National College of Art and Design

Faculty of Design

Department of Industrial Design

The Development and Effects of Technological Innovation in Irish Indigenous Manufacturing Industry - a Design Perspective.

by

Barry Robinson

Submitted to the

Faculty of History of Art and Design and Complementary Studies

in candidacy for the degree of

Bachelor of Design

1996

Acknowledgements

I wish to acknowledge the assistance of the following persons.

Andrew Bradley	for the inspiration
Dr. John Turpin	for initial direction
The library staff at Forbairt	for their help during research
Dermott O'Doherty, Forbairt	for his encouragement and assistance
Declan Lyons, Forbairt	for his interest, help and advice
Deirdre Ní Loingsigh	for constant support always
Paul Caffrey	for his suggestions and focus
Gerry Walker	for his enthusiasm and guidance

Contents

INTRODUCTION

This thesis examines the persistent problems of industrial development in Ireland, focusing on the current technological innovative capacity of Irish indigenous industry. In historical perspective, it examines the effect of Ireland's colonial and post-colonial experience and, in particular, its demographic history of emigration and population decline, on the development of our National Innovation System.

It shows that Ireland's characterisation of a weak national system of innovation has been a major cause of under-development.

Ireland's National Innovation System refers to the institutional factors that together play the major role in influencing the innovative performance of our national firms. These include educational and government institutions such as the Industrial Development Authority (IDA), the Irish Export Board and Forbairt.

Differences in National Innovation Systems lie, to a significant degree, in differences in national histories and cultures, including the timing of a country's entry into the industrialisation process. In terms of timing, Ireland is considered an 'industrial latecomer' and this has had a detrimental effect on the current structure of Irish industry.

When Ireland gained independence in 1922, our National Innovation System was extremely weak due to the non-existence of such institutions which were not established until the 1950's. This almost totally inhibited Irish industrial development. Indeed, it was 1966 before a free post-primary education system was introduced and, as a result of this, many key people in Irish industry, including Chief Executives of large firms never received a third-level education and, in some cases, even Second-level education was not complete. Factors such as these are still being felt today and have influenced greatly the technological innovative capacity of Irish manufacturing industry as it currently stands.

CHAPTER ONE

HISTORICAL DEVELOPMENTS WHICH INFLUENCED IRELAND'S NATIONAL INNOVATION SYSTEM AND THE ROLE OF DESIGN IN IRISH INDUSTRY

This chapter outlines the historical factors which are the essential background to the Irish economy and its policies. It traces the development of both industrial design and manufacturing industry in Ireland since the foundation of the State. The discussion centres on how these two have related to each other and, in particular, how the role of industrial design and technological innovation in Ireland's national innovation system has been addressed.

The island of Ireland is located next to that of Britain on the extreme west of Europe. However, despite this, Ireland, with an area more than one third the extent of Britain has a population just one twelfth the size and a national income only one twentieth that of its neighbouring island. While efforts to explain this include Ireland's increased geographical isolation and deficiency of mineral resources, it is clear that historical factors have been the primary cause of these differences.

Historically, Ireland has been strongly influenced by Britain both politically and economically and the colonisation of this country from Britain which began in the sixteenth century operated to prevent the growth of Irish industry even before the Industrial Revolution. However, this colonisation was only partially successful due to native resistance and, instead of being fostered as a part of Britain, Ireland was considered an alien and hostile land which represented both economic and political danger to Britain itself. As a result of this, British governments of the seventeenth and eighteenth centuries actually legislated to prevent the growth of Irish industry and trade. Such policies remained in place

until British industrial dominance in the wake of the industrial revolution favoured a change in policy towards free trade. By this stage, Irish industries, weakened by colonial exploitation were unable to compete or prosper under such conditions and Ireland remained an agricultural country throughout the nineteenth century.

Unfortunately, Ireland's dependence on agriculture and, in particular, the potato, then the subsistence food of the vast majority of the population, led to an unprecedented disaster when the potato crop failed year after year in the late 1840's. The census of 1841 showed that Ireland had a population density greater than Britain, with a land area one third the size supporting a population half the size of Britain. The populations were eight million and sixteen million respectively. The Great Famine reduced the population of Ireland by 25% and began a demographic decline unique in both its intensity and duration. In the decades following the famine Ireland was transformed economically mainly in an effort to prevent a repetition of this disaster. The economy spread westwards from Dublin and there was a general rise in the standard of living but this was achieved at the expense of a continuous high level of emigration. For three quarters of a century the Irish population fell and was barely half its pre-famine level when Ireland achieved political independence in 1922. "These exceptionally adverse demographic trends reflect a failure to achieve the kind of transition to a modern industrial economy which during the past century and a half has taken place in other north European countries. The suppression of Irish industrial activity in the seventeenth and eighteenth centuries and the enforced free-trade policy vis-a-vis industrially advanced Great Britain during the nineteenth and early twentieth centuries provided a hostile environment for industrial development and inhibited the growth of non-agricultural employment" (Fitzgerald, Dr. G. in O'Hagan, 1975, p9).

Ireland entered the twentieth century demoralised by a long history of British rule and a seemingly endless struggle for freedom. This struggle culminated in the rebellion of Easter 1916 and, later, the establishment of The Irish Free State in 1922.

In the light of freedom, the new Sinn Féin government put into place a policy of political and economic independence to distance itself from the shadow of Britain.

The industrial revolution had little positive influence on Ireland and, at its outset, the Irish Free State was in a poor economic position, with only a small industrial sector.

"By the 1920's manufacturing industry was very weak in the new independent Irish State, employing 60,000 people, or little more than 4% of the labour force." (Fitzpatrick and Kelly, 1985, p10)

As a result of the depression in the early 1930's, Britain began flooding the Irish market with cheap products and Irish industry was unable to compete for its home market. The new Fianna Fáil government of 1932, led by Eamonn deValera, immediately imposed tariffs and customs duties on imports leading to the 'economic war' with Great Britain. The new government's main policy was self-sufficiency and, central to this, was the development of Irish industry behind a barrier of protective tariffs.

In the absence of competition in the domestic market, and with a practical strategy of import-substitution, Irish industry began to grow steadily and "between 1931 and 1936 the number of people employed in manufacturing industry in Ireland rose from 61,000 to 98,000". However, this success should be seen in the context that "by international standards, Ireland was one of the most heavily-protected economies in the world by 1936" (Ryan, 1984, p15). Despite this, it must be recognised that these policies were remarkably successful and were the first major contribution towards Ireland becoming a modern manufacturing nation - an achievement which may not have been possible by any other means.

