PAPER BY LIAM CONNELLAN, DIRECTOR GENERAL

CONFEDERATION OF IRISH INDUSTRY

ON

EDUCATION AND CHANGING TECHNOLOGY

AT R.D.S., 9TH DECEMBER 1981 AS PART OF

THE 250TH ANNIVERSARY SCIENCE LECTURE SERIES

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1. HISTORICAL PERSPECTIVE

The steam engine was introduced into Ireland in 1740, only nine years after the foundation of the Royal Dublin Society. This revolution in technology, together with water-driven mills, had a major impact on the Irish economy: there was a remarkable expansion of the linen industry. While British manufacturing industry had opposed free trade with Ireland in 1775, by the time of the Act of Union in 1800, Britain's industrial dominance had reduced the need for protection against competition. After 1815, prices of manufactured products fell sharply and, despite a continuing rise in the volume of exports, the value fell. The depression of the early 1820s showed up major weaknesses in Irish industry, due to specialisation in large scale production of the woollen industry in Yorkshire and the cotton industry in Lancashire. The development of the railway network meant that these very competitive products could be distributed throughout the country and that the Irish textile industry, which had provided a vital source of employment for the growing population outside agriculture, declined rapidly.

In some areas of Ireland, however, industry continued to flourish; for example, the linen industry in the Lagan Valley, and the ship-building industry, which initially served the needs of the linen industry but later became a significant manufacturing industry in its own right. The linen industry in the Lagan Valley had adopted the methods of large-scale production and specialisation favoured by the Yorkshire woollen and Lancashire cotton industries, and continued to flourish until the early part of the twentieth century.

The capacity of Irish people to adapt to technological change throughout the Nineteenth Century must be seen in the context of the relatively low level of educational attainment at that time. For example, in 1830 it was not uncommon for only one-quarter of the children to obtain any type of formal education. At that time, about half the workforce were engaged in agriculture. A century later, in 1926, (See Chart 1) there was little change in the situation, when 54% of the workforce were engaged in agriculture, and only 13% in industry, a figure which comprised less than 5% in manufacturing activity.

Chart 2 shows the number of people engaged in the manufacturing sector in what is now the Republic of Ireland in 1926. At that time, only 56,400 people were engaged in manufacturing employment, comprising 4.6% of the total workforce. More that half the total employment was in the food, drink and tobacco sector; clothing, textiles and footwear accounted for a further 17%; and other manufacturing including furniture, joinery, paper, printing and metalwork accounted for 32%.

Chart 3 shows the changing structure of the Irish economy since 1926. Over the last fifty-five years, there has been a steady decline in the proportion of the workforce engaged in agriculture, and a corresponding increase in the proportion engaged in industry, comprising manufacturing and construction activities, and in the services sector.

While the structure of the economy was changing, so also was the structure of manufacturing industry. Chart 4 shows the sectoral distribution of industry in 1926 and 1981. It can be seen that, while the food industry has remained significant as a source of manufacturing employment, its relative share of total manufacturing employment has declined. Other manufacturing increased from 32% to 57%.

Since Ireland is now part of the European Community, it is worth noting the great similarities which exist between the proportion of manufacturing employment engaged in individual sectors of industry in Ireland and on average throughout the European Community. (See Chart 5) The major variations are in food processing, where Ireland retains an exceptionally high proportion of employment, and in engineering. (see chart 6) This relatively greater concentration of employment in the food industry in Ireland is likely to continue, since Ireland has three times more agricultural land per head of population than on average within the EEC - a factor which will ensure that agriculture and food processing remain major contributors to Irish economic development. The most rapidly expanding industrial sectors in recent years have been chemicals and electrical engineering, particularly electronics. Over the last decade, these sectors have accounted for almost all the growth of industrial employment.

This change in structure highlights the continuing change which will always occur in the productive sector of the economy. Industrial sectors rise and decline over long periods of time. (See Chart 7) Thus, the 1600s witnessed the growth of the woollen industry; the 1700s, the growth of the silk industry; the 1800s, the growth of the linen and ship-building industries, particularly in the North East; the latter half of this century has witnessed a remarkable growth of the electronics industry, which is likely to be followed by major developments in bio-technology in the 1990s.

2. CURRENT GROWTH SECTORS

Chart 8 shows a tentative forecast for the distribution of the Irish workforce in the year 2000. It is expected that industries such as electronics and bio-technology will be the major growth sectors and may well employ up to 40% of the manufacturing workforce compared with 7% to-day.

Let us look briefly at the characteristics of these two sectors which are likely to have such a major impact on the economy in which young people will work.

(i) The Electronics Industry

There are now over 80 companies in Ireland manufacturing electronics products. They employ about 15,000 people and have an annual output of £600 million, most of which is exported. Electrical and electronic products now account for about 10% of total exports, compared to meat products (17%); dairy products (9%); textiles (6%) and clothing (3%). Ireland now produces about 2% of the total demand in the European Community for computer products, and in some segments of the market, already accounts for 10% of European demand. The output of the industry in Ireland has doubled over the last two years; within a few years the industry is expected to employ directly about 40,000 people.

Many leading international producers of micro-electronic products have set up manufacturing operations in Ireland, and offer this country the opportunity of developing a European centre of excellence for these products.

