An Investigation of the Response of Irish Food Firms to the Technological Discontinuity Caused by the Emergence of New Biotechnological Techniques.

By

Clare Kavanagh B.Sc.(Mgmt.)

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The present thesis is based on the work of Clare Kavanagh, Post Graduate Research Student at the College of Marketing & Design, DIT, during the period October 1991 - December 1993. The research was carried out under the supervision of Ms. Kate Ui Ghallachoir, Senior Lecturer, College of Marketing & Design, DIT.

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of Master of Business Studies is entirely my own work and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

Signed: Clare Kavanagh **Date:** 28-02-95

Candidate

Date: ______________________

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An Investigation of the Response of Irish Food Firms to the Technological Discontinuity Caused by the Emergence of New Biotechnological Techniques.

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Abstract.
New biotechnological techniques have been identified as a factor determining the future success of industries as diverse as healthcare and agriculture. They have the potential to revolutionise primary food production and food processing activities. The primary objective of this research was to investigate the response of the Irish food industry to the technological discontinuity caused by the emergence of new biotechnological techniques.

A three phase methodology was developed to achieve this objective. Phase one involved exploratory research of expert opinion to assist the development of a research design specifically tailored to the unique features of the Irish food industry in the context of the applications of new biotechnological techniques. The second phase involved extensive primary research of identified potential early adopters of new biotechnological techniques. Pivotal response factors investigated were: firms' technological capacity to apply the techniques, strategies used for involvement in R&D and attitudes to the emergence of the techniques. In phase three food firms' response to the technological discontinuity caused by the emergence of new biotechnological techniques was inferred through an appreciation of their performance with regard to the three factors examined in unison. In addition, a scoring system was developed that allows quantification of firms' responses to one of the topics at issue, technological capacity. The scoring system also allows comparison with international findings.

Findings indicated responses were twofold. Most firms were non-responsive to the emergence of new biotechnological techniques or were involved in a monitoring strategy only. The sole group for which possible future direct use was indicated were high value low volume ingredient supply firms.

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Introduction.

"In recent years scientific advances have transformed that group of technologies referred to as biotechnology into a set of increasingly powerful tools for many industries. Biotechnology is identified by many as an important factor determining the future success of industries as diverse as healthcare and agriculture"[1] With reference to developments overseas this study aims to investigate the response of the Irish food and drink industry to this new technological paradigm. The study is based in the food and drink industry (henceforth food industry) for two reasons:

1. The food industry is of significant strategic importance to Irish economic life.

2. New biotechnological techniques have the potential to improve both primary food production and food processing activities. To illustrate: Use of new biotechnological techniques can provide improved crop varieties and also aid in their processing.

The study is of a pioneering nature as little is known of Irish food firms' response to the technological discontinuity caused by the emergence of new biotechnological techniques. Areas identified as important for investigation of Irish food firms' response to the techniques are:

1. General patterns of adoption and diffusion noted with new technologies in general and in particular patterns of adoption and diffusion noted with new biotechnoogical techniques in other industrial sectors and countries.

2. Characteristics of the techniques and their potential specific to the food industry.

3. The impact of public perception issues.

4. The existing Irish food industry and in particular the part new biotechnological techniques might play in this sector's strategies for future development.

References.

1. Ui Ghallachoir K. and Kavanagh C. (1993), "Biotechnology-Beauty or Beast," *Irish Marketing Review*, vol.6, pp.70-77.

Chapter 1 New Technology Adoption and Diffusion in Industry.

1.0 Introduction.

Technology and the innovative process have been identified as important determinants of economic success. It is assumed that technological leads and lags are major determinants of the relative efficiencies, competitiveness and incomes of firms and countries.[1] The emergence of new industrial technologies can have significant implications for individual firms and indeed entire industrial sectors. Schumpter has termed radical technological change as a "force of creative destruction" because the emergence of revolutionary new technologies can destroy companies using existing outdated technologies while concomitantly breathing life into new companies based on emerging technologies.[2]

In recent years the unprecedented instability caused by the emergence of rapidly changing technologies in the environment has afforded technology management a new importance in industrial life. In 1981 Booz, Allen and Hamilton showed that most senior executives expected their organisations future growth and profits to come largely from new technology based products.[3] Also, of the 43 companies which Peters and Waterman, jr. judged to be excellent in "In Search of Excellence", almost half were classified as "high technology" or as containing a substantial high technology component.[4] It would seem thus that in the words of Capon and Glazer,

> "the avoidance of technological risk today may lead to considerable market risk tomorrow"[5]

In this chapter the focus of the literature accessed is high technology innovation, adoption and diffusion in the industrial sector. The work is organised as follows: The first section is concerned with theories relating to industrial innovation, adoption and diffusion in general. Presentation is made of: Alternative conceptualisations of the nature of and the procedures associated with technological change, a detailed analysis of the agents of technical change and the processes of diffusion associated with new technologies adopted in an industrial sector. The next section explores patterns of adoption and diffusion specifically associated with the technological discontinuity caused by the emergence of new biotechnological techniques.

1.1 Technology and Knowledge

In advance of making a detailed review of the nature and evolution of high technologies it is necessary to distinguish technology from science or the general notion of knowledge. Capon and Glazer defined technology as a subset of knowledge and is unlike all knowledge in that it is intended for use. They proposed that technology could be defined broadly as "know-how", or more specifically with respect to a firm as the information required to produce and/or sell a product or service.[6] A more impressionistic definition is offered by Dosi who defines technology as a set of pieces of knowledge,{both directly "practical" (related to concrete problems and devices) and "theoretical"(but practically applicable although not necessarily already applied)}, know how, methods, procedures, experience of successes and failures and also, of course physical devices and equipment.[7]

Technology as described by these definitions is much less well articulated than is scientific knowledge; much of it is not written down and is implicit in experience, skills, etc. As the industrialised world has been shifting from a labour and capital intensive to a knowledge or information based economy it now seems reasonable to regard knowledge as a primary commodity and knowledge capitalised as know-how or technology as an asset for most firms.[8]

1.1.1 Technological Change.

As noted the relationship between economic growth and change on the one hand and technical progress on the other is a rather evident and well recognised fact in economic thought. The nature of the relationship between the two, however, has been a much more controversial issue of economic theory. The theoretical problem concerns the direction of the causal relationship. In general, theories of technical change have been classified into two main categories, namely 'technology push' and 'demand pull'. Difficulties are associated with extreme forms of both theories. Interpretations based on 'demand pull' theories present a rather crude conception of technical change, as an essentially reactive mechanism based on a 'black-box' of readily available technological possibilities. On the other hand, extreme forms of 'technology push' approaches, allowing for a one-way causal determination (from science to technology to the economy) fail to take into account the intuitive importance of economic factors in shaping the direction of technical change.[9]

Alternative conceptualisations of the process of technical change seek to avoid these difficulties. Arrow in 1962 conceptualised technology as information about the methods of production of any one good. As such technology, like information, is a durable public good. In this context the rate of innovation in any industry can be analysed as the equilibrium outcome of a race for the acquisition of valuable information among profit maximising competing agents. The primary failing of this conceptualisation is that technology, far from being a public good, also involves important private aspects which are related not only to the protection provided by patents and secrecy but also to its tacit and specific nature. Although some portions of technological knowledge may be available in universities and research institutes, technology also depends on the development of the internal, specific and tacit capabilities of any one company. [10]

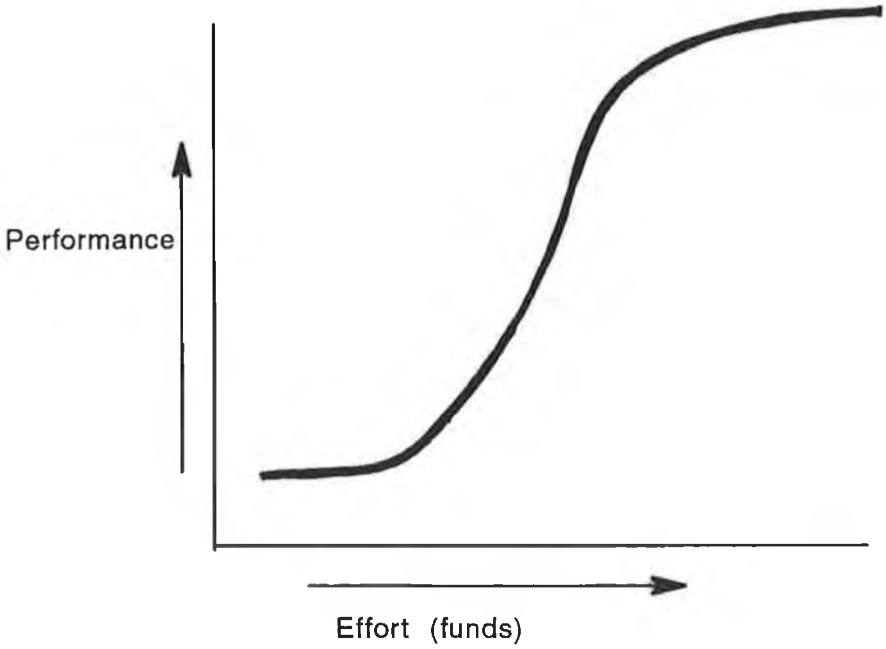
Dosi on the other hand proposed an interpretation of technological change using technological paradigms and technological trajectories. Using Dosi's model it is proposed that the procedures and the nature of technologies are broadly similar to those which characterise science. In particular it is proposed that 'technological paradigms' or research programs perform a similar role to 'scientific paradigms' or research programs. A technological paradigm is defined by Dosi as a,

> "...model or pattern of solution of selected technological problems based on selected principles derived from natural sciences and on selected material technologies".[11]

In other words a technological paradigm embodies strong prescriptions on the directions of technical change to pursue and those to neglect. A technological trajectory is defined as the pattern of 'normal' problem solving activity on the grounds of a technological paradigm. Thus, continuous changes are related to progress along a technological trajectory defined by a technological paradigm, while discontinuities are associated with the emergence of a new paradigm.

Technological discontinuities are also discussed by Richard Foster in 'Innovation - the Attackers Advantage.'[12] Foster recommends graphical representation of progress along a technological trajectory defined by a technological paradigm to aid management of the R&D function. He calls these graphs 'S Curves'. (Figure 1.0)

Figure 1.0 The S Curve



Source: Foster R. (1986), *Innovation-the Attackers Advantage,* Macmillan Ltd., London.p.31.

They show,

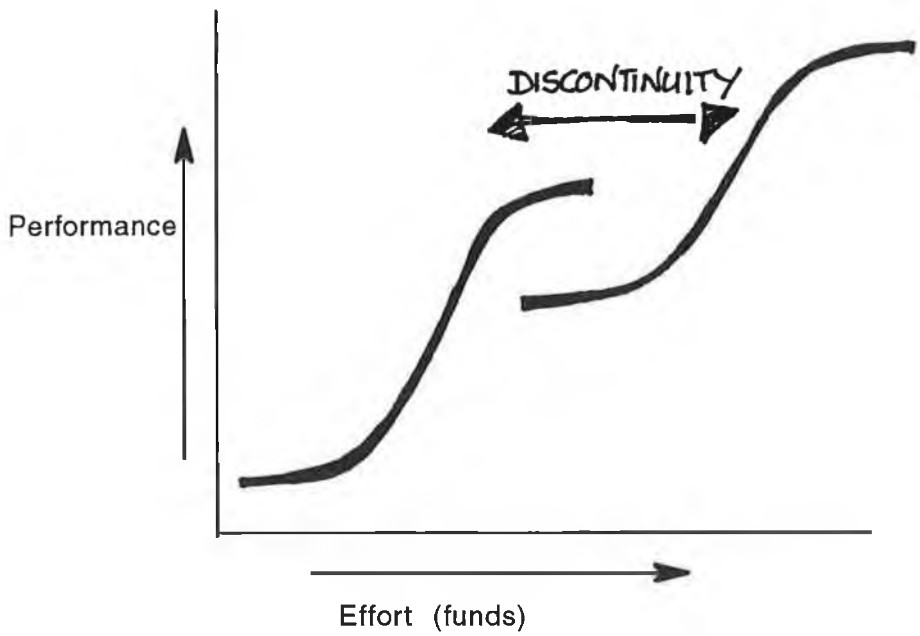
> "...the relationship between the effort put into improving a product or process and the results one gets back for that investment".[13]

If a technological paradigm is conceptualised as an S Curve it is easy to track progress along a trajectory defined by that paradigm. As Foster explains;

> "...initially as funds are put into developing a new product or process progress is very slow. Then all hell breaks loose as the key knowledge necessary to make advances is put in place. Finally, as more dollars are put into the development of a product or process, it becomes more and more difficult and expensive to make technical progress. Ships don't sail much faster, cash registers don't work much better and clothes don't get much cleaner. And that is because of the limits of the S Curve."[14]

These limits are what lead to the development of a new S Curve or a new paradigm. While one competitor is nearing it's limits on an S Curve (technological paradigm) another perhaps less experienced is exploring alternative technologies with higher limits. There is a break between S Curves and a new one begins to form, not from the same knowledge that underlays the old one but from an entirely new and different knowledge base. One technology replaces another. It is for this reason that S Curves in periods of technological change or discontinuity occur in pairs. (Figure 1.1)

Figure 1.1 S Curves and Technological Discontinuities



Source: Foster R. (1986), *Innovation-the Attackers Advantage,* Macmillan Ltd., London.p.102.

Examples of technological discontinuities offered by Foster include the following,

> "...the switch from propeller driven planes to jets, the switch from natural to synthetic detergents or fibers, the switch from cloth to paper diapers, the switch from records to tapes to compact disks..."[15]

The emergence of new biotechnological techniques which are the focus of this study have also caused a technological discontinuity. Use of these techniques will transform the manner in which scientists produce plant and animal species, the pharmaceutical industry and many other industries. They represent a new technological paradigm, a new S Curve and a unique challenge to firms involved with their use.

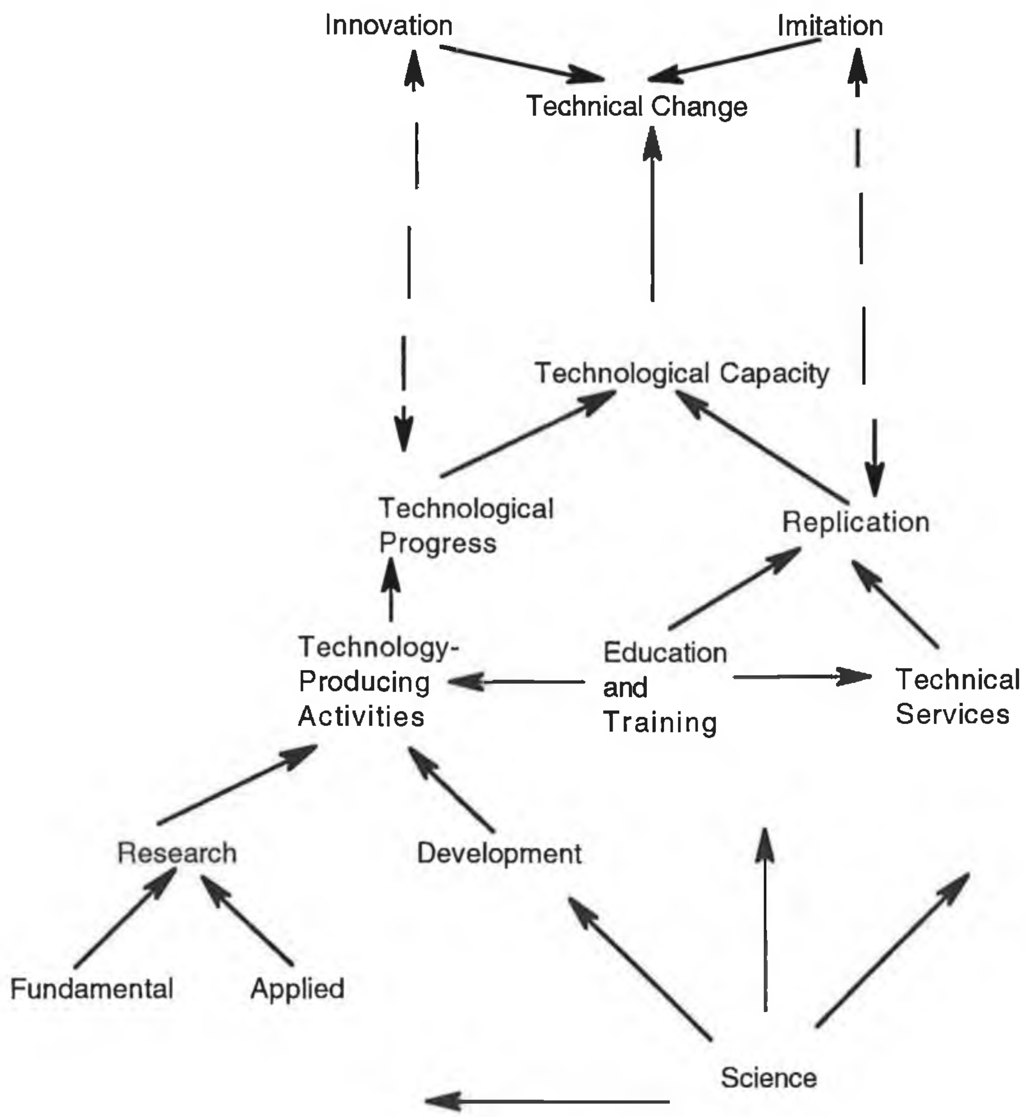
1.1.2 Agents of Technical Change.

Agents of technical change must be concerned with their 'technological capacity'. The term 'technological capacity' is used to describe a number of different aspects of technology necessary to effect technical change.[16] The pattern of technical change outlined in Figure 1.2 shows clearly the primacy of technological capacity as a determinant of technical change. Effective agents of technical change need to possess strong technological capacity. This point was highlighted by the report of Central Advisory Council for Science and Technology as far back as 1968 when they stated,

> "any firm or indeed any country engaged in world trade in advanced industrial products must repeatedly modernise its manufacturing processes and introduce new or updated products if it is not to lose markets and go out of business because of competition from advances elsewhere. Hence the constant need for market awareness and for technological innovation."[17]

Figure 1.3 shows the resources associated with the average product life over time and identifies the key technological functions that relate to the individual stages in this cycle. Key functions such as R&D and process technology are often used as a measure of the technological capacity of individual firms and a medium to high level of competence in each is needed for competitive success.[18]

Figure 1.2 Pattern of Technical Change.

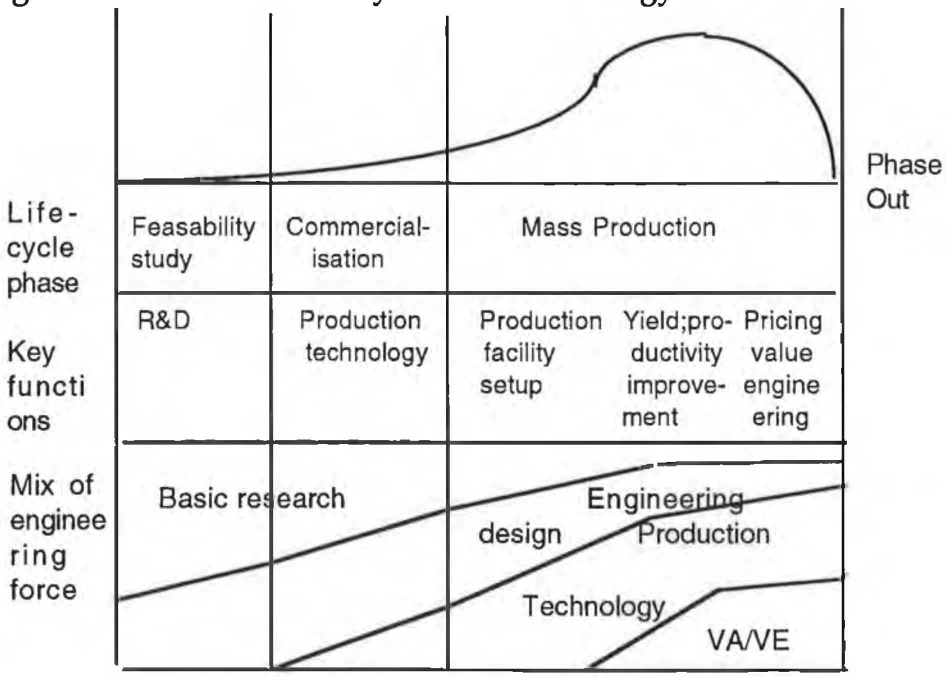


Source: Cotter A. (1979), *Science and Technology in the Irish Food Processing Industry,* NBST, Dublin. p.32.

On a nation-wide scale Schmookler asserts that the rate of growth of a country's technological capacity sets what is probably the most important ceiling on a nation's longterm rate of economic growth. According to Schmookler the rate of growth of technological capacity is jointly determined by the rate of technological progress which is the production of new knowledge and the rate of replication, which is the rate at which the existing technology is disseminated.[19]

The purpose of increasing a nation's technological capacity thus is clearly to increase the potential for technological change. Activities which increase the rate of technological progress and the rate of replication (the determinants of technological capacity) are research and development, education and training and general technical specialist services.

Figure 1.3 Product Lifecycle and Technology focus.



Source: Ohmae K. (1982), *The Mind of the Srategist - Business Planning for Competitive Advantage.* McGraw Hill, England. p.115.

In 1959 Carter and Williams developed a classification for firms according to the degree of technical progressiveness attained by them. These were:

1. Those which are in the forefront of discovery in applied science and technology, quick to master new ideas and to perceive the relevance of work in neighbouring fields.

2. Those which are quite uninterested in science and technology and are perfectly content to continue with traditional methods without even examining alternatives.
3. A large middle group, neither outstanding leaders in technology nor wholly uninterested in it.[20] It may be assumed that those firms commanding significant technological capacity to effect technical change would be represented in the first group of the Williams and Carter classification.