It was at this stage that it became apparent that the lack of competition from abroad and the weakness of Irish technical ability were contributing to a low standard of Irish products in general. In many cases the Irish products were simply copies of the imports which they were substituting, and original product design was almost non-existent. This issue of industrial design was first addressed in 1937 "when, on October 22nd, Sean Lemass, Minister for Industry and Commerce, set up a departmental committee 'to advise on the matters affecting the design and decoration of articles' manufactured in the Irish Free State'. After 42 meetings the final recommendation of the committee was for an exhibition of design in industry, but the planning of this was set aside with the outbreak of war in 1939." (Mulcahy, 1992, pp. 5-6)

The Second World War had very little impact on Ireland, compared to the rest of Europe, mainly due to our neutrality. Neutrality was seen as an assertion of Ireland's independence, but it also led to isolation from the rest of Europe. This re-affirmed the need for the government's policy of self-sufficiency, but, in the short-term, government efforts concentrated on getting the country through the war, with little resources and major difficulties in importing essential supplies.

Ireland emerged from the war unscathed, and indeed, much the same way it had gone into it. Neutrality meant that Ireland had not been challenged by a war effort into technical developments or high-volume production, although it continued to experience rapid industrial growth. By 1949, when the Republic of Ireland was established, the country was far behind the rest of Europe in technological terms, and, in particular, industrial design. These issues were addressed in a report on the arts in Ireland by Thomas Bodkin, published in 1949, which pointed out that "there never had been a sustained alliance between the arts and industry in Ireland and ... no civilised nation had neglected art to the extent that we have done during the past fifty years, with consequent injury to our native industries". (Turpin, 1986, p45)

Following from this report, the Arts Council, set up in 1951, was given responsibility for the promotion of industrial design. To this end, a number of exhibitions were organised to increase design awareness in industry and the public at large. Among these was the "Irish Design Exhibition" in March 1956 which included Irish-manufactured products. "However, while making some impression on the general public, the Council never succeeded in establishing contact with industry, and was thus unable to influence events in particular companies" (Bradley, 1984, p5)

At this stage, Irish manufacturing companies were still concentrating on the protected domestic market, and a policy of import substitution, which had delivered success since before the war, remained dominant.

Flaws were appearing, however, and the rate of success was not what it had been previously. Efforts to assist industry included the establishment of the Industrial Development Authority (IDA), in 1949, and Coras Trachtála (CTT), the export board, in 1951. It became obvious that the phase of import substitution was complete and that further expansion, based on this strategy, was no longer possible due to the limited size of the domestic market. Along with this, Irish industry became very heavily import-dependant for fuel and materials not yet available in Ireland and this, in conjunction with a low level of exports, led to a crisis in the balance of payments. Irish manufacturing began to struggle while the rest of the world experienced rapid growth in the post-war economic boom, and "between 1955 and 1957 Ireland was the only country in the Western World where the total volume of goods and services actually fell" (Mulcahy, 1992, p9).

While protectionist policies, responsible for the establishment of a modern industrial base, had indeed been successful, the time had come for a critical re-assessment of Irish industrial policy. This was reflected in the government report 'Economic Development', published in 1958, which began the process of change. The government now recognised that a small nation in the modern world could not survive independently and that

international trade was essential to develop the economy and, in particular, to develop the industrial base. This led to a switch to an outward-looking policy which hoped to achieve export-led growth through free trade with Europe and the attraction of foreign investment. The IDA was given the responsibility of attracting foreign investment and the Export Promotion Act of 1959 included new responsibilities for CTT.

The government, and in particular the Taoiseach, Sean Lemass, who had first addressed the issue as Minister for Industry and Commerce in 1937, was well aware that, if Irish products were to be successful abroad, the level of design in Irish manufacturing industry would have to be improved. In October 1960, Lemass announced his decision in the Dáil to transfer to CTT statutory responsibility for the improvement of the standard of industrial design, including design for both home and export markets. This decision was welcomed by Fr. Dónal O' Sullivan, director of the Arts Council "who was of the opinion that an Arts Council was not the correct body to promote industry-linked design in Ireland". (Mulcahy, 1992, p7) CTT had already established working contacts with industry and was familiar with the international marketplace through its export-promotion activities, and was clearly in a better position to promote the awareness of industrial design in Irish manufacturing industry.

William H. Walsh, manager of CTT, was interested in design, and saw improvement in the design of exported products as an important element in the successful exportation package he was trying to achieve. Walsh, with the assistance of Paul Hogan, a practising designer, invited a group of Scandinavian experts to make an overall assessment of design in Ireland, on which future policies could be based. The Scandinavian countries were, at the time, world leaders in design and "the scale of their industry, their raw materials and the patterns of their society were similar in many respects to ours" so it was felt that the results of their assessment would be particularly relevant. (Franck et. al. 1962, p. xi)

The Scandinavian design group visited Ireland in April 1961 and made a comprehensive study of Irish design including visits to factories, colleges, museums and shops. As a result of this, the report 'Design in Ireland', referred to as 'the Scandinavian report', was published in February 1962. The Scandinavians noted that "Irish culture had developed a distinct leaning towards literature, theatre, the spoken word and abstract thinking rather than creation by hand or machine and the visual arts" (Franck et. al., 1962, p1)

This may have resulted from our political history which forced previous generations to transfer their culture by word of mouth due to colonial oppression including the infamous 'penal laws'. The Scandinavians also commented on design in Irish industry noting good product designs in traditional craft industries but a poor quality of design in other industrial sectors which were incapable of competition on international markets. They pointed out that the successful development of industry required a much greater input to industrial design at management level. The report also included a chapter on education which focused on raising the general level of design-consciousness and "the problem of how Ireland is to get the industrial designers she needs now" (Franck et. al., 1962, p40)

However, government responsibility for dealing with the recommendations of the Scandinavian report was conveniently delegated to CTT. In response to this, CTT opened its design section in 1962, to deal with some of the problems highlighted in the report. Most notable among these were, firstly, "the general low level of design consciousness in the country, especially among those manufacturers who were best positioned to raise standards" and, secondly, "the almost total absence of skilled personnel, either on the management or design side". (Bradley, 1984, p8)

CTT tackled these problems through a design programme which focused on management education. In conjunction with the Irish Management Institute (IMI) and the Institute of Industrial Research and Standards (IIRS), the CTT design section organised seminars and

lectures to develop an understanding among Irish manufacturers of the role of design in Industry.

The design programme included direct contact with industry, which CTT had divided into sectors, producing annual programmes of advice on the benefits of design in each sector. This advice conveyed to many manufacturers the systematic design process, and how it could improve productivity and profits.