The manufacture of microelectronics, and microprocessor based products is particularly well suited to Ireland for the following reasons:

1. such products are small in volume and high in value - transport costs are not significant, an important consideration in view of our geographical location:
2. it is a clean industry with no polluting characteristics;
3. working conditions and hygiene within the manufacturing plants are of the highest standard;
4. it is a light industry, equally well suited to male and female workers;
5. the industry places a premium on technical knowledge and skill;
6. the technology used in manufacture requires precision in measurement and in process control, which can have spin-off applications in many other industrial sectors. The transfer of technology can be of major assistance to older sectors of industry.
7. Technical knowledge within the industry is changing rapidly. It should be easier for a country having a very young population structure to adapt its education and training emphasis for maximum relevance, than to achieve the equivalent performance by re-educating and re-training an older workforce.
8. The greater the opportunity to obtain exciting careers in microprocessor manufacturing or application, the greater the possibility that technical innovation can be achieved in Ireland.

The rapid development of the microprocessor based manufacturing industry has five major implications for the Irish economy:

1. Ireland can become a significant centre of excellence for the manufacture of these products in the EEC. Ireland currently accounts for less than 1% of total EEC manufacture, but already produces 2% of the requirements of Europe's computer market. This proportion could double within five years. Irish exports per capita of electronic products are already three times higher than those of the United Kingdom.

2. The location of a significant manufacturing centre will stimulate a more rapid growth of the associated computer services sector. It is estimated that there are about 14,000 people employed in selling, servicing, developing software, preparing data or operating computers in Ireland.

3. There will be a significant spin-off from the electronics manufacturing and services sector into other sectors of industry and commerce in Ireland. This will enable products and services to be up-graded and will boost competitiveness.

4. A microprocessor-based ethos must permeate all sectors of Irish society, if the full benefit is to be obtained quickly from its application. It is vitally important that the microprocessor is applied with enthusiasm and commitment in every sector of society in order to improve productivity, raise quality, reduce costs, and increase demand for Irish-made products. This approach must be adopted not only in manufacturing, but also in the provision of administrative type services, in order to improve the overall efficiency of the eocnomy.

5. The rapid change in technology made possible by the microprocessor has created a demand for a major increase in the output of engineering technicians and technologists from the education system. The 1980s will be the decade of the technologist in the application of the microprocessor. Some of the new manufacturing firms in this sector require 30% of their total staff to have third level qualifications. There have recently been shortages of hundreds of electronic, industrial and electrical engineers, and further shortages of hundreds of specialist computer operating staff.

(ii) Bio-Technology

Bio-technology is a relatively new term which is used to describe some of the oldest known processes, as well as many interesting and exciting new developments. It describes the application of biological organisms, systems or processes to manufacturing and service industries.

Many of the natural techniques which are now being seriously considered for commercial exploitation have been known for a long time. The fermentation method for producing a range of chemicals such as alcohols, aldehydes and hydrocarbons was well known before the advent of the petroleum industry. The cheap availability of oil made a number of these methods obsolete, but with oil scarce and expensive, a reversion to fermentation processes is not only considered feasible, but necessary.

As its central process, the brewing industry uses fermentation in which enzymes contained in the yeast play a crucial role. Malting in the distilling industry is a natural process, and it rightly claims to be a bio-technological industry. For centuries, milk processors have used the enzyme, rennet, comprising microbial structures in cheese production. Skim milk is now being fermented successfully to produce industrial alcohol.

Modern bio-technology is changing the concepts of these traditional processes and has led to an explosion of research and development work aimed at improving the performance of enzymes in everyday use.

Developments in bio-technology have been particularly successful in the manufacture of high fructose syrups from maize. The cost is substantially less than that of the traditional route from sugar cane or beet to sucrose. At present, EEC tariffs are invoked to safeguard the agricultural sector of the European sugar industry from cheap imports using this new technology.

Bio-technology also looks at the whole question of energy and its use in the manufacture of proteins. With increasing costs and the realisation that petroleum reserves are limited, the direct harnassing of solar and bio-technical routes to chemical and nutritional energy supplies are being examined. The large scale growth of plant, animal or microbial life has been given the name "biomass". Applications can vary from the growth of forest to supply timber of particularly high calorific value for burning in power generation plants to the possibility of changing the form of natural materials, including timber and sewage, to give a range of products comparable with those derived from petroleum.

The production of single cell protein is a further important aspect of bio-technology. The growth of organisms as a direct protein source is now considered desirable, and food sources are being developed, aimed not only at reducing cost, but also at improving the nutritional balance. Current applications are mainly for animal feedstuffs.

There are also interesting possibilities for making human insulin at vastly reduced cost.

The search continues in the application of microbial systems to many chemical and mechanical industries. Microbes may one day alter the technology of mining by replacing the mechanical techniques in use to-day.

Many of these processes are at an early stage of development. The next step will be their commercial exploitation. There is a growing requirement for personnel skilled in engineering with an awareness of bio-chemical processes and their limitations. Several of our third level institutions are already offering courses in bio-technology.

Within a few years, the application of bio-technology is expected to have an influence on our lives similar in scale to that of the micro chip to-day.

3. POPULATION, EDUCATION AND EMPLOYMENT TRENDS

Chart 12 shows the projections for the population and labour force in the period from 1980 to 1985. The Irish labour force is currently one of the fastest growing in Europe and may be second only to France. It is estimated that the total labour force is currently expanding by between 9,000 and 16,000 per annum, and that the demand for non-agricultural employment is expanding by 17,000 to 22,000 per annum.