1.1.3 Industrial Diffusion of New Technologies.

Innovation occurs with the introduction by the first enterprise of a given technical change and imitation when other enterprises follow suit, both factors jointly determining the rate of technical change.[21] Tushman and Anderson have shown that competitive conditions after a technological breakthrough are often sharply different from those that prevailed before the discontinuity. They pointed out that dramatic shifts in industry structures and competitive positions can follow as the traditional advantages of established firms are eroded under revised competition rules. Other characteristics of a marketplace following a technological breakthrough are increased levels of technical and market uncertainty, changed terms and sources of competition and new strategic choices and options available.[22]

In this section discussion is focussed upon the imitative process which results in diffusion of a new innovation throughout an industrial sector. Diffusion as defined by Everett Rogers,

> "...is the process by which an innovation is communicated through certain channels over time among the members of a social system."[23]

Rate of adoption is the relative speed with which an innovation is adopted by members of a social system. Research has shown that the most important factor in explaining the rate of adoption are the innovations perceived attributes. Studies indicate that between 49% and 87% of the variance in rate of adoption is explained by the five attributes; Relative Advantage, Compatibility, Complexibility, Trialability and Observability. [24]

In the diffusion of industrial innovations relative advantage may be experienced in a number of ways. To illustrate: Advantage may be created through a change in either a product or a process leading to a reduction in the average total cost of production per unit or alternatively advantage may be the result of increased demand for finished products because of improved quality or variety or price.[25] Size of investment is an important factor governing perceived relative advantage and Mansfield notes that the probability of diffusion and adoption of an innovation is a decreasing function of the size of investment required.[26]

Compatibility and complexity of innovations are also important indicators of diffusion rates. Webster identified these factors as obstacles claiming,

> "Factors which tend to retard diffusion include the degree to which an innovation is incompatible with existing processes and requires major process change, the degree to which increased technical skills are required to use the innovation and the probability that major improvements will rapidly alter the innovation making delay in adoption advantageous"[27]

All of these factors cause increased uncertainty for the potential adopter which may in turn result in an assessment of greater risk. A study undertaken among a Columbian farming community illustrates well how incompatibility with existing processes may result in a negative evaluation of an innovation. Farmers presented for the first time with a chemical fertiliser applied the substance on top of their potato seed, as they had previously done with manure, thereby damaging their seed. As a result they were loathe to adopt the new innovation In general Rogers postulates that the compatibility of an innovation with existing methods, as perceived by members of a social system, is positively related to its rate of adoption and complexity is negatively related.[29]

The importance of trialability and observability in dictating diffusion rates stems from their role in communication of ideas. Trialability is more important for earlier adopters than those who adopt later. The more innovative individuals have no precedent to follow when they adopt, while the later adopters are surrounded by peers who have already adopted the innovation.[30] Thus, later adopters are likely to learn about the innovation through observation rather than through first hand experience.

Quite apart from these innovation attributes other factors also influence the rate adoption of innovations. One important factor is termed by Mansfield as the 'bandwagon' or 'contigon' effect. He postulates that the probability that a given firm will adopt a product or process is an increasing function of the proportion of firms in the industry already using it and of the probability of their doing so.

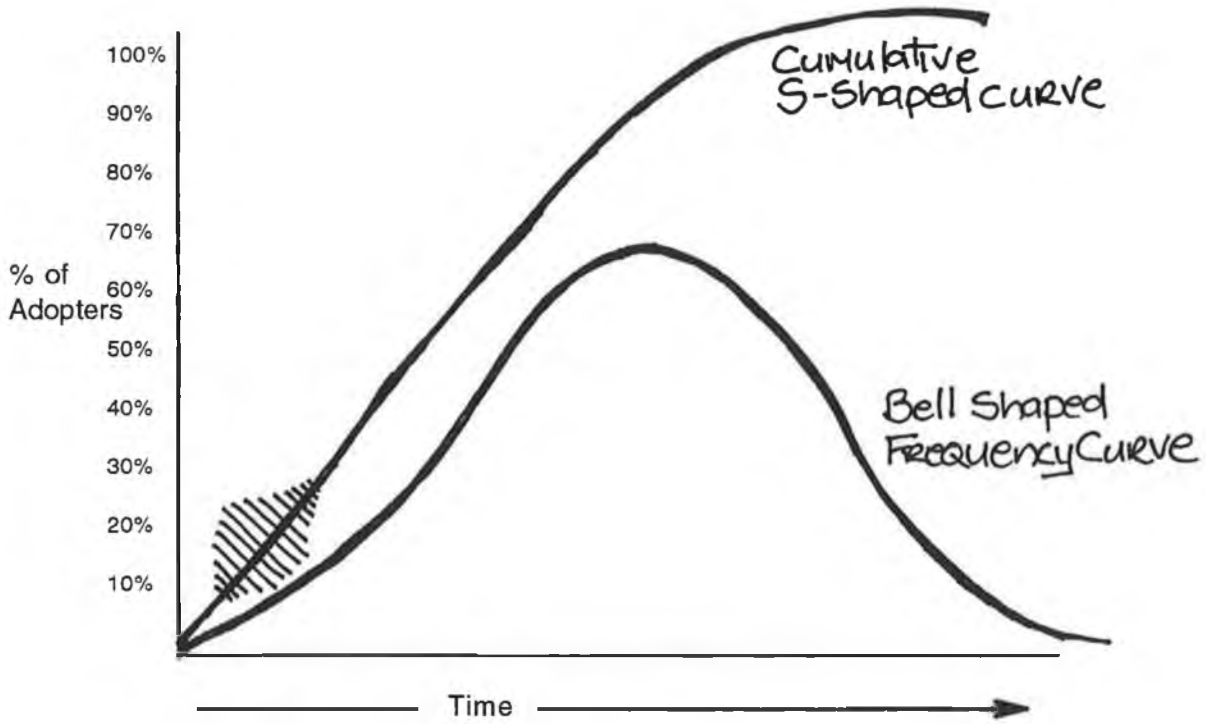
> "As the number of firms in an industry using an innovation increases, the probability of it's adoption by a non-user increases. This is because, as experience and information regarding an innovation accumulate, the risks associated with it's introduction grow less and competitive pressures mount. Moreover in cases where the profitability of an innovation is difficult to assess, the mere fact that a large proportion of a firms competitors have adopted the innovation may prompt the firm to consider it more seriously". [31]

Rogers calls this the 'diffusion effect' and explain it as,

> "The cumulatively increasing degree of influence upon an individual to adopt or reject an innovation resulting from the activation of peer networks about an innovation in a social system".[32]

It is because of the diffusion effect that the S shape diffusion curve takes off at about 10-25% adoption. (Figure 1.4)

Figure 1.4 Bell Shaped Frequency Curve and S shaped Cumulative Curve of an Adopter Distribution.



Source: Rogers E.M. (1971), *Diffusion of Innovations*, 3rd Edition,The Free Press, New York.p.243.

Interestingly, researchers have not found a relationship between firm size and ability to innovate, nor has a relationship been found between firm size and speed of adoption of innovations.[33] Webster contends that larger firms more able to afford investment required for adoption

and the associated risk will adopt innovations earlier.[34] However, smaller firms with less complex decision-making processes might also be among the earliest adopters of new innovations. [35]
It is clear however that for any innovation there exists a significant time lag between its introduction and any wide economic and social impact of use. Mansfield estimated that diffusion of a major new technique could often take twenty years or more before all major firms adopted and seldom took less than ten years.[36]

1.1.4 Adopter Categories

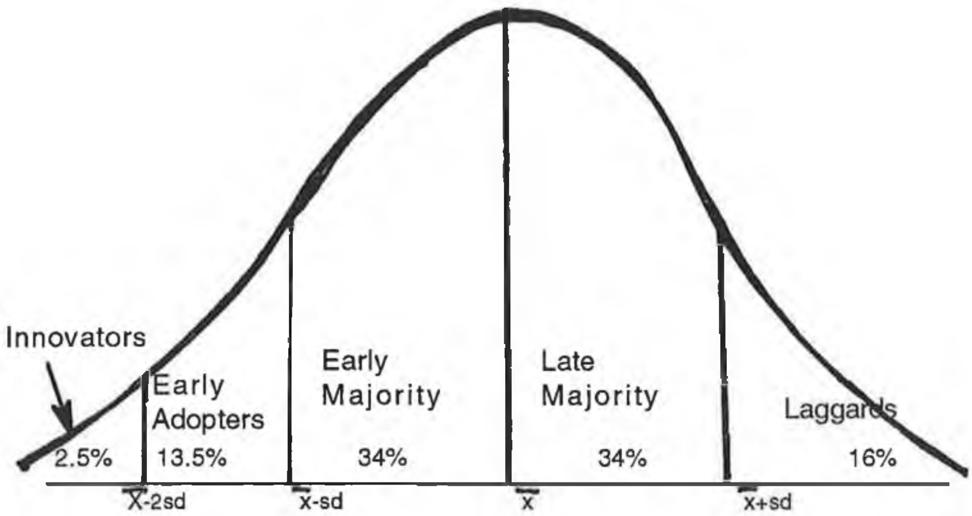
An Innovation spreads through a social system, whether that be an industry or community or neighbourhood, because individuals adopt it. However not all individuals in a social system will adopt an innovation at the same time. Rather they adopt in a time sequence and they may be classified into adopter categories on the basis of when they first began using a new idea. The adopter categorisation of Rogers (1962) has gained widespread prominence. It is based on the S shape curve of adoption shown in Figure 1.4. Note that both these curves are for the same data, the adoption of an innovation over time by the members of a social system. The bell-shaped curve shows these data in terms of the number of individuals adopting each year, whereas the s-shaped curve shows the data on a cumulative basis. The shaded area marks the time period during which the s-curve of diffusion "takes off".[37]

The five adopter categories put forward by Rogers are, innovators, early adopters, early majority, late majority and laggards. Dominant attributes of each category are as follows:

"Innovators - venturesomeness
Early Adopters - respectable
Early Majority - deliberate
Late Majority - skeptical
Laggards - traditional"[38]

Use of new biotechnological techniques is still quite limited, for this reason focus in this study will be on possible innovators and early adopters the first 15% of those who may use the techniques. (Figure 1.5)

Figure 1.5 Adopter Categorisation on the Basis of Innovativeness.



Source: Rogers E.M. (1971), *Diffusion of Innovations,* 3rd Edition,The Free Press, New York.p.247.

1.2 Patterns of Adoption and Diffusion noted in Response to the Emergence of New Biotechnological Techniques.

The emergence of new biotechnological techniques has been heralded as a new technological paradigm. Using the words of Richard Foster they represent a new S curve. The remainder of this chapter focuses on patterns of adoption and diffusion noted following the emergence of these techniques. The techniques are initially described and then the response of emerging and established firms discussed.

1.2.1 New Biotechnological Techniques.

> "It is more than a decade since the international fascination with biotechnology began. From 1979 to 1981 eighteen official reports across the industrialised world announced that biotechnology would be the new technological base for our civilisation."[39]

'Biotechnology' is not in itself a science, an industry, a product or a 'thing'. It is a powerful set of tools which may be used to develop and produce medicines, agricultural products and foods and many other goods for everyday personal consumption and industrial use.[40] Biotechnology is not new. It represents a developing series of technologies with roots established (in may cases) thousands of years ago. It includes many traditional processes such as baking, winemaking and cheesemaking. However, it is new or modern aspects of biotechnology, founded in recent advances in molecular biology, genetic engineering and fermentation process technology which has captured the imagination of scientists, financiers and the public. New biotechnological techniques have applications in many industries. They have the potential to treat previously incurable genetic diseases, provide us with better and healthier food products and afford us a reduction in use of toxic pesticides.[41]

1.2.2 Defining Biotechnology.

Biotechnology has been defined in many forms but as yet no dictionary definition has achieved universal acclaim.

> "While in practice the word often refers vaguely to technologies associated with genetic engineering, formal definitions give it wider scope. Consequent problems of definition have sometimes rendered meaningless comparisons between expenditures of different nations or even different agencies within a single government."[42]

Perhaps the most popular definition is that offered by the UK Advisory council for Science and Technology. Biotechnology is defined as a,

> "broad term used to describe the production of innovative products, devices and organisms by exploitation of biological processes. Traditional biotechnology was based on enrichment and purification, modern biotechnology on the manipulation of genes and on the genetic structure of cells. Much of its importance stems from recent advances in genetics and biochemistry and from the emergence of molecular biology."[43]

1.2.3 Adoption and Diffusion of New Biotechnological Techniques.

It has been estimated that the companies, institutes and universities involved in biotechnology number in the thousands worldwide.[44] The techniques have been adopted by two main types of firms, startup and established firms. The most dynamic adopters are the small, pioneering biotechnology firms which have emerged since the early 1970's with the support of venture capital and corporate investors. In the early 1980's the US saw an explosive growth in the number of these small companies. Cetus and Genentech are generally considered among the leaders in this group.[45] More than 350 such firms appeared in the US between 1971 and 1987.[46] Established firms have moved more slowly into biotechnology, but their commitments are growing as potential applications become more apparent.

The distinction between emerging and established firms is an important one in the development of a new technology. Hamilton has defined an emerging firm as,

> "one created to exploit a new technology" whereas "established firms are, in contrast, those with positions in existing technologies and markets at the time a new technology appears"[47]

Emerging firms created to exploit new biotechnological techniques are popularly referred to as new biotechnology firms. Established firms can be divided into two groups: those with established positions in a particular market or industry to which applications of the new technology may be directed, which are termed incumbents, and new entrants which are those firms with established positions in other industries who attempt to enter new markets or businesses through applications of the new technology.

Established and emerging firms have different core technical and complementary assets. These assets have a bearing on their potential for success with technical innovation. Core technical assets are defined by Hamilton as the codified and tacit knowledge associated with radically new science and technology. Complementary assets are required to make a technological innovation a commercial success and may be broken down into those which have specific applicability to the technology or markets of interest (innovation specific assets) and those which are generally applicable (generic assets). Hamilton's proposed distribution of core and complementary assets among participants in technological innovation is shown in Table 1.0. This Table indicates that following a technological discontinuity established incumbent firms may enjoy some initial advantages over established new entrants. However, both lack the core technical assets which the emerging new entrant enjoys. Strategies for involvement with new biotechnological techniques differ between established and emerging firms due to their differing core technical and complementary assets. Both established and emerging firms experience different types of difficulties in becoming involved with the techniques.

1.2.4 Emerging Firms Involved with New Biotechnological Techniques.

Research shows that problems of new biotechnological firms or emerging new entrant firms working to become involved with new biotechnological techniques tend to stem from financial difficulties. A study by Watson (1992) of smaller EC firm startups in the biotechnology industry found that few firms were able to generate substantial sources of finance and were dependent on successive rounds of equity for survival. [48] Debt financing is not a viable alternative for these companies due to the long lead time and heavy expenditure required to develop major new biotechnological products. Steven Burill reporting from Ernst and Young's fifth biotechnology survey "Biotech'91: A Changing Environment" underlined the importance of this issue as he asserted that smaller companies are consumed with finance worries. This study indicated that smaller firms were suffering due to lack of finance and US biotechnology companies indicated that they expected increased future financing to come from strategic alliances and public equity.[49]

Table 1.0 Distribution of Core Technical and Complementary Assets among Participants in Technological Innovation.

FIRM POSITION		TYPE OF FIRM: ESTABLISHED	TYPE OF FIRM: EMERGING
	INCUMBENT	Innovation-Specific Complementary assets	
	NEW ENTRANT	Generic Complementary assets	Core technical assets

Source: Hamilton W.F.(1990), "The Dynamics of Technology and Strategy", *European Journal of Operational Research*, vol.47, pp.141-152.

Strategies undertaken to overcome the financing problem for smaller firms include the strategy of product progression noted by Smith and

Fleck. This involves starting with products that require relatively little capital, such as contract research or production, then moving on to diagnostic products with the production and sale of drugs as the most ambitious and capital demanding objective.[50] Daly has also endorsed this evolutionary path for new biotechnological firms. He highlighted the strategic possibilities open to firms in terms of market focus and time frame of R&D effort. A focussed strategy involves concentration on a narrow market to achieve overall product differentiation or cost leadership. Genentech is a prime example of a company pursuing such a strategy as it attempts to become an integrated market leader in human and animal therapeutics. The broad based strategy is more readily illustrated by companies like Amgen and Cetus who attempted to reduce competitive risk by developing a broad R&D portfolio. An early products strategy is characterised by the development of products with short R&D times and relatively low entry barriers. These markets are extremely competitive and new biotechnological firms run the risk of loosing out in the longer term with more complex products. [51]

1.2.5 Established Firms Involved with New Biotechnological Techniques.

Following the emergence of a technological discontinuity such as new biotechnological techniques established firms must make a decision concerning possible future involvement. Daly has outlined the options available to established firms following the emergence of a new technology. These are:

"1. Do nothing.
2. Monitor only.
3. Attempt to prevent the development of the new technology.
4. Improve old technology.
5. Participate in some manner."[52]

Obviously many firms will choose not to become involved but will continue to use outdated technologies for as long as they remain profitable.

Established firms considering involvement may decide to become leaders or followers in the development of the new technology. According to Porter the choice between leadership and followership is a function of ,

> "the technological opportunity to influence cost or differentiation, the uniqueness of the firm's technological skills, first mover advantages, the continuity of technological change, the rate of change in process technology or customer purchasing behaviour, the irreversibility of investments, uncertainty and leadership externalities."[53]

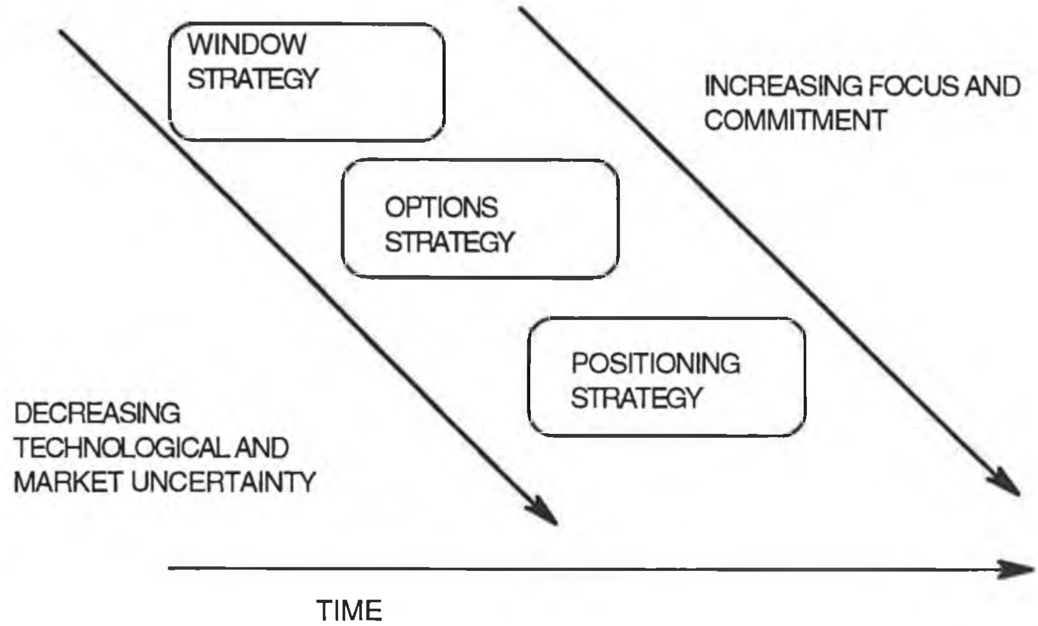
In the context of the technological discontinuity caused by the emergence of new biotechnological techniques a policy of late entry leadership is indicated as particularly important as it would allow the established firm to 'leap-frog' ahead of the new biotechnological firms. However, Daly points out that technological followership may also be a wise strategy in those markets where there is a high level of product and process uncertainty and this would appear to be the implied strategy of some established firms.[54] However, because of the complex nature of many established firms and the range of markets in which they are involved, firms may pursue alternate strategies in different markets.

Firms may also pursue differing strategies as their strategic commitment to the techniques increase. These are:

Opening Windows: Mainly concerned with monitoring and identification of important technologies.
Creating Options: Primary trust is creation of defined opportunities for active participation in new technology and it's commercial applications.

Establishing Positions: Firms using this strategy are staking out their competitive positions in selected technologies and markets with the intention of long-term commitments in these or closely related commercial markets. (Figure 1.6)

Figure 1.6 Progression of Technology Strategies.



Source: Hamilton W.F.(1990), "The Dynamics of Technology and Strategy", *European Journal of Operational Research*, vol.47, pp.141-152.

These evolutionary strategies highlight the logical progression in strategic emphasis from information gathering to more focussed commitments as technologies and markets develop. Hamilton posited that increased involvement would lead to internalisation of technical assets over time. [55] Prior to this level of commitment the primary problem of established firms, both new entrants and incumbent firms, lies in their lack of core technical assets. Hamilton proposed that in order to circumvent this problem established firms should participate with new biotechnological firms or universities affording access to their technical skills. Types of participation available to established firms include:

Equity investments in new biotechnological firms.
Joint Ventures and licensing with new biotechnological firms
In house R&D investment
Investment in academic Institutions[56]

1.2.6 Strategic Alliances.

As outlined the differing assets enjoyed by emerging and established, (incumbent and new entrant firms) provide the primary motivation to collaborate. As Shan and Visudtibhan said of the new biotechnological techniques,

> "although the technology is revolutionary and represents in Dosi's terms, a new paradigm of technology its commercialisation may require utilisation of much of the commercial infrastructure of the existing pharmaceutical industry, which is owned or otherwise controlled by incumbent established firms."[57]

The classic view is that the emerging firms who have in their command core technical assets collaborate to gain access to marketing distribution and finance. Established firms collaborate to gain access to technical skills. Companies use collaborative arrangements to add complementary strength to internal strength.[58] The popularity of collaborative arrangements in the biotechnology field bears testament to their efficacy. According to Roberts and Mizouchi,

> "Collaborations have become as popular as they are important and an alliance map of the biotechnology industry looks like a spiders web where a single company is involved in many different types of relationships with different partners"[59]

Research undertaken by Schwartz and Dibner indicates that strategic alliances represent a significant proportion of biotechnology firm R&D activities. They found that in 1992 biotechnology firms performed, on average, 24.4% of their research and 17.1% of product development externally. This represented over $1 billion in R&D spending.[60] Similar research undertaken by Dibner indicated that the first increase in collaboration between biotechnology firms was noted in 1985.[61] Collaborations are increasing in popularity not only among domestic companies. Wagner showed in her study of international strategic alliances among biotechnology firms, that those firms who have not undertaken international R&D are now the exception to the rule. 47% of those interviewed in 1986 were involved in international strategic alliances compared with 67% in 1991.[62] Strategies of collaboration formally used to access capital, marketing and distribution are now also utilised to access regulatory expertise, knowledge of foreign culture and markets.[63] However, market access, income and technology were rated the three most important objectives to be achieved through strategic alliances by US firms. Interestingly these firms ranked European and Japanese objectives in reverse order.[64]

Studies undertaken in 1986 and 1991 to identify companies most likely to become involved in strategic alliances indicated firm size is negatively correlated with the use of cooperative relationships. Research also indicated that strategic alliances are predominantly used by high tech startup firms in foreign markets and the more products a firm has brought to commercialisation the less likely they are to become involved in a cooperative relationship. These studies differed however, with regard to the relationship between firm status and propensity to cooperate. The 1986 results indicated that followers were more likely to cooperate than leaders. In 1991 however, leaders were shown to be most involved with strategic alliances. It is hypothesised that the static nature of both snap-shot studies failed to capture the dynamic nature of firms involved. If follower firms cooperated to improve their competitive position then they would have moved up against rivals in the intervening period.[65]

Hamilton has identified 5 principal forms of collaborative arrangements open to firms.