A programme of grants was announced by the government for the improvement of design standards in Irish firms, which included consultant advice services, which CTT had made possible through its register of designers.

The general level of design-consciousness in the public arena was also improved by exhibitions including an exhibition of Japanese design in the Municipal Art Gallery and an exhibition in the Royal Dublin Society (RDS) of product design from a number of European countries.

The manager of CTT, William H. Walsh, must have been encouraged by the developments in design at the time but his continued interest in design led him to pursue new goals, and, still to be addressed, was the training of designers in Ireland. During a visit to Norway "Walsh ... had been very impressed by the Flush craft workshops at Frederickstad ... and resolved to set up something similar in Ireland. The result was the establishment of the Kilkenny Design Workshops (KDW) in 1963" (Mulcahy, 1992, p29).

The main purpose of the workshops was to advance good design in industry and the workshops were also to be a starting point for new manufacturers as a sort of enterprise incubator under CTT.

Initially the workshops were staffed by designers and craftsmen from Britain, Denmark, Sweden and Germany and were largely craft-oriented when they opened officially in 1965. A catalogue of KDW work produced in that year explained the early emphasis on craft-based industries as follows: "Attention has been concentrated on traditional products. This is where innovation starts, where a country's cultural characteristics show themselves and where the standard for its manufacturers is set." (Ryan, 1990, p14)

The recognition given to discerning the national identity of Irish design through concentration on traditional products is extremely admirable, but, in practice, the KDW designers struggled to break away from the prevailing trends, and instead their work seemed more to emulate the highly-praised Scandinavian model - possibly due to the nationalities of many of the designers and mentors.

Indeed, the identification of traditional products as the starting point for innovation, or incremental innovation, is equally admirable, especially when merged with the idea that these products, which were so highly-praised by the Scandinavian report, should set the standard for manufacturers to follow.

It seems clear that, at this stage, the Kilkenny Design Workshops were indeed focused on the transition from craft-based prototype production to the development of design in Irish manufacturing industry in the immediate future.

By the end of 1966, Kilkenny Design Workshops had forged for itself an independent existence, similar to that of CTT, and had its own management structure. William H. Walsh, by now chief executive of KDW, resigned his parallel position as general manager of CTT, to concentrate his efforts on design.

The workshops fast became a success story as sales of surplus 'prototypes', which began at the KDW official opening, led to the emergence of 'The Kilkenny Shop' in Dublin, which was important in terms of publicity. The success of this shop in selling 'prototypes' led to an exhibition of these items in London in 1967 and to the opening of a Kilkenny Shop in New York later that year. It seemed that Irish design was on the crest of a wave, even by international standards.

However, all was not as it seemed and, while these developments certainly did improve the standard of craft design in Ireland, the KDW had lost sight of its role of "advancing good design in industry", for which it was originally established. The workshops had almost become a factory, producing craft objects to meet the demand of its retail offspring, and the rapidly expanding needs of Irish manufacturing industry had practically been forgotten.

Ireland's industrial structure was changing rapidly since the adoption of outward-looking industrial policies by the government in 1958. Craft-based industries became less dominant and "the engineering industries in particular became a salient growth sector, their output having increased by 280% between 1960 and 1972, with every sign of continued acceleration". (Marchant and Addis, 1984, p35)

The KDW approach to introducing design to industry was still to develop prototypes for a certain market area and then try to sell the design to manufacturers on a royalty basis. In response to criticism that they should have been concentrating on industrial design, in the sense of large production numbers associated with industry, Paul Hogan, then design manager at CTT, pointed out that prototypes "... were easy to make. It would have taken too long to research, design and develop a normal industrial design object ... rather than going to a manufacturer and talking about design, you could bring, and show, a prototype, thus optimising Kilkenny's work. But it was always felt that this would develop into industrial design". (Mulcahy, 1992, p30)

However, ten years after the establishment of the KDW this method had not developed into industrial design, despite the fact that during that decade manufacturing employment in Ireland rose at an annual average rate of 1.7%, almost three times the OECD average. These were years of unprecedented and sustained economic and industrial growth and, among other benefits, led to an increase in living standards in Ireland.

Probably the most important benefit to emerge during these years was the improvement in the Irish education system, which would have a long-term effect on Ireland's technological ability, including industrial design. The report 'Investment in Education' is considered to be one of the most important documents in the history of modern Ireland. It revealed that only 28% of primary school-leavers had passed the Primary Certificate, and that almost half of the pupils in the system had not even reached the final year. In the secondary school system, less than 10% of pupils took sciences and the report concentrated on the appalling lack of technical and science subjects in the curriculum and was directed towards the development of an educational system capable of supporting an expanding industrial economy. In July 1966, Donagh O'Malley became Minister for Education, and made the revolutionary decision to introduce a free post-primary education scheme which he announced on September 10th, 1966. Efforts to improve design education began following the Scandinavian design report when the Minister for Education, Dr. P. J. Hillary, commissioned the Council of Design, established in September, 1963, to examine design activity, focusing on the training of industrial designers. This report by the Council of Design which echoed the recommendations of the Scandinavian report several years previously, marked the beginning of reform in design education. However, developments in this area were slow, mainly due to the lack of response from the Department of Education, and the first real breakthrough was the industrial design education seminar in November, 1970. The main objective of this seminar was to review international developments in industrial design education and examine their application to the Irish situation. It marked the first time that Irish industry and the educational authorities came

together with international design experts. Among the conclusions of the seminar organised by CTT and the Department of Education, were the following goals:

1 industrial design education should be at university level.

2 there was an urgent need for proper programmes of visual education in primary and secondary schools.

3 Irish industry required the services of industrial designers.

4 the government should establish a co-ordinated policy for comprehensive student-centred art and design education as soon as possible.

5 the new autonomous College of Art and Design should be elevated to university level.

6 a post-graduate course in industrial design (engineering) should be established in the faculty of architecture and engineering at UCD. This course would eventually be part of an industrial design education programme at university level.

In response to some of these conclusions the National College of Art was restructured in the National College of Art and Design Act of 1971, which led the way for the new college premises in Thomas Street, Dublin. However, it was not until 1978 that an industrial design department was established, offering a degree in industrial design, in conjunction with the new National Institute for Higher Education, now the University of Limerick.

The first graduates of this course only became available to Irish manufacturing industry in the 1980's, almost two decades after the need for them was highlighted by the Scandinavians' 'Design in Ireland' report of 1962.