This growth of the labour force during the 1980s will take place at a time when there are increased worries that the birth rate in some European countries is falling below the replacement level. The number of 18-21 year olds in the United Kingdom will start to decline by over 1% per annum from 1984. Addressing the European Parliament in February 1981, Gaston Thorn, President of the EEC Commission, expressed his concern as follows:

> "Is there any need to mention the consequences for the Community of a declining population and of the effects - of which so many Europeans feign ignorance - on the labour market, economic activity, social innovation, political life and Europe's place in the world? If the present trend were to continue, the population of Germany, now some sixty-one million, would fall to a mere forty million or so by the year 2050. If Europe's present birthrate continues beyond 1990, Europe will be on the brink of extinction in demographic terms. Europe would be the only region of the world with a stagnant, declining or at least ageing population. History has shown us that economic and demographic change frequently go hand in hand. I am afraid that a declining, ageing population may reduce our capacity to adapt and innovate, reinforce the Malthusian pattern and make the dialogue with young, prolific nations even more difficult."

The combination in recent decades of a high birth rate and nett immigration has resulted in Ireland having a very youthful population structure, with 50% of the population under 25 years of age and almost 30% under 15 years of age. These trends present a unique challenge to everyone concerned with the development of the Irish economy. Towards the end of the decade, many of our neighbouring countries are likely to experience labour shortages. Jobs will be available for young Irish people in other countries. If young people are to remain in Ireland, non-agricultural employment must expand by about 20,000 per annum in order to keep pace with the increase in the labour force.

Participation rates in full-time education have expanded dramatically. Whereas compulsory attendance at school now ends at 15, about half those aged 17 are in full-time education and this proportion is expected to reach 55% by 1986.

However, participation rates in third level education in Ireland are low by international standards (See Chart 13). Thus the participation rate in 1976 was 11% or 26,200 students. The White Paper on Educational Development published in December 1980 estimated a participation rate of 38,800 in 1980 or 14%, and that this would increase to 51,000 or 18% by 1990.

These figures compare less than favourably with most other developed countries (See Chart 14).

The conclusion to be drawn from these comparisons is that participation rates in third level education would need to more than double to reach the levels currently being achieved by the most advanced world economies.

Job Opportunities

Before considering the nature of the education required, it may be helpful to examine the first jobs taken by second level school-leavers and third level award holders.

Chart 15 is derived from the 1979 School Leavers Survey. From this it can be seen that over 50% of boys and 20% of girls who enter employment directly from school take up industrial occupations or apprenticeships.

Chart 16 shows the first job destination of third level award holders. Whereas only 16% of all University graduates seeking employment enter industry directly, the proportion is very much higher for those having technological qualifications. Thus in 1980, 41% of engineering graduates, and 34% of science graduates took up employment directly in industry.

While 46% of National Council for Education award holders seeking employment enter industry directly, the proportion is also very much higher for those having technological qualifications. Thus in 1980, 73% of engineering, and 45% of science award holders took up employment directly in industry.

Nonetheless, until the onset of the 1980 recession, and despite the high proportion of people having technological qualifications employed in industry, there were considerable shortages of people having these qualifications. For example, in 1978, a National Manpower Service survey indicated that the shortages for skilled staff, outlined in Chart 17, existed. These shortages occurred at a time when the average level of unemployment in the economy was 7½%, and reflected a failure in educational planning over the previous decade.

Chart 18 shows a ten-year indicative plan 1980-1990 for the supply of, and demand for, graduate engineers in the economy.

4. THE EDUCATIONAL NEEDS OF INDUSTRY

Up to 50,000 people are recruited annually by industrial firms to replace employees who retire, or leave to fill vacancies or newly-created jobs. A combination of the expansion of existing firms and of new projects are contributing to a continuing change in the structure of Irish industry and the nature of industrial employment. For example, about 50% of the jobs associated with new projects are in the engineering and electronics industry, compared to only 29% in existing industry.

Jobs associated with new industries and new projects tend to require higher levels of skills and qualifications than those in older industries.

The main bottleneck in technological development is usually not the availability of technology which can enable processes to be carried out more efficiently, but the capacity of people to understand the potential of new products and processes, and to incorporate them in applications as soon as they become economically viable. The primary challenge is to bridge the gap between potential and practical application. In this way, productivity can be increased while reducing physical effort and cost. The country which can apply new technology at a faster rate than its competitors will obtain a competitive advantage.

Ireland's current capacity to adapt and develop new technological products and processes is indicated by the proportion of graduate engineers in the total workforce. In 1980 it was estimated that there were 6,000 graduate engineers in the economy, comprising 0.5% of the workforce. This compares with an estimated proportion of 1.6% in the United States in 1975. (See Chart 19).

The low proportion of engineers in the workforce indicates the magnitude of the gap, which must be closed.

However, major changes are currently taking place in Irish third level education, which should result in a 40% increase over the 1979 level of new entrants to third level education by 1990. It is questionable if even this degree of expansion will be sufficient to meet the needs of the economy if living standards and employment rates are to approach average European levels by the end of this century.

The supply of technical manpower will have a direct bearing on the rate at which the economy adapts to new technology and will have a strong influence on the pace of economic development.

Third Level Education and Industry

The most significant development in third level education during the 1970s was the setting up of the then Regional Technical Colleges, and the NIHE in Limerick. Whereas only 16% of all University graduates seeking employment enter industrial employment directly on qualifying - mainly because of the low proportion of University faculties directly related to industrial employment - about 46% of award holders from Colleges of Technology and the National Institute for Higher Education take up employment in industry.

Thus, the higher the proportion of students graduating from Colleges of Technology and National Institutes of Higher Education, the higher will be the proportion of all third level award holders entering industry.