1. Research Contracts
2. R&D Contracts
3. Licences
4. Equity Investments
5. Joint Ventures. [66]

Each of these collaborative relationships may be use by a variety of firms with multiple partners and different application areas. Roberts and Mizouchi in their survey of 100 Japanese companies involved with biotechnology pointed out the suitability of particular collaboration forms as the firm increased its commitment to the new techniques. They outlined a strategic collaborative pathway which begins with research contracts or minority investments, moves on to licensing to corporate alliances and terminates with acquisition.[67]

Research confirms the complementarity of various collaborations. Arora and Gamberdella tested the hypothesis that the strategies of external linkage of the large firms with other parties are complementary to each other. Using data from a sample of large US, European and Japanese chemical and pharmaceutical producers they found that these strategies were positively correlated even after controlling for firm specific characteristics.[68]

The research indicates the efficacy and usefulness of strategic alliances in the evolution of firms following the technological discontinuity caused by new biotechnological techniques. Hamilton has proposed that as companies evolve towards ultimate commercialisation of products and as market and technical uncertainties decline the motivation to collaborate will also lessen. As we reach the commercialisation stage with new biotechnological techniques however, strategic alliances are increasing not decreasing. A high degree of satisfaction was noted by those firms interviewed by Dibner and Schwartz and two thirds intended to seek more alliances in the future.[69] The future of new biotechnological techniques would seem to involve more collaboration. Perhaps the use of alliances is not just a 'short term fix' as proposed by Porter [70] but essential to strategy due to the effects of globalisation.[71]

1.3 Summary.

It is an accepted fact that technology and the innovative process are important determinants of economic success. Theories of technical change have in the past been classified as either 'technology push' or 'demand pull'. Difficulties are associated with extreme forms of both theories. A more balanced conceptualisation of technical change is offered by Dosi. He proposed that continuous technical changes are related to progress along a technological trajectory, defined by a technological paradigm, while discontinuities are associated with the emergence of a new paradigm. The emergence of new biotechnological techniques has been heralded as a new technological paradigm.

Firms involved in technical change must have a high level of competence in the different technological requirements of different stages of production in order to remain competitive. This is referred to as firms' technological capacity.

Following the introduction of an innovation it is often adopted by other firms. Diffusion is the process by which an innovation is communicated through certain channels over time among members of a social system. Rate of adoption is the relative speed with which an innovation is adopted by members of a social system. The most important factors in explaining the rate of adoption are the innovations perceived attributes, i.e. relative advantage, compatibility with existing processes, complexibility, trialibility, and observability.

Not all members of social system will adopt an innovation at the same time rather they may begin to use the idea in time sequence and thus can be categorised in terms of their innovativeness. The first 15% of those who adopt a new idea are called innovators or early adopters.

Difficulties of definition have been associated with new biotechnological techniques but perhaps the most popular definition is that offered by ACOST. Biotechnology is defined as

> "a broad term used to describe the production of innovative products, devices and organisms by exploitation of biological processes. Traditional biotechnology was based on enrichment and purification, modern biotechnology on the manipulation of genes and on the genetic structure of cells. Much of its importance stems from recent advances in genetics and biochemistry and from the emergence of molecular biology."[72]

New biotechnological techniques have been adopted by two main types of firms, startups and established firms. In the adoption of new biotechnological techniques the problems of emerging firms tend to stem from financing worries whereas established firms considering involvement suffer from a lack of core technical assets. These deficiencies of emerging and established firms in the adoption of new biotechnological techniques are complementary and have lead to a large number of strategic alliances. Whereas emerging firms are set up with the primary objective of exploiting the new techniques, established firms have many options following the emergence of the technological discontinuity caused by the introduction of new biotechnological techniques.

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Chapter 2 New Biotechnological Techniques - Applications and Use in the Food industry.

2.0 Introduction.

Experts are often at pains to highlight the evolutionary rather than revolutionary impact new biotechnological techniques may have on the food industry as other industries.[1] As a set of, albeit powerful, tools certain conditions are necessary for adoption and use by individual food firms. In this chapter analysis is undertaken of the applicability of new biotechnological techniques to the food industry. The techniques will be reviewed through use of the marketing mix framework. The marketing mix is defined as,

> "a set of marketing tools that the firm uses to pursue it's marketing objectives in the target market."[2]

There exists a myriad of marketing mix tools. However, McCarthy has popularised a four factor classification of tools called the 'four P.s', - Product, Price, Promotion, Place.[3] In the following review analysis will be made of what new biotechnological techniques have to offer with regard to each of the 'four P.s'. In this way the salient aspects affecting adoption and use of new biotechnological techniques are examined from the perspective of the potential user.

2.1 The 'Four P.s' of New Biotechnological Techniques.

In the McCarthy classification of marketing mix tools the first 'P'- for product, refers to features/services afforded a potential consumer. In the context of new biotechnological techniques potential users are concerned with the functions these techniques may provide them. The techniques have applications in both Primary Food Production and Food Processing.

2.1.1 Primary Food Production.

In primary food production use of new biotechnological techniques can aid crop and lifestock production. The initial wave of research in plant biotechnology, driven by the seed and agrichemical industries has concentrated on 'agronomic traits' of direct relevance to these industries. Work is directed towards the control of insects, weeds and plant diseases.[4] "Typical goals for crop improvements are:

Better Flavour
Longer Shelf Life
Insect resistance
Disease Resistance
Herbicide Resistance
Expanded geographical growth range
Drought resistance
More nutritious composition
Increased value composition
More rapid growth
Earlier/later maturation
Better fertiliser utilisation

These are the same characteristics geneticists have tried to introduce through selective breeding for many years. However use of rDNA technology means the traditional hit and miss random and empirical processes of mutation, breeding and selection have been replaced. New biotechnological techniques offer methods to identify and directly alter specific genes to produce desired characteristics.[5] Examples of successful application of advanced biotechnological techniques for construction of crop varieties with improved properties are listed in Table 2.0.

New biotechnological techniques have also a lot to offer those involved in the lifestock industry.

> "Successful embryo transplants are speeding up the genetic improvement of cattle at lower cost to the farmer. Embryo technology also offers an economically viable way of transferring superior animal genetics to developing or geographically isolated countries. Several superior vaccines to prevent animal

Table 2.0 Successful Application of Advanced Biotechnological Techniques for Construction of Crop Varieties with Improved Properties.

Product	Companies	Projected Introduction	Regulatory Status
Fresh market tomatoes with improved taste and shelf life	Calgene	1993	Approved for commercialization
Processing tomatoes with higher solids	Calgene	1993	Field trials
Herbicide resistant corn	Dekalb	mid 1990's	Field trials
Virus resistant tomatoes, cantalupes, cucumbers	Asgrow seed (Upjohn)	mid 1990's	Field trials
Insect resistant tomatoes, other crops	Monsanto other co.s	Early and mid 1990's	Field trials
Fish	Several	Mid 1990's	Field trials
Herbicide tolerant sugar beet	Plant Gentic Systems	mid 1990's	Status unknown
Canola with modified fatty acid content	Dupont/DNA Plant technology others	Early and mid 1990's	Commercial products
Freeze tolerant tomatoes	DNA Plant Technology	mid 1990's	Applied for field tests
Foods resistant to spoliage microorganisms	DNA Plant Technology	mid 1990's	Applied for fiels tests
Insect resistant or nutritionally improved corn	Biotechnica International	1996	Applied for field trials, 1991
Virus resistant potatoes	Monsanto	1996-97	Field trials, 1991
Cold tolerant crops using fish gene	DNA Plant Technology	after 2000	Applied for field trials
Hybrid rice (based on genetic sterility system)	Plant Genetic	after 2000	Status unknown

Source: The Hale Group/Decision Resources, Inc.(Updated by Food Processing magazine)(1993), "Food Related Biotechnology Products", *Food Processing*, January, p.55.

diseases have been developed through biotechnology. Also disease diagnostic techniques are being developed to detect animal diseases, oestrus and pregnancy and aflatoxin in lifestock feed. In addition to controlling animal diseases, a major contribution of genetic engineering will be to increase the productivity of farm animals. For example: Treating cows with Recombinant Bovine Somatotropin (rbST), a natural protein hormone manufactured through recombinant DNA technology, can increase milk production per lactation on less feed per unit of milk, thereby reducing milk production costs. Similarly administering recombinantly produced Porcine Somatotropin, a natural swine protein growth hormone to finishing pigs can improve feed efficiency, increase lean muscling and reduce fat deposition".[6]

2.1.2 Food Processing.

New Biotechnological processes may also be applied after the commodity leaves the farm gate. One area attracting considerable interest is the genetic improvement of food fermentation microorganisms. Microorganisms have been used for centuries in the production of fermented foods, such as cheese, sausage, saurkraut, wine and bread. Genetic engineering provides an alternative to classical mutation and selection procedures for improving microbial starter cultures with improved metabolic processes. Some examples of how genetic engineering could be used to improve organisms for various fermentation processes are provided in the Table 2.1. Availability of such strains would have an impact on several aspects of fermentation, including production economics, shelf life, safety, nutritional content, consumer acceptance and waste management. Microorganisms are also used in the production of ingredients for processed foods or enzymes. Enzymes perform many valuable functions in food systems. They help control texture appearance and nutritive value as well as the generation of desirable flavours and aromas. Improved enzymes will expand the uses for enzymes in food processing and increase the kinds of raw materials which can be utilised as food for animals and humans. [7]

Table 2.1 Genetic Improvement of Microorganisms.

Type of Fermentation	Nature of Improvement	Benefit
Dairy	Bacteriophage (virus) resistance	Eliminate economic losses due to destruction by virus infection.
	Accelerated ripening of cheese	Decreased storage costs
	Higher levels of the enzyme Beta-Galactosidase	More digestible for Lactose - Intolerant individuals
Meat	Bacteriocin Production (natural preservative)	Inhibit pathogenic or spoilage organisms.
	Addition of cholesterol - Reducing enzymes	Reduction of an undesirable dietary component.
	Addition of fat - modifying enzymes	Alteration of the saturated to unsaturated fat ratio.
Beer	Alpha - Amylase production	Production of lite or low calorie beer.

Source: Harlander S.K., BeMiller J.N. and Steenson L. (1991), "Impact of Biotechnology on Food and Non-Food Uses of Agricultural Products" in *Agricultural Biotechnology, Issues and Choices,* Baumgardt B.R. and Martin M.A., ed.s, Purdue University Agricultural Experiment Station, West Lafayette, Indiana.

Experts considering exploitation of these advances must be aware of the regulatory environment in which they exist. The European regulatory approach places an emphasis on the techniques as a trigger for regulation and does not, as in the US, emphasise the product itself. This process has met with strong criticism as many believe it increases costs and regulatory uncertainty for potential users. In Europe products of biotechnology are assessed through application of safety, quality and efficacy criteria in conjunction with relevant horizontal legislation to ensure consumer safety, economic interests and permit protection of human, animal and plant health and the environment.[8] The EC Commission has rejected the systematic use of a fourth criteria in addition to safety, quality and efficacy for assessment (ie the socioeconomic impact of proposals) as proposed by the European Parliament. (Use of socioeconomic criteria in assessment procedures has become known as the fourth hurdle.) However, it has reserved the right to make exceptions and the continuing moratorium concerning the commercialisation of rbST is the exception so far. Draft proposals have also been put forward requiring the labelling of Genetically Modified Organisms, (G.M.O.'s) as such. If labelling does not guarantee acceptance, it at least recognises the right of some consumers not to choose food produced in this way.[9]

2.2 Price.

The investment required for a potential user to become involved in new biotechnological techniques is enormous. According to statistics compiled by Mark Dibner the average R&D budget for biotechnology firms involved with agriculture is $4.5million.[10] Also in the past translation of scientific findings into commercial products has been a slow process and many have been disappointed in the long lead time to commercialisation. However, a few products have begun to emerge in the food sector and many believe the techniques have now begun to realise their potential.[11]

What are the paybacks to those successful in bringing an innovation to market? Marvin Scher answers this question by considering the case of the tomato. In 1991 the US retail tomato market was estimated worth about $5 billion. This food also records high levels of consumer dissatisfaction. An improved tomato could obviously provide a substantial dividend. Calgene an American company has developed such a tomato which boasts superior taste and is less vulnerable to spoilage than existing retail varieties. The gene-spliced tomato is branded and will be marketed under the trade mark Flavr Savr™.[12] It must be noted that under European law the improved tomato can not be patented, however US intellectual property law allows both plants and animal varieties to be patented. As the holder of a plant patent for the Flavr Savr™ tomato, therefore, Calgene can exclusively reproduce, sell and use this tomato for 17 years. European law stipulates that patents may not be issued for plant or animal varieties.[13] The performance of this product will be closely monitored in order to estimate potential revenues from future G.M.O.'s. In general, experts assert use of new biotechnological techniques will bring food costs down but increase farm incomes because of lower input costs, increased efficiency and new markets.[14]

2.3 Promotion.

The promotion of rDNA technology adoption and use has been hampered by the division in the public as to the merit of products produced in this way. Opposition stems from environmental and safety concerns, concerns relating to the possible adverse social and economic effects of its application and ethical and religious concerns. Industrial organisations however view science and thus biotechnology as an engine of economic progress. The conflict of attitudes towards gene-technology produced food has resulted in opposing views presented in the media and ultimate confusion for the consumer. Because of the primacy of public perception issues with regard to adoption and diffusion of new biotechnological techniques a more complete discussion of this issue has been undertaken later in the chapter. Suffice to note, promotion of new biotechnological techniques to date is highly fragmented and often deleterious.

2.4 Place.

The location of new biotechnological expertise has evolved with the techniques. In the US emerging biotechnology firms were founded as scientists moved out of academic research laboratories with a vision of the commercial opportunities of their knowledge.[15] In Ireland apart from in house company research most biotechnological research is performed in the universities and the research institute.[16] Differing levels of involvement may also be noted between nations. Foxe has indicated two prerequisites for a country to involve and compete in biotechnology. These are :

(i) A strong research base and

(ii) The industrial capacity to convert the basic research into products.[17]

2.4.1 International Competitiveness in Biotechnology.

On the basis of identified prerequisites, it is asserted that the United States is comprehensively the most successful country in the commercialisation of Biotechnology. This is primarily due to its strong research programs but also associated with it's well established foundations in pharmaceuticals and agriculture. It has been estimated that of the 2,600 firms involved with new biotechnological techniques in 1989 , 1,600 were US based and 1,000 of these were new biotechnology firms.[18] Other factors identified as contributing to the success of new biotechnological techniques in US industry are extensive venture capital and public markets available to provide finance and US patent law which, as noted, provides generous protection for all kinds of biotechnology derived innovations. [19]

Western Europe controls the next largest world biotechnology market. In Europe of 700 firms identified as involved with new biotechnological techniques in 1989 half were established firms and half new biotechnology firms.[20] It is asserted that particular countries in Europe do not have the research base or industrial capacity to convert basic research into products. Problems in Europe also stem from the lack of availability of venture capital for funding, adverse public opinion and fragmentation of research efforts.[21]

Japan remains the other major competitor in the area of new biotechnological techniques.[22] The Japanese have displayed a time honoured excellence in traditional biotechnology, and have made it a national priority to dominate the new biotechnological industry by the year 2000.[23] The primary problem in Japan is the lack of strong research base which has lead companies to seek access to research and training overseas, particularly in the US. Experts have also identified weaknesses in both Japanese agriculture and pharmaceutical industries which complicates the process of developing new innovative products in these areas.[24] In 1992, 300 Japanese firms were involved with new biotechnological techniques the great majority (240) of which were established firms.[25]

2.4.2 Irish Involvement with New Biotechnological Techniques.

In Ireland the first National Biotechnology Program was announced in June 1987 with the objective of developing centres for commercially oriented biotechnology research in Irish universities.[26] Five university based research centres have been formed. These include the National Food Biotechnology Centre at University College Cork and the National Agricultural and Veterinary Biotechnology Centre at University College Dublin. In University College Cork research interests include the development of genetically engineered organisms for the enhancement of bioprocesses, cheese and meat biotechnology and natural flavours. The work in University College Dublin focuses on plant and animal biotechnology.[27] Incubation companies have been established on the different campuses and established companies have demonstrated their interest through involvement in cooperative research. This represents an important partnership between the industrial sector and academic institutions.[28] The work of these centres of excellence is co-ordinated by a dedicated body, BioResearch Ireland, also established in 1987.[29] Other Industrial bodies supporting the development of biotechnology in Ireland include the IDA (supports growth within the Irish manufacturing and services industries and promotes Ireland as a sound strategic location for foreign investment) and Eolas (The Irish Science Agency which develops and promotes science and technical services to industry.)[30]

Due to the paucity of research undertaken to date it is difficult to estimate the number of Irish food firms involved with new biotechnological techniques. Results of a study undertaken in 1988 indicate that in that year most Irish food firms felt enzyme/genetic engineering would have a major impact on food processing /development in the years 1995 to 2000. Also, when questioned with regard to the relative R&D priority different technical areas should be given by government agencies, biotechnology was included in the top three priority areas. [31] In 1990 eleven food and drink companies were reported as involved with biotechnology research and development in an MBS study, however the level of biotechnology use sophistication was not indicated.[32]

2.4.3 Industrial Policy.

Industrial Policy used to promote the development of biotechnology is an important determinant of different nations' involvement and success in exploiting the techniques. Biotechnology policy varies tremendously between countries. The US has no biotechnology policy but both in Europe and Japan there is a strong government influence on the way in which biotechnology is developed and commercialised. National policies promoting biotechnology R&D may be categorised as targeted or diffuse. Countries like Japan, Singapore and Taiwan which have targeted biotechnology share an emphasis on export driven growth and they view comprehensive government policies strongly promoting biotechnology as the key to future development. In the US and in some areas of Europe where growth promotion is less prominent the development of biotechnology is one of many competing social concerns.[33]

2.5 Target Market.

It is necessary to identify those firms, individuals, research institutes who might potentially adopt new biotechnological techniques given their characteristics as outlined under the 'four P.s'. While it is acknowledged that new biotechnological expertise has had a strong academic base in the past and remains so in an Irish context, the focus in this chapter will be on potential adopters in industry. As outlined, the techniques offer applications in both primary food production and food processing.

2.5.1 Food Processing Sector.

With regard to the Food processing sector, authors Angold, Beech and Taggart assert that advanced biotechnological techniques are relevant primarily to low volume production as in the manufacture of flavours and functional ingredients. These authors describe two scales of biotechnology practice; Small scale and Large scale. (Table 2.2) Small scale biotechnology practice is associated with high value added production, commands higher R&D cost and readily embraces techniques such as genetic engineering. This level of biotechnology practice is associated primarily with the pharmaceutical industry. Large scale biotechnology practice is concerned with low value added production, lower R&D costs and process engineering and fermentation technologies. This type of biotechnology is used in the food industry and developments have occurred in this area steadily and undramatically over the years. Large scale biotechnology practice refers to that used in advance of the developments associated with new biotechnological techniques.

Table 2.2 Two Scales of Biotechnology Practice.

	Small Scale	Large Scale
Scale of Plant	100-1000 1	10000 1
Value added in Production	High	Low
Type of Product	Medical, Pharmaceutical Highly Specialised	Food, Transformed Commodity
Main area of R&D	Genetic Manipulation	Process Engineering, Fermentation technology
R&D Cost	Higher	Lower

Source: Angold R., Beech G. and Taggart J. (1989), *Food Biotechnology*. Cambridge University Press, p.2.

Angold, Beech and Taggart offer the following explanations for food firms reticence in becoming involved with the less established currently fashionable advances in biotechnology, including genetic manipulation and cloning of plant tissue cells.

1. The food industry operates a large scale commodity transformation type of biotechnology, characterised as in all food processing by a low profit margin. Cheap raw materials are converted by cheap processing

methods to cheap products. The low profit margin of the food processing industry would not support expensive R&D associated with small scale biotechnology practice in the pharmaceutical industry.

2. Because of the desirability of advances and improvements in healthcare, R&D is often subsidised in the pharmaceutical industry by governments of affluent nations. Also, even without subsidies, people are often willing to pay high prices for healthcare products. This gives an economic climate for the pharmaceutical industry in which expensive R&D may be undertaken.

Angold, Beech and Taggart assert :

> "Generally speaking where higher cost biotechnology is used in the food industry it is likely to apply to the production of materials used in small volumes such as flavours and functional ingredients, lower cost biotechnology being used where large volumes are involved."[34]

This would indicate that the target market for new biotechnological techniques in the food processing industry would be food ingredient suppliers and not necessarily food processors. It may be remembered that over the years a large share of new technologies used in the food processing industry have originated in other industrial sectors. Stevens asserts that internal R&D in the food processing industry is primarily concerned with product innovation.