However, while the Department of Education had slowly implemented long-standing recommendations, the 1970's also saw more positive developments in industrial design. The first of these was the opening of the first private product design consultancy in 1970. This consultancy - Manus Coffey & Associates - specialised in engineering design. This development was almost immediately followed by the opening in 1971 of another design consultancy - Michael Ozmin Designs. Another designer - Barry Dipper - who had moved to Ireland from the UK, was employed by Donnelly Mirrors Ltd. to work on their highly-successful 'day/night' mirror. Private initiative had taken the lead in the development of industrial design in Ireland, with the government and institutional actors lagging behind. Among these were the Kilkenny Design Workshops, who responded with a notable development when they employed an English industrial designer - Nick Marchant - in 1973. His first task was to prepare the report 'Industrial Design for Engineering-Based Manufacturers', which was submitted to the Department of Industry in 1975. The report covered the design requirements of the Irish engineering sector which had become the largest sector of Irish manufacturing industry by this stage. However, the report received little government attention due to the oil price-shocks which were distinctive features of the 1970's.

Another event in the international arena which had a major effect on Irish industry was Ireland's entry to the EEC in 1973. This meant free trade with most of Europe and contributed further to growth. Ireland became an excellent low-cost manufacturing base in terms of exports into Europe, and was an extremely attractive location for multi-national firms, mostly from the US. Industrial output in the 1960's and 1970's grew at over three times the rate of the 1950's and manufactured exports grew particularly rapidly as Irish exports share of foreign markets continuously increased.

As a result of free trade, Irish manufacturers had to produce more competitive products to survive. This required improvements in industrial design across a wide range of product areas. The establishment of an industrial design consultancy service in the Kilkenny Design

Workshops addressed these requirements and the consultancy quickly gained clients from both indigenous and foreign-owned industries. The success of the consultancy, under the direction of Nick Marchant, led to a restructuring of KDW from craft-based work to industrial design consultancy work. KDW had finally achieved the objective for which it was established over a decade previously.

The increase in the number of practising designers in Ireland in the early 1970's led to the establishment of the Society of Designers in Ireland in 1972. In fact, the overall increase in Irish design-consciousness, together with the other numerous developments in design in Ireland in the fifteen years previous, led to the major event of Irish design history in 1977. In that year, the International Council of the Societies of Industrial Design (ICSID) held their twentieth international congress in Ireland. The congress was significant for a number of reasons. It recognised Ireland's developments in industrial design, it allowed Ireland the opportunity to learn from the leading members of the international design profession, and much publicity was gained by Irish design and Irish products. In summary, the ICSID twentieth congress was the most important international event in industrial design to take place in Ireland.

However, the limelight soon faded when the statutory responsibility for the promotion of industrial design in Ireland was transferred from CTT, who had made most of the design developments of the previous 15 years possible. CTT felt that, due to its expanding export promotion activities, it was no longer in a position to effectively promote industrial design. Most observers would have expected this situation to give rise to the establishment of a new national design council, as had been recommended by the Council of Design report over a decade earlier. This was echoed by numerous parties since then, including the Society of Designers in Ireland and the Confederation of Irish Industry, who believed that "the most effective solution to the problem is the establishment of a national design council. The purpose of the council would be, firstly, to formulate a national design policy, and secondly, to undertake the role of co-ordinating its implementation" (Bradley, 1984, p32)

However, on June 28th, 1978, the Minister of State at the Department of Industry, Commerce and Energy, Mr. Burke, granted Kilkenny Design Workshops, a private company, the statutory responsibility for industrial design in Ireland. Despite their success in design, it was inappropriate for a private company to be involved in the subsidised promotion of an activity in which it participated.

Ironically, as a result of these developments CTT no longer supported the KDW and with the emergence of a number of private design agencies, winning contracts was becoming a problem for KDW who were seen by many companies to be over-priced. Probably one of the biggest blows to KDW was the loss of the government contracts, and by 1983 Kilkenny was beginning to suffer. Government cutbacks in 1985 forced KDW to become self-sufficient within four years, when funding would be ended. However, a series of financial blunders in the rationalisation plan and bad publicity led to the closing of the Kilkenny Design Workshops in November, 1988.

Also involved in the promotion of product design and development were the Institute of Industrial Research and Standards (IIRS) and the National Board for Science and Technology (NBST). The IIRS was established by the government in 1946 to provide basic technical services for industry, including substantial research and development. Its main aims were to provide technological support to industrial firms attempting to grow or introduce radical change and to provide viable investment opportunities in technology to firms committed to growth in Ireland.

While having interest in research and development, the IIRS was also involved in the application of science and technology in industry. The sort of engineering design carried out at the IIRS design and development department on new products meant they were very conscious of the need for good industrial design.

The NBST, a semi-state body, provided services which included the provision of an analysis of State investment in science and technology and the preparation of a national programme for science and technology. The NBST viewed industrial design as a technology and, therefore, provided analysis to the government concerning State aid to design. Their main interest in industrial design was through the research and development which took place in Ireland. The NBST places a very high value on R&D, which it regards as being very much under-utilised by Irish industry. Among their recommendations to the government was increased investment in research and innovation to raise the level of science and technology in manufacturing industry, thereby increasing profitability.

These two bodies were later merged to form Eolas and, today, are known as Forbairt which is now the main body influencing technological capabilities in Irish industry.

CHAPTER 2

THE STRUCTURE AND CHARACTERISTICS OF IRISH MANUFACTURING INDUSTRY

The structure of the `Irish economy has changed considerably since the publication of the Government report 'Economic Development' in 1958, and the consequent adoption of outward-looking economic policies in the 1960's.

The Irish economy can be divided into three main sectors and these are listed below along with their respective contributions to the economy, before the adoption of outward policies and their contributions in recent times.

	1961	**1992**
Agriculture	37%	13%
Manufacturing	24%	28%
Services	39%	59%

These figures show clearly the reduction in the contribution made by agriculture to the National economy over the last three decades and the rise in the contribution of services. Less obvious, but perhaps most significant, is the relative stagnation of the manufacturing contribution which rose by just 4% over the last three decades and was more than outpaced by the services sector, contrary to the experiences of most other European countries.

In Ireland, the total number of manufacturing establishments in 1990 was 4,804, of which the vast majority of 4,766 were classified as small and medium enterprises (SME's). In recent years, there has been much attention focused on the contribution of SME's to the

overall industrial performance of advanced nations and internationally SME's are defined as those businesses which employ less than 500 people. Such attention is of particular relevance to Ireland because SME's account for over 99% of the total number of manufacturing establishments in this country.

Although the relative contribution of Irish manufacturing industry to the national economy has changed little over the last three decades, yet a major transformation of this area has taken place during this time. The most significant change has been the growth of the metals and engineering sector which has more than tripled its employment from 21,000 in 1958 to over 67,000 in 1990. This sector now employs almost twice as many people as the next largest employer, the food sector, which was in fact the leading employer in 1958. The metals and engineering sector now accounts for almost one-third of manufacturing establishments and employment in Ireland and, as a result of this, and its particular relevance to product design and technological innovation, this thesis has chosen to focus on this sector, which could best be described as representative of Irish manufacturing.

In the nineteenth and early twentieth century the engineering industry in Ireland developed in the north-eastern counties and, in particular, around Belfast, due to the more favourable environment created by the relative success of British colonisation in this area. However, in the remainder of the country engineering manufacture was mostly limited to the production of agricultural utensils and equipment, except for the notable exception of products manufactured for railway use including locomotives on the east coast.

However, most of the engineering industry in Ireland was unable to compete with the large-scale manufacturers that developed in Britain and Europe after the Second World War and almost all of the larger Irish-owned, traditional engineering firms have long since disappeared.

Fortunately, Ireland's entry into the EEC and intensive efforts by the Industrial Development Authority (IDA) combined to attract foreign investment in the engineering industry and, to some extent, prevented the loss of skills which often disappeared along with firms. New industries which replaced many of the traditional firms during the 1970's were mainly based on high technology products and processes. "Criticism of the transition in the engineering industry during the 1970's must focus on the lack of product design in the country and the near-total dependence of the sector on foreign parent company research and development" (Timoney, S. in Ryan, L., 1984, p48).

This lack of product design and R&D in Irish-based companies left them vulnerable to changes in market requirements due to their inability to change product direction quickly. Through the 1980's this became a contributory factor to the demise of many foreign-owned Irish companies.

Today, the vast majority of enterprises in Ireland are Irish-owned (82% of 3,805 firms). This applies to all sectors including metals and engineering in which Irish-owned enterprises account for 77% of the total figure of 1,468 establishments. Unfortunately, a shadow is cast on this seemingly positive situation when it is realised that all of these Irish-owned establishments produce less than half of the net output produced by the relatively small 17% of total establishments which are foreign-owned. In fact a total of 315 companies from the USA manage to contribute 48% of net output in the industrial sector, compared with a contribution of 31% by a total of 3805 Irish establishments. The foreign-owned establishments also employ 45% of the Industrial workforce compared with 54% employed by Irish establishments. Together, these figures reveal the nature and composition of Irish industry, particularly in terms of establishment size and ownership. "The Irish industrial sector consists of a large number of Irish-owned establishments which are small in nature in contrast to the relatively few foreign-owned establishments who appear to be very large, highly mechanised and very important in their contribution towards industrial output" (O'Doherty, D. and Scully, N., 1994, p12).

It is clear from this that Ireland is overly dependent on a relatively small number of foreign industries based in Ireland, both in terms of industrial output and employment. When this is considered in the light of the fact that over 99% of the total number of manufacturing establishments in Ireland are actually indigenous Irish-owned manufacturers, it seems only natural that these should be developed into more productive and successful manufacturers. Indeed, the development of the indigenous manufacturing base of the economy has been a fundamental aim of economic policy in Ireland for many years. With over 4,000 firms each employing less than 100 people, successive governments relished the thought of expanding even a small percentage of these firms, to be more productive and to create more employment, through appropriate intervention. However, under constant pressure to reduce unemployment and achieve national growth, governments have concentrated on attracting large multinational companies to Ireland, while neglecting the development of these Irish enterprises. This has proved detrimental to indigenous industry and, between 1980 and 1990, the number of Irish-owned establishments employing over 100 people fell by over 40%. By this time also the number of Irish-owned establishments employing over 500 people had fallen to just 12 plants. In the light of such decline and the small size of most Irish-owned industry it is not surprising that we have so great an unemployment problem in this country.

However, the most significant feature of this extremely high closure rate which included 43% of all Irish-owned establishments between 1980 and 1990, was the fact that the closures were equally prevalent among modern high-tech sectors and declining traditional industries. "Such a high failure rate was partly due to a lack of technical and design sophistication in the products being produced and a resultant inability to compete in the domestic and export markets" (MacNamara, 1994, p18).

It seems that factors such as these are indeed leading to a decreased level of competitiveness and performance in Ireland's small manufacturing firms.

In the past, the reasons given to explain the lack of success of small Irish firms often included convenient old standards such as taxation, employment legislation, government paperwork or inadequate marketing. However, such explanations were over-simplified mainly because they were based on the assumption that these companies were totally capable of manufacturing to the appropriate design, quality and price requirements of their markets. In fact in more recent years " . . . research evidence . . . suggests that such an assumption is unjustified and that inadequate design, poor and frequently inconsistent quality and lack of price competitiveness are major factors constraining the growth and threatening the survival of many small firms" (O'Farrell and Hitchens, 1989, p5).

In practice, many of these problems can be attributed to the failure of management to upgrade their knowledge and expertise, leading to an inability to increase standards due to a lack of familiarity with the prevailing best practice. Many small firm proprietors are not even aware of their own firm's strengths and weaknesses in their market segment and instead try to compete on the basis of the same criteria as successful businesses rather than attempting to build a competitive edge based upon a strategy of differentiation.

The Irish market is relatively uncompetitive in comparison to most European countries and is quite limited in terms of size. This means that a large number of enterprises are able to establish themselves in Ireland but soon become limited by the market size. This creates the necessity for small Irish firms to turn to exporting at a relatively early stage in their development. While many companies achieve this transition, with the overall export penetration by Irish companies at about one-quarter of sales, the increase in competition in the international marketplace proves too much for many small firms who remain limited to the Irish market with the consequent limitation on company growth.

It is clear that these small Irish firms can only grow further if they become competitive in terms of design, quality and price in the international marketplace. This is particularly

relevant to high-tech industries such as precision engineering and injection moulding which currently lag behind in these areas in comparison with their British counterparts.

In a comparative study of British and Irish firms matched as closely as possible with respect to product design, age group and employment size category, it was found that " . . . in skill-intensive product segments such as precision engineering, injection mould making and tool-making, many Irish companies, when shown samples from matched British firms conceded under questioning that they could not produce to the tolerances and finish displayed by the British samples" (O'Farrell and Hitchens, 1989, p64).

This study also showed that one third of Irish products evaluated by British firms were considered to be of an unacceptable quality while just 12% were regarded to be high-quality products. Also, most of the firms sampled proved to be weak in precisely those activities where they need to be strong to compete internationally, namely design, product development and consistent quality production. Indeed, design tended to be given a low priority by small firms, a long way behind such concerns as financial control, production and marketing. Design is perceived as a cost rather than a source of added value.

Such factors suggest that small Irish firms, which represent the majority of indigenous establishments would achieve more growth through a move towards the manufacture of products based on improved quality and design. Ideally, these products would have a high added value, require low capital investment and be capable of meeting the demands of the international marketplace.

CHAPTER 3

TECHNOLOGICAL INNOVATION IN IRISH INDIGENOUS MANUFACTURING INDUSTRY

This chapter focuses on the technological innovative capacity of Irish indigenous manufacturing industry. The importance of this area stems from the increased realisation internationally that the technological capabilities of a nation's firms are a key source of their competitiveness on world markets. Further, it is also recognised that the economic performance of a nation's firms has a major influence on the performance of the nation's economy as a whole. This has prompted efforts from governments world-wide to improve their national innovative systems and, in particular, the technological innovative capacity of their national industries.

Technological innovation is the process used to transform an idea into a new or improved saleable product or operational process in industry, usually in response to, or anticipation of, changing market requirements and developments in technology. Unfortunately, due to the creative nature of innovation it is often misunderstood and is frequently confused with the activities of invention and design. "Invention is the process of discovering a principle, design is the process of applying that principle" and innovation is the process which leads to the diffusion of the principle through its first commercial application to the marketplace (Pye, 1964, p19). Industrial product design is the part of the innovation process which translates ideas into the technical information required to manufacture products. The process of technological innovation in modern industry is quite broad and embraces all the activities which occur between the initial problem identification and idea generation through research, design and development, production and the diffusion of new products and processes. However, a simple explanation of the process is that successful technological innovation means the development of new products and processes.

The initial stage in developing a new technically innovative product is that of research and development (R&D). This term is used to describe basic and applied research in science and technology and the design and development of prototypes and processes. Although research and development does not necessarily produce commercial innovations, it is often used as an indicator of the level of technological innovation occurring in a country. In Ireland the current expenditure on R&D is only 0.55% of GDP which leaves the country in eighth place in the EU according to figures released by the Science and Technology Evaluation Unit of Forfás in their report 'Research and Development in Ireland'. Over 90% of this expenditure came from private enterprise with a contribution of just over 5% from the government. This ranks as one of the lowest percentages of the OECD countries and is only half that of Denmark and one-third that of Great Britain.

Also significant is the fact that just 12% of Irish-owned companies engage in R&D which suggests that this is the highest possible percentage of firms engaging in technological innovation. This means that less than 500 indigenous firms have the capacity for technological innovation.

A breakdown of R&D activities by sector shows that over 75% of R&D in Ireland was carried out by just 3 sectors namely the food, drink and tobacco sector, the chemicals and drug sector and the electrical, electronic and software sector. This implies that the metals and engineering sectors, which, as mentioned previously, comprises one-third of Ireland's indigenous industrial units accounts for less than one-quarter of R&D activity - and a detailed analysis suggests this is, in fact, about 15% at most.

The objectives of R&D in Irish firms were as follows:

Improving Existing Processes	14.5%
Developing New Processes	14.8%
Improving Existing Products	23.3%
Developing New Products	47.4%

In terms of R&D expenditure, almost 300 or 64% of Irish-owned companies spend less than £50,000 per year compared with double this figure for 57% of Irish-based foreign companies.

These figures which represent the level of expenditure by Irish-owned establishments on R&D are described as "dismally low" by IBEC in their submission on innovation and technology (O'Doherty and Scully, 1994, p33).

However, although the research and development figures are indeed useful as indicators of the level of technological innovative capacity of Irish indigenous industry, further indicators are required to reveal the entire scene.

A recent survey by Forfás which surveyed Irish manufacturing firms with ten or more employees is the most comprehensive study of technological innovation ever undertaken in Ireland. This survey found that one in three manufacturing enterprises can be described as innovative. The electrical/electronic and chemical/pharmaceutical sectors are the most innovative of Irish firms. Irish industry as a whole spent 2% of its turnover in 1992 on innovation-related activities. 18% of Irish industry's turnover also in 1992 was accounted for by products changed or introduced within the previous two years. Research and development accounts for approx. one third of industry's innovation budget. Different

groups have different priorities for their innovation spend. The main objectives underlying innovation include the improvement of product quality and the maintenance or growth of existing markets

Market analysis takes up 10% of Irish industry's innovation budget while the purchase of patents and licences accounts for the remainder of current spending. Differences in the way different groups spend their innovation budget show that hi-tech companies allocate their budget primarily to R&D and product design as against low-tech enterprises where the innovation budget is spread more evenly across all categories of expense. An interesting difference is that the medium-tech sector seemed to allocate the bulk of their resources to product design work and trial production rather than R&D. Division of the innovative group into those with low-, medium- and high proportions of turnover taken up by current expenditure on innovation, shows that the highly innovative actually spend the greatest proportion of their budget on product design.

It is inappropriate to describe R&D as a single activity with just one objective. In fact, in manufacturing industry research is quite different from design and development which can be regarded as the core of technological innovation especially in terms of new product development. Indeed development in this sense is the process of proving a design through the testing of prototypes and selection of materials and processes. "It is insufficiently appreciated that successful innovation in high technology industries often is not so much a matter of invention as a patent examiner would define invention, as it is a matter of design in the sense of trying to devise a product or process that will achieve a desirable cluster of performance characteristics subject to certain cost constraints" (Nelson, 1993, p8).

Indeed the importance of product development and its management are gaining increasing recognition internationally as a competitive strategy in firms. The responsibilities associated with new product development are too important to be viewed as so often is the case, as little more than an extension of the engineering design department. New product

development requires input from all levels and functions within a firm to maximise a success rate of innovation efforts.

A paper presented to the eleventh conference of the Irish Manufacturing Committee in 1994, which describes the status of product development activities in the engineering sector of Irish industry is probably the most in-depth survey of this area carried out to date.

The survey sampled 62 of a possible 133 firms which Forfás regarded as being engaged in R&D. Unfortunately, a large proportion (82%) of the sample group was foreign-owned, although they were based in Ireland. In the light of previous studies on R&D carried out by the science and technology evaluation unit of Forfás, it can be assumed that Irish indigenous firms were unlikely to be more innovative than their counterparts who spend twice as much on R&D as a percentage of total sales with the figures standing at 0.62% and 1.21% respectively. The survey notes that in Irish-based engineering firms the level of innovation is low when measured in terms of patent applications as it was in the report of the Industrial Policy Review Group, 1992. A total of 61 patent applications had been made by the sampled group within the previous five years, which amounts to about one each. In terms of spending on new product development as a percentage of total sales a figure of 4.6% was returned. This is substantially higher than that of 0.62% recorded for the total of Irish indigenous industry.

In most cases responsibility for new product development was given to a new product development manager appointed for this purpose, although in smaller firms this was usually the responsibility of the Chief Executive. In terms of product planning most firms still used manual methods and it should be noted that almost a quarter of firms had no formal planning cycle.

The success of the product development was measured in terms of time, quality, innovation and technology acquisition. The results of these indicated less than a 50% success rate

being reported by 50% of the sample in terms of meeting the project delivery date. Projects were also considered to be too long in duration with almost 80% of all projects taking between one and two years. The remainder took between two and three years.

In terms of quality a total of 60% of the sampled firms received the ISO 9000 award which includes assessment of the use of formal design reviews.

Innovation was measured in terms of patent applications in the last 5 years. Only 10% of the firms had made more than 7 applications, while 30% each had applied for 3-7 patents, less than 3 patents, and no patents in this time.

Technology transfer to overseas locations was achieved by 31% of the firms while 25% licensed a new technology.

The sampled firms were extremely weak in the use of design tools to support their development activities and many of the low investment manual methods used by world-leading companies were virtually unheard of. Computer based design tools were also absent with the exception of CAD which was used as a PC-based drafting tool by 80% of the sample. However, even the utilisation of these facilities was low at around 20% for half of the systems (Hurst, 1994).

The results of this survey can be regarded as the 'best practice' of Irish engineering firms due to the fact that all of the sample firms were engaged in R&D activities which itself is limited to a small percentage of firms in Irish industry.

The most relevant findings of this survey are as follows.

1 Low levels of innovation consistent with general industry trends previously recorded were present in the sample firms.

2 The ability of the firms in the study generally to compete through development is doubted.

3 Basic methods which support meeting customer needs as well as enhancing product development capabilities are generally absent in the sampled firms.

4 CAD facilities which are installed are poorly used and unsuitable as a support to advanced new produce development activities such as concurrent engineering.

5 There is a low level of understanding displayed by firms generally towards design tools either manual or computer based.

6 There is evidence to suggest that product development methods will remain deficient as compared with international best practice methods to compete effectively through new product development.

When one considers that these findings represent the cream of Irish-based innovators, it can be inferred that, on the whole, design and development practices which could provide the competitive edge to the development efforts of Irish industry are essentially absent in Ireland.

Of almost 5,000 manufacturing firms in Ireland only about 100 practice product design techniques. This has resulted in a low level of added value in Irish products which has caused Ireland's lack of competitiveness in the international marketplace.

CHAPTER 4

DESIGNING MARKETABLE NEW PRODUCTS

"We have a major product problem in this country. There is a major need for investment in product design, packaging, and the application of technology. In order to go to market, you have to have marketable products ..." This is according to the chief executive of the Irish Exporters Association in an article in the Irish Times in October, 1993.

Marketable products are the cornerstone of manufacturing industry and commercial success depends on the efficient management of product development processes.

The relationship between management in manufacturing industry and their consumable products is complex but determines the company's commercial success. The optimisation of this success is achieved through the efficient production of such market-focused products. A successful product realisation can therefore be seen as crucial to profit. Successful manufacturing is a consequence of product innovation and design which is based on an objective appraisal of markets, technology and production leading to the appropriate innovative products. Although innovation is often seen as radical, the importance of incremental innovations and design improvements has been greatly underestimated. Attention tends to be focused on the research, design and development work involved in getting from an idea or invention to an innovation on the market for the first time. However, just as important are the processes of successive re-design, component improvement and evolution of the product to improve its performance and reduce its cost.

The economic benefits of innovation manifest themselves in the form of either increased sales, reduced costs, or markets protected that would otherwise have been lost. In addition

to these directly quantifiable benefits other benefits, arguably equally important in the long-term are the raising of internal levels of staff technological competence within firms and the transfer of acquired technology to other beneficial applications.

Ireland's failure is that we are not creating and supplying enough good products: products that are so well designed, made and serviced as to out-perform the competition. Without new, improved, better performance we cannot win new markets. A recent study of Irish manufacturers and how they stand up to the critical examination of potential buyers in overseas markets supports the view that Irish firms, though very often better equipped than overseas competitors, may still be much less competitive because the products they make and the service they offer are frequently not up to the mark which commands market share and premium prices.

In Ireland the real need, if we are to develop successful new products and strong relationships with buyers in new, as well as existing markets, is to concentrate assistance and funds on the development of higher capacities, capabilities and standards of performance at all levels of business. Unless product designs, manufacturing methods and the level of quality and service are brought up to the sophisticated standards of affluent and demanding buyers then we cannot rely on markets or products to produce jobs.

CONCLUSIONS

The crux of Ireland's development problem is the weak development of indigenous industry and this has been the case since before the foundation of the State. Efforts by government to intervene in support of industry included both the protectionist and outward-looking phases. The former gave high employment growth and the latter gave high productivity growth but neither managed to progress both of these goals simultaneously.

Efforts to achieve both these goals during the 1970's, financed by excessive borrowing, led to a record National Debt and the resurgence of emigration in the form of a 'brain drain'. Nations with a weak manufacturing sector look to successful countries wondering how they might emulate their performance. Ireland, in an effort to compensate for its lack of a solid National Innovation System attempted to import a foreign innovation system based on US, UK and German influences. In view of the fact that expatriation of profits by foreign-owned Irish firms is now 12% of GNP and linkages between these firms and indigenous industry are weak, one realises that these efforts have had only limited success.

A major task for Ireland must therefore be the stimulation of our own National Innovation System to support our indigenous industry into the next millennium. This will involve an innovative approach, particularly in the area of export competitiveness. This is indeed a major challenge for a small nation which has not previously reached advanced industrialisation.

Central to this goal is the need to increase the technological innovative capacity of Irish indigenous manufacturing industry as quickly and effectively as possible. This will be the back-bone of the country's National Innovation System and the thrust of the country's economic performance.

APPENDIX

Definitions

The following definitions have been adopted throughout this thesis.

Indigenous refers to industries / firms which were first established in Ireland excepting those established between the early 1930's and the early 1960's, which were influenced by the control of manufacturers act and are deemed indigenous only by present day Irish ownership .(Fitzgerald and Kelly, 1984, p12)

Innovation refers to "the process by which firms master and get into practice product designs and manufacturing processes that are new to them ..." (Nelson, 1993, p4)

Irish Manufacturing Industry refers to manufacturing industries based in Ireland including foreign owned as well as indigenous.

Manufacturing refers to the act of transforming or changing raw materials into usable products.

National Innovation System refers to "a set of institutional actors that together play the major role in influencing innovative performance of national firms" (Nelson 1993, p4)

Research and Development (R&D) refers to a range of activities from basic and applied research in the sciences and engineering to the design and development of prototypes and processes.

In basic research the investigator is concerned primarily with gaining a fuller knowledge or understanding of the subject under study.

In applied research the investigator is primarily interested in the practical use of the knowledge or understanding for the purpose of meeting a recognised need.

Development is systematic use of the knowledge and understanding gained from research directed towards the production of useful materials, devices, systems or methods, including design and development of prototypes and processes. It includes quality control, routine product testing and production.

Technological Innovation refers to "... the transformation of an idea into a new or improved whiter than white saleable product or operation process in industry..." (OECD 1981) and embraces " the full range of activities from the initial problem definition and idea generation through research and development engineering, production and diffusion of new technical devices , processes and products" (Kelly et. al. in Roy and Wield, 1986, p20).

BIBLIOGRAPHY

Barrett, J., "Product design, Bearings: How the experts can help." Eureka, Jan 1995 pp. 42-48

Barry, D., "Companies and colleges: Factors determining successful R&D partnerships in Ireland", Thesis B. Comm., Dublin, UCD, 1984

Bradley, A., "The development of Industrial Design in Ireland", Thesis, B. Des., Dublin, NCAD, 1984

Breathnach, M. and Fitzgerald, A. "Technological Innovation in Irish manufacturing industry", Dublin, Forfás, 1994.

British Parliament (Chancellor of Duchy of Lancaster) Realising our potential - A strategy for science, engineering and technology, London, 1993.

Campbell, Patrick, "New products, new markets, new jobs", Business and Finance, Oct. 1992, pp. 27-30.

Comerford, K., :Innovation in Irish engineering companies: A study of the factors affecting the introduction of new products in medium-sized Irish engineering companies", Thesis, MBA, Dublin, UCD, 1978.

Design Engineering, "Simplicity becomes an aim in the design process", Design Engineering, December, 1994, pp 19-22.

Douglas, Gordon, and Kemp, Philip, Cook, Jeremy Systematic new product development, Hants., England, Gower Publishing Company Limited, 1983

FFrench-O'Carroll, Dr. Michael, Report of the council of design, Dublin, 1965.

Fitzgerald, A., and Harding, L., Research and development in Ireland, Dublin, S & T evaluation unit, Forfás, 1992.

Fitzpatrick, J. and Kelly, J., Perspectives on Irish Industry, Dublin, Mount Salus Press, 1985.

Flurcheim, C., Industrial design in engineering, London, The Design Council, 1983.

Franck, K., (et. al.) Design in Ireland - Report of the Scandinavian design group in Ireland, Dublin, CTT, 1962.

Freeman, C., The Economics of Industrial Innovation, Harmondsworth, Penguin, 1974.

Hollins, B. and Pugh, S., Successful Product Design, London, Butterworths, 1990.

Hutchins, D., Just in Time, Hants., Gower Technical Press, 1988.

Industrial Policy Review Group (Culliton Report) A time for change: industrial policy in the 1990's, Dublin 1992.

Irish Manufacturing Committee, Lean Production from concept to product, 1994, Belfast, 1994.

Johne, Dr. F. A., Industrial Product Innovation, organisation and management, New York, Nichols Publishing Co., 1985.

Kennedy, A., "Research, Innovation, industrial development", Enterprise Innovation, Issue 4, Vol. 1, Feb. 1995, pp 8-9.

Kieran, J., Technology transfer - "A study with reference to the Irish engineering industry", Dublin, Government Publications Sales Office, 1975.

Kilkenny Design, Twenty One years of design in Ireland, London, Lund Humphreys, 1985.

Langdon, R., Design and Industry, London, The Design Council, 1984.

Lindbeck, J., Product design and manufacture, New Jersey, Prentice-Hall, 1995.

MacNamara, M., "Ahead through technology", Business and Finance, June 16, 1994, pp 18-19.

Major, J., "A partnership for prosperity", Design engineering, Sept. 1994 p9.

Moriarty, P., "Encouraging the development of new products", Business and Finance, October 1992, pp 3-5.

Mortell, M., "Design in the product life cycle: Ballygowan Spring Water", Irish Marketing Review, Vol. 6, 1993, pp 83-90.

Mulcahy, G., "The development of Irish Design Awareness in the 1960's", Thesis, B. Des., Dublin, NCAD, 1992.

National Board for Science and Technology, Innovation in small manufacturing firms - an Irish Research Study, Dublin, 1979-80.

National Economic and Social Council, The Irish Economy in a comparative institutional perspective.

Nelson, R., National Innovative Systems: A comparative analysis, New York, Oxford University Press, 1993.

O'Doherty, D. and Scully, N., STIAC, Industry in Ireland: Structure, ownership and R&D performance, Dublin, 1994.

OECD, "Contribution of science and technology to economic growth", The technology/economy programme, June 1989, pp 7-18.

O'Farrell, P. N. and Hitchens, D., Small Firm Competitiveness and Performance, Dublin, Gill and Macmillan, 1989.

O'Hagan, J. W., The Economy of Ireland - Policy and Performance, Dublin, Irish Management Institute, 1975.

Pye, D., The Nature of Design, London, Studio Vista, 1964, p19

Rothwell, R. and Zegveld, W., Innovation and the small firm - their role in employment and economic change, Francis Pinter (Publishers) Ltd., 1982.

Roy, Dr. R., "Case studies of creativity in innovative product development", Design Studies Magazine, Vol. 14, No. 4, Oct., 1993, pp 378 - 424.

Roy, Dr. R., and Potter, Dr. S., Design and the economy, London, The Design Council, 1990.

Roy, Dr. R. and Wield, D., Product design and technological innovation, Buckingham, Open University Press, 1986.

Ryan, D. M., "Kilkenny Design Workshops: 25 Years of design in Ireland", Thesis, B. Des. Dublin, NCAD, 1990.

Ryan, L., Irish Industry in the eighties, Dublin, Helicon Ltd., 1984

Sectoral Development Committee, "Report and recommendations on the technological capacity of indigenous Irish industry", Report 8, June 1985.

Turpin, Prof. J., "The Irish design reform movement of the 1960's", Design Issues, Vol. III, No. 1, Spring 1986.

Walsh, V. et. al., Winning by design: technology, product design and international competitiveness, Oxford, Blackwell publishers, 1992.

Williams, G., "Summertime", Design Week, Jan. 1995, pp 14 - 15.