Examination of the projections in the White Paper on Education, published in 1980 suggests that, while the proportion of third level award holders (rather than those seeking employment directly) entering industry had increased from about 5% in 1970 to 10% in 1980, it is likely to reach 20% of a much larger volume of award holders in 1990. For example, in 1970, only 8,000 students entered third level education. By 1980, this figure had increased to 13,000 and by 1990, the number entering third level education will have increased to almost 18,000. This means that close to 4,000 third level award holders will be entering industry annually by 1990, compared with less than 1,000 today.

If current relationships are maintained (See Chart 20) between engineering and other studies at Universities and among NCEA awards, it is likely that by the early 1990s about 18% of award holders will qualify in engineering. This proportion will then be similar to the distribution of technological qualifications in countries such as Japan and Britain to-day. (See Chart 21). Total participation rates in third level education in Ireland will still be very low.

What Third Level Qualifications are Required by Industry?

The distribution of new graduate recruitment by industry is shown in Chart 22. Thus 49% are engineering graduates; 23% are science graduates; 12% are commerce/business studies and 8% are arts/social science graduates. This pattern of recruitment broadly reflects the proportion of vacancies for executive/professional functional positions in industry. (See Chart 23) 48% of these positions are in production research and development; 16% in data processing; 8% in marketing; 24% in finance and 3% in personnel and training. It is clear from these figures that the primary demand from industry is for people having technological qualifications.

The initial requirement is usually for technical staff to manage the production process. As firms expand and intensify their activities, people are required who can innovate and develop new products and processes. There are many international studies which demonstrate that the capacity of industry to grow is directly related to its capacity to innovate in response to the changing demands of the market place.

The Demand for Places is High

Over the last two years there has been a remarkable increase in the interest in obtaining technological qualifications. In 1980, there were three applicants for every engineering place in the Universities, and five applicants for every place in the Colleges of Technology. While many students may have applied to a number of colleges, these figures demonstrate a very high level of interest in obtaining technological qualifications. They provide a clear indication that young people want to participate in the technological development of the economy.

Need for Preparation at Second Level

It is vitally important that the 10,000 to 15,000 students who are likely to apply annually for engineering courses at Universities and at Colleges of Technology should have studied appropriate subjects at second level. For example, Honours Mathematics at Leaving Certificate level is necessary for entry to most engineering degree programmes, but only 16% of boys and 4% of girls actually sit for the higher level paper. (See Chart 24). The total number of students achieving honours (Grade C) standard in 1980 was only slightly more than 2000. Even if all of these pursue engineering studies (rather than about half) there will clearly be a major shortfall of suitably qualified entrants if third level engineering intake is increased to about 4,000 within the next few years. Physics and Chemistry are also very desirable subjects for students considering an engineering or science qualification. At present, only 28% of boys and 3% of girls take physics; while 29% of boys and 12% of girls take chemistry. It is essential that more second level students are given the opportunities to study higher level mathematics, physics and chemistry, so that the opportunity remains open for continuing education at third level.

In view of the rapid pace of technological change, it is desirable that every Leaving Certificate student should take at least one science subject. Furthermore, while there is currently a two to one ratio favouring biology over physics and chemistry, current economic trends would suggest that a more even balance between each of these three major subjects should be attempted.

5. STRATEGY FOR INDUSTRIAL INNOVATION

Ultimately, the needs of the market place must take priority. Firms must have the capacity to identify those needs accurately and to meet them economically. They require staff who can research potential markets, speak the language of the consumer, develop products to meet criteria set by the potential buyer, plan a marketing and distribution strategy which will yield a profitable return.

A strategy for innovation must start and finish with the consumer. It requires highly skilled marketing expertise, allied to technological competence.

Sustainable employment in industry can only be created if firms have the capacity to innovate and replace obsolescent products and processes with those which are more efficient and use the latest advances in technology. Because the emphasis on Irish industrial development over the last twenty years has been to expand the productive base in order to expand employment rapidly, it has been necessary to take a relatively short-term view when attracting firms to Ireland. Similarly, firms which have had to cope with the abolition of tariff barriers throughout the 1970s placed considerable emphasis on reducing unit costs by investment in machinery which could manufacture longer runs for a wide international market.

While this process of improving productive efficiency through investment in equipment must continue, Ireland has now reached the stage where more resources must be devoted by individual firms to planning for the future and creating new products and processes.

Chart 26 shows the proportion of research and development expenditure of companies in the manufacturing sector as a proportion of the output of the sector in 1975 for different European countries. The proportion of the value of industrial output which was ploughed back by Irish industry into developing new products and processes was only 1% compared with almost 4% in Germany, the Netherlands, France and the United Kingdom. I consider, however, that there is a direct correlation between the low relative density of technologists in industry, and expenditure on research and development. It is worth noting also that the tendency to spend money on research and development was much greater among new companies than old. (See Chart 27) It is no coincidence that new companies tend to recruit proportionately more technologists than their older counterparts.

Education/Industry Links

It is essential that very close links are formed between the twenty third level educational institutions engaged in technological education and the industrial sector. These links are necessary in order to ensure the maximum relevance of the education provided by the institutions and of research projects undertaken in these institutions. A close link between manufacturing firms and graduate researchers results in major benefits for both parties. Let us now examine these links and the potential for developing them.

The third level education system is itself playing a useful role in industrial innovation and many members of the academic staff have brought research projects to commercial fruition, have patented their inventions and have been responsible for the setting up of companies to exploit the particular invention. University/industry co-operation has been encouraged by the National Board for Science and Technology through the Higher Education - Industry Scheme. This scheme was introduced to promote mutually beneficial co-operation and interaction between the two sectors. In 1979/80, thirty eight new projects were selected for support at a cost of £300,000, and twelve projects at a cost of £100,000.

The Industrial Development Authority has fostered co-operation between Universities and industries through the product and process development grant scheme. This scheme encourages industry to undertake research and development work in order to improve their manufacturing methods and products. As a development of this scheme, the Industrial Development Authority is promoting the concept of incubator factories alongside the Universities. The idea is that persons in industry and on the College staff are provided with support and have access to college facilities for the development of possible new products and processes. Once the project has reached a commercial stage, it would leave the incubator factory and establish commercial production elsewhere.

A Bio-Medical Research Unit has been established at University College Galway, and it is understood that several developments are emerging as commercial products.

A pilot plant for the food processing industry has been established at University College Cork, in which technical staff from food firms can work with university staff in developing new products.

An Innovation Centre and Micro-Electronics Applications Centre have been established on the campus at the National Institute for Higher Education in Limerick. These centres have been established as a bridge between the know-how of semi-state and research organisations and those firms which want to break new ground. The Applied Research and Consultancy service in Trinity College represents a co-ordinated effort to link the University to industry. Full-time research personnel are appointed to collaborate with academic members of staff on projects of immediate interest to industry.

Other ideas under consideration range from the establishment of industrial science parks alongside academic institutions, to the co-ordination of inter-disciplinary efforts of a number of departments within a University to serve given sectors of industry.

Encouragement should be given to academic staff and post graduate staff to spend periods of time in industry. It is highly desirable to second academics into industry, where they can develop a real feeling for the actual technological problems incurred and establish long-term linkages. Scientists and Technologists in third level institutions should be encouraged to take on consultancy assignments for manufacturing firms, and to obtain appropriate financial rewards.

However, much still remains to be done in developing synergy between the industrial sector and the third level education system. I would suggest three areas for close examination as a means for developing significant capacity in Ireland for research and development.

Suggested Areas for Examination

1. Formation of University/Industry Innovation Centres

These could include arrangements between different third level institutions and an industrial sector to carry out sector-oriented research, similar to those now being developed for food, microelectronic and biomedical research. Facilities of this nature are common in highly developed countries, but the small scale, and relatively underdeveloped stage of the Irish economy make it necessary to provide financial incentives in order to ensure that such projects come to fruition. It is worth noting the contents of an EEC Commission document of 21 April 1981, which examined the success of Japanese industrial and commercial strategy and placed particular emphasis on the objective of the Japanese Government to raise expenditure on research and development from the current level of 1.7% of GNP to 2.5% by 1985, and 3% by 1990. This report went on to state:

> "It is important to note the key role played by joint action on the part of Government and industry. If it is true that Japanese firms compete strongly on internal and world markets, this does not apply to the phase which precedes the production of high technology goods. It is the normal procedure that in strategic areas, and in accordance with long term targets, the responsible

Government bodies and agencies join with the main industrial firms to conduct research through sharing the efforts involved. It was in this way that the problems relating to the development of microelectronics were tackled in 1972/73.

A similar course occurred in 1980, when the formation of a 'bio-technology forum' was announced, comprising the five major Japanese firms and MITI. A 140 million ECU 10 year programme will seek to develop technologies in the four areas: bio-reactors, cell cultivation, genetic engineering, and cell fusion. The development of computer software has been fostered by the activities of the Information Production Association, in which industry representatives, research workers, and Government officials participate, as well as through specific official projects.

By these means the Japanese Government and industry succeed in using relatively small amounts of money in order to develop projects with a high nett added value, and with a concentration on the industrial application of manufacture of the product concerned."

This approach has even more relevance in a small economy such as Ireland, where greater difficulties may be encountered in developing the critical mass for effective research effort.

2. Recruitment of Development Technologists

Irish industry has been limited in its technological development capacity, partly because qualified technologists were not available. In the next few years, there will be a major increase in the number of technicians and technologists qualifying from third level institutions such as Universities, NIHE's and the RTCs. It is vitally important that there should also be a major increase in the number of technologists employed in Irish industry in product and process development functions. This applies to every sector of industry and will increase the defensibility of each firm against international competition. I would suggest that a scheme should be introduced to provide financial assistance for the recruitment of development technologists in small and medium sized manufacturing firms.

3. Teaching Companies

The Development of Teaching Companies in Ireland similar to that operating in Britain would have significant advantages for industry. This scheme involves the recruitment by Universities of high calibre graduates in consultation with the manufacturing company in order to assist the permanent academic staff of the university in their interaction with the company. These graduates are placed full time in the manufacturing company and work in collaboration with in-house and participating academic staff on problems defined by the programme. Specialised tuition is given by the academic institution, and the primary motivation is to place the graduate in manufacturing industry with substantial responsibility. The British scheme is run jointly by the Science Research Council and the Department of Industry.

6. CONCLUSION

Society in the 1980s and 1990s will be dominated by technological changes in microelectronics and information transfer; bio-technology and energy related sciences.

The pace of economic development will be a function of the absorption of scientific knowledge and the acquisition of skill in its application. It is probable that at least half of the labour force will be working in a technological environment.

In this paper, I have attempted to trace the historical development of industry in Ireland, its changing structure and changing needs. I have looked at the likely developments through to the end of this century, placing particular emphasis on growth sectors the development of the microelectronics industry and on biotechnology.

I then went on to examine population, education, and employment trends, compared them with the future educational needs of industry. and have suggested by means of international comparisons quantitative and qualitative changes which appear necessary.

I have indicated the role which I believe educational institutions can play in cooperation with industry in contributing to an effective strategy for industrial innovation.

Ireland is in a unique position to cope with the current rapid changes in technology. A young and rapidly growing population can, if given the opportunity, contribute significantly to technological development. One third of the Irish population is engaged in full-time education at primary, secondary and third level. It is vitally important that the education which they receive has the maximum relevance to the environment in which they will spend their working lives. The capacity of young people to innovate and improve the performance of existing products and processes will determine the living standards which the economy will be able to support in the coming decades. The opportunity of making significant strides forward must be grasped with enthusiasm and commitment.

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Chart 1

DISTRIBUTION OF IRISH WORKFORCE

	1926
Agriculture	54
Industry	13
Services	33
	100

Chart 2

STRUCTURE OF IRISH MANUFACTURING EMPLOYMENT: 1926

	No. of Persons	Percent
Food, Drink & Tobacco	28.5	51
Textiles, Clothing and Footwear	9.8	17
Other Manufacturing	18.2	32
	56.4	100

Chart 3

DISTRIBUTION OF IRISH WORKFORCE

	1926	1981
Agriculture	54	19
Industry	13	32
Services	33	49
	100	100

Chart 4

DISTRIBUTION OF MANUFACTURING WORKFORCE

	1926	1981	
Food, Drink & Tobacco	51	26	
Textiles & Clothing	17	17	
Mechanical Engineering)		29)	
Electrical/Engineering)		)	
Clay Products)		7)	
Paper & Printing)	32	5)	57
Chemicals)		6)	
Plastics)		)	
Wood & Furniture)		3)	
Other)		7)	
	100	100	

Chart 5

DISTRIBUTION OF MANUFACTURING WORKFORCE

	Ireland	EEC
Food, Drink & Tobacco	26	9
Textiles, Clothing & Footwear	17	15
Mechanical Engineering) Electrical Engineering)	29	48
Chemicals	6	10
Paper & Printing	5	6
Wood & Furniture	3	5
Clay Products	7	5
Others	7	2
Total	100	100

Chart 6

MANUFACTURING WORKFORCE

	1971	1981*	Change
Food,Drink & Tobacco	53.2	53.1	–0.1
Textiles, Clothing & Footwear	47.2	35.3	–11.9
Mechanical Engineering) Electrical Engineering)	38.8	61.3	+22.5
Chemicals	8.1	11.7	+3.6
Paper & Printing	16.8	15.6	–1.2
Wood & Furniture	7.9	7.0	–0.9
Clay Products	10.3	14.4	+4.1
Others	14.0	9.7	–4.3
Total	196.3	207.9	+11.6

* March 1981

Chart 7

GROWTH SECTORS

1600's	Woollen
1700's	Silk
1800's	Linen Shipbuilding
1950/2000	Electronics Biotechnology

Chart 8

FORECAST DISTRIBUTION OF WORKFORCE 2000

	Ireland 1980	EEC 1980	Ireland 2000
Agriculture	19	8	12
Industry	32	39	37
Services	49	53	51
Total	100	100	100

Chart 9

ELECTRONICS INDUSTRY

Advantages
High Value/Low Volume
Clean
Hygienic
Suited to Male and Female
Knowledge & Skill
Spin–Off
Rapid Change
Stimulates Innovation

Chart 10

IMPLICATIONS

Centre of Excellence

Associated Services

Other Sectors

Ethos

Demand for Technologists

Chart 11

BIOTECHNOLOGY

Fermentation Method

Brewing

Distilling

Milk

High Fructose Syrups

Protein Manufacture

High Calorific Timber

Insulin

Mining

Chart 12

LABOUR FORCE GROWTH : INTERNATIONAL COMPARISONS

Annual Growth Rates (percentage) : 1980-85	
Canada	1.80
USA	1.26
France	1.27
Italy	0.59
UK	0.67
Japan	0.36
West Germany	0.50
Ireland (est. 1975 — '86)	
(a) Total Labour Force	1.04
(b) Non-Agricultural Labour Force	1.75

Sources : OECD, NESC.

Chart 13

THIRD LEVEL PARTICIPATION RATES

	1976	1980	1990
Number	26,200	38,800	51,000
Percent (est.)	11%	14%	18%

Source: White Paper on Educational Development

Chart 14

ANNUAL ENTRANTS TO HIGHER EDUCATION AS PERCENTAGE OF RELEVANT AGE GROUP : 1976

Ireland (est.)	14%
France	28%
Denmark	38%
Japan	39%
United States	43%

Chart 15

FIRST JOB TAKEN BY SECOND LEVEL SCHOOL–LEAVERS 1978

Occupation	Boys	Girls
Industry/Apprenticeship	54%	22%
Office & Service Jobs	24%	61%
Nursing	1%	11%
Farming	12%	1%
Other	9%	5%
Total	100%	100%

Source: NMS Survey published December 1979

Chart 16

PERCENTAGE TO JOBS IN INDUSTRY : 1980

	Graduates	NCEA Award Holders
Engineering/ Construction	41%	73%
Science	34%	45%
Business Studies	12%	26%
Arts/Social Science	6%	15%
Total numbers entering industry :	332	531

Chart 17

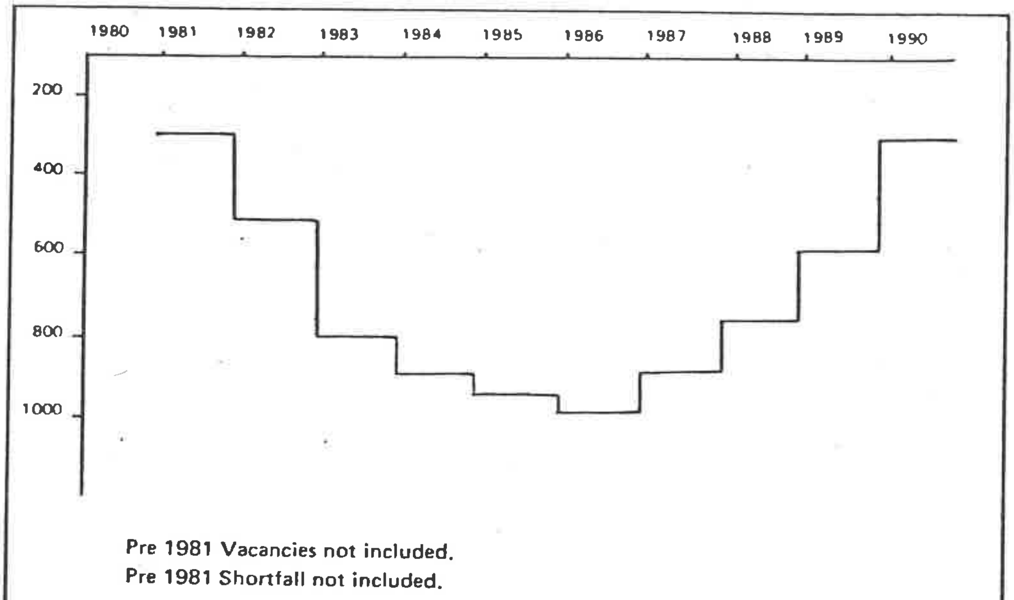
OCCUPATIONAL SHORTAGES: DECEMBER 1979

Mechanical/Production/Industrial Engineer	160
Electrical/Electronic Engineer	100
Chemical Technologist	20
Electronic Technician	90
Systems Analyst	50
Mechanical/Electrical Draughtsman	60
Fitter	200
Toolmaker	105

Source: Manpower Consultative Committee Report 1979

Chart 18

CUMULATIVE SHORTFALL OF ENGINEERS



TEN YEAR INDICATIVE PLAN 1980-'90 OUTPUT OF ENGINEERS

Chart 19

DISTRIBUTION OF MANUFACTURING WORKFORCE : U.S.

	Economy	1975 (est.) Manufacturing
Engineers	1.6%	3.9%
Natural Scientists	0.5%	0.9%
Technicians (excl. medical)	1.6%	3.0%
	3.7%	7.8%

Source: *Tomorrow's Manpower Needs*, U.S. Department of Labour

Chart 20

PERCENTAGE OF ALL AWARD HOLDERS: 1980

	Universities	NCEA
Engineering/Constr.	12%	40%
Science & Computer Studies	19%	21%
Total Awards	4326	2366

Chart 21

PERCENTAGE DISTRIBUTION OF NEW ENTRANTS TO UNIVERSITY BY FIELD OF STUDY: 1977

	Humanities	Social Science/Law	Technology /Arch.	Pure Sciences
Ireland	52.2	8.8	8.6	16.3
Japan	14.6	42.0	20.6	4.1
Germany	25.2	14.1	13.3	18.4
United Kingdom	12.4	21.2	17.0	26.2

Chart 22

PERCENTAGE EACH QUALIFICATION COMPRISES OF TOTAL THIRD LEVEL RECRUITMENT BY INDUSTRY – 1980

	Graduates	NCEA Awards
Engineering	49%	64%
Science	23%	16%
Business Studies	12%	7%
Arts/Social Science	8%	1%
Total Recruitment At All Third Level	332	531

Chart 23

ESTIMATED PERCENTAGE OF EXECUTIVE JOBS IN INDUSTRY

(Excluding General Management)	
Production, Research and Development	48%
Data Processing	16%
Marketing	8%
Finance	24%
Personnel/Training	3%
Total	100%

Source : MSL Survey; Oct 80 — Mar 81.

Chart 24

PERCENTAGE OF STUDENTS TAKING SUBJECTS IN LEAVING CERTIFICATE: 1980

	Boys	Girls
Honours Maths	16%	4%
Physics	28%	3%
Chemistry	29%	12%
Biology	41%	63%
Engineering Workshop	9%	—
Tech/Mech Drawing	18%	0.1%

Chart 25

HIGHER LEVEL MATHEMATICS: Leaving Certificate 1975 — 1980

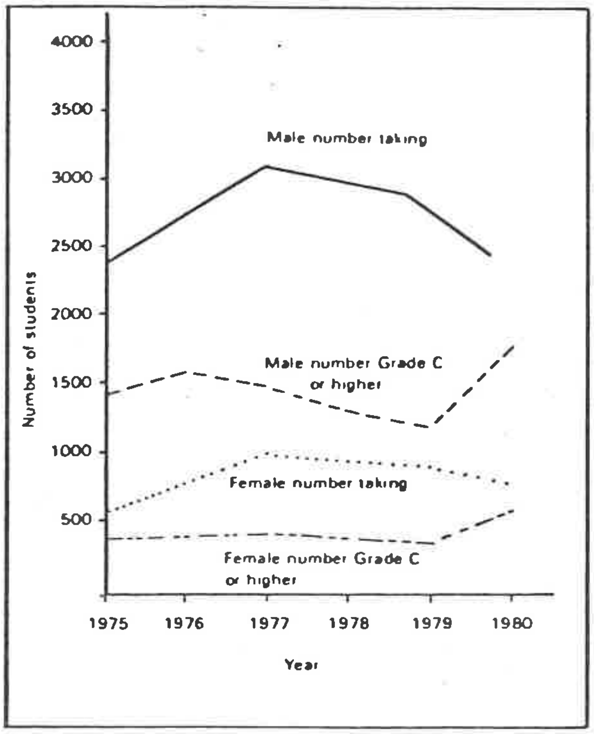


Chart 26

R & D EXPENDITURE OF COMPANIES AS A % OF THE GROSS DOMESTIC PRODUCT OF THOSE BRANCHES: 1975 (PERCENT)

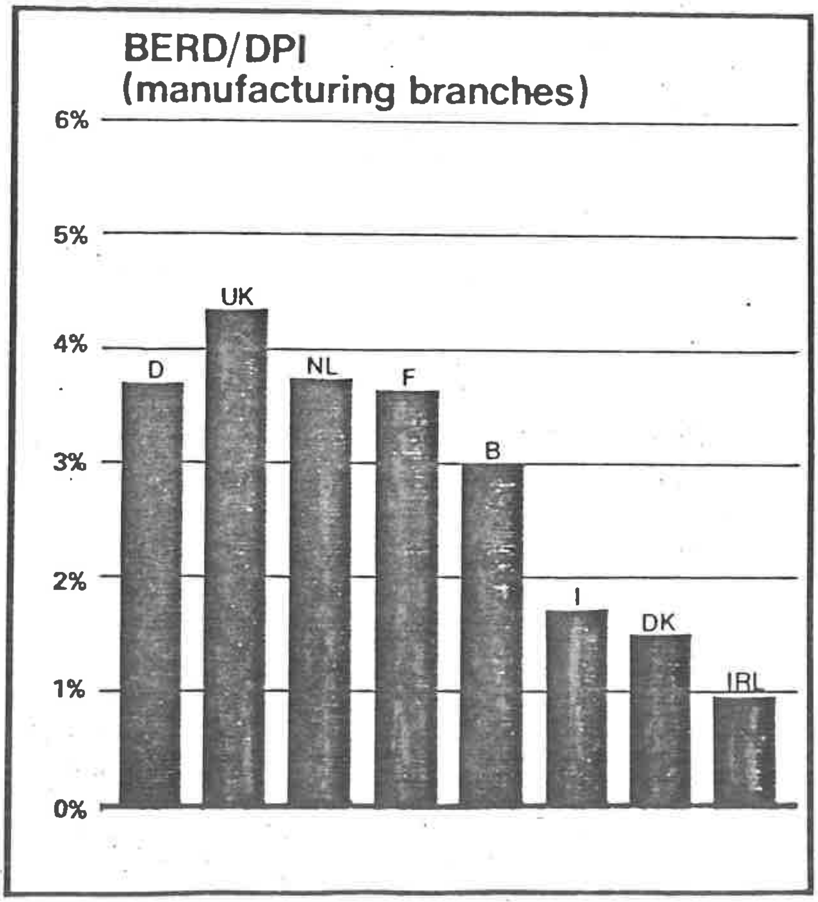


Chart 27

BUSINESS ENTERPRISE SECTOR: 1975

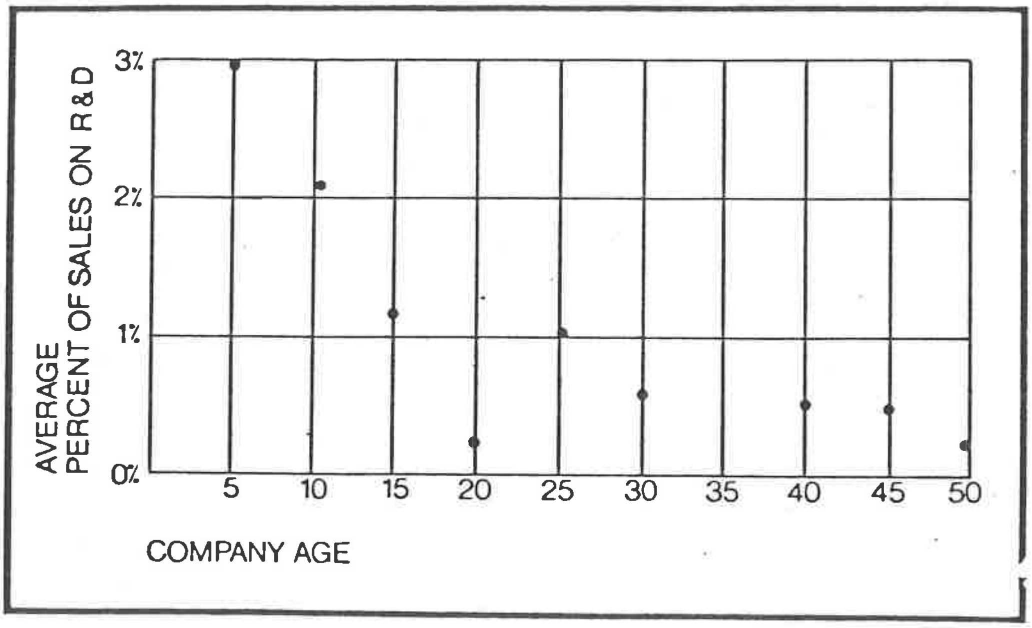


Chart 28

EDUCATIONAL/INDUSTRY LINKS

Academic Staff Patents

NBST Higher Education/Industry Scheme

IDA Product & Process Development Scheme

Incubator Factories

Biomedical Research (UCG)

Food Research (UCC)

Innovation Centre (NIHEL)

Micro-Electronics Application Centre (NIHEL)

Applied Research Centre (Trinity)

Science Parks

Consultancy