> "The food processing industry develops a continual stream of new products, some of which are based on far reaching innovations in processing and packaging. However a great deal of food industry R&D is focussed on minor features of end products which are often variations or imitations of existing products."[35]

2.5.2 Primary Food Production.

Similarly, in the farm sector common sense would tell us that while farmers may adopt and use innovations made possible through the use of advanced biotechnological techniques they would not be involved in the laboratory in development. Literature indicates that one of the factors affecting what farmers implement in their operations includes the degree of sophistication required for effective use. [36] The greater the level of complexity associated with any innovation the less likely it is to be adopted inside the farm gate.

Literature accessed indicates, therefore, that the target market for new biotechnological techniques are not primarily the farmers and the food processors but suppliers to these sectors. In the food processing industry the sector of greatest potential use is indicated as those involved in small scale biotechnology, manufacturing flavours and functional ingredients. In primary food production the sector of greatest potential use is identified as chemical and seed companies suppling the inputs to farmers. Farmers and food processors are identified as secondary users.

2.6 Public Perception.

The primacy of the public perception issue relative to the future diffusion and adoption of new biotechnological techniques is self - evident. In democratic nations,

> "The rates and risks of progress are matters for society to decide."[37]

Public opinion influences the rate and direction of diffusion of new biotechnological techniques through straight forward sales and also through the generation of governing regulatory environments. In the following section discussion is focussed upon the public's perception of new biotechnological techniques, the regulatory and commercial environments which have evolved, directed by public perception issues as well as P.R. strategies undertaken by proponents of these techniques.

2.6.1 Attitudes to Use of New Biotechnological Techniques.

To date public opinion has been divided as to the merit of biotechnology use. While industrial groups often perceive new biotechnological techniques as important determinants of future success in industries as diverse as healthcare and agriculture, opposition stems from multiple concerns relating to use. Lacy, Busch and Lacy have characterised public concern in terms of nine major dimensions.[38] These are concerns relating to the environment, health, agriculture, science, social justice, economic concentration, progress, nature and the sanctity of life.

The perceived risk of biotechnology to the environment relates primarily to the release of genetically modified organisms. Opponents of the new techniques warn that G.M.O.s may displace existing plants and animals, disrupt the functioning of ecosystems and reduce biological diversity. They highlight the fact that, while any given introduction has only a small chance of becoming a problem, each is characterised as a low probability, high incident risk, with long run consequences which can be enormous and irreversible.
The public also fear negative health impacts through exposure to genetically engineered food products. Portions of the public believe that certain genetically engineered products could have unintended negative consequences, for example they may contain increased levels of toxins or disease causing micro organisms which are resistant to antibiotics. Concerns have also been voiced with respect to the possible pain and suffering to farm animals as a consequence of genetically engineered changes.

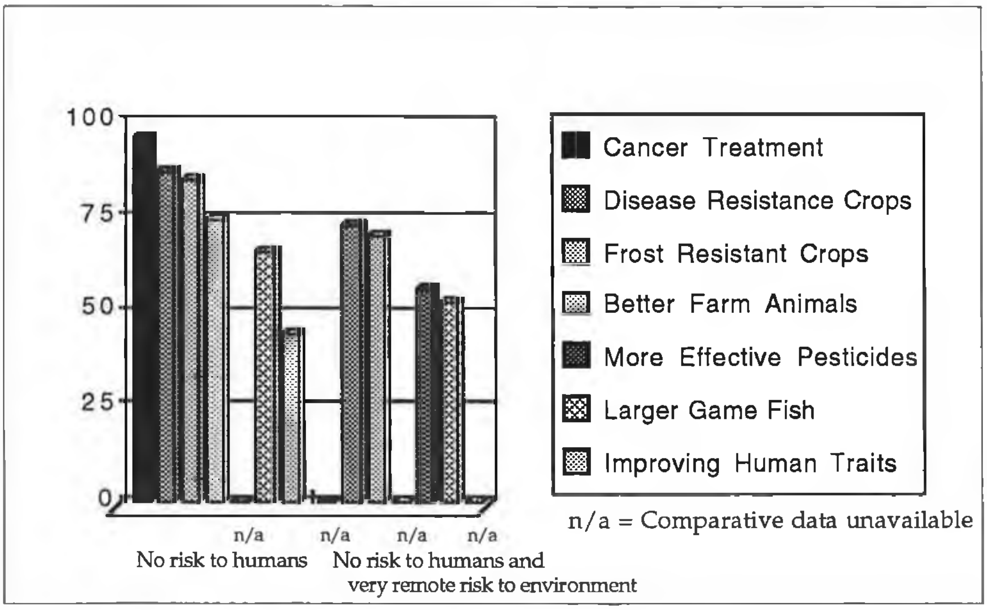
Use of biotechnology is also seen as another step in the process of reductionism in science. Through use of new biotechnological techniques scientists have been able to rearrange the genetic code in order to produce short-term commercial gains. This approach permits only the most simplistic understanding of the subcellular world and de-emphasises a more sophisticated understanding of complex eco-systems. The fundamental issue relating to concerns of social justice is, 'Who will gain and who will lose in the application of new biotechnological techniques?' This issue is increasingly cited as a rationale for moving cautiously on new technologies and has lead to the generation of the fourth hurdle in the EC. Opposition to the commercialisation and use of rbST is largely based on the expected negative impact its introduction would have on the incomes of smaller farm families. On a broader level, there is concern that biotechnology will continue and accelerate the trend towards increasing concentration of power in the hands of a small number of corporations. It is predicted that by the next century a small number of highly diversified, multinational corporations will likely control most of the food system. This scenario is quite probable as, increasingly, powerful intellectual property rights, particularly in the US, allow ownership of genetically modified organisms.

The seventh concern relates to our fundamental concept of progress. Opponents of new biotechnological techniques argue that we need to redefine progress, extending it beyond terms such as output, utility and efficiency. It is asserted that a definition of progress should encompass the entire context in which human beings live including all of the economic, social and ethical dimensions. New biotechnological techniques then need to be evaluated in terms of their contribution to progress as redefined. Opponents also question the appropriateness of manipulation, control and domestication of nature to serve our economic purposes. Proponents of this perspective assert that nature has an order, an integrity and a purpose of its own that one should respect, not for our sake but for it's sake. Importantly those concerned with preserving the integrity of nature are not posing the issue strictly in terms of risks and benefits. Finally, opponents of new biotechnological techniques argue that use of these techniques makes any animal, including Homo sapiens no different than a manufacturing process that can be claimed as an invention and patented. They argue that the sacredness of life as well as the very concept of life are challenged by genetic engineering.[39]

2.6.2 Awareness and Concern.

Research undertaken in the US has shown that acceptance of biotechnology applications are firmly rooted in the end objectives of each specific use.

Figure 2.0 Levels of Approval of Different Applications of Genetic Engineering



Source: Office of Technology Assessment, U.S. Congress (1987), *New Developments in Biotechnology:Public Perceptions of Biotechnology*. OTA-BP-BA-45 U.S. Government Printing Office, Washington D.C.

In an OTA survey in 1987 respondents were asked, first, to assume that applications involved neither direct risk to humans nor an environmental risk and then to evaluate their approval of different applications of genetic engineering. (Figure 2.0) Seven applications of genetic engineering were examined: a new treatment for cancer, new vaccines, cures for human hereditary diseases, disease resistant crops, frost resistant crops, more productive farm animals and larger game fish. A clear majority approve of all seven applications of genetic engineering. However, approval ranged from a high of 96% for new treatments of cancer to a low of 66% to produce larger game fish. The results also illustrated a variation in enthusiasm for financing these applications of genetic engineering, with 75% strongly approving of vaccines and only 25% strongly approving of larger game fish.[40] It is interesting to note that research also undertaken by the Office of Technology Assessment in the US indicates that with increasing awareness will likely come increasing concern. In a study on familiarity and concern about several environmental issues levels of concern closely paralleled levels of familiarity.[41]

2.6.3 Opposition Groups.

Opposition to the use of new biotechnological techniques is becoming more apparent as public interest groups gain support and power. Jeremy Rifkin of the Washington based Foundation on Economic Trends is thought to be biotechnology's most important foe. He and his group are the creators of the Pure Food Campaign, which was set up with the objective of organising a boycott of genetically engineered foods. In 1992 some 1500 US chefs agreed to display the campaign's logo bearing the words,

> "We do not serve genetically engineered foods."

on their menus. However the Pure Food Campaign has also targeted growers, distributors, retailers and food processors to boycott gene-technology foods. The Campbell Soup Co. has been singled out for special attention. This is because of it's involvement with Calgene in the development of the Flavr Savr™ tomato. Campbell Soup Co. own the right to use Flavr Savr™ tomatos in their processed products.[42] The Pure Food Campaigners are particularly incensed as genetically engineered food products need not be labelled as such by US law. In the US Food and Drug Administration's May 29 1992, *Statement of Policy:Food Derived from New Plant varieties*, it was strongly signalled that it will fall to the product developers to prove safety and inform the consumer.[43]

Figure 2.1 Pure Food Campaign Logo.

Source: Vines G.(1992), "Guess what's coming to dinner", *New Scientist*, 14 November, pp.13-14.

In Europe draft proposals have been put forward requiring the labelling of genetically modified organisms as such.[44] In the absence of labelling, campaigners believe American consumers and their children will become the unwitting guinea pigs for these radically new foods. In the words of Jeremy Rifkin,

> "If food producers are so proud of these brave new world products, why are they so afraid to label them?" [45]

2.6.4 P.R. Strategies of Companies Involved with New Biotechnological Techniques.

Many food experts have come out strongly in support of voluntary labelling. They assert

> "...just because the regulators don't insist on labelling recombinant foods doesn't mean we shouldn't label them. If we deny consumers the knowledge that a product is engineered, we deny them the opportunity to choose biotechnology for themselves...And that is no way to build a market."[46]

This approach is certainly reflected in Calgene's Public Relations policy for the Flavr Savr ™ tomato. Carolyn Hayworth manager of public relations for Calgene outlined a three pronged approach to the promotion of the Flavr Savr ™ tomato.

> "First she thought there was a need to educate food industry people about the new technology and the products. Second, Calgene was planning to label the tomato and to provide point of purchase brochures explaining the tomato to the consumer. Third, Calgene plans to be completely open to the public with regard to information, regulatory filings etc. The company position is that informed consumers will make sound decisions."[47]

Public education is also asserted to be the corner stone of Monsanto's promotional plans for their gene spliced products.[48]

Carol Tucker Foreman has highlighted the inherent problems of educational campaigns in the promotion of gene-technology products.

She has noted that often,

> "there is an assumption that if the public can just be made understand, it will open its arms and receive biotechnology as an unmitigated blessing."[49]

This ignores the fact that even expert academic biotechnologists have often admitted diametrically opposed views on the social risks and benefits of biotechnology. Also this concept of communication leans more to reassurance than to a two way communication channel, where the consumer has an opportunity to speak, to listen, to be heard, to act and to respond. It must be remembered that the problems associated with biotechnology might not be connected with communication but with conflicts of values, (noted previously) which must be resolved in order to move forward.

Tucker has also outlined two specific difficulties associated with educational campaigns. The first concerns the considerable mistrust of scientific advances which exists today. Consumers are influenced by the growing public dismay over accidents and failures of other technologies such as the nuclear power plant at Chernobyl. In addition it appears consumers are becoming increasingly concerned about source credibility. The public has lost confidence in the government institutions it once counted on to resolve questions of safety and conflicts between scientific and social and economic view points.[50] A study undertaken in 1991 which investigated European consumer's perceptions with regard to biotechnology indicated that the most reliable sources of information on biotechnology/genetic engineering are considered to be, respectively, consumer organisations, environmental organisations and schools and universities.[51]

2.6.5 Attitudes of Consumers to Gene-Technology Foods.

Development of a successful promotional campaign for gene-technology products necessitates a comprehensive knowledge of existing attitudes of potential consumers. In the US extensive research has been undertaken on consumer perceptions of milk produced by rbST treated cows. Studies undertaken in the state of Wisconsin, where consumers are familiar with the concept of rbST indicated that 71% were concerned about the possible ill health effects of milk from treated herds and 77% expressed a preference for milk labelled as coming from untreated herds.[52] Further research undertaken in North Carolina indicated that 34% of consumers are very concerned and 43% somewhat concerned about eating genetically engineered vegetables.[53]

New biotechnological techniques and their applications have not been the focus of vociferous public debate in Ireland as in many other European countries, notably Germany and Denmark. Public interest and knowledge thus of the techniques is naturally lower here than in other countries with greater involvement. In Ireland research undertaken in December 1989 indicated that understanding of the term biotechnology is very limited among Irish adults. Only one in four have any spontaneous knowledge of the topic. Over half of all those interviewed had never heard of it and only one in ten felt they knew anything about it. Research did indicate a more positive than negative attitude towards biotechnology and the more knowledgeable people were in the area the more positive their outlook. To a limited extent respondents recognised that biotechnology would play a more important role in the future of Ireland than it does at present and agriculture and health care were the areas of future potential impact identified.[54] Research undertaken on behalf of the Directorate General, Science Research and Development of the European Commission indicated that, in a ranking of EC countries objective knowledge of biotechnology, Ireland came ninth out of twelve. Using an index of objective knowledge score where seven is complete knowledge and zero is no knowledge Irish respondents scored a mean of 3.56. Irish respondents also indicated high levels of support for Biotechnology research.[55]

2.7 Summary.

In this chapter new biotechnological techniques were reviewed through use of the marketing mix framework. It was hoped that use of this framework would allow identification of the salient factors affecting adoption, from the perspective of the potential user.

New biotechnological techniques offer applications to both food processing and primary food production sectors. In primary food production use of the techniques can aid development of improved crops and more productive lifestock. With regard to food processing, the techniques may be used to improve the performance of food fermentation microorganisms and enzymes. Due to the expense associated with becoming involved with new biotechnological techniques and the high volume nature of food processors' production activities, experts assert the techniques are most usefully targeted at food ingredient producers. In the context of primary food production, use would be anticipated in agricultural supply firms.

The US leads the race in the development and use of new biotechnological techniques followed by Western Europe and Japan. Ireland has begun to become involved with the techniques through the National Biotechnology Program initiated in 1987. Most work is centred in the universities and little is known about the involvement of Irish food firms with the techniques. Strict regulations govern use of the techniques and experts assert European food firms face tougher regulatory environments than those operating in the US.

The rate and direction of diffusion of new biotechnological techniques depends largely on consumer response to use of these technologies. To date opposition to use of the techniques stems from concerns relating to environment, health, agriculture, science, social justice, economic concentration, progress, nature and sanctity of life issues.
Proponents of the techniques are experiencing increased public relations problems as opposition groups continue to gain support and media attention. However, although gene-technology foods are not required to be labelled as such, most firms are pursuing a very open P.R. strategy with genetically engineered foods marketed. Difficulties have been highlighted with regard to educating consumers to accept genetically engineered foods and many feel problems of consumer resistance stem not from communication difficulties but conflicting values. Research shows that knowledge of new biotechnological techniques is poor in Ireland although attitudes to use are more positive than negative.

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Chapter 3 Review of the Irish Food and Drink Industry.

3.0 Introduction.

This study is based in the Irish food and drink industry. The primary objective is to investigate Irish food and drink firms' response to the technological discontinuity posed by the emergence of new biotechnological techniques. The purpose of this chapter is to analyse the Irish food and drink industry and review the context into which new biotechnological techniques may be adopted. The review will be undertaken through a SWOT analysis as proposed by Kotler.[1] Opportunities and threats posed by the external environment will be identified and corresponding strengths and weaknesses of the food industry presented. The chapter concludes with a brief review of State plans for Irish food and drink.

3.1 The Irish Food and Drink Industry.

The food and drink industry is very important to the Irish economy. In total it accounts for 10.5% of GDP, 14.5% of employment and 25% of exports. The industry is particularly important because of the low level of profit repatriation associated with it.[2]

Two hundred and seven thousand people are involved with the Irish food and drink industry, 167,000 are producers in agriculture, forestry and fishing and 40,000 are involved in processing. Food processing is largely controlled by indigenous companies and food exports account for almost 40% of foreign exchange earnings.[3] In 1989 the C.S.O. estimated there were 835 establishments employing three or more persons in the food, drink and tobacco sector.[4]

3.2 The Irish Food Industry: Strengths and Weaknesses, Opportunities and Threats

Discussion in this section shall be centred on information contained in Table 3.0 The Table outlines the most important Opportunities and Threats posed by the external environment to the Irish food industry and corresponding Strengths and Weaknesses. It has been compiled through reference to multiple texts concerning the Irish food industry.

Table 3.0 The Irish Food Industry: Strengths and Weaknesses, Opportunities and Threats.

Strengths	Weaknesses
*Green, environmentally clean image. *Factor cost advantages. *Government support.	*Over reliance on intervention and third country markets leading to a narrow products range. *Scale. *Seasonality.
Opportunities	**Threats**
*New Competitive markets. *Increased value added production.	*CAP reform. *increased industry concentration and consolidation. *consolidation in food retailing.

Source: Compiled through reference to relevant texts.

3.2.1 Strengths.

Central strengths of the Irish food industry are;

*The association of Irish food with a green and environmentally clean image

*Factor cost advantages enjoyed by Irish food producers through grass based production of milk and beef

*Generous government support of the food industry in Ireland

The first and perhaps most important strength is the green and environmentally clean image of Irish food. This was highlighted as a growing source of competitive advantage by the report of the P.A. Consulting Group to the Industrial Policy review group in 1992. The report highlighted the importance of protecting and developing this advantage by the establishment of tight but appropriate environmental standards.[5] Research indicates that the environmentally clean image of Irish food will become more important in the future. According to a report from Euromonitor,

> " environmental awareness, although often difficult to document in statistical terms, has become an inevitable and almost ubiquitous aspect of European consumer behaviours in the 1990s."[6]

In relation to food consumers are willing to pay extra for goods which they perceive to be environmentally sound - including substantial premiums for "organic" fruit and vegetables, grown without the use of artificial pesticides and fertilisers.[7]

The second strength of the Irish food and drink industry is that it possesses factor cost advantages through grass based production systems for Dairy and Beef products. It is asserted that,

> "Given an efficient processing sector, we ought to be the lowest cost European producer of products that suit our raw material production cycle, which are mainly commodity products".[8]

Factor cost advantages have also been developed in mushroom and poultry sectors.

The remaining identified strength of the Irish food industry is government support. Over the years State incentives to the food industry have been generous and seem to have been primarily designed to increase the pace of industrial restructuring. Programs have been successful in rationalising the industry and developing scale. This however has been achieved at significant cost and the sector remains primarily a commodity based industry which is significantly dependent on non-commercial markets.[9] Significant support for this industry seems set to continue. Most recently the Industrial Policy Review Group highlighted the food industry as a sector of national advantage and recommended policy to develop this sector particularly in the area of food processing.[10]

3.2.2 Weaknesses.

Primary factors which contribute to the uncompetitive nature of the Irish food industry have been identified as;

> *The seasonal pattern of Irish agriculture particularly in milk and beef production.
>
> *Insufficient scale of food companies for competing in European markets.
>
> *An over reliance on commodity products supported by the particular features of price and market framework of the Common Agricultural Policy [11]

Pronounced seasonality of production due to a relatively short growing season is the price producers pay for grass based production systems. Recent reports have urged incentives to ensure year round supply of milk and beef. In particular the highly seasonal nature of the beef kill, with a large concentration in the fourth quarter, has contributed to an over reliance on intervention and Third world sales.[12]

Food companies also need to develop scale if they are to compete in the

European food industry of the future. While a number of food based PLCs are developing in Ireland, they are still small by European standards and lack the scale to launch brands, make major acquisitions or invest heavily in medium term development.[13] Trends of increasing concentration and globalisation in the European food industry discussed later in this chapter necessitate that food firms develop scale in the short rather than long term if they are to become players in the European food market of the '90s.

Limitations due to seasonality and lack of scale, as well as other factors, have lead to the creation of an food industry in Ireland which is heavily dependent on intervention and third world markets, involved with low levels of value added production. In 1990, 45% of beef output, 55% of butter output and 54% of skim milk powder output went into intervention identifying Ireland as the country with the highest dependence on intervention in these commodities of all EC member states.[14]

Value added levels, while increasing, indicate a high dependence on commodity products. In 1987 value added as a percentage of gross output for the entire Irish food processing sector was just 27%.[15] Trends in R&D spending would not indicate any short term change in the value-added component of production. As a percentage of sales the average R&D spend for firms in the Irish food sector is 0.3%.[16] This spend is low when compared with that spent in a European context. The results of a survey conducted on the R&D activities of food firms all over Europe indicated the average spend in 1987 as a percentage of sales was 0.8%.[17] Comparison of government support policies with those undertaken overseas would indicate that research and development and new product development appears to be given a higher priority for the development strategies for the food sectors of other countries. This has lead to a recommendation by the PA consulting group that in the future,

> "Existing State assistance for the food sector should be reallocated away from fixed asset investment towards R&D/new product development supports."[18]

3.2.3 Threats.

Weaknesses identified have increased in importance in light of the proposed dismantling of the Common Agricultural Policy. CAP reform must be regarded as the primary threat facing Irish food firms. It is because the food industry cannot continue to build strategies to exploit the CAP that a new direction must be found. CAP reform will involve a gradual reduction of price and market supports, which, it is hoped, will put an end to intensive efficient production of large quantities of unnecessary foodstuffs. This information has lead many including David Hedigan, Food and Natural Resources manager at An Bord Trachtala to recommend that Irish food companies, in spite of their weaknesses, should endeavour to develop new competitive markets to ensure their future.[19]

The European food market represents a golden opportunity for Irish food firms seeking to make the transition. This food market accounts for sales of $600 billion annually and services the needs of 320 million consumers. [20] Features of the burgeoning food marketplace however, may make success difficult for potential Irish exporters. Two key issues effecting change in this huge industry will pose serious difficulties for Irish food firms. Theses are;

> *The trends towards, increasing concentration and globalisation of the European food market

*The trend towards consolidation in food retailing [21]

Trends of industry concentration and globalisation have lead to a situation where power in the European marketplace is increasingly concentrated in the hands of a few giant conglomerates. A number of factors have contributed to this trend;

1. Many companies feel that in order to compete in a pan-European market they need to achieve a critical size. In order for companies to achieve economies of scale increased concentration and globalisation will continue.

2. Mergers and acquisitions are a cost effective method of establishing positions in both domestic and foreign markets. They provide firms with an established distribution network. This was reported to be BSN.s main justification for the high price it paid for HP foods in 1988. (Table 3.1)

3. The importance of established brands cannot be underestimated in today's food markets. The cost of building brands in foreign markets can be prohibitively expensive and many companies are prepared to pay a high price for established brands. Nestle paid £2.5 billion for Rowntree for this reason.

4. Finally harmonisation of food law has encouraged companies to expand their interests outside their domestic markets to exploit the total EC market of 320 million consumers.[22]

As noted Irish food firms suffer from limited sale of operations, thus these trends must be regarded as a significant threat. The enormity of the problem is highlighted if one considers the case of MD Foods. MD Foods dominate the Dairy sector in Denmark, the company enjoys a turnover of about £1.3 billion. Concerns have been expressed about the ability of this company to compete on a pan-European scale. This company as other processing giants who dominate the food industry in Denmark and other European states are significantly larger than their largest Irish competitor.[23]

Table 3.1 Takeovers by European Food Groups, (1988-1989)

Purchaser	Purchased	Product Range
BSN(France)	Birkel(West Germany) Galbani(Italy) Nabisco European	Pasta Dairy Biscuits
Cadbury Schweppes(UK)	Bassett(UK) Trebor(UK)	Confectionery Confectionery
DMV(Netherlands)	Melkunie(Netherlands)	Dairy
Douwe Egberts(Netherlands)	Van Nelle(Netherlands	Coffee
Grand Metropolitan(UK)	Pillsbury(US) Burger King and Wimpy	Various Fast food chains
J Lyons(UK)	Dunkin' Donuts(US)	Coffee and doughnuts
Nestle(Switz)	Rowntree(UK) Buitoni Group(Italy)	Confectionery Pasta, Confectionery
United Biscuits(UK)	Raffinerie Tirlemontoise Ross Youngs(UK)	Sugar Frozen Foods

Source: Euromonitor Plc. (1990), *European Food Companies*, European Publications, London.

The trend towards retail concentration has also been noted in the developing European food market. This phenomenon must be regarded as a mixed blessing for food manufacturers intending exporting to Europe. On the one hand fewer outlets reduce distribution costs and facilitate supply. On the other hand dependence on fewer suppliers reduces the bargaining power of manufacturers especially those marketing secondary brands. Consequently, manufacturers are under pressure to provide heavier trade support both for existing and new products.[24] This may be regarded as a serious threat for Irish food firms who have little experience with commercial end-user products.

3.2.4 Opportunities.

There are two primary inter-related opportunities open to Irish food firms. These are to;

*Develop new competitive markets

*Move into increased value added production.

As outlined the most obvious competitive market for Irish food exporters to target is that of mainland Europe. In the last section problems posed by features of this developing marketplace were discussed. However, the increasing importance of environmental issues for consumers on a pan-European level represents a window of opportunity for Irish food firms. As Ireland has an internationally recognised green and environmentally clean image this feature is one which Irish food firms could use to their advantage. 'Kerrygold' is one Irish brand which has already succeeded with this strategy. [25]

Value-added production is also supported by trends in the European marketplace. Research indicates that trends influencing the European food industry may be summarised as follows;

* Growth in Popularity of convenience food products

* Growing awareness of diet and health

* More adventurous consumer tastes

* Changing consumer food spending patterns.[26]

Increasing use of convenience food products is a function of changing lifestyles where main occasion, multiple person meals are becoming obsolete. Experts predict convenience foods are set to increase as a proportion of total retail food purchases. Volume sales of microwave ovens, predominantly used for heating pre-cooked food may be used as an indicator of the growth of this sector of the food market. In 1992 microwave ovens were found in almost one third of all West European households, particularly in Finland (53% ownership) in Britain(48% ownership) and in Sweden (37% ownership). [27] This sector is also predicted to grow to the year 2000. (Table 3.2)

Table 3.2 Microwave Ovens Volume Sales 1990-2000

Thousand Units	1990	2000	%increase 1990-2000
Austria	140	202	41.2
Belgium	220	331	50.7
Denmark	60	83	51.6
Finland	342	476	38.3
France	1,620	2,304	47.0
Greece	26	37	37.8
Ireland	39	58	49.5
Italy	240	351	37.5
Luxemburg	15	29	53.3
Netherlands	190	291	50.1
Norway	165	206	50.7
Portugal	40	82	77.8
Spain	280	452	67.6
Sweden	420	604	26.5
Switzerland	112	165	40.9
United Kingdom	2,400	3,256	34.0
West Germany	3,100	4,434	54.5
East Germany	388	802	106.7

Source: Euromonitor Plc. (1991), *Book of European Forecasts* from National Statistical Offices/UN/Eurostat/other.

Data compiled by 'Europanel' agencies also clearly shows the increasing popularity of convenience foods. Table 3.3 compares penetration and trend data for frozen ready cooked meals and a staple product, butter, in a number of European countries. The data clearly shows that while butter enjoys a greater penetration in most European countries than Frozen Ready Cooked meals its franchise is declining while that of convenience foods is increasing rapidly. Other convenience products enjoying a surge in popularity include;

Frozen Pizzas - sales increased in '93 by 18% and 14% in Denmark and Ireland respectively,

Prepared Salads - Market grew by 16% in Great Britain in '93

Packet Soups - Sales increased during '93 by 16% in Austria.[28]

Table 3.3 Household Trends and Penetration Data - Food Products (1992-1993)

	Frozen Ready Cooked Meal		Butter	
	Trend '93/ '92%	Penetration	Trend '93/ '92%	Penetration
Belgium	-5	B	-3	A
Denmark	+25	B	-19	A
France	-1	B	-1	A
West Germany	-1	B	-3	A
Great Britain	+35	B	-3	A
Ireland	+7	N/A	-2	B
Norway	+18	B	+1	A
Spain	+16	B	+17	B
Portugal	+15	C	-5	B
Switzerland	+12	B	+2	A
Turkey	+/-0	C	+/-0	B

Key: *Trend 93/92% - Volume*
Penetration - Quarterly Market
A = Over 50%
B = 20-50%
C = Under 20%

Source: The Europanel International Research Co-ordination Centre (1994), *Europanel Marketing Information for Europe*, Europanel EIM, Switzerland. pp. 8-9.

Growing awareness of health and diets has also paradoxically lead to an increasing demand for value added products. Europes' affluent and well educated populations are becoming increasingly aware that the food we eat affects our state of health. In 'Europe 2002' author Bengt Walstrom predicts that by 2002 special diets will form an integral part of immortality programs to help us live longer.[29] The progressive ageing of the European population, as in other industrialised populations, has also contributed to this 'healthiness' trend as an older population often exhibits a model of food consumption with less fats and with a total lower calorie intake. In sum it expresses a greater need for nutritionality.[30]

Trends towards increasing affluence coupled with more adventurous consumer tastes are also encouraging increased levels of development in the food industry. Products like yogurt, also a prime beneficiary of the health trend, has consolidated its position in recent years. (Table 3.4) Yogurt sales are expected to increase steadily in the next five years.[31]

Table 3.4 Yogurt: Per Capita Consumption 1985-1990

Kilograms	1985	1990
Belgium	6.6	7.2
Denmark	15.5	14.8
Finland	39.4	39.5*
France	12.7	16.1
West Germany	7.9	10.6
Netherlands	17.5	21.5
Switzerland	16.2	16.9
United Kingdom	3,0	4.1*

*Data unavailable for 1990, 1989 data presented

Source: Euromonitor Plc. (1992), *The Euromonitor Compendium of Marketing Information* , Ist Edition, Euromonitor Publications Ltd., London, p.177.

Changing consumer spending patterns are also leading to increasing demand for value added food products. Fast food has become increasingly popular worldwide not least so in Europe. (Table 3.5) Not only does fast food fit in better with modern lifestyles (shorter working lunch breaks, etc.,) but it also represents an effective response to the traditional complaint that normal restaurant eating is too expensive to be affordable as a regular habit.[32]

Table 3.5 Fast Food: Market Size 1988-1991

Million National Currencies

	1988	1989	1990	1991
Belgium	11,400	12,300	13,900	14,600
France	5,9000	6,200	6,600	7,100
Germany	2,200	2,400	2,500	2,700
Italy	160,000	153,000	151,000	*
Netherlands	420	460	495	530
Spain	14,000	21,000	31,000	45,000
United Kingdom	3,593	3,960	4,360	*

* No data available

Source:Euromonitor Plc. (1992), *The Euromonitor Compendium of Marketing Information* , Ist Edition, Euromonitor Publications Ltd., London p.253.

Increasing use of technology is also noted at each stage in the food production process. At farm level results of a Delphi exercise among food technologists in 1987 indicated that biotechnology is forecast to have a major impact in this area to the year 2000. Experts feel that the application of advanced biotechnological methods will allow the development of new raw materials with improved processing characteristics.[33] As yet however, progress is limited. Technologies including biotechnology are also having a significant impact on food processing and preservation. Particular technologies have allowed scientists to develop whole new ranges of new materials and ingredients to satisfy the needs of industry. In food preparation the emergence of the microwave is regarded of major significance and has aided development of convenience food markets.(Table 3.1)

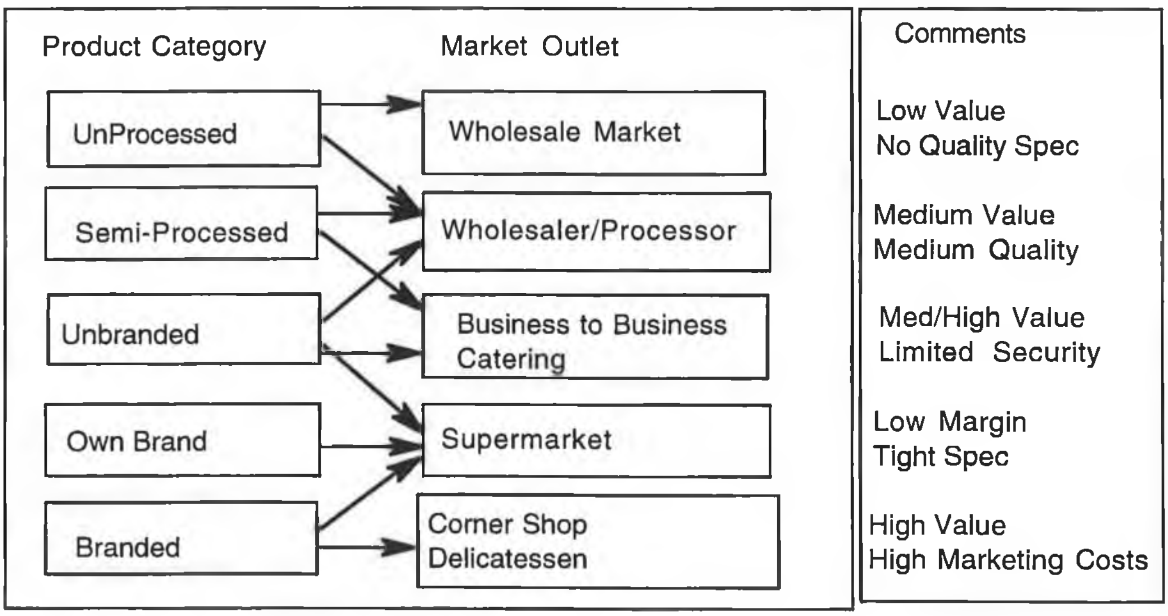
To sum up, limitations of the Irish food industry, linked to problems of scale and seasonality of production have created a sector heavily dependent on intervention and third country markets. Following the reform of the Common Agricultural Policy producers need to find new outlets for their product. The European food market is identified as the most viable alternative. This market demands vast amounts of value-added food products and represents a window of opportunity for food firms. However, trends of concentration and globalisation of food firms and consolidation of retailers on a pan-European level will make it difficult for Irish food firms to succeed here. They will need to build heavily on strengths such as their reputation for environmentally friendly food, to make an impact. Bearing in mind this short introduction to the Irish food industry State plans for its development are presented in the next section.

3.3 Review of State Plans for the Irish Food and Drink industry.

The four most recent policy documents outlining proposed government support for the Irish food industry are "A future in Food-Strategy for the Food and Drink Industry 1988-1992" by IDA Ireland. "Agriculture and Food Policy Review" undertaken by eight officials of the Department of Agriculture and Food, the findings of the "Industrial Policy Review Group" presented in January '93 and the report of the expert group on the food industry presented in April 1993. The reports include specific plans and ideas for individual sectors within the food industry, I will limit my review to the main thrust of their policy proposals.[34]

The four reports recommend strategies for increased involvement in the competitive food export industry. Control of costs, a culture of innovation and marketing and a greater involvement in high growth sectors like prepared/branded consumer products and ingredients are central factors of strategies suggested. The reports acknowledge the reality that most of the Irish food companies currently in existence have not the resources, financial, technical or marketing based necessary to become involved in branded consumer markets. The IDA report identifies several product/customer linkages possible and suggests that most Irish food companies should aim for business to business involvement as a means by which the Irish food processing industry can move from being a commodity producer to being a producer of semi-processed or consumer foods.(Figure 3.0)

Figure 3.0 Product Consumer Linkage.



Source: Industrial Development Authority (1987), *A Future in Food--- Strategy for the Food and Drink Industry 1988-1992*, Industrial Development Authority, Dublin. p.10.

This strategy seems viable in light of Pat O' Neill's (Avonmore's chief executive) assertion that,

> "any business setting out to achieve a pre-eminent position as a food company will need as a minimum a twenty year development plan which will have a real vision of the long term future". [35]

The IDA report recommends increased marketing and technological support for food firms especially large (ie sales of £500million) to ensure success.[36] The report of the expert group however, takes a more optimistic view and they recommend the creation of a substantial brand product development fund to aid food companies with a history of marketing culture and expertise to seriously pursue a brand development strategy.[37] In this way successful brands can generate the price premium required to compensate for extra costs associated with our peripheral location and make use of the 'Irish image' in continental EC states.

The reports also emphasise the importance of increasing support to the R&D function of food firms. The report undertaken by the P.A. Consultancy Group for the Industrial Policy Review Group recommends that existing state assistance for the food sector should be reallocated away from fixed asset investment towards Research and Development supports. They also propose that the direction of these supports should encompass greater industry involvement. The report of the expert group recommends that the share of overall public research funds (EC and National) devoted to the food area should be in proportion to the importance of the food sector in the economy, which would mean that food should benefit from around 23% of overall public research funds.[38] In all reports a distinction is drawn between the needs and possibilities of large scale compared with smaller 'niche' companies. It is recommended that many schemes and support be made available only to companies of sufficient scale for commercial European Markets.

3.4 Summary.

The food and drink industry is very important to the Irish economy. The industry is currently experiencing some difficulties as it grapples with the implications of CAP reform. As primarily a producer of commodity products for intervention markets CAP reform presents a serious threat. However, the industry possesses some factor cost advantages, enjoys high levels of government support and has a green, environmentally clean image. Opportunities for development and growth are identified as increased value-added production and expansion into new competitive markets. Due to problems of scale and lack of experience with branded products, government policy recommends a gradual move into consumer products, beginning with a business to business involvement in commercial markets.

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Chapter 4 Methodology.

4.0 Introduction.

The primary objective of this study was to investigate the response of Irish food firms to the emergence of new biotechnological techniques. Literature reviewed indicates little is known of their response. In order to learn more about food firms involvement or non-involvement with the techniques a three phase primary research methodology was generated. Phase one involved exploratory research of expert opinion to assist the development of a research design specifically tailored to the unique features of the Irish food industry in the context of the applications of new biotechnological techniques. The second phase involved extensive primary research of identified potential early adopters of new biotechnological techniques. Pivotal response factors investigated were; firms technological capacity to use the techniques, strategies used for involvement in R&D and attitudes to the emergence of the techniques. In phase three food firms' response to the technological discontinuity caused by the emergence of new biotechnological techniques was inferred through an appreciation of their performance with regard to the three response factors examined in unison. Development of a scoring system allowed international comparison of the technological capacity of firms interviewed.

4.1 Phase One.

The objective of this preliminary phase in the research was to gain an indepth knowledge of the Irish food industry in the context of the applications of new biotechnological techniques to assist the development of a pertinent research design. In depth interviews were undertaken with a sample of experts working in the Irish food industry and industry support functions. The sample was chosen to represent informed opinion from all sectors of the food industry on uses of new biotechnological techniques. Respondents were identified experts in biotechnology use in the food industry. All were higher degree scientific graduates and those working directly in the Irish food industry were R&D managers. The judgement sample achieved included five scientific experts performing industry support functions, (Experts were selected from the National Food Centre, Eolas, BioResearch and the National Agricultural and Veterinary Biotechnology Centre, U.C.D.) and four R&D managers working in the Irish food industry.

Table 4.0 Exploratory Interviews - Sample Achieved.

	No. of Experts
Industry support functions	5
The Irish food industry	4
Total Sample	9

Those selected from the Irish food industry were representative of the diversity of firms active in this sector. An R&D manager was interviewed from an emerging food biotechnology company, one from a multinational food company and two from indigenous food companies. The chairman of BioResearch was among those interviewed. Those selected for interview performing industry support functions included an expert on the commercial applications of new biotechnological techniques and an expert on the regulatory environment of new biotechnological techniques. Two experts were selected because of their knowledge of the agriculture and food applications of new biotechnological techniques.

Interviews were undertaken through use of a theme sheet presented in Appendix (A). Interviewees were allowed to expand at length on any particular issue of interest. Interviews were conducted in the interviewees place of work during summer 1992. Where possible interviews were recorded and lasted on average 45 minutes. Cassette transcriptions and notes were analysed and used to guide the research design for the next stage of the research. Three phases of analysis were applied to each topic discussed. First Order analysis involved gathering together responses of all respondents to a particular topic. Second Order analysis involved summarising and paraphrasing what was said. In final analysis regularities and patterns were noted and conclusions reached for each topic discussed.[1]

4.1.1 Phase 1: Implications for Research.

Exploratory research highlighted the salience of public perception issues with regard to the future use of new biotechnological techniques in the food industry. Respondents indicated an anticipation of negative consumer response to food produced in this way. Experts emphasised the difficulty of investigating food firms' response to the techniques. They felt that food firms would be loathe to report involvement or interest for fear of a consumer backlash. The importance sample members attached to this issue cannot be overemphasised. This finding indicated the necessity of developing a research design which would allow indirect investigation of food firms' response to the techniques. A suitable research design was generated and employed in phase two.

Sample members also indicated minimal involvement of Irish food firms with advanced biotechnological techniques. Experts believe that the Irish food industry continues to avoid new biotechnological techniques primarily because of concern regarding consumer resistance. Consequently it is likely that conventional methods will continue to be used by the industry. This finding dictated that any investigation should focus only on those firms identified as actual or potential early adopters of new biotechnological techniques. Experts asserted such firms tend to be larger firms with substantial R&D spends. As new biotechnological techniques represent a new technological paradigm other firms would most likely be unaware of their existence. They would not have an informed opinion on possible future involvement and thus are not of interest.

Finally, experts drew attention to the suitability of new biotechnological techniques to improve low volume high value ingredient production (starter cultures, enzymes etc) as opposed to high volume low value food processing. It was decided thus that any investigation should include such firms in addition to Dairy firms also identified as an important food sector of impact.

4.2 Phase Two.

Exploratory research undertaken in phase one indicated the necessity of indirect investigation of food firms' response to new biotechnological techniques due to anticipated negative consumer response. Literature reviewed has highlighted the strong consumer resistance that proposed use of new biotechnological techniques has encountered in many countries. The furore concerning the introduction and use of rbST remains a case in point. Thus, direct questioning of respondents' detailed plans and current involvement with the techniques was regarded as an unsuitable form of enquiry. Experts might feel obliged to understate involvement or interest to avoid consumer disapproval. Food firms' response to the technological discontinuity caused by the emergence of new biotechnological techniques was inferred thus from a detailed exploration of three factors suggested by the literature. Individually and together these three factors are seen as important determinants of food firms' response to the technological discontinuity caused by the emergence of new biotechnological techniques. They are described as follows:

4.2.1 Technological Capacity to Use New Biotechnological Techniques.

Literature accessed cited the importance of 'technological capacity' for agents of technological change. It was asserted that companies involved with technical change would need medium to high levels of competence in a number of technological functions to be successful in affecting technical change. As emerging new biotechnological techniques have been heralded as a new technological paradigm it is imperative to investigate the technological capacity of Irish food firms to become involved with the techniques.

4.2.2 Strategies Used for Involvement with R&D.

Literature reviewed also highlighted the myriad of different strategies firms use to become involved with new biotechnological techniques. It was decided thus to investigate Irish food firms' strategies for involvement with R&D generally. Existing involvement with R&D would be an important factor dictating strategies for involvement with new biotechnological techniques.

4.2.3 Attitudes to the Emergence of New Biotechnological Techniques.

Food firms' attitudes to the technological discontinuity caused by the emergence of new biotechnological techniques also represent an important factor influencing response to these techniques. Literature accessed suggested three main areas of investigation; attitudes regarding public perception issues, attitudes regarding the regulatory environment and attitudes regarding the impact new biotechnological techniques might have on the food industry.

Food firms response to the technological discontinuity caused by the emergence of new biotechnological techniques thus was to be inferred from a detailed exploration of three factors;

Technological capacity to use the techniques.

R&D Strategies generally.

Attitudes to the emergence of new biotechnological techniques.

4.2.4 The Sample.

In choosing the sample the researcher's objective was to obtain a judgemental census of actual and potential early adopters of new biotechnological techniques within the food and drink sector only. Early and potential adopters only were of interest. As noted, other firms would tend not to have the experience or knowledge relevant to the objectives of the research. Academic institutions were not included in the sample although it is acknowledged that new technologies tend to be first adopted in the academic arena. The experiences of industry only was required by the primary objective.

For the purposes of the study, the food and drink manufacturing sector was defined as firms producing products defined by NACE codes 411 to 428 inclusive. (The abbreviation NACE refers to the General Industrial Classification of Economic Activities in the European Community {Nomenclature Activite Communaute Europeen} The industrial sectors relating to each of these codes are shown below:

411 Vegetable and Animal oils and fats
412 Slaughtering, preparing and preserving of meat
413 Manufacture of dairy products
414 Processing and preserving of fruit and vegetables
415 Processing and preserving of edible fish and other sea-food
416 Grain milling
417-418 Miscellaneous foodstuffs
419 Bread, biscuits and flour confectionery
420 Manufacture and refining of sugar
421 Cocoa, chocolate and sugar confectionery

422 Animal and poultry foods
423 Miscellaneous foodstuffs
424 Spirit Distilling and compounding
425-426 Manufacture of wine, cider and soft drinks
427 Brewing and malting [2]

The food sector was also taken to include firms involved with plant and animal breeding services. These firms were included in sample due to their importance at the high technology end of the food sector.

As use of advanced biotechnological techniques is a relatively new phenomenon with regard to Irish food and drink production, it may be realistically assumed that few if any of Irish firms have adopted these techniques. In choosing a census of actual and potential adopters of new biotechnological techniques the sample size was dictated by the level of interest in industry. Firms evidenced interest and/or involvement in the techniques through membership of pertinent lists. The list were;

1. Coombs J. and Alston Y.R. (1991),*The International Biotechnology Directory 1991, Products, Companies Research and Organisations,* Macmillan, London. (This directory lists companies from all over the world with interests in biotechnology.)

2. Participants on the Labip conference, Cork 1992. (Organised under Bridge "Biotechnology Research for Innovation, Development and Growth in Europe" The Lactic Acid Bacteria Industry Platform offers a forum for exchange of views in relation to Biotechnology of Lactic Acid Bacteria Research. The conference which took place in Cork in May 1992 was attended by Biotechnology experts from both industry and academic sectors.)

3. "Top 1200 companies 1992". *Aspect -The Investors Business Journal* ,Aspect Publications,Wicklow. (Companies listed in order of turnover)

These lists identified food firms interested in or involved with new biotechnological techniques. They are also the largest firms in terms of turnover. (Secondary research indicated new technology adopters tend to be larger firms involved with high levels of R&D.)

Thirty seven firms were identified. Thirty five of these were established incumbent firms and two were emerging firms set up to use biotechnology. The sample included Dairy firms and low volume high value ingredient firms - identified sectors of opportunity for new biotechnological techniques. Other sectors of the food industry were also represented, namely brewing, fish and meat, bakery and miscellaneous food and drink. (Table 4.1)

Table 4.1 Judgement Census of Potential Early Adopters - Identified and Achieved.

	No. of firms identified	No. of firms achieved
High volume low value food processors	**28**	**21**
Dairy	14	10
Brewing	4	2
Fish + Meat	3	2
Bakery	3	3
Misc. - general	4	4
Low volume high value supply firms	**9**	**6**
Ingredients	7	5
Animal and Plant Breeding	2	1
Total Sample	**37**	**27**

Companies were initially self selected from the list mentioned in accordance with their evidenced interest in or use of new biotechnological techniques. The balance were chosen to ensure a representative sample of food firms in the context of the applications of new biotechnological techniques. Effective interviews were undertaken with 12 firms who had evidenced to the researcher a prior interest in new biotechnological techniques and 15 firms chosen by virtue of their turnover.(Table 4.2)

Table 4.2 Sample Achieved by Basis of Selection: Evidence of Interest / Involvement in New Biotechnological Techniques or Turnover.

	Prior Interest/Involvement	Turnover	Total
Dairy	7	3	10
Misc	0	4	4
Brewing	0	2	2
Fish & Meat	1	1	2
Bakery	0	3	3
Ingredients	3	2	5
Animal & Plant	1	0	1
Total Sample Achieved	**12**	**15**	**27**

The sampling unit was the food and drink company. One response from each company was sought either from the Research and Development Director, the Technical Manager or the Quality Control Manager. Secondary research indicated that, in the absence of a named R&D Director in food firms, the responsibilities of this post are taken by the Technical manager or the Quality Control manager. In cases where both Technical manager and Quality Control manager existed within a respondent firm, response was sought from that person most involved with R&D management in their firm. For the purposes of the research, scientific personnel of this caliber were assumed expert with regard to research and development in their own organisations and the food and drink industry in general. In order to elicit all of the information needed, the questionnaire may on occasion, have been addressed by several persons in an organisation but one response per question was recorded.

4.2.5 Research Method

The study was undertaken through use of a structured telephone interview. Many of the standard difficulties associated with telephone interviewing were overcome as respondents on undertaking the interview had had an opportunity to scan the questionnaire and responded with the questionnaire in front of them. In firm procedure dictated that a questionnaire and covering letter was posted care of the Research and Development Director, Quality Control Manager or Technical Manager to each firm identified. A few days later the researcher telephoned the company to make contact with the relevant company representative. If unsuccessful a minimum of six call backs were made in order to make contact and additional questionnaires were faxed on if necessary. When contact was made the researcher arranged a convenient time to undertake the interview and at this appointed time the structured interview through use of the questionnaire was undertaken over the phone. Interviews lasted on average 45 minutes. A copy of the questionnaire and covering letter is included in Appendix (B).

It was decided to undertake interviews over the phone for a number of reasons.

1. Cost and time constraints prohibited personal interviews with 37 firms scattered all over the country.
2. Group interviewing was ruled out due to the perceived

confidentiality of information required.

3. Many questions required more than one word answers and for this reason it was felt a postal study would not illicit the full depth of feelings present.

The interviews were undertaken during November 1992. A response rate of 73% was recorded.

4.3 Description of Measurement Techniques.

As outlined interviews were conducted over the phone through use of a questionnaire. The questionnaire was designed to illicit the maximum information from respondents in the shortest time frame possible. The questionnaire may be divided into three parts corresponding to the three main objectives of the study. These are, those questions relating to the investigation of firms' technological capacity to use new biotechnological techniques, questions which explored firms' R&D strategies generally and those questions which investigated firms' attitudes to the emergence of new biotechnological techniques.

4.3.1 Investigation of Firms' Technological Capacity to Use New Biotechnological Techniques.

As outlined agents of technical change need medium to high levels of competence in key functions such as R&D and process technology for competitive success. This is referred to as their 'technological capacity'. In Report 8 of the Sectoral Development Committee (S.D.C.) (1985) the technological capacity of Irish firms was assessed in terms of;

(a) Current processes and skills
(b) New product development capability

(c) Use of state resources for research and development.[3]

(a) Current Processes and Skills.

In the report of the Sectoral Development Committee current processes and skills were measured through expert assessment of the International competitiveness of the human and physical resources used in manufacturing. Consideration was made of the relative sophistication of processes and plant and equipment in comparison with international competitors. Human resource skills and production systems were similarly assessed.[4] For the purposes of this piece of research identified companies' processes and skills were assessed through investigation of the size and skill profile of their R&D staff and through exploration of the relative use sophistication of biotechnology in manufacture and R&D.

The size and skill profile of R&D staff was explored using a question adapted from a study undertaken by Cogan and McGovern. In this study undertaken in January 1984 firms were asked to indicate the size and skill profile of their workforce at startup and at end of the last trading year.[5] (Appendix (C)) The question posed in this piece of research applied only to the R&D workforce and respondents were required to indicate size and skill profiles in 1985, 1992 and those anticipated in the year 2000. In this way it was possible to undertake analysis of trends in R&D employment.

Exploration of biotechnology use sophistication in manufacture and R&D was undertaken through use of a table indicating the continuum of progress noted with regard to biotechnology in recent years. Respondents were required to self report the level at which they work with biotechnology. The development of a continuum of progress was particularly important as literature had highlighted the problems of definition associated with biotechnology and the meaningless comparisons which may result from such difficulties. Use of this self report method insured results reflected the true biotechnology use sophistication of companies and levels of use of individual firms could be compared accurately.

The continuum of progress was prepared with the help of a scientific expert in BioResearch and respondents were required to indicate level of use of biotechnology in R&D and manufacture in 1992 and that anticipated in the year 2000. This allowed tracking of any trends of use. The continuum contained three levels of biotechnology use sophistication. Level 1 represented the most basic use of biotechnology, for example in the production of wine and cheese. Level 2 corresponded to more advanced techniques available prior to the emergence of new biotechnological techniques and Level 3 indicated use of new biotechnological techniques including techniques such as genetic engineering. The continuum is presented as part of the questionnaire in Appendix (B).

(b) New Product Development Capability.

Taking direction from the assessment of technological capacity undertaken by the S.D.C. R&D spend as a percentage of sales was also used as the primary indicator of new product development capability in this study. [6] Respondents were asked to indicate approximately the percentage of turnover which was spent on R&D in 1992, 1985 and that anticipated in 2000.

(c) Use of State Resources.

This was the final factor included to measure technological capacity of

Irish firms. The S.D.C. in their assessment of the technological capacity of Irish firms explored in aggregate the use of State technical resources and supports to assist firms undertake product and process research and development.[7] As this research was focussed on the response of a small group of more technically advanced food firms the general use of State resources by the food sector was not of interest. Respondent firms were instead questioned as to their current or intended involvement with State science and technology programs. These were both open ended questions and in interview respondents were probed as to the details regarding programs involved and reasons for non-involvement.

4.3.2 Exploration of Firms' R&D Strategies.

Questions in this section explored firms' new product sourcing activities, R&D spend allocation and internal and external strategies used to become involved in R&D.

The question concerned with sourcing or line improvement activities of Irish food firms was developed through exploratory interviews and background reading. An exhaustive list of new product sources was generated and respondents were asked to indicate the percentage of products sourced using the different methods in 1992 and 2000.

A question which explored firms allocation of R&D spend was adapted from one used in the 1984 Cogan and McGovern study.[8] (Appendix (C)) Respondents were required to indicate their R&D spend allocation in 1985, 1992 and 2000.

Respondents were also questioned specifically about internal and external strategies used to become involved in R&D. Presentation was made of table adapted from a paper prepared by Mark Dibner in which different strategies used to become involved with new biotechnological techniques were discussed. They were than asked which strategies they had used and which they might consider using in the future.[9] (Appendix (C)) As with all questions respondents were probed for maximum detail in answering.

4.3.3 Exploration of Firms' Attitudes to the Emergence of New Biotechnological Techniques.

As outlined it was decided to explore respondents' attitudes with regard to public perception issues, the regulatory environment, and the possible impact of new biotechnological techniques on their industry. Four questions were generated to explore experts' attitudes with regard to public perception issues. All questions dealt specifically with public perceptions of gene-technology food and drink. The first question was open-ended and enquired of respondents how they felt consumers would react to gene-technology food and drink. Although a negative reaction would be assumed from the research to date the question was designed so as not to bias respondents. The next two questions may be taken together. Respondents were required to indicate their personal numerical risk assessment of gene-technology food and drink and estimate the numerical risk assessment of consumers, thereby allowing comparison of the risk scientific experts associate with gene-technology foods and their perceptions of consumers' risk assessments of food produced in this way. Use of the numerical scoring system allowed accurate comparison and contrast. Potential numerical risk assessments ranged from 1(low risk) to 10 (unacceptably high risk) The final question in this section enquired of respondents how they felt possible adverse consumer reaction to gene-technology foods should be dealt with.

Four questions were also generated to explore respondents' perceptions of the impact new biotechnological techniques might have on their industry. Respondents were asked about the impact they felt new biotechnological techniques might have on the Irish food and drink industry to the year 2000 and were asked to predict the sector for which the techniques would have greatest potential. They were also asked to identify the greatest barriers to use and to give their opinions on possible future involvement. The question which enquired about their intention to become involved was the final question included in the questionnaire. Two open-ended questions were generated to explore the issue of the regulatory environment. Respondents were asked;

1. Did they feel the regulations in Ireland encourage or discourage work in the area of genetic engineering?
2. Did they feel genetically engineered food and drinks should be labelled as such?

Three additional questions were also included in the questionnaire. The first allowed sector classification of respondents. Two other questions were generated to explore high volume low value food processors use of food ingredients. The questions were posed; Did the food processor purchase ingredients and what were the technologies used in the manufacture of these products? In this way assessment was made of food firms use of high value, low volume ingredients and their perception of the technologies used in the manufacture of these ingredients. These questions were not asked of low volume high value ingredient suppliers or plant breeders.

4.4 Phase Three.

In Phase three food firms' response to the technological discontinuity caused by the emergence of new biotechnological techniques was inferred through an appreciation of their performance with regard to the three factors examined in unison.

Analysis was undertaken in three consecutive, cumulative steps.Following fieldwork, questionnaires were checked and edited. The data was sorted and counted through the construction of frequency distributions of the answers to each question. Individual questions were initially the focus and results compiled per question. Following this results were analysed and conclusions drawn in terms of food firms' performance with regard to each of the three response factors identified. Finally food firms response to the technological discontinuity caused by the emergence of new biotechnological techniques was inferred from analysis of the three factors taken together and trends of response compared and contrasted. Patterns of response noted were categorised where possible using both Daly and Hamilton frameworks of strategy and options available to firms following a technological discontinuity.[10] In this way trends of response were made available for contrast with the acknowledged response of food firms internationally. An alternative methodology was also considered. Using this research method respondent firms would have been presented with the options available to them as outlined by Daly and Hamilton. They could then self report their responses according to these strategic frameworks. This alternative methodology was abandoned. It was felt that detailed analysis of the indicators of response would give greatest understanding of the capabilities of Irish food firms and their response to the emergence of new biotechnological techniques.

Two objectives were generated in relation to the analysis of food firms' inferred response to the emergence of new biotechnological techniques. The first was to determine on characteristics, such as firm

status, food production activities or any characteristic identified as of interest if any statistically significant relationship exists between the differentials of these characteristics and trends of response to the technological discontinuity caused by the emergence of new biotechnological techniques. This objective allowed identification of differences and similarities in response to the emergence of new biotechnological techniques by emerging and established firms and firms involved with low volume high value food production as well as those involved in high volume low value production.
The second objective stemmed from the importance of commercial European markets for Irish food firms following the dismantling of the Common Agricultural Policy. It was decided to compare European firms' response to the techniques with that of Irish identified potential early adopters. The response of European and Irish food firms was compared using technological capacity to use the techniques as the primary indicator of response. A scoring system described later in the chapter was developed to allow this comparison. Comparative information in the form of Daly and Hamilton frameworks was not available in a European context.

4.4.1 Analysis of Individual Questions.

As outlined, the first stage of the analysis process involved the construction of frequency distributions of the answers to each question. This was done through use of the Statistical Package for Social Sciences (SPSS). Data obtained was both numerical and literal. In the analysis of numerical data use was made of descriptive statistics such as the median, range, midmean and interquartile range. The median indicates the middle value in a frequency distribution, below and above which lie values with equal total frequencies. Use of the median allowed note to be taken of the activities of the middle or more usual firm. The range allowed cognisance to be taken of the spread of data and the midmean is a measure of the mean of the middle 50% of scores. By focusing on the interquartile range or middle 50% of firms it was possible to get an idea of what the usually more reliable half of firms were doing. Using this method the extremes which may bias other descriptive statistics are ignored. SPSS proved a useful tool in the generation of these statistics. While use of this package is most popularly associated with the analysis of larger amounts of data it's use in this context aided prompt production of the necessary statistics.

Literal data was content analysed. Content analysis was undertaken using a format suggested by Jankowicz. [11] Content analysis of the impact assessment question is presented to illustrate the format used. (Table 4.3)

Table 4.3 Content Analysis Format.

Sample:	37 Food Companies
Respondents:	27 Respondents 10 respondents unavailable Response rate 73%
Recording Unit:	What was said.

Context Unit: That part of the structured interview where respondents discussed their opinions on the impact of advanced biotechnological techniques with regard to the Food and Drink industry to the year 2000. The question was presented as: "What do you think the impact of advanced biotechnological techniques such as genetic engineering will have on the Irish Food and Drink industry to the year 2000? Whole of reply treated as an entry under one category, regardless of the number of utterances.

Data: A transcript of 27 conversations, with the relevant part of the interview highlighted, each coded with a number 1 to number 6 according to the categories below.

Categories:

1. No impact
2. Very little impact
3. Some/little impact
4. Major Impact
5. Futuristic - Post year 2000 impact
6. Don't know

Data was validated where possible using existing available research. Crosstabulation was used to determine if any statistically significant relationships existed between the differentials of firm characteristics, such as status and production activities and trends of response.

4.4.2. Analysis of Findings Relating to Individual Determinants of Response.

The first step in the analysis of findings relating to individual determinants of response was to group together questions relating to the exploration of each. Exploration had been made of food firms' performance with regard to four indicators of technological capacity. A scoring system was developed to draw together these four indicators. This was a unique methodology tailored to the particular features of 'technological capacity' measurement used in the study. The system allowed presentation of firms' performance with regard to each of the indicators of technological capacity and the relative contribution of each indicator. It also facilitated comparison of the technological capacity of food firms with that of firms dedicated to the exploitation of new biotechnological techniques. Use of the system allowed comparison of the relative technological capacity of food firms to use new biotechnological techniques in an Irish and European context.

The system employed a simple scoring procedure. Points were allocated to firms which reflected their perceived performance on each indicator of technological capacity. Each indicator was worth a maximum of 5 points. All indicators contributed equally to technological capacity thus the maximum score possible for strong technological capacity was 20. The unit of comparison on each indicator was the performance of firms dedicated to the exploitation of new biotechnological techniques. Points were allocated to reflect the relative performance of firms investigated as compared with published data pertaining to dedicated firms. Secondary data was also used to explore the technological capacity of European food firms. It may be noted that points were allocated arbitrarily and specific scores may be open to discussion. However, the rationale for individual score allocations is presented, each relating directly to secondary or primary research presented. The systems strength lies in its ability to highlight the ranked performance of firms with regard to technological capacity and the individual indicators investigated. It is a useful tool as it distils the many components of technological capacity into a single score to facilitate comparison. Yet the process leading to score generation in review of secondary and primary research insures that firms performance on each facet of every indicator impacts on the final score indicating technological capacity to use new biotechnological techniques.

Findings relating to the remaining determinants of response; firms R&D strategies and attitudes to the emergence of new biotechnological techniques necessitated a contrasting analysis procedure. Questions generated investigated different aspects of each determinant. In analysis thus the objective was to uncover a pattern of response while retaining the detail of individual issues explored. Using knowledge gained through exploratory research related questions were grouped together and significant trends highlighted.

4.4.3 Analysis of Three Identified Determinants of Response Taken Together.

Final analysis involved appreciation of food firms' performance with regard to the three determinants examined in unison. This allowed food firms response to the technological discontinuity caused by the emergence of new biotechnological techniques be deduced. Analysis was undertaken using a synthesis of methods suggested by Griggs.[12] Explanations were derived for firms' performance on individual determinants and regularities and patterns noted. With increased understanding specific instances were subsumed into larger patterns. Patterns of response were then categorised using both Daly and Hamilton frameworks of strategies available to firms following a technological discontinuity. [13] In this way trends of response could be discussed in an international context.

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2. *Census of Industrial Production* (1990), Central Statistics Office, Dublin.

3. Sectoral Development Committee (1985), *Report and Recommendations on the Technological Capacity of Indigenous Irish Industry,* Government Publications Office. Dublin. pp.133-4.

4. ibid.

5. Cogan D.J. and McGovern B. (1984), *The Nature and Needs of High Technology Industry.* Education, Innovation and Entrepreneurship Research Programme, Dublin.

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11. Jankowicz A.D. (1991), *Business Research Reports for Students,* Chapman&Hall, U.K. p.192.

12. Griggs, op.cit.pp.15-33.

13. Hamilton (1990) and Daly (1985), op.cit.

Chapter 5 Analysis and Findings.

5.0 Introduction.

Analysis and findings are presented in two parts. In this chapter respondents' performance with regard to each individual factor identified as important in determining food firms' response to the emergence of new biotechnological techniques is presented. Chapter 6 presents findings relating to food firms' response to new biotechnological techniques inferred from a detailed exploration of the three identified determinants examined in unison.

The primary identified determinant of food firms' response to new biotechnological techniques was technological capacity to use the techniques. Indicators of technological capacity used were;

size and skill profile of R&D staff,

use of biotechnology in manufacture and R&D,

R&D spend as a percentage of sales,

current and intended involvement with State science and technology programs.

Findings relating to each individual indicator are presented and scores allocated to indicate the relative performance of Irish and European firms on each indicator.

5.1 Size and Skill Profile of Research and Development Staff.

In advance of any detailed exploration of the size and skill profile of R&D staffs investigated, it is useful first to note the number of formal R&D departments operated in food firms in Ireland. Perhaps the most striking result which emerged from the investigation of identified potential early adopters of new biotechnological techniques was the high number of those who do not operate a formalised R&D department in Ireland. Those who do not operate a formalised R&D department are divided between those who are uninvolved with R&D and those who benefit from R&D carried out overseas. As might be expected, those undertaking R&D overseas tend to be MNC's with interests in other markets. (Table 5.1.0)

Table 5.1.0 Respondent Companies Operating a Formal R&D Department. (1985, 1992, 2000)

	1985		1992		2000	
	No.	%	*No.*	%	*No.*	%
Formal R&D Dept.	16	59	18	67	18	67
R&D Overseas	6	22	5	18.5	5	18.5
Uninvolved with R&D	5	18.5	4	14.8	4	14.8
Total	27	100	27	100	27	100
Base: All Respondents						

For the purposes of this investigation an R&D department was deemed to be in operation if one or more persons were employed full-time with research and development activities. A similar definition was used in the 1991 Eolas Business survey of R&D. However, for the purpose of the Eolas survey it was also required that a physical space be allocated to R&D. The findings of the Eolas survey 1991, indicated that, of the ninety six technology performing companies identified in the Irish food, drink and tobacco sector of that year, forty seven operated formal R&D departments. Technology performing companies as defined by Eolas are those which are involved with either intramural or extramural expenditures on R&D, joint ventures, R&D consortia or technology licensing. As the tobacco sector is quite small in Ireland it may be assumed that the vast majority of the forty seven formal R&D departments highlighted are operated by food and drink firms.
Thus of the ninety six technology performing food and drink firms identified by Eolas, 49% operated formal R&D departments.[1] Results of the research undertaken on potential early adopters of new biotechnological techniques indicate that 66% of those interviewed

operate formal R&D departments. Early adopters of new technologies in the industrial sector tend to be firms which are technologically advanced. It is not surprising thus that in the identification of a judgemental census of Irish food firms thought to be actual or potential early adopters of new biotechnological techniques that a higher proportion of these firms would operate formal R&D departments than is normal among technology performing food companies in general. Taking the results regarding low volume high value ingredient supply firms separately it may be noted that only one such supply firm indicated that it operated a formalised R&D department in Ireland, two undertake R&D overseas, one is uninvolved in R&D and one refused to give details of R&D staff.(Appendix (D)Table 5.1.1)

Additional secondary data accessed indicates that the number of formal R&D departments operated in food and drink companies has increased rapidly since 1982. The Sectoral Development Committee reported that in 1982 eighteen Irish food companies operated formal R&D departments. This study did not include the activities of drink or tobacco companies. However, due to the food industries dominance of the food, drink and tobacco sector, it is reasonable to assume the figures might not have increased greatly by their inclusion.[2] Results of the study under discussion indicate that in 1985 sixteen of the identified potential early adopters of new biotechnological techniques operated formal R&D departments. It must be noted that while the number of food firms operating formal R&D departments in Ireland is increasing such firms remain the exception rather than the rule. This point is highlighted when one considers out of 835 food, drink and tobacco firms (establishments employing three or more persons) estimated in existence by the CSO in 1989,[3] Eolas has identified only 47 as operating formal R&D departments.

Investigation of the size and skill profile of the R&D workforce was limited to those firms which operated a formal R&D department in the years of interest. A disappointing response rate was recorded among firms, particularly with regard to details of staff in years 1985 and 2000. Experts were often unable to supply information for 1985 and unwilling to make estimates of anticipated staff profiles for 2000. Details were not recorded of overseas staff profiles.(Most likely users of R&D based overseas are multinational companies. It may be assumed thus that as the R&D department of the parent company will provide R&D services to all countries of operation that this department would be large and well staffed.) Firms uninvolved with formal R&D activities indicated a per project attitude to product development. Personnel from related departments would come together to solve research and development problems as required. Formation of a formal R&D department was regarded as unnecessary. Tables 5.1.2, 5.1.3 and 5.1.4 show the size and skill profile of R&D staffs in the years investigated for respondent firms. The response rate was particularly low for the year 2000. However, those companies who declined to estimate the size and skill profile of R&D personnel anticipated in the year 2000 were united in their assertion that numbers would remain constant or increase. Using the most conservative estimate thus that R&D staffs will 'Stay the Same' figures were substituted for non-estimating companies to calculate the median, range and interquartile range of total staff numbers anticipated in the year 2000. This information is included in Table 5.1.5 It may be noted that the anticipated size of R&D departments in the year 2000 is slightly smaller when current figures are substituted for non-estimating companies. This is as expected as companies who estimated normally included a growth factor in terms of personnel employed. However, in substituting current figures we are using the most conservative estimate of non-growth. Also those companies with larger R&D

departments would, by definition, have more formalised plans than their smaller competitors. These larger companies would be more able to give estimations of future R&D staffs thus raising the descriptive statistics for anticipated R&D personnel in the year 2000.

Table 5.1.2 Size and Skill Profile of R&D Departments. (1985)

	Higher Scientific Degree Staff	Scientific Degree staff	Scientific Diploma staff	Other Scientific staff	Total R&D staff
Median	0.00	1.00	0.00	0.00	5.00
Range	3.00	5.00	12.00	3.00	20.00
Qu	1.50	3.00	2.75	0.00	10.00
Ql	0.00	0.00	0.00	0.00	2.00
Unanswered	4	4	5	5	2

Base:Companies operating formal R&D departments in Ireland (16)

Unit of Measurement:Full time research employee.

Table 5.1.3 Size and Skill Profile of R&D Departments. (1992)

	Higher Scientific Degree Staff	Scientific Degree staff	Scientific Diploma staff	Other Scientific staff	Total R&D staff
Median	0.00	2.00	1.00	0.00	6.00
Range	4.00	20.00	12.00	3.00	20.00
Qu	3.00	4.500	2.00	0.00	14.00
Ql	0.00	1.00	0.00	0.00	4.00
Unanswered	3	2	4	4	1

Base: Companies operating formal R&D departments in Ireland (18)

Unit of Measurement:Full time research employee.

Table 5.1.4 Anticipated Size and Skill Profile of R&D Departments. (2000)

	Higher Scientific Degree Staff	Scientific Degree staff	Scientific Diploma staff	Other Scientific staff	Total R&D staff
Median	1.00	2.00	2.00	0.00	9.50
Range	5.00	12.00	12.00	3.00	23.00
Qu	2.00	5.00	6.00	0.50	14.00
Ql	0.00	2.00	1.50	0.00	5.75
Unanswered	7	7	9	8	8

Base:Companies operating formal R&D departments in Ireland (18)

Unit of Measurement:Full time research employee.

Table 5.1.5 Anticipated Size of R&D Departments in the year 2000 (Using Current Figures for Non-Estimating Companies.)

Median	8.00
Range	23.00
Qu	14.00
Ql	4.00

Base:Companies anticipating operation of a formal R&D department in Ireland (18)

Unit of Measurement:Full time research employee.

Results indicate a trend towards increased staffing of the R&D department. In 1985 the median number employed in the R&D department was 5, in 1992 this had risen to 6 and in the year 2000 the most conservative estimate for anticipated staff employed was 8. However, in discussion of these figures the wide range of size and skill profiles reported must be noted. To illustrate: In 1992 the research staff employed in individual firms ranged from one to twenty. By focusing on the interquartile range or middle 50% of firms an indication emerges of what the usually more reliable half of firms are doing. Using this method the extremes which may bias other descriptive statistics are ignored. In 1992 thus, the middle 50% of firms employed between 4 and 14 in their R&D departments. This figure had risen from an interquartile range of 2.0 to 10 employed in 1985. In the year 2000 the most conservative estimate would indicate an anticipated 4 to 14 employed in the R&D departments of the middle 50% of firms.

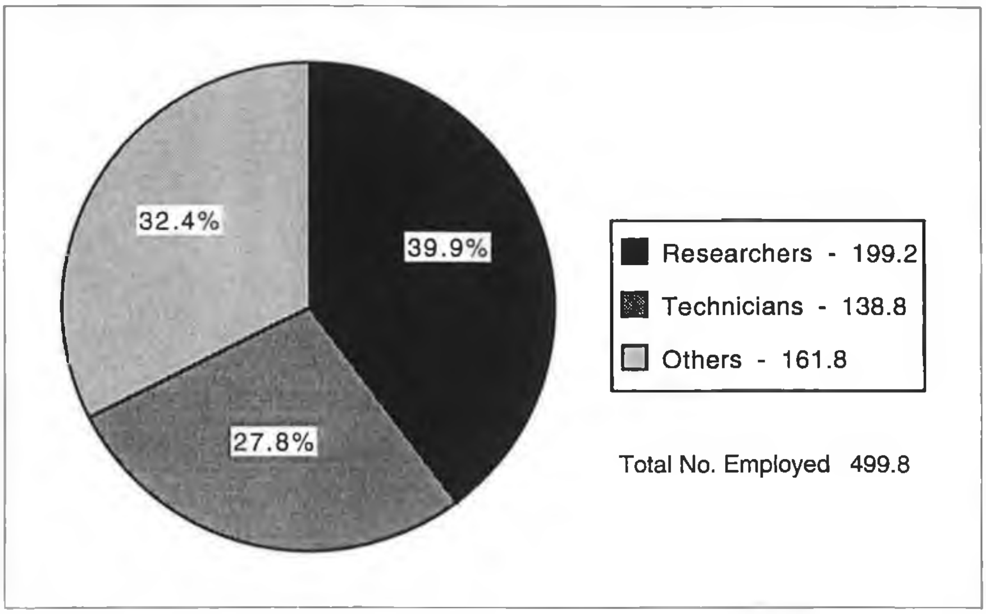
In terms of skill profile of R&D staff employed, responses rates were very low. Many respondents again were unwilling or unable to give a detailed breakdown of the R&D workforce in terms of skills or qualifications. However by ignoring the extreme responses of the top and bottom 25%s it may be noted that R&D departments tend to contain between 0 and 3 Higher Degree scientific personnel (Master's Qualification plus) between 1 and 4.5 Scientific Degree staff, between 0 and 2 Scientific Diploma staff and no 'other scientific personnel' (helpers, cheese makers, scientific personnel without formal scientific qualifications employed in the R&D department). Results indicate that increasing numbers of all personnel types have been employed in the R&D department since 1985 but that at present, Degree level scientific staff are most popularly employed.

Comparison of R&D staff numbers with total staff numbers may be misleading due to the worldwide operations of some firms and the differing methods of staff calculation employed. This comparison is not included. It may be noted however, that the emerging firm interviewed employed almost half of total staff in R&D and the R&D departments of established firms ranged in size from 1 to 20 in 1992. Crosstabulation of evidenced interest in new biotechnological techniques does not reveal any significant trends. R&D staff sizes are spread across firms which have evidenced a previous interest in new biotechnological techniques as well as those who have not.

On first glance comparison of figures gathered through the 1991 Eolas survey would indicate that those firms identified as potential early adopters of new biotechnological techniques employ fewer R&D staff than other R&D performing food firms. The Eolas survey presented a figure of 499.8 for full time equivalent personnel employed in the food, drink and tobacco sector or a mean of 10.6 R&D staff per food firm.[4] (Figure 5.0) However, if one subtracts those staff categorised as 'other' - skilled and unskilled labour including clerical and administrative staff which were not assigned to the R&D department in this survey the mean number of R&D staff employed per R&D performing firm according to Eolas falls from 10.6 to 7.19. The average number of staff employed in those firms identified as potential early adopters of new Biotechnological techniques in 1992 was 7.05. Identified potential early adopters thus display similar trends of R&D employment to other Irish

R&D performing food companies.

Figure 5.0 Personnel Engaged in R&D in the Irish Food, Drink and Tobacco Sector. (1991)



Source: Science and Technology Evaluation Unit (1992), *Business Tables for 1990,* Eolas, Dublin. p.11

5.1.1 Comparison with International Food Firms.

Specific information regarding identified potential early adopters of new biotechnological techniques in the international food sector is unavailable. Descriptive statistics thus detailing the size and skill profile of R&D departments in food related industries worldwide are used to assess R&D performing Irish food companies scientific personnel relative to their international competitors. Data presented in Table 5.1.6 indicates that while the Irish food industry accounts for 0.6% of OECD food production it employs 0.4% of OECD food related RSE personnel. (RSE denotes researchers. The definition of such personnel as outlined in the Frascati manual is,

> "Researchers are scientists or engineers engaged in the conception or creation of new knowledge, products, processes, methods and systems"[5]

Employment of such personnel is used as an indicator of the relative sophistication of R&D staff profiles in International food companies.) Only four OECD nations control a significantly greater percentage of total OECD food related RSE employment than OECD food production. These nations are Japan, Sweden, the US and the UK. The ratio of share of food related RSE employment to share of food production in the OECD indicates that RSE employment levels in Irish food firms are about parity with other European nations. Expressing this another way; Considering our small share of total OECD food production our share of total OECD food related RSE employment indicates similar R&D staffing levels per unit of food production to other European countries.

Table 5.1.6 Food Production and Employment of Food Related RSEs for Selected OECD Nations. (1985)

	% Share of OECD Production (adjusted)	%Share of RSE Employment	Ratio
Australia	1.94	1.32	.68
Austria	1.02	.7	.69
Belgium	1.02	.7	.69
Canada	4.8	2.2	.46
Denmark	1.33	.79	.59
Finland	1.0	.8	.8
France	7.89	3	.38
Germany	6.0	3.2	.38
Greece	.5	.07	.14
Iceland	0.04	.02	.5
Ireland	0.6	0.4	.66
Italy	4	1.0	.25
Japan	14.75	33.58	2.27
Netherlands	3.07	1.6	.52
Norway	0.8	0.13	.16
Portugal	0.4	0.09	.225
Spain	2.76	0.6	.22
Sweden	1.22	1.3	1.06
UK	6.5	7.1	1.09
US	39.56	40.7	1.03

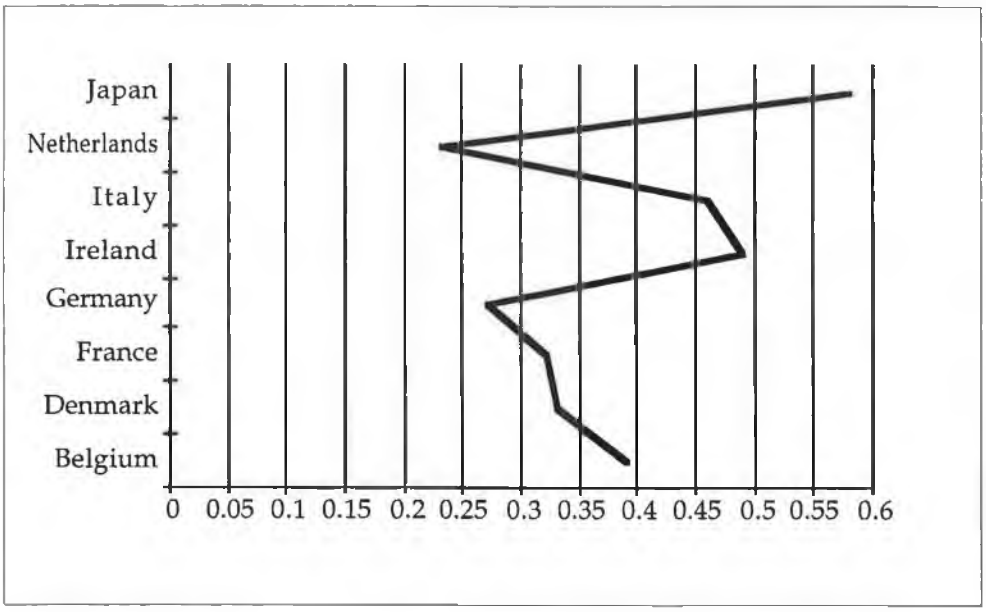
Source: *Basic Science and Technology Statistics* (1991), OECD, Paris. Table 13 and Stevens C. (1987), "Technology and the Food processing Industry" *STI Review*, September, no.2, OECD, Paris p.17.

It should also be noted that in terms of the ratio of food related RSEs employed to general food related R&D personnel,

> ("all persons employed directly on R&D should be counted, as well as those providing direct services such as R&D managers, administrators and clerical staff"[6])

the Irish food, drink and tobacco sector compares well to other OECD countries. We have the highest ratio of food related RSE's to general food related R&D personnel in all European countries. This indicates that staff employed in the R&D function of Irish food firms are well qualified. (Figure 5.1)

Figure 5.1 Ratio of Food Related RSE Employees to Total Food Related R&D Employees in Selected OECD Nations. (1987)



Source: *Basic Science and Technology Statistics* (1991), OECD, Paris. Tables 13 and 12 .

Two points should be noted in the discussion of these finding.

1. Experts assert that for progress in the development and use of new biotechnological techniques "a critical mass" of scientists is necessary, along with a good infrastructure and broad based communication among the specialists working all over the world. It has been pointed

out that,

> "these basic conditions for successful R&D activity are to be found mainly in the advanced industrialised countries and in large MNCs and that this is where biotechnology is going to develop fast".[7]

Thus, although potential early adopters of new biotechnological techniques along with all R&D performing Irish food firms employ in relative terms similar numbers of researchers to their European counterparts, taken in absolute figures the opportunity to generate the 'critical mass' of food scientists in the Irish food sector is small. Table 5.1.7 details business enterprise R&D personnel and RSEs for the food, drink and tobacco sector in selected OECD countries.

Table 5.1.7Total Business Enterprise R&D Personnel and RSE's, for the Food, Drink and Tobacco Sector in Selected OECD Nations. (1985, 1986, 1987)

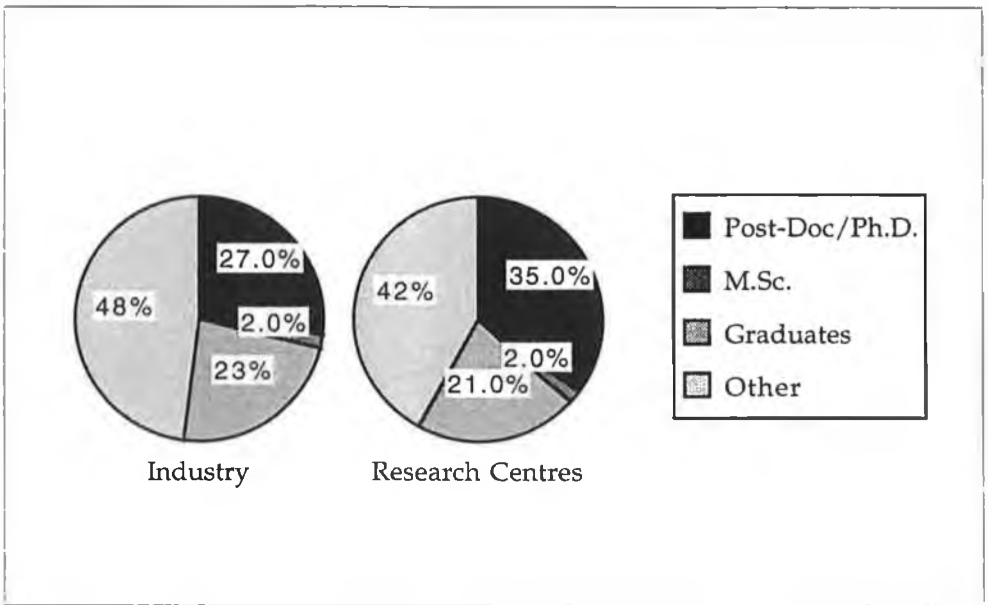
	1985		1986		1987	
	Total R&D staff	RSEs	Total R&D staff	RSEs	Total R&D staff	RSEs
Belgium	530	187	592	227	592	230
Denmark	587	201	^	^	707	231
France	2395	762	2739	850	2729	882
Germany	3296	813	^	^	3150	866
Greece	^	^	48	18	^	^
Ireland	276	108	299	147	293	146
Italy	595	276	586	295	689	321
Luxemburg	^	^	^	^	^	^
Netherlands	1850	420	1850	440	1920	440
Portugal	^	^	69	26	^	^
Spain	483	171	616	203	^	213
UK	4900	1800	^	^	^	^
US	^	10300	^	^	^	^
Japan	14519	8480	16713	9700	17805	10495

Source: *Basic Science and technology Statistics* (1991), OECD, Paris. Tables 12 and 13.

In total in 1987 OECD figures indicate the Irish food, drink and tobacco industry employed 293 persons in R&D generally and 146 RSEs. Compare that figure to Denmark which employed 707 persons in R&D and more specifically 231 RSE's.

2. Taken in absolute figures numbers employed in R&D in Irish food firms are low compared with our European competitors. When compared to R&D personnel employed by those firms dedicated to the exploitation of new biotechnological techniques Irish food firm R&D staff profiles are indicated as very basic. In 1991 the Eolas Business survey indicated there were 161.2 full-time equivalent R&D personnel engaged with biotechnology in Ireland.[8] In 1986 3,500 technical employees at graduate level were working with novel biotechnology in the UK.[9] Exploration of the qualifications of approximately 2000 of these is presented in Figure 5.2.

Figure 5.2 Working with Novel Biotechnology in the UK - Employment Structure By Qualification Level.(1986)



Source: Bevan S., Parsons D. and Pearson R.,(1987) *Monitoring the Biotechnology labour market*. A study for the Biotechnology Directorate of the Science and Engineering Research Council. Brighton January, p.17.

The information clearly shows that for those firms involved with advanced biotechnological techniques the preferred minimum skill level is generally the PhD. The median number of higher degree scientific staff employed by Irish food firms identified as potential early adopters of new biotechnological techniques was zero in 1992. These figures would indicate that without considerable upgrading of R&D personnel in terms of scientific qualifications it would be very difficult for identified potential early adopter Irish food firms to compete against firms currently involved with new biotechnological techniques. This finding also applies to European food firms which secondary data accessed indicated had a lower ratio of food related RSEs to general food related R&D personnel than Irish food firms.

5.1.2 Technological Capacity : Allocation of Scores.

As outlined in chapter 4 a unique scoring system was developed which facilitates direct comparison of the technological capacity of respondent firms to use new biotechnological techniques with that of dedicated firms worldwide and of European food firms. Using this system respondent firms are allocated a score on each individual indicator of technological capacity which reflects their performance relative to dedicated firms. Each indicator is worth a maximum of five points. The sum of all four scores awarded for size and skill profile of R&D staff, use of new biotechnological techniques, R&D spend and use of State resources reflects their overall performance on technological capacity. Scores are also allocated to European firms using the same system.

In this section we are concerned with the allocation of scores for that indicator of technological capacity, size and skill profile of R&D staff. Assuming those companies dedicated to the exploitation of new biotechnological techniques have the optimum personnel skill profile for exploitation of the techniques such a company is awarded a maximum of five points.

Irish food firms are awarded two points. The rationale for this score is as follows: The R&D personnel employed by Irish food firms is underqualified to compete in any meaningful manner with that employed by dedicated new biotechnology firms. However, Irish food firms are involved in R&D and they do employ albeit small numbers of R&D staff. Additionally, trends of R&D employment in the Irish food industry are improving and in 1991 they recorded the highest ratio of food related RSEs to general food related R&D personnel in all European countries. Staff employed thus are well qualified.

Table 5.1.8 Scores Allocated for Size and Skill Profile of R&D Staff.

Firms dedicated to the exploitation of new biotechnological techniques.	5 points
European food firms.	3 points
Irish food firms identified as potential early adopters of new biotechnological techniques.	2 points

European food firms have been awarded three points. A greater number of points were allocated to this sector to reflect the greater absolute number working in R&D in European food companies as compared with the Irish food industry. Reaching a critical mass of food scientists is important to progress work with new biotechnological techniques and European food firms are indicated as more likely to reach this critical mass than Irish food firms. However, similar to the

Irish situation, trends of R&D employment in the European food sector are dismal compared to that of dedicated new biotechnology firms. Consequently they could not be awarded as many points as dedicated firms.(Table 5.1.8)

5.2 Level of Biotechnology Use in Manufacture and R&D.

In order to track the level of biotechnology use in food firms investigated a three level continuum of biotechnology sophistication was developed. Firms were asked to indicate on the continuum which level best reflected their use of biotechnology in manufacture and R&D. The continuum is included in Appendix (B).

Level 1 and Level 2 on the continuum of progress correspond loosely to techniques used in advance of the recent developments associated with new biotechnological techniques. This type of biotechnology is popularly used in high volume low value food production. Level 3 on the continuum of progress corresponds more closely with techniques such as genetic engineering or small scale biotechnology as defined by Angold, Beech and Taggart.[10] Level three indicates use of new biotechnological techniques.

Table 5.2.0 Level of Biotechnology Use in Manufacture. (1992, 2000)

	Level of Bio Use in Manufacture 1992		Level of Bio Use in Manufacture 2000	
	No. of firms	%	No. of firms	%
Level 1	6	22.2	4	14.8
Level 2	11	40.7	11	40.7
Level 3	0	0	0	0
Not Applicable	3	11	3	11
No Answer	7	25	9	33
Total Base: All Companies	27	100	27	100

Table 5.2.1 Level of Biotechnology Use in R&D. (1992, 2000)

	Level of Bio Use in R&D 1992		Level of Bio Use in R&D 2000	
	No. of firms	%	No. of firms	%
Level 1	4	22.2	2	11
Level 2	4	22.2	4	22.2
Level 3	0	0	3	16.6
Not Applicable	3	16.6	3	16.6
No Answer	7	40	6	33.3
Total	18	100	18	100

Base: All Companies operating formal R&D departments in the years 1992, 2000.

From the information presented in Table 5.2.0 and Table 5.2.1 it is evident that low to intermediate levels of biotechnology use are most favoured among general food processors as well as ingredient suppliers in manufacture and R&D to date. Not one expert anticipated use of Level three in manufacture in the year 2000.

Three companies felt that biotechnology was not relevant to their activities in food processing. Two of these indicated possible involvement at field level in the purchase of seeds for better strains of crops. The remaining company which indicated that the techniques were not applicable to activities is uninvolved in R&D and it's manufacturing operations are also organised at a very basic level.
The high number of those who were unprepared to estimate future involvement with the techniques either in manufacture or R&D (33% respectively) is noteworthy. The refusal to associated with any prediction is perhaps a reflection of the perceived uncertainty surrounding these techniques and their development. Many experts from the general food processing sector asserted that high level/Level Three biotechnology use is irrelevant to activities to date and anticipated in the future. They felt that this level of biotechnology use

only had relevance in the food sector in the production of ingredients, enzymes, starter cultures etc. which they might purchase. They felt thus that they might be using these advanced techniques 'second hand'. This finding is in support of the assertion by Angold, Beech and Taggart that new biotechnological techniques have primary application in low volume high value ingredient production.[11] In light of this finding the response of high value, low volume ingredient firms were focused upon. The response rate was poor and the results should be treated with caution. However, respondent firms indicated involvement at all levels predominantly at Level 2. One of the ingredient firms indicated an anticipation of using Level 3 or most advanced biotechnological techniques in R&D in the year 2000.(Table 5.2.2)

Confusion was indicated among food processors as to the exact technologies used in the production of high value low volume ingredients. 86% of the food processing companies interviewed, confirmed they used food additives /food ingredients in manufacture. The host of products which were mentioned as used included: yeast products, enzymes, emulsifier, stabilisers, flavourings, colourings, rennet, starter cultures and salt. These products are popularly purchased from Irish ingredient suppliers. Technologies used in the production of these products are mainly centred on drying technologies and biotechnology. When questioned respondents were often unsure as to whether ingredients used were manufactured through use of advanced or basic biotechnological techniques. Two experts suggested that rennet used may have been manufactured through use of advanced biotechnological techniques but they were unsure. Other respondents asserted that ingredients used by them were manufactured through use of standard biotechnological techniques. Still others felt that although the technologies used might not encompass genetic engineering they would still be classified as advanced (genetic manipulation).

Table 5.2.2 Level of Biotechnology Use -Low Volume High Value Ingredient Firms.

	Level of Bio Use in Manu 1992	Level of Bio Use in Manu 2000	Level of Bio Use in R&D 1992	Level of Bio Use in R&D 2000
Firm 1	No answer	No answer	R&D else -where	R&D else -where
Firm 2	No answer	No answer	R&D else	R&D else
Firm 3	No Answer		No Answer	
Firm 4	No answer	Level 2	Level 1	Level 3
Firm 5	Level 2	Level 2	Level 2	No answer

To my knowledge there is no secondary research extant detailing the level of involvement of Irish food companies with new Biotechnological techniques. I feel however it is reasonable to assume that the companies interviewed for the purposes of this research represent most advanced users of biotechnology in the Irish food industry. Certainly the sample was chosen to achieve this objective.

5.2.1 Comparison with International Food Firms.

From the information gained in the research undertaken it is clear that low to intermediate levels of biotechnology use are most favoured in the Irish food sector. Angold, Beech and Taggart have asserted that food processors world-wide tend to be involved with biotechnology at this level.[12] They believe that more advanced techniques are only used by the food sector in the production of ingredients. The poor response from the ingredient sector in the survey disallowed comprehensive investigation of this phenomenon in an Irish context. It may be noted however that those involved with high volume low value production asserted that advanced technologies may be used in the production of ingredients purchased. Also, exploratory research undertaken indicated a perception among food experts of more advanced technologies used in the production of ingredients than in general food processing. I feel it is reasonable to assume thus that use of biotechnology is at a more sophisticated level in high value low volume ingredient production than in low value high volume food processing. However, it is impossible to state with any degree of accuracy whether new biotechnological techniques are used by Irish food ingredient supply firms.

By definition firms dedicated to the exploitation of new biotechnological techniques are involved with the most advanced biotechnological techniques including technologies such as genetic engineering and hybridoma technology. Results indicate techniques used by such firms are very much advanced to that used by Irish and European food firms.

5.2.2 Technological Capacity : Allocation of Scores.

The research undertaken indicates the most popular level of biotechnology use in Irish food firms is Level Two. However food processing firms questioned did indicate the possibility that the ingredients which they purchase may be manufactured using more advanced techniques, thus they may be using the techniques second hand. Confusion was evident however as to the exact technologies used in ingredient production. Literature accessed and exploratory research undertaken also supports the hypothesis that ingredient firms may be using biotechnology at a more sophisticated level than that used by large volume food processing firms. Investigation of ingredient firms in this survey was hampered by a very poor response rate, thus for the purposes of scoring all Irish food firms are presumed to display similar use sophistication of biotechnology as food processing firms.

The maximum of 5 points is allocated to those firms dedicated to the exploitation of new biotechnological techniques. By definition such firms are involved with the most advanced biotechnological techniques. Both European and Irish firms are allocated two points. They are awarded equal scores as according to Angold, Beech and Taggart European firms are involved with biotechnology as Irish firms at Level Two. Two points are awarded as although neither sector is involved with new biotechnological techniques the firms concerned have moved from use of the most basic techniques to a modicum of sophistication in application. In future years thus use of more advanced techniques may be embraced more easily than if they were still involved at a primitive level. The allocation of less than half the maximum possible points to European and Irish firms however reflects the long road ahead of such firms were they to consider becoming involved with the most advanced techniques.

Table 5.2.3 Scores Allocated for Level of Biotechnology Use.

Firms dedicated to the exploitation of new biotechnological techniques.	5 points
European food firms.	2 points
Irish food firms identified as potential early adopters of new biotechnological techniques.	2 points

5.3 Research and Development Spend.

In this section results are presented in two parts. Initially analysis is undertaken of the R&D spends of those companies operating formal R&D departments.(Table 5.3.0) This is followed by presentation of information regarding the spend of all R&D performing companies.(Table 5.3.1) Those firms who do not operate formal R&D departments incur expenses on a per project basis and have often an R&D budget as do firms who contribute a fixed amount to R&D undertaken overseas. Their R&D spend thus is of interest although they do no operate a formal R&D dept. R&D expenses were recorded as a percentage of turnover.

Table 5.3.0 Research and Development Spend -Companies Operating Formal R&D Dept.s. (1985, 1992, 2000)

	1985 R&D Spend	1992 R&D Spend	2000 R&D Spend
Median	0.6%	0.4%	0.75%
Range	100%	30%	30%
Qu	1.50%	1.00%	2%
Ql	0.1%	0.16%	0.33%
Midmean	0.64%	0.49%	0.78%
Unanswered	3	2	3
Formal R&D Depts.	16	18	18

Base:All Companies with formal R&D Depts. in years 1985, 1992, 2000.

Table 5.3.1 Research and Development Spend-All R&D Performing Companies.(1985, 1992, 2000)

	1985 R&D Spend	1992 R&D Spend	2000 R&D Spend
Median	0.2%	0.3%	0.5%
Range	100%	30%	30%
Qu	1.00%	1.00%	1.5%
Ql	0%	0.1%	0.2%
Midmean	0.27%	0.47%	0.57%
Unanswered	3	2	5

Base:All R&D performing companies.

The results indicate that R&D spend as a percentage of turnover is consistently higher for those firms operating formal R&D departments compared with general R&D performing companies. The median percentage of turnover spent for those operating formal R&D departments was 00.6%, 00.4% and 00.75% for the years 1985, 1992 and 2000 respectively. The corresponding median values taking an overview of all R&D performing food companies are 00.2%, 00.3% and 00.5%. The midmean values which are perhaps the most interesting descriptive statistics in this context reveal the middle 50% of firms operating R&D departments to be spending a mean of 00.64% in 1985, 00.49% in 1992 and anticipating a spend of 0.78% in 2000. The median R&D spend fell between 1985 and 1992 for those companies operating formal R&D departments. The reason for this decline may be explained by the growth in number of formal R&D departments operated. As more companies became involved the median figure decreased, affected by initially low spends of recently involved firms. However, overall the figures indicate an increasing percentage spend on R&D although the spend is low at less than 1% median spend anticipated in 2000. Mean calculations were not included as they would be a nonsense when one notes the fact that the R&D spend as a percentage of turnover ranges from 0 to 100% in 1985 and 0 to 30% in 1992 and 2000. The emerging firm included in sample spent 100% of turnover in 1985 on R&D and now invests 30% of turnover in R&D and anticipates to continue investment at this level to the year 2000.The spend of established firms ranged from 0.1% to 5% of turnover. Of the ingredient firms who responded spends indicated mirrored those of established food processors. It should be noted that all firms including those who declined to offer any concrete estimates of spending, past, present or future indicated an expectation of increased R&D spending within their own companies and worldwide in the future. However, three companies interviewed anticipate spending nothing on R&D in 2000 as they do not anticipate becoming involved in R&D.

Crosstabulation of evidence of interest in biotechnology by R&D spend in 1985, 1992 and anticipated in 2000 did not reveal any trends of any significance. Those firms who evidenced a previous interest in biotechnology were spread over a wide range of R&D spends as were those who had not. Comparison of results with secondary data detailing the R&D spend of technology performing food firms in an Irish and International context reveals some interesting trends.

Secondary data accessed indicates similar R&D spends among those Irish food firms identified as potential early adopters of new biotechnological techniques as all Irish R&D performing food firms. In 1982 the 40 indigenous food companies who were involved with R&D spent £4.1 million on this activity. This expenditure represented 0.2% of sales for these companies. It is noteworthy that in the report of the S.D.C. this expenditure was highlighted as being exceptionally low and the assertion was made that it should have been two to three times higher to equal international standards.[13] The data compiled on R&D performing potential early adopters of new biotechnological techniques also indicated a median spend of 0.2% among these food firms in 1985. The Eolas Business survey of 1991 indicated a similar R&D spend measured as a percentage of sales among general R&D performing food companies as those identified as potential early adopters of new biotechnological techniques. The Eolas figures indicated a spend of 0.3% of sales for R&D performing companies in the food, drink and tobacco sector.[14] The research undertaken on identified potential early adopters indicated a median spend of 0.3% among these firms generally although the median spend of those companies operating formal R&D departments was 0.4% of turnover. It would seem from these descriptive statistics thus that identified potential early adopters have similar R&D spending patterns as all Irish R&D performing food firms.

5.3.1 Comparison with International Food Firms.

In this section, as in the section which contrasted Irish food firms', R&D staff, size and skill profiles with those overseas, data relating to food related industries worldwide will be used for the purposes of comparison. The data available detailing the R&D spend of food companies in Europe and elsewhere indicates lower spending patterns evident among Irish companies relative to their International competitors. In the 1980s Angold, Beech and Taggart asserted that the following crude rule of R&D spending could be applied to UK food companies:

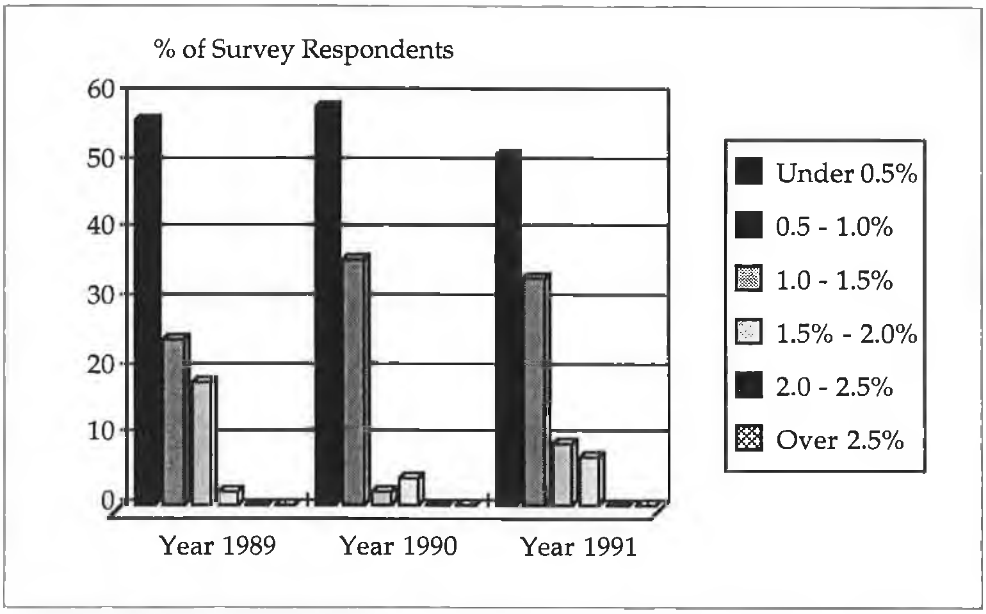
1. Multinational food manufacturers selling branded consumer goods will spend about 1% of sales revenue on R&D.

2. National companies making and selling branded consumer goods will spend about 0.5% of turnover on R&D.

3. Companies involved in commodity processing and trading will spend about 0.1% of turnover on R&D.[15]

In 1985 the R&D performing companies investigated in this survey were spending just 0.2% of turnover on R&D. They were in the main National companies thus the Sectoral Development Committee were correct in asserting at least compared to the UK, R&D spending in Ireland was low.[16] More recent information indicates that in 1992, US food companies spent on average 0.7% of sales on R&D.[17] This information is balanced by the finding that of the top US food companies included in the 1991 Food Processing survey, 84% asserted they spent less than 1% on R&D. In fact 51% spent less than 0.5%.[18] (Figure 5.3) In the light of this information an average spend of 0.7% reported by 'Business Week' seems high. However, whatever the exact percentage of sales spent on R&D in the US in 1991 and 1992 secondary data does indicate that spending was at least twice as high as that spent by Irish food firms at 0.3% of sales. If one compares Irish food firms' R&D spend with that of the large European food firms the deficiency noted is larger. R&D expenditures (1987) taken as a percentage of sales for large European companies are detailed in Table 5.3.2.

Figure 5.3 R&D Budget as a % of Sales for US Food Companies. (1989, 1990, 1991)



*Note: 30% of respondents include QA/QC in R&D budget

Source: Sweintek R.J. (1991),"14th Annual Survey -Top 100 R&D Trends" *Food Processing,* August, pp38-46.

Analysis of these figures reveals an average spend of 0.8% among the largest and most powerful European food companies. With increased consolidation of the European food industry, Irish food firms can no longer afford to ignore the practices of these larger competitors.

R&D spending in the food industry relative to the R&D spend in other industries is higher in Ireland than other OECD countries. In other words of all OECD countries the percentage of general manufacturing R&D expenditure spent on food is highest in Ireland. In 1985 14% of Irish general manufacturing R&D expenditure was allocated to food and in 1981 the proportion was one fifth. Thus, while R&D spending in the Irish food industry is inferior to that spent overseas, in terms of general spending on R&D in Ireland the sector is quite well funded.[19] (Table 5.3.3)

Table 5.3.2 R&D Expenditures as a Percentage of Sales for Large European Companies. (1987)

	R&D expenditure as % of sales
Bahlsen	0.8
Barilla	0.6
BSN	0.6
Cadbury Scheweppes	0.5
Ferrero	0.3
Nestlé	1.5
Parmalat	0.5
SME	1.2
Unilver	1.2
United Biscuit	0.4
average spend	0.8

Source: Petroni G.(1991), "New Directions for Food Research" *Long Range Planning*, vol.24, no.1, p.43.

Comparison is also made between the R&D spend of food firms generally and that spent by companies whose core of business is dedicated to the exploitation of new biotechnological techniques. It is necessary first to note the low level of R&D spending generally in the food sector compared with other manufacturing sectors. To illustrate, the data presented in Business Week in 1992 indicated an average R&D spend of 0.7% of sales for food companies. Comparable figures indicate the average R&D spends (taken as a percentage of sales) for healthcare firms was 9.0%, Office equipment and services 8.3% and Electrical and Electronics 5.8%.[20] The R&D spends of recognised successful biotechnology companies are in another league.

Table 5.3.3 Research and Development Expenditures by OECD Food Related Industry. (1988 except where otherwise noted)

million constant $ (1985 prices and ppp-purchasing power parities)

Country	Total (million) US $	Share of OECD Total	Share of Home General Manufacturing R&D.
Australia	52.7	2%	4.8%
Austria†	12.2	.4%	2.2%
Belgium	33.3	1.1%	2.4%
Canada	64.1	2.1%	1.9%
Denmark∫	29.6	1%	6%
Finland∫	16.3	.5%	3%
France	155.7	5.2%	1.6%
Germany∫	140.1	4.7%	1%
Greece	1.8	.06%	3%
Iceland∫	.512	.02%	11%
Ireland	18.196	.6%	14%
Italy	43.7	1.4%	1%
Japan	863.0	29%	3%
Netherlands	106.9	3.6%	5%
Spain∫	35.1	1.2%	3%
Sweden∫	46.7	1.6%	2%
UK	170.8	5.7%	2%
US∫	1162.7	40%	1.3%
Norway∫	5.6	.2%	1%
Switzerland*	17.2	.5%	1%
OECD Total	2976.208	100%	

* 1981 † 1984 ∫ 1987

Source: *Basic Science and Technology Statistics* (1991), OECD, Table 9.2.

In 1991 Business Week attributed the following R&D spends as a percentage of sales to five such companies.(Table 5.3.4) While it is recognised that a long lead time to the development of marketable products will have artificially inflated these figures, in terms of the percentage of sales allocated to R&D, it must be accepted that the R&D involvement of these companies is very much advanced compared with food firms. Statistics taken from Dibner's 'Biotechnology Guide to the USA' also presented in Table 5.3.4, indicate the absolute budget allocated by these companies to R&D in 1991. Budgets are many times greater than turnovers of many Irish food firms.

Table 5.3.4 R&D Spend for Selected Dedicated Biotechnology Companies.

	1991 R&D expenses as a % of Sales.	Total R&D Budget (1991)
Centacor	126.7%	$60,000,000
Chiron	115.7%	$50,230,000
Biogen	72.1%	$35,260,000
Genetics Institute	55.2%	$65,000,000
Genentech	46.3%	$173,100,000

Source: Anon (1992),"On a Clear Day you can see Progress" *Business Week*, June 29, p.55. and Dibner M. (1991), *Biotechnology Guide USA*, second edition, Macmillan Publishers Ltd.

Perhaps the most telling statistic however is that the average R&D budget for biotechnology firms involved with agriculture according to Mark Dibner is $4.5 million.[21]

5.3.2 Technological Capacity : Allocation of Scores.

The rationale for allocation of scores on this third indicator of technological capacity is perhaps the simplest explained. Results indicate that the R&D spend of Irish food firms compared with dedicated firms is miniscule. Yet Irish food firms are involved in some spending and their expenditure is predicted to increase, thus they deserve recognition of this activity in the scores. European firms on the other hand are indicated as spending twice as much as Irish firms and should receive twice as many points.

The R&D burn rate of dedicated firms insures they receive the maximum five points, Irish firms are allocated a half point to reflect the disparity of their spend and that of new biotechnology firms and

European firms are awarded twice that of Irish firms.

Table 5.3.5 Scores Allocated for R&D Spend.

Firms dedicated to the exploitation of new biotechnological techniques.	5 points
European food firms.	1 point
Irish food firms identified as potential early adopters of new biotechnological techniques.	0.5 points

5.4 Use of Relevant State Aid Programmes.

Use of relevant State aid programs was the final indicator of technological capacity identified and investigated. Results indicate that more than two thirds of those firms interviewed remain uninvolved with science development programs. