FIGURE 2

SUBSECTION OF GOVERNMENT SYSTEM FOR SUPPORT OF
R & D FOCUSSED UPON IN STUDY

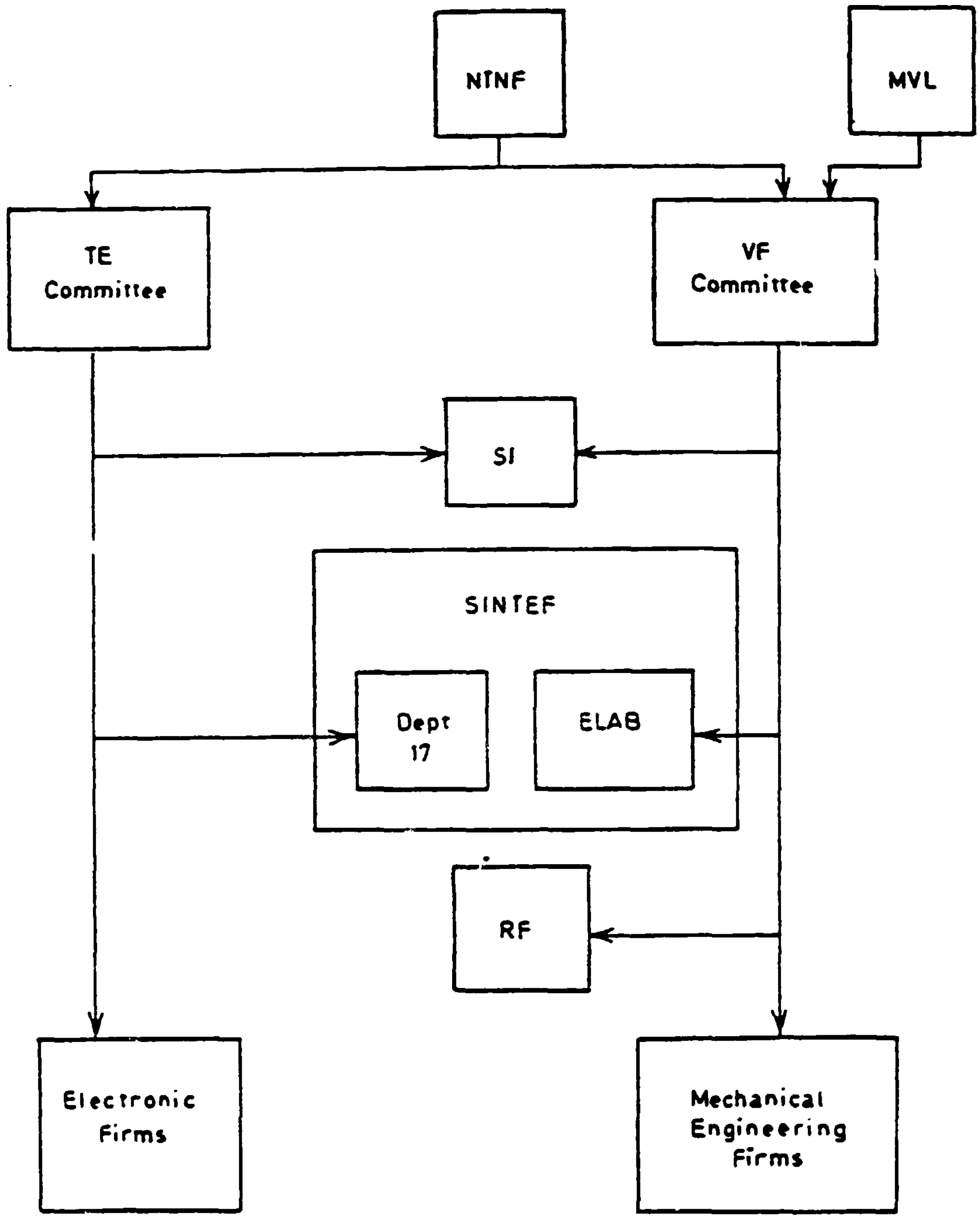

Table 2: Summary of Collective Industrial Research Efforts in Eight Countries.

Country	Collective research organizations	Manpower employed	Expenditure on collective research	Percentage of total industrial R & D expenditure	Source of funding
France	22 industrial technical centres	5239 (1976)	850 mill. francs (1976)	5	7% (1978) public financing; 59% parafiscal taxes and voluntary subscriptions; 34% own resources (private contracts, etc.)
Japan	18 government centres;	4115 (1976)	29 760 mill. yen	1.0	100% government funding
	187 local centres	6115 (1976)	31 000 mill. yen	1.1	90% local authority; 3—9% M.Y.; 1—7% industrial services
	5 semi-public centres	262 (1976)	2765 mill. yen	0.1	50—90% direct or indirect subsidies approx. 30% from testing and services. Less than 10% voluntary industry funds
Netherlands	TNO Organization for Industrial Research	1700 (1978)	18.5 mill. dutch florins (1978)	5	33% government stimulation subsidy; 67% industry contributions
Républic of Ireland	I IRS and Agricultural Institute	1240 (1979)	£ 19 mill.		I IRS: 37% fee-paid consultancy; 63% government grant Agric. Inst.: 100% government grant
Sweden	23 cooperative research institutes	—	£ 14 mill.	—	50% government funding via STU; 50% industry contributions
United Kingdom	42 research associations	4718 (in 37 RAs) (1975)	£ 70 mill. (42 RAs)	3.2	33% subscription income; 2.66% statutory levy; 27.3% government funding; 33% industry contracts and contributions; 5.16% information services, etc.
United States	100 cooperative research organizations	—	$ 125 mill. (1976)	Approx. 1% of industrial non-military contracts R & D	20% government contracts; 80% industry subscription and contracts
	4 proposed generic research centres	—	Initially $6—8 mill.		Initially mainly government funding, reducing to 20% after 5 years
West Germany	63 collective research institutes	3500	277 mill. Deutschmarks	3	75% membership fees; 25% governmental support

Source: R. Rothwell & W. Zegveld, Industrial Innovation and Public Policy: Preparing for the 1980s and the 1990s, Frances Pinter (Publishers) Ltd. London, 1981.

3.4 Collective research: some critical issues.

As Table 2 shows, collective research is organised and financed in a variety of ways in different countries. Despite these national differences, however, there are a number of important issues common to collective research in all countries. The most critical of these are discussed briefly below.

3.4.1 *Funding of collective research.*

Clearly the mode and level of funding of collective research will have a significant impact on both its effectiveness and its orientation (long-term or short-term; basic or applied, etc.). The three main modes of b a s e funding for collective research are:

- subscription income from industrial membership;
- compulsory levy (e.g. parafiscal tax);
- direct government grants.

Other sources of finance are:

- government contracts;
- voluntary contributions;
- contract research, either for a single firm or on a multi-client basis.

In most cases, base funding derives from a combination of two or more of the above sources, and government support is often linked to specific projects or programmes. The different modes of base funding each have marked advantages and disadvantages. A high base level of support, from what-growth dropping from about 90% in 1968 to just over 50% in 1978. More recently, however, this trend has started to be reversed, on the argument that increased prosperity is first required in order to pay the costs of meeting the second and third goals.

The objectives of the NTNF Institutes are also three-fold:

(i) to develop long-term research and technological know-how;
(ii) to encourage the adaption and us of this know-how and research through contract work carried out for industry and government;
(iii) to ensure the widespread use of specialized know-how and technical equipment (OECD, ibid., p. 113).

Thus, to a certain extent, these three aims correspond to the three stages of «research», «development», and «implementation» in the overall R&D process. In later sections, we look in turn at how well the institutes perform each of these tasks.

5.3 The flow of funds.

5.3.1 *NTNF.*

Figures for the flow of funds into and out of NTNF for the period 1970 to 1979 are contained in Tables 3 and 4 below. The latter shows how NTNF money is distributed between the institutes (in the form of general funds and research projects) and industry. The percentage of Funds given out in the form of grants to industry has in fact varied very little over the decade, staying in the region of between 9 and 12%. It should be noted that a significant amount of this money is in turn recycled back to institutes, since the recipients of these grants are encouraged to use at least part of it in sponsoring research at institutes. This can, however, sometimes lead to two rather unconnected piece of work being carried out, one at an institute (sponsored by the firm using its NTNF grant) and one in the firm (putting in their matching 50%). The implications of this are discussed later.

Table 3: *Main Sources of NTNF income 1970—79 (million kroner).*

SOURCE	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Department of Industry	97.3	126.7	142.7	154.9	164.3	175.3	145.4	170.5	194.7	192.9
Department of Oil and Energy							69.4	75.8	93.0	98.2
Department of Environment	—	—	—	—	—	20.8	26.0	27.7	29.9	33.2
Departement of Municipalities	—	—	—	—	—	—	—	3.0	19.0	16.8
Football pools	18.9	20.3	23.5	27.1	27.1	25.9	24.5	29.8	35.7	49.0
Other income	12.6	5.2	6.2	3.3	3.5	4.8	4.8	4.4	5.0	6.4
TOTAL	128.8	152.2	172.4	185.3	194.9	226.8	270.2	311.2	377.3*	396.5*

* Excluding the Innovation Plan.

Table 4: *Expenditure by NTNF 1970—79 (million kroner)*

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
General funds to institutes +	79.2 (62%)	94.0 (62%)	101.3 (59%)	105.5 (57%)	106.3 (54%)	112.5 (49%)	125.8 (46%)	136.1 (43%)	153.3 (40%)	155.2 (38%)
Research projcts in industry	14.2 (11%)	15.0 (10%)	16.1 (9%)	17.1 (9%)	21.0 (11%)	28.0 (12%)	34.2 (12%)	34.2 (12%)	37.6 (10%)	46.7 (12%)
Other research projects (in institutes, etc.)	21.1 (16%)	25.4 (17%)	34.2 (20%)	42.6 (23%)	52.1 (26%)	63.4 (28%)	77.8 (28%)	96.2 (31%)	119.9 (32%)	127.1 (31%)
Other expenditure	14.3 (11%)	17.8 (12%)	20.8 (12%)	19.6 (11%)	19.2 (10%)	26.4 (11%)	37.0 (13%)	46.8 (15%)	67.9 (18%)	74.8 (19%)
TOTAL	128.8	152.2	172.4	184.8	198.6	230.3	274.8	313.3	378.7	403.8

+ Including the Institutt for Atomenergi and the Institutt for Kontinentalsokkelundersøkelser
* Excluding the Innovation Plan

more important sectors of the Norwegian economy. During its 30 years of existence, SI has grown in size, so that it currently employs about 340 staff and has an annual budget of approximately 70 million kroner. Its development has not been without problems, however, particularly during the first half of the 1970s, when the Insitute passed through a period of financial crisis. At the time, projects appear to have been costing more than planned and some were not being completed at all. The researchers themselves seem not to have been well geared to meeting the demands of their user community, and were poor at remaining within both budgets and time schedules, failings which at the time the central management of the Institute were unable to control. When the first Director of SI retired after some 25 years of service, there were therefore certain problems to be overcome. Since then, far greater emphasis has been placed on the financial aspects of project management, a point to which we return in Section 11 when discussing the strengths and weaknesses of the various institutes.

SI has three main sources of income:
(i) NTNF general funds;
(ii) NTNF project grants;
(iii) sponsored research.

The relevant figures are shown in Table 7 below. It can be seen that over the ten-year period, the percentage of SI's income derived from the first of these sources has halved from 28% to 15%. The income from sponsored research first declined from 53% in 1970 to 44% in 1973 when the institute experienced certain financial difficulties, and has since increased to 58%. However, of that 58%, only 32% comes from Norwegian industry, with the remaining 26% from public agencies, other institutes, and abroad. Moreover, of the 32% from Norwegian industry, perhaps a third comes from firms receiving support from NTNF or the Innovation Plan, and there fore represents government money being recycled through industry to the Institute. Therefore, the percentage of SI funds that corresponds to Norwegian firms investing their own money in the Institute is probably less than 25%.

Table 7 *Sources of Income at SI for 1970—79.*
(The figures are in million kroner.)

Source of funds	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
NTNF general funds	7.0 (28%)	7.7 (28%)	7.5 (26%)	7.8 (26%)	8.1 (23%)	9.0 (19%)	9.8 (19%)	9.8 (18%)	10.8 (16%)	11.2 (15%)
NTNF project funds	4.6 (19%)	4.9 (18%)	7.9 (27%)	9.0 (30%)	10.0 (28%)	11.9 (25%)	14.2 (28%)	17.6 (32%)	18.0 (27%)	19.0 (26%)
Sponsored research projects	13.2 (53%)	14.5 (54%)	13.5 (47%)	13.1 (44%)	17.6 (49%)	26.4 (56%)	25.5 (52%)	28.3 (51%)	35.4 (54%)	41.7 (58%)
Other (NTNF investment fund)	—	—	—	—	—	—	—	—	1.3 (2%)	0.4 (1%)
Total	24.8	27.1	28.9	29.9	35.7	47.3	50.5	55.7	65.5	72.3

SI is organised into four research sections — Materials Research, Industrial Chemistry, Electronics, and Data Systems. We concentrated our attention on the last two of these, interviewing the Section Heads and about 25 researchers. In these interviews, we obtained detailed information on nearly 30 projects. Of these, eight could be classified as «research» projects—that is, they began as long-term research work funded initially by NTNF, with industry generally contributing at a later stage as the work progressed to the «development» phase. The remaining 20 were «industrial R&D» projects — i.e. with far less research content, and generally funded by a public agency or by a firm (sometimes with an NTNF grant) right from the start. The assessment of these industrial R&D projects is left to a later section where development projects at all three institutes are considered together. We shall concentrate here only on research projects.

(1) *AUTOKON.*

This project involved the development of a system for automated ship design, or, more generally, for the numerical design and construction of large steel structures. The re-

13). We focussed specifically on ELAB and Department 17, the Production Engineering Laboratory. Two other Departments, Departments 16 (Materials Technology) and 18 (Machine Design) also obtain substantial funding from VF, but since part of their activities fall outside the mechanical engineering sector (and since ELAB and Department 17 are both large and required our full attention during the week of interviewing), these were excluded from the study.

Like SI, SINTEF had a single Director during its first twenty years of existence. However, unlike SI, the transition from the first Director to the second does not appear to have been marked by any great difficulties, nor does SINTEF seem to have faced the same degree of economic difficulty as SI. The smooth transition between one Director and the next was possible partly because the person taking over was previously Rector of NTH and therefore fully familiar with SINTEF when he started. But of far greater importance is the fact that SINTEF has always been a distributed system, as opposed to the centralized hierarchical organizational structure of SI. The structure of SINTEF is based on a number of largely independent centres, each responsible for their own scientific and financial activities, with only a fairly low degree of coordination and strategic planning carried out by a small central administration. The smooth running of the Institute is therefore less dependent on the Director.

Like SI, SINTEF has three main sources of finance:

(i) NTNF general funds;
(ii) NTNF project grants;
(iii) sponsored research.

However, this third category is best broken down into sponsored research for industry and for the public sector. The relevant figures are given in Table 8. These show that SINTEF currently earns roughly similar amounts from NTNF projects, public sector projects, and industry, while its support from NTNF general funds (5%) is only about one-third the corresponding figure for SI (15%).

Table 8: *Sources of Income at SINTEF for 1970—79.*
(The figures are in million kroner.)

Source of funds	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
NTNF general funds	2.5 (8%)	2.7 (7%)	2.5 (5%)	3.1 (6%)	4.1 (6%)	3.9 (4%)	4.5 (5%)	6.2 (5%)	6.8 (5%)	7.7 (5%)
NTNF project funds	7.0 (23%)	9.0 (25%)	11.2 (24%)	14.2 (28%)	18.2 (26%)	22.0 (25%)	25.7 (27%)	33.0 (26%)	39.3 (27%)	41.8 (27%)
Public sector projects	8.5 (28%)	9.5 (25%)	13.2 (29%)	14.1 (27%)	12.5 (18%)	16.9 (19%)	19.7 (20%)	30.4 (25%)	42.3 (29%)	43.0 (27%)
Industrial projects	6.6 (22%)	7.2 (20%)	7.5 (16%)	9.4 (18%)	23.2 (33%)	31.8 (36%)	30.1 (31%)	41.6 (33%)	38.6 (27%)	43.7 (28%)
Foreign	0.4 (1%)	1.3 (4%)	2.0 (5%)	1.9 (4%)	2.2 (3%)	3.9 (4%)	3.8 (4%)	3.4 (3%)	3.7 (3%)	5.0 (3%)
Other, and unspecified*	5.0 (17%)	7.0 (19%)	9.7 (21%)	8.9 (17%)	10.2 (14%)	10.9 (12%)	12.7 (13%)	11.1 (9%)	13.1 (9%)	15.5 (10%)
Total	30.0	36.5	46.1	51.6	70.4	89.4	96.5	125.7	143.8	156.7

* This includes different kinds of repayment and unspecified contract research.

As with SI, one problem faced by SINTEF is that much of its money from NTNF comes in the form of small project grants, but SINTEF does seem to be reasonably successful in grouping these projects together, thereby giving some coherence and continuity to its research efforts. For example, Department 17 recently applied for 13 grants which could quite easily be combined to form 6 larger programmes.

ELAB is organised into 12 main research groups. Since we were less interested in acoustics work, we concentrated our attention on 9 of these, and on the 6 groups within Department 17. In each case, we generally interviewed the group leader and one other member of the group, making a total of about 30 interviews in all. The same questions were put to them as had been addressed to SI researchers. From these interviews, we obtained detailed information on about 50 projects. The breakdown between «research» and «industrial R&D»-type projects is shown in the table below.

Table 14 shows the effects of the R&D intensity on the use of institutes made by electronics and electrical engineering firms. Here, the picture is somewhat confused. High R&D intensity firms make more use of institutes for product development, but for process development and «other uses», the reverse is true. The reason for this is probably that firm size is the dominant factor: and since most large firms (which are almost entirely in the electrical engineering rather than the electronics sector) have a low R&D

Table 14: *Use of Institutes by Electronics and Electrical Engineering Firms. Nature of usage by R&D intensity of firm.*
(The figures show the percentage of firms in each R&D intensity category making a particular use of institutes.)

Nature of firm's use of institutes %	R & D Intensity of firm: High (> 10% of sales) (n = 11) %	Medium (5—10% of sales) (n = 7) %	Low (< 5% of sales) (n = 8) %	All firms (n = 26) %
A product Development				
A1 Industrialisation of product developed at institute	36	29	0	23
A2 Institute as main contractor for product development by firm	0	43	13	15
A3 Institute developing part of product for a firm	91	86	13	65
A4 Institue carrying out background research for product development	27	43	50	38
A All product development work	91	86	50	77
B Process Development				
B1 Industrialisation of process developed at institute	9	43	25	23
B2 Institute as main contractor for process development by firm	0	14	0	4
B3 Institute developing part of processfor firm	27	43	38	35
B4 Institute carrying out background research for process development	27	43	50	38
B5 Software for production planning control	27	29	25	27
B All process development work	45	57	75	58
C Other Uses				
C1 Use of central facilities, e.g. instruments	36	57	25	38
C2 Testing or centalisation ...	27	71	63	50
C3 Provision of non-technical services	0	0	13	4
C4 Small contracts to develop/maintain links with institutes	18	43	25	27
C5 Small contracts to help recruit trained staff	9	29	13	15
C All other uses	44	86	87	69
Firms having no contact whatsoever with institutes	9	0	13	8

tory» by the firms. At SINTEF, process development projects have also proved less satisfactory than product development projects, but for both, the levels of satisfaction (50% and 71% respectively) were significantly higher than at SI (where the corresponding figures are 9% and 50%). It seems clear that with one or two notable exceptions, most electronics and electrical engineering firms do not appear to have been very satisfied with projects carried out by SI, particularly in recent years.

Turning now to mechanical engineering firms, it can be seen from Table 23 that for all three institutes a majority of the projects have involved process development, and in particular the development of part of a process for a firm (category B3). This is in line with the suggestion in section 4 that Norwegian mechanical engineering firms generally have a greater need for process development rather than product development. In the case of SINTEF, approximately four-fifths of the projects (21 out of 26) have involved the development of processes rather than products, and, according to the firms, these have mostly (86%) been completed satisfactorily. At SI, in contrast, the ratio of product to process development projects is much more equal (7 to 9) suggesting that SI has been somewhat less successful in meeting the demand from mechancial engineering firms for process development work; but, as with SINTEF, these projects have generally been satisfactorily carried out, the overall percentage satisfaction rate (75%) being double that for electronics companies (37%). This indicates that SI has been far more successful in projects sponsored by mechanical engineering firms than in those for electrical and electronics firms, perhaps because the latter are in general more technologically advanced and therefore more exacting in the demands they place on institutes.

Having seen that different institutes and different types of projects have varying success rates, the next question to consider is, «What factors account for these differences?» One possible factor has already been mentioned — whether the project involves product or process development. But there are others, including whether the project is initiated by the firm or the institute, the size of the firm involved, and the R&D intensity of the firm.[1] The effect of each of these factors can be seen in Table 24.

[1] Yet another is distance of the firm from the institute. We have not been able to examine the effect of this factor in the limited time available.

Table 24: *Factors Affecting the Success of Larger Industrial Research Projects Carried Out by Institutes.*

a) All firms.

	SI		SINTEF		RF	
	No. of projects	% completed satisfactoriiy	No.of projects	% completed satisfactorily	No.of projects	% completed satisfactorily
Type of project						
Product development ...	29[1]	55	29[1]	76	4	100
Process Development ...	20[1]	40	31[1]	74	8	63
Who initiates?						
Firm	27	48	41	80	10	80
Institute	19	53	14	64	2	50
Size of firm						
<200 employees	16	38	15	80	7	100
>200 employees	30	57	40	75	5	40
R&D intensity of firm						
High	12	58	17	82	3	100
Medium	14	45	24	71	4	75
Low	14	50	14	79	5	60
Total	46	50	55	76	12	75

[1] Since some projects involve both product and process development, these figures are non-additive.

Table 29: *Types of Sponsored Research Project That Have Proved Least Satisfactory to Firms.* The figures in brackets show the percentage of projects judged by firms to have been carried out satisfactorily

	Electronics and electrical engineering firms	Mechanical engineering firms
SI	(1) Process-development projects (9%) (2) Projects for low R&D intensity firms(17%) (3) Firm-initiated projects (20%)	(1) Projects for smaller firms (33%) (2) Institute-initiated projects (50%)
SINTEF	(1) Institute-initiated projects (44%) (2) Process-development projects (50%)	—
RF	—	(1) Projects for larger firms (40%) (2) Institute-initiated projects (50%)

In this section, we have seen how the institutes have had differing degrees of success in carrying out projects sponsored by industry, and how projects of certain types have been more successful than others. Some reasons for these differences have been briefly mentioned here. In the next section, we shall attempt to put these on a more systematic basis and to integrate them in order to give a better picture of the relative strengths and weaknesses of the various institutes.

11. THE INSTITUTES — STRENGTHS AND WEAKNESSES

It is obviously of interest to ascertain the reasons why firms have had more successful dealings with some institutes than with others. In an attempt to identify the possible reasons, we again adopted the two-fold approach of asking both firms and institute researchers for their views. In this section, we consider each of these in turn, and from them attempt to arrive at conclusions about the relative strengths and weaknesses of the institutes studied.

11.1 The views of firms.

During the industrial interviews, firms were requested to identify the main problems encountered in dealing with those institutes at which they had sponsored research projects. On the basis of this, they were then asked to point to areas in which those institutes might be able to improve and thereby provide a better service to industry. The areas mentioned have been grouped in a number of categories, and the results are shown in Table 30 below. It is important to note that these figures refer to the problems that the firms themselves brought up for discussion. If we had instead asked directed questions on each possible type of problem, we would undoubtedly have found a much higher percentage of firms citing these as areas in need of improvement. In other words, the figures under-estimate, perhaps quite appreciably, the percentage of firms encountering each of these problems.

If we first consider the responses of the electrical and electronics firms, it can be seen that for SI by far the most commonly cited problem concerns the calibre of the staff; in over a third of cases, firms feel that this needed to be improved. Also frequently mentioned were the need for better project management, for better contacts with industry, and the adoption of a less academic approach. These three problems are apparently shared with ELAB at SINTEF, although the slightly lower percentage figures for the latter suggest that the problems are not quite as severe as at SI. However, ELAB could, in the view of firms, certainly do more to improve its links with industry, several firms (17%) mentioning that it should temporarily transfer staff to ensure the successful implementation of project results in industry, and (14%) that it should employ staff with more industrial experience. If ELAB did this, there might then be less of a tendency to adopt what the firms see as too academic an approach to industrial R&D.

As for mechanical engineering firms, the main problems encountered at SI concerned, first, the administration of projects, and failures to keep to budgets (25%) and time schedules (19%); and secondly, the need for better links with industry through the temporary transfer of staff to industrialise the results of projects (19%), employing staff with more industrial experience (13%), and adopting a less academic approach (13%.) Similar views were expressed on SINTEF

Table 32: *SI — Strengths and Weaknesses.*

	STRENGTHS	WEAKNESSES
Services offered	— wide range of expertice — good technical facilities — instrument loan service — some good longer-term R&D (e.g. AUTOKON, robotics, wave-power)	— research projects below a certain size sometimes not viable because of bureaucracy and paperwork — too many rautine consultancy projects initiated in order to achieve 60% external funding level — Some longer-term research not sufficiently linked to industrial needs — May be attenpting to cover too many areas of technology with the resources available
Organization and management		— section managment weak — too much paperwork required to inform central organization of sectional activities
Funding and finance	— strict accounting to ensure projects completed within budgets	— pressure to achieve 60% of funds from sources external to NTNF has led to some problems — salary levels creating problems in recruiting and retaining staff
Programme selection		— declining level of general funds and pressure to get 60% external funds causing a drift towards shorter-term development work — concentration of electronics efforts on microelectronic circuits has limited the resources available for other types of work
Knowhow input and personnel		— weak links with Oslo University — some groups contain few experienced staff because of recruitment by industry — very little use of overseas fellowships
User identification	— very good contact with a few companies	— much of electronics R&D aimed at helping a single firm — high cost of setting up new projects and lack of contact with STI diminish SI's ability to help small firms in particular — staff have very little industrial experience
Other outputs	— spin-off companies set up by former staff	— relatively small contributions to scientific knowledge as evidenced by few publications and citations

operation is essential), the two areas are still complementary, and each could benefit from closer links with the other. In particular, STI could act as a «middleman» between RF and the smallest firms who do not possess the technical skills to approach even RF. Besides STI, RF also has relatively weak links with the national research institutes. For example, few researchers at RF know much about the work being carried out at other institutes. To a certain extent, RF suffers from not being an NTNF institute — it is still on the fringes of an NTNF system that, to some outsiders, has the appearance of being a rather exclusive «club» for the centralised institutes and the large, often state-owned, firms. The situation has been somewhat improved in the case of robotics by the establishment of KORO, the informal committee set up (on the initiative of the TESA co-operative) to co-ordinate work on robotics (and avoid duplication) at RF, SI, SINTEF, and the two robot manufacturers (see Section 6). But RF is still not very well represented in the NTNF committee structure, and therefore feels that it suffers when decisions are being made on the distribution of funds.

A second major problem at RF centres on the shortage of qualified staff, this being a serious limiting factor in the number and type of projects the institute can take on, and the speed with which they can react to new initiatives. One group already has enough work to keep it fully occupied over the coming year, while in certain areas of technology, RF lacks the «critical mass» of researchers needed to make a worthwhile contribution. There are difficulties in recruiting new staff partly because so few are trained in Norway, and partly because of the low salaries offered in relation to industry in the Stavanger area. The low salaries mean that existing staff, particularly the more

11.0 GOVERNMENTS ROLE IN DEVELOPING COUNTRIES

The UNIDO report id. 79-910 joint UNDP/UNIDO Evaluation of industrial research and service institutes contains some information about the financing of IRSI's.

p. 33 deals with financing and the table on p. 34 shows the sources of finance for the 7 institutes visited by the evaluation teams.

FINANCE

111. The main sources of IRSI financing were found to include the following:

* Government subsidy of annual operating budget;
* Government grants for strategic research;
* Sale of IRSI services (to government and industry);
* Industry assessments or other grants;
* International and bilateral assistance.

The desk analyses revealed that 39 percent of the IRSIs obtain less than ten percent of their annual operational costs from fess/contracted services. The data are particularly skewed in this direction by the inability to determine the annual level of contracted income for 12 IRSIs or 43 percent of the sample (although this is probably also less than ten percent). On the other hand, 14% (i.e., 4 IRSIs) obtain more than 50% of their annual operational costs from contracts. If the 1977 income data for the six IRSIs which received UNDP/UNIDO assistance visited by the missions is examined, it is found that approximately $ 24 million in collective income, less than $ 11 million or 6 percent results from contracts with industry and government and fees for services.

112. While many IRSIs have been established with the objective of financial self-sufficiency, it is apparent that the majority of the IRSIs have not been successful in this respect. It is interesting to not that the four IRSIs who receive more than 50 percent of their annual services from contracts and fees have between ten and twenty years of experience.
The seven IRSIs visited by missions reported as income from industry contracts in 1977, a collective total of $ 5.404.000 (approximately 20 percent of the collective gross income), which almost $ 4.900.000 was received

by one IRSI only, leaving $ 504,000 for the remaining six (less than four percent of their gross income). It is not known whether this amount represents the face value for contracts undertaken over a period of more than one year. It is also not clear whether this amount also includes routine services; usually such services are ad hoc and not normally contracted for. The income distribution for the seven IRSIs is shown in the following table.

INCOME AND EXPENDITURES IN 1977 (1000 $U.S.)

	A	B	C	D	E	F	G
Number of employees	101	104	132	262	444	431	946
Institute Income in 1977:							
Subsidies and grants from government	420	451	-	no data	1,605	8,231	416
Contracts with government	-	-	339	-	-	12	6,519
Contracts with industry	50	-	132	-	162	163	4,897
International assistance	-	155	111	-	-	117	-
Bilateral assistance	-	-	-	-	-	-	-
Other	-	-	218	-	95	48	1,236
Total	470	606	800	1,300	1,862	8,571	13,068
Institute Expenditures in 1977:							
Operational	418	289	786	625	1,201	3,677	12,041
Equipment and Facilities	52	160	14	300	256	3,570	3,168
Other	-	-	-	-	126	-	500
Total	470	449	800	925	1,583	7,247	15,709
Operational Expenditures per IRSI staff member	$4.138	$2.778	$5.954	$2,385	$2,705	$8,531	$12.728

12.0 POSSIBLE MERGING BETWEEN INTEC AND PART OF THE UNIVERSITY OF CHILE

The University has many activities. Some of them are mainly service functions of no or little importance to the students, nor to the more basic research carried out. Economically they just break even. If these units were merged with INTEC, a rationalization would be possible. Such a merger would cause closer contact with INTEC and the University. The divisions which could be merged with INTEC do services amounting to of 2,5 mil US$. INTEC sells services for about 3 mil US$. In addition to the rationalization the merger ought to result in a closer cooperation also with units of the University which are not transferred. INTEC could buy services on a high professional level without having to cover the cost of maintaining a high level of competence.

The advantages for INTEC are rather obvious. But also the University could benefit by sharing facilities (and people) with INTEC and by taking advantage of INTEC's ability to sell and administer paid projects.

CORFO does not want to get rid of INTEC if they can be convinced that INTEC has the potential to promote development of the chilean industry. This is understandable. But if the University transfers totally certain units to INTEC, INTEC could remain the property of CORFO.

From Norway it is the experience that a research institute (SINTEF) living in a sort of symbiosis with a technical university can be more successful than similar institutions without such university affiliation.

CORFO top leaders are against the merger on the terms proposed, but it may be worthwhile to try once more if an acceptable model can be developed.

12.1 UNIDO Experience

The UNDP/UNIDO IRSI evaluation report id. 79-910 contains some useful information and an interesting example of IRSI -University cooperation from Turkey. It also tells about WAITRO.

Universities

164. Relations with universities have special significance. They are usually the main source of theoretical knowledge in a country and a certain amount of fundamental research is being carried out in university laboratories by graduate students and professors. On the other hand, universities are a good source of academically trained researchers and engineers which can be easily converted to technical research. A few institutes included in the evaluation sample were established and developed with the help and under the auspices of universities, for instance CARIRI in Trinidad-Tobago and the Marmara Institute in Turkey.

WAITRO

165. On a world-wide basis, interrelationships between institutes are facilitated by the existence of the World Association of Industrial and Technological Research Organizations (WAITRO). This is an independent association of organizations either actively engaged in technological research (technical members) or interested in encouraging, promoting and supporting industrial research (sustaining members).

166. The aims of WAITRO are to: assist the development and improve the capabilities of technical members, especially, in developing countries; identify fields of research needing co-operation or assistance by outside agencies; promote co-ordination and co-operation between members; encourage the transfers of research results and technical know-how between members; and promote exchange of experience and research management between members. Implementation of these aims includes: sponsoring technical meetings; training of personnel; information exchange and improvement of research facilities; operation of a central information clearing-house; exchange of research workers and use of research facilities; serving as link between members and international associations and federations; acting as spokesman for members on matters of common interest.

167 Establisched in October 1970, WAITRO released in 1972 a report on "Prio-

rity of Needs of Industrial Research Institutes in Developing Countries", which formed the basis of subsequent programmes of assistance introduced by the association. In 1974 WAITRO started its linkage programme under which two or more members are linked for the purpose of co-operatively undertaking technological projects for the benefit of the younger partner, such linkages or twinning arrangements being set up for periods of 2 to 4 years and financed by national and international agencies often through the intermediation of the WAITRO secretariat. The latest WAITRO meeting in October 1978, supported by UNIDO, tried to identify (a) subjects for co-operative research and (b) potential twinning arrangements. These arrangements are definitely oriented toward institution building especially through staff development.

Examples

168. Examples of the linkages described above were found in the profiles of the desk study and some were investigated further by the field missions. Here are a few illustrative cases:

- The Federal Institute of Industrial Research (Nigeria) established working relations with various African institutes mainly for exchange of technical information, and with institutes in industrialized countries, notably the Tropical Products Institute of the United Kingdom and the Denver Research Institute of USA. The DRI provided services in economic and managerial analyses, while the TRI is associated with research into indigenous materials available for use in industry and the processes which can be used most effectively to convert them.

- The Instituto de Investigaciones Tecnológicas (Colombia) sought to promote its growth by entering into general co-operation agreements with other national institutions concerned with technological development. e.g. SENA, COLCIENCIAS. The purpose was to develop the exchange of technical information and co-operate in research for the fulfilment of contracts with industry.

- The Caribbean Industrial Research Institute (CARIRI, in Trinidad-Tobaço), established in 1971, has had a twinning agreement with the Research and Productivity Council of New Brunswick, Canada, during the period 1974-1977 made operative thanks to a financial contribution by CIDA under bilateral Canadian co-operation and additional UNDP funds. Under the arrangement, CARIRI staff was trained in Canada and Canadian technicians came on site to assist in solving various industrial problems.

- The Central American Research Institute (ICAITI) has special linkages with the Denver Research Institute and CODOT, a consortium of US universities concerned with the development of technology, especially for staff training and research programmes. It also has working agreements with universities in Central America and the Food Technology Institute of the Central Bank of Nicaragua.

- The Materials and Research Division (MRD) of the Marmara Scientific and Technical Research Institute (Turkey) keeps special relations with the University of Istanbul under which auspices it was established. A large proportion of the senior staff originally came from the university and some of this staff still on-board retain their professorships. Within Turkey, it has working arrangements with the other large research institute in the country, viz., the Research Institute on Mineral Resources. Abroad, it keeps contacts for information purposes with, among others, Battelle (USA) and the Central Organization for Applied Scientific Research or TNO (Netherlands). Its internal control system was patterned after, and adapted from, well-established, successful institutes such as those two.

- Most interesting to this study, the MRD also has a twinning arrangement with the Yugoslav Institute of Zenica from which it receives technical assistance in the field of metallurgy. Through this twinning arrangement, which is sponsored by UNIDO and financed under a UNDP/UNIDO project, Zenica is retained as a sub-contractor and is providing assistance in training and research. The activities take place at the plant site of a government-owned steel plant in Turkey. The Yugoslav engineers and researchers conduct research and experiments on site and provide on-the-job training not only to the personnel of the plant but also of the institute with the purpose of building up the capabilities to the point where the MRD could carry out the same activities by itself in the future. Thanks in a large part to the UNDP/UNIDO project in general and this twinning arrangement in particular, the MRD has already developed its skills to such an extent that there is a proposal for the institute to provide technical assistance to one or several other institutes in the Middle East in the field of materials research and development.

- The Singapore Institute of Standards and Industrial Research (SISIR) has linkages with (a) the University of Wisconsin of the U.S.A. which provides training in instrumentation and electronics and (b) the Department of Scientific Research of New Zealand. At home, SISIR has established close working relationships with several institutions, e.g. the Consumers Association.

- The Korea Institute of Science and Technology (KIST) is an example of numerous and widespread linkages. It has working agreements with three national universities and co-operates with over 30 institutes abroad of which more than half are in industrialized countries. KIST has more formal linkages for technological exchanges with a number of sister organizations, viz.:

  Battelle Memorial Institute (USA)
  Research Triangle Institute (USA)

Cornell University (USA)
Mitsubishi Research Institute (Japan)
Nippon Steel Corportation (Japan)
TNO (Netherlands)
Industrial Technology Research Institute (Taiwan)

The principal sister organization has been Battelle since KIST was established with its close assistance which was financed by U. S. bilateral aid. First, Battelle and KIST staff carried out an extensive survey of industry needs and demand in order to find out what kind of an institute KIST should be. Then Battelle helped in the selection and training of the original staff and was instrumental in finding Koreans who had acquired R & D experience in the U. S. A. In addition to institutional and staff development, the principal value which was obtained through this relationship concerns management of research and administration of research facilities. Specifically, Battelle contributed in setting up the cost accounting system which is the backbone of the administrative procedures of KIST.

13.0 NEEDS FOR FINANCIAL SUPPORT

CORFO is responsible for INTEC and has an understanding for the need to provide INTEC with a financial base which can promote INTEC's developments. CORFO recognises that under the present terms INTEC will suffocate and die or change its role, dropping research and provide engineering and technical services in line with what private consulting firms do.

CORFO's main problem is that it is difficult to convince the people in power that a subsidized INTEC can be economically justified. One purpose of the UN mission is to provide valid arguments for maintaining a multi branch multi-disciplinary IRSI's in Chile. Below it is attempted to present reasons for having such an institute.

Many developing countries have a very naive research policy. believing that an IRSI can make them more or less independent of imported te[illegible]ogy. They think it is cheaper to reinvent the wheel than importing it. This policy is very counterproductive to development. It will cause a great time lag and probably result in an inferior industry if the projects ever reach that stage.

Research-based industry is the slowest and most costly of all roads to industrialization. Why then have a research institute?

- Imported technology will soon become obsolete and need improvement. Sometimes it is already obsolete when imported. Improvements can e.g. relate to: better monitoring and control of processes, automation, taking into use local inputs. These tasks lend themself very well to be handed by an IRSI.

- Gradually Chilean entrepeneurs will start new industries and will need IRSI assistance.

- In some cases the IRSI can create new or improved technology. Examples from INTEC are the reprocessing of refactory brick and production of methane from garbage.

- An IRSI can have some sophisticated equipment and skills, which the individual enterprises need occasionally, but not enough to establish their own facility. The presence of an IRSI can thus heighten the level of technology and facilitate product control.

- In various conflict situations the IRSI can solve the problems.

- All industries have problems from time to time, such as: too high reject; inability to meet a quality standard, low efficiency, low yield, problems with new raw materials, corrosion etc., etc. An IRSI can in the role of trouble-shooter provide very valuable services.

- Industry is in our days developing very rapidly and all the sudden competitors can take new technology into use and the competing enterprises may be at a loss. An IRSI can often be better oriented about new trends and propose improvements before it is too late.

- An IRSI with highly qualified staff, doing advanced research, not only produces tangible results but also produces skilled people which can go over to the industry.

- Industry can normally procure engineering and more conventional inputs, but certain more sophisticated components may not be available, not even on sale from abroad. One of the more important tasks of an IRSI is to provide these small but essential contributions. The peak technology, e.g. related to complicated design calculations, process control and similar.

13.1 If the services of an IRSI are so valuable why is it necessary to subsidize the IRSI's?

- One reason is that the client will only pay a reasonable man-hour price for advice, trouble-shooting etc. although it may be worth more. Investigations made by an IRSI can e.g. prevent importing a certain technology which would have caused heavy losses.

- Without a certain risk willingness industry will only invest in projects which give relatively low, but sure profit. Most countries have found it appropriate by research subvention to encourage more risky undertakings, involved research.

- If the IRSI shall be able to give services on a high level, it must invest in establishing this expertise: sending people out of the country to learn, buy or build equipment and do inhouse (IRSI financed) research. It will not be accepted by individual clients to pay for this as it may not be of interest to him.

- As development goes on also in Chile the industry will become more sophisticated and will need sophisticated services. If there has not in time been made an effort to build up these capabilities, development will suffer.

An IRSI is seldom a profit-making enterprise. But although it is non-profit per se, it may be cost effective, very cost effective for the nation both in the short and the long term.

14.0 THE ROLE OF FOUNDATION CHILE

It is not within the terms of reference to come with an assessment of Foundation Chile, but it is impossible to discuss INTEC's position without considering the role of Foundation Chile.

Foundation Chile has invaded many of the fields in which INTEC was involved and is threatening to block new fields, which could open up new opportunities for INTEC.

It can be said that competition is a good thing: the best will win, if the competition is fair. But in this case it is not, as Foundation Chile not only has a large fortune, but also continues to receive government money.

It is not obvious that the way Foundation Chile operates is only beneficial to Chile. It has a disturbing effect on institutes like INTEC, to the point where INTEC is in danger of disappearing.

It is, as mentioned, not within the terms of reference to recommend changes for Foundation Chile, but it may perhaps be permitted to suggest that a redefinition of Foundation Chile could be desirable.

Foundation Chile can be a link with U. S. A. and other countries providing services of experts, running conferences, courses and seminars and give study grants for Chilean people to learn new technology. It can provide various types of technoeconomic information and have a first class library. If there is more money available Foundation Chile could grant money for research projects. It could also have an advising team for research institutes in Chile.

Foundation Chile could continue its efforts to identify possibilities of technology and research projects. The Foundation Chile director told the consultant that Foundation Chile has three people in the marketing section and that he wanted ten. This may be a good idea as projects identified could be handled by other Chilean institutes such as INTEC. With its good international contacts, Foundation Chile can do this work better than anyone else.

It is questionable if Foundation Chile should do research of its own. Possibly it could have some research but not sponsored research payed by clients in competition with the national research institutes.

INTEC Chile could in principle take over Foundation Chile's applied research and this would solve the problem of critical size!

It is not known if this is a realistic proposal, but may be it should be considered!

15.0 SHOULD INTEC BECOME MORE INDEPENDENT OF GOVERNMENT?

Most countries have found that research institutes which shall serve industry should not be owned and operated by the government. Some are independent non-profit foundations, but the more common model is to give them a semi-governmental status. This can mean:

- being an autonomous jurisdicial person.
- employees not being civil servants and not having a government salary scale.
- a board of directors partly appointed by the Government.
- partial funding with government money via special channels in the various departments or via a National Research coordinating body often called council.

The present status of INTEC being owned by CORFO may not be in harmony with the ideas of private enterprises. It may make INTEC a less attractive partner for the private sector, may be even for the public sector. The consultant does not know enough about Chile to be able to judge if INTEC's status has an unfavourable effect, but this effect has been observed in many other countries. One unfavourable effect is that INTEC can not receive project grants from the newly established Research Council.

16.0 COMMENTS TO 7 QUESTIONS ASKED TO THE NORWEGIAN CONSULTENT BY THE DIRECTOR OF INTEC MR. BARTOLOME DEZEREGA

1. Is it realistic to foresee INTEC Chile to be totally self financed?

   The answer is NO. Not if INTEC shall maintain its role as a promoter of industrialization and a place where industry can have services on an advanced level.

2. What is the optimum size of INTEC?

   The question is complicated. If it shall maintain all the activities covered today, INTEC is too small. 200 people may be more appropriate. If INTEC can become dominating in fewer fields,cooperating effectively with other institutions, a size of 100 persons could be adequate. The crucial question is, if fewer fields could provide a large enough market. Today the answer is probably NO. In 5 years, if the industry expands successfully, the answer may well be YES. In any case a change of this nature must come slowly, in harmony with the developent of new markets.

3. Is INTEC well managed and are the overhead expenses reasonable?

   The answer is YES. INTEC is well managed and operates very economically. In the long run it can not be expected to be so efficient. Under the present economic pressure,it exhausts its resource without having a chance to renew human and physical resources.

4. Should INTEC be more highly specialized (high level of sophistication) versus generalists working a wider field on a lower level of sophistication and less research oriented?

<u>Answer</u>: At present INTEC has very little freedom of choice and the composition is well suited to the market served.

In the long term INTEC like other IRSIS's can not be considered a success unless they move in the direction of more high level services, but it should maintain also some generalistic (engineering) services at least for another 10 years. The correct balance depends upon the industrial development in Chile and on the services offered by INTEC's competitors.

5. Should INTEC associate with other institutions to become more powerful?

<u>Answer</u>: Such merger or association should be sincerely considered. It is not possible for the consultant to say more than that, as there are so many ways and means and alternatives. General agreements to cooperate seldom gives results. The relationship must be very intimate to be useful.

6. Can INTEC benefit from being better incorporated in CORFO's short and longterm planning?

<u>Answer</u>: It must be very difficult for INTEC to operate under the present uncertainty of CORFO's contributions and needs. CORFO can improve the situation for INTEC by better planning and by defining the role INTEC can play. But CORFO alone can not be expected to understand in detail the role INTEC can play and in order to produce such plans INTEC must itself contribute in a joint effort with CORFO.

7. Sorces of finance.

a) Support (economic platform) provided by CORFO.
b) Sale of services to CORFO.
c) Sale of services to the industry.

Answer: It is not possible for the consultant to come up with a firm recommendation. There may be other sources of finance too. As a guideline the following proportions can be considered normal in capitalistic countries.

10 - 40% general subvention to secure stability and healthy development and for inhouse research.

30 - 40% government payed projects preferably with industry participation.

The projects should aim at developing new skills needed for the future and to promote new industrial developments.

40 - 60% sale of services needed by industry (private or public), as well as government bodies, eg. for environmental protection, safety and health or development of national resources. Such projects should be billed in full, including overhead.

INTEC CHILE

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Santiago, 13 de Octubre 1982

Señor Westergaard:

Agradeceré sus comentarios y opiniones sobre los siguientes temas, tanto en su informe preliminar al término de su visita de dos semanas, como también mas extensamente en su informe final:

1.- Juicio del experto sobre la real posibilidad de financiar totalmente a INTEC-CHILE (incluyendo en ello no solo los gastos de operación sino también el costo de reposición de equipo, reciclaje de personal y desarrollo institucional). Apreciación sobre la conveniencia (si la hay) de forzar el autofinanciamiento total.

2.- Juicio del experto sobre los criterios fundamentales para determinar el tamaño crítico de INTEC. Estimación de número de investigadores mínimos para hacer eficaz la acción de INTEC en 1983.

3.- Juicio del experto sobre la organización actual del INTEC (que abarque la organización matríz, montò del overhead, gestión de comercialización, gestión administrativa, calificación del staff profesional, facilidades físicas, actitud del personal y comunicaciones en el interior de INTEC).

4.- Juicio del experto sobre la actual situación de especialización o generalidad del personal técnico. ¿Cual sería a su juicio la mejor situación : más especialización o más generalización, ¿mix adecuado?

5.- Juicio del experto sobre la bondad o inconveniencia de asociación con Universidades u otros organismos afines (otros institutos CORFO o externo). Señalar alternativas desde simple cooperación hasta integración en un nuevo organismo.

6.- Juicio del experto sobre la conveniencia y posibilidad de establecer planes y programas de desarrollo tecnológico para INTEC de mediano plazo, para enmarcar la acción de INTEC en la acción de desarrollo de CORFO. Las interrogantes que aún subsisten:

7.- Juicio del experto sobre la proporción más conveniente de financiamiento por:

a) Aporte de CORFO a una función subsidiaria tipo "Centro de Información tecnológica ".

b) Compra de servicios de CORFO para su acción de desarrollo

c) Venta de servicio a la industria y otros organismos de Gobierno.

BARTOLOME DEZEREGA S.

17.0 SOME OBSERVATIONS

INTEC is operating under conditions which are rather unique in developing countries.

- There is an open economy and no protection for local industry. In most countries new industry is helped by import restrictions, etc.

- INTEC does not receive any economic subvention and has to be self-financing.

- There is a buyers market for research and technical services. One reason being that the open economy swept away most of the manufacturing industry. In its place has come import, and assembling industries, which need fewer services of the kind INTEC can offer.

- Most contracts are based on competion and bidding and one must be able to offer a complete package deal (turn key) instead of supplying specialized services which is the normal in developed country IRSI's.

- Because of increased competition and the deterioration of the market for its services and also the global economic recession, INTEC has for the last 5 years had to contract. The staff has dropped to about 100, while at one time it was 400. The contraction has mainly hit the most junior staff, this creates higher average salary and unfavourable age distribution.

- In the country the primary industry (extraction of natural resources) dominate, 50% of INTEC work relates to the primary industry (more emphasis on secondary industry would create more work both for INTEC and the population in general).

- INTEC can because of jurisdicialconstraints caused by its CORFO affiliation not apply for research grants from the National Research Council.

- INTEC gets projects from CORFO of a more general nature. Pollution, natural resources, prefeasibility studies and similar. CORFO being the owner of INTEC can give such projects to utilize over-capacity. Up to 50% of the budget has been CORFO projects, but there seems to be a decline, and the future is most uncertain.

- INTEC has to compete with CIMM, Fundación Chile and the Universities on rather unequal terms as these institutions, to some extent, have their basic needs covered by government money, while INTEC has not. This makes the situation very tough for INTEC. There is little money for new instruments, training of staff and opening up new fields of activity. If the situation continues INTEC will either disappear or change from research to consulting and routine services.

18.0 INTEC ACTIVITIES

The following is not a complete description of what INTEC does and how it does it. Rather it covers some aspects which are considered spec 1.

The general impression is that the institute is well organized and highly efficient even when using IRSI's in developed countries as the yardstick. It has a professional staff of high standard, dedicated and hard working. The work is pragmatic and result oriented rather than academic.

Because of the market situation and need to earn money INTEC takes on work of a very diversified nature and the staff having to cover so many things become generalists rather than specialists.

In less developed countries this is the norm at an IRSI. In the industrial countries like in Norway the trend is to be more specialized, offering peak technology rather than engineering and routine services. The INTEC mix seems to be well adjusted to the market, but if industrialization develops favourably, a concentration on more sophisticated services will be desirable.

The problem of spreading too thinly over many fields in each institute and many institutes all having undersized groups is well known both for more and less developed countries - more so in developed. Competition will eliminate the least successful and of those surviving the best will grow.

Long range planning and good foresight is essential, but without some economic freedom it may not be possible to succeed.

INTEC now has three main divisions:

- chemistry and metallurgy (extractive)
- food and agroindustry
- and various industries

Having only 45 professionals many of the projects or activities are virtually one-man-shows and this is a severe problem INTEC is facing. The dangers are:

- If a key-person is lost the activity or project is in great danger.
- It requires great skill, knowledge and character to work in such small groups and the quality of work is in jeopardy (this does not indicate that such deficiences have been observed!).

- Even within a narrow field several experts are often needed.

- The flexibility is very poor. Large project - which are so desirable - may be difficult to take on.

In the UNDP/UNIDO IRSI - Evaluation the concept " Critical Mass" (from atomic reactors) was often used. Many of the INTEC activities are in danger because the groups are too small. Merging with others to become larger and more capable certainly is a solution which must be considered. Another means would be to create new markets, which it may take and can be risky to do.

One important characteristic of INTEC is its extended use of subcontracting. This allows a small INTEC staff to handle large projects and is an example of a beneficial market mechanism.

18.1 INTEC's Marketing unit

This is somewhat unusual for an IRSI and therefore is briefly described below.

Its place in the organization can be seen from the attached organization chart. It consists of two engineers, a secretary and a technician and also draws on 10% of the time of the professionals. It has several functions and routines.

- General INTEC promotion makes sure the potential clients are properly informed about INTEC's existence and capabilities.

- One means for promotion is 20 module descriptions presenting 20 activities, capabilities and the staffing (a) client can thus be given selected information.

- The most difficult task is to identify the potential clients possible needs and problems. Conversation between INTEC and client's professionals seem to be the best method.

- The marketing division is responsible for all the paper work related to projects.

18.2 Quality Control

Because of the hi. .y compatible situation no report leaves the institute without being properly controlled and checked. The heads of the division use up to 50% of their time to read and control reports. There are also some people who can check language style and format.

18.3 Economic Control

The economic recording of project costs is based on weekly time - sheets and is never more than 10 days behind at the end of each month financial status is ready after a few days. It is computarized.

The working hours are about 200 a week - which is much and the staff charges 78% of its time to projects, which is extremely high. Most IRSI's are satisfied with 60-65% and in most underdeveloped countries it can be much less. If the time charged to projects approach 80% there is too little time left for self development, reading journals, going to courses and seminars and there is too little time to prepare for new projects. The solution may be to charge higher fees, or if that is not possible the institute must receive some money from government, a foundation, or special tax or other source.

INTEC CHILE 1982

18.4 Brief of on-going projects

18.4.1 External

1. Bread Manufacturing Sector Analysis.
   It is a multiclient project with the purpose of analyzing common problems in bread manufacturing. Second phase will be the solution search starting by raw material specification and quality control method.

2. Quality control of paper board packages. The objective is to check periodically samples following international standards.

3. Feasibility study to analyze a dehydration plant (fruit and vegetables) already built but not operating.

4. Diagnosis of the present situation (space, facilities, equipment, etc.) of the Hospital for old people in the Chilean region # 7.

5. Quality control of flexible pouch to package wine.

6. Shipment simulation of irradiated avocados to analyze a possible shipment to Europe because Chile is thinking to export avocados.

7. Market and Prefeasibility study of different posibilities of exporting berries.

8. Advisory services to stablish a Mining information system in the Region # 2, (both production and technical information).

9. Prefeasibility study for a new refrigeration-fumigation fruit plant to be presented to obtain investment loans.

10. Analysis of the present situation and possibilities of enlargement and computer aplication in the Technical Documentation Center of CODELCO (Holding of State Copper Mines).

11. Acceptability test for foods distributed by joint school help and fellowships.

12. Study of the solvent content in packages.

13. Pollution measurements in a foundry.

14. Design and building of a plant to extract liquids in the biogas plant (using Municipal wastes) of Gasco.

15. Advisory services to solve a problem in a fish canning plant, related with the metal used for canning.

16. Geochemical analysis and ore dressing treatment of samples for an exploration mining program (foreign investor).

17. Prefeasibility study of a National Mining information system.

18. Study of the air quality in the region of influence where a new Mining enterprise is established.

19. Metallurgical essays by flotation to recovery a specific mineral.

20. Metallurgical essays to recovery Copper and Molibdenum front tailing.

21. Costs control of the on-going project of the Natural Resources Institute (using the computer system designed for INTEC).

22. Design of the enlargement of a fruit fumigation plant.

23. PVP Syntesis Pilot plant essays.

24. Flotation at pilot plant scale of gold mineral.

25. Bacterial leaching of copper. Characterization of local bacterium and analysis of the influence of AS.

26. Preservation of avocados. An experimental comparative analysis of different alternatives.

27. Evaluation of the possibilities of using wind energy in rural comunities of the north.

28. Post harvest treatment of vegetables; a technico-economic comparison among alternatives.

29. Industrialization possibilities of the Chilean hazelnut.

18.4.2 CORFO

1) Seminar of treatment and industrialization of fruits. Lectures of INTEC researchers to transfer foreign and local technologies.

2) Technico-economic analysis of different possibilities of recovering chemical wastes.

3) Seminars (4) to promote the production and utilization of biogas recovered from municipal wastes (deposited in land fill).

4) Diagnosis and perspectives of the agroindustries in region N°3.

5) Experimental study to recovery litium and potasium from summer salts.

6) Industrial mining complex study for the Región N° .. (coal, polimethalic minerals and limestone).

7) Study to analysise in which field will be useful bio engineering processes in production.

8) Diagnosis and perspectives of the refrigeration capabilities of region N°8.

9) Li and K recovering from sulphate salts.

10) Seminar in the region N° 3. Topics:
   - Gold recovering (different technologies)
   - Cobalt recovering
   - Solar dehydration of grapes
   - Other solar energy aplications

11) Post-harvest treatment of fruits for export; technological improvement of already developed technologies (INTEC).

12) Possibilities of producing in Chile specialised chemical products used in Mining and Food industries.

13) Nitrogen fixation in prosopis tamarugo (northen tree of desertic regions) with rizobium.

14) Aluminum recovering from alunitas minerals. Pilot plant essays.

15) Industrialization of datiles a fruit of the north of Chile.

16) Efficiency studies of a new model of a solar collector (installed in INTEC).

17) Analysis of energy saving in local industry, a survey.

18.4.3 Internal

1) Participation in the 5th. National Seminar on Technology and Science of Foods. Lectures on technology activities and capacities of INTEC and on Packaging.

2) Mycotoxins control in fishmeal and foods for broilers.

3) Fruit Seminar. Lecture on post-harvest treatment of table grapes.

4) Techno-economical assessment of a mining company.

5) Preparation of a Manual to Implement Sanitary Landfills.

6) Development of the technical basis of a system to predict pollution episodes in industry.

7) Survey of the production of avocado oil.

8) Study of methods to prospect and analyse alluvial gold.

9) Production of plum juice.

10) New design of fumigation and pre-cooling chambers for fruits. Modular construction.

11) Study of crane movements in the converters building of copper refinery.

12) Pile leaching of gold and silver minerals.

13) Metallurgical treatment of cobalt minerals.

14) Studies on Metallurgic balance, simulation and control of foundries.

15) Chemical and geo-chemical analysis of minerals. Up-to-date studies on new techniques, mainly related to improve accuracy.

16) Chromatographic analysis of wines and liqueurs, testing of new methods.

17) Development of a simulation program for flotation process.

19.0 COMPARATIVE ANALYSIS OF BALANCES (1979 - 1980)

CIIM - Fundación Chile - INTEC/CHILE Conclusions

- Making the analysis of the normal antecedents obtained from the balances, it is possible to conclude, in general terms, the following:

  - In the operational level, it is possible to appreciate a fundamental difference in the amount of the real costs transferred to the clients in the services given.

    INTEC-CHILE has obtained a tranference of 103% in 1979 and 80% in 1980 while CIMM only transferred 28% and 47% in the same period. The Fundación Chile transferred no more than the 12%.

  - The difference experimented in INTEC-CHILE (103-80) could be explained observing the increasing of unfair competition (mainly of CIMM). That fact shows more access to the market in damage of INTEC-CHILE market, obtained with great resources as the ones given in the antecedents and with cost subsidy strategies which are impossible of being equalled or improved.

  - The operational investments presents a disadvantaged situation for INTEC, specially in relation with CIMM.

    Nevertheless analyzing the productivity of them, in terms of sales volume obtained in relation with the investments, INTEC-CHILE presents an efficiency that is four times in comparison with the others.

  - The solvence index shows the three institutions in a good position in front of their creditors, nevertheless it is easy to appreciate a big amount with respect to INTEC (between 1.6 and 9.8 times) the resources of this last one.

- In relation with the sales management and as a direct consequence of the patrimony and the capital exploitation available it is possible to appreciate that the INTEC performance is considerably more effective because it is selling over the 35% of its patrimony and in average of three times its exploitation capital in comparison with figures of less than 10% and only one time of the other institutions.

- A table is adjointed to compare the so-called survival index (measured in days).
- A table is adjointed to compare the period to receive the payment of sales.

- The observed results (non-operational) shows an absolutely non-equal situation between INTEC and the others, mainly looking at the constributions given by the State (rate is 4:1 between CIMM an INTEC in 1980).

- Having big amounts of financial resources there are also non-equal results between INTEC and the Fundación Chile with respect to incomes from the financial market.

- However, it is interesting to show that with respect to the non-operational incomes INTEC is financing only the 5% of the operational cost, while CIMM is about 60% and Fundación Chile about 130% in 1980.

- Based on the comparisons done and in the present policy, which is stimulating the efficiency, it is not just to punish to the Institution (INTEC) that is showing the best efficiency indexes.

19.1 Consultant's comments

The degree of self-financing is not the only yardstick of success. A high degree of self-financing proves good efficiency, but not necessarily national benefit. Despite relatively small project income, Foundation Chile may well be equally or more beneficial to Chile than INTEC for each dollar spent, if it is instrumental in creating important new industries (such as salmon farming) or to transfer important technology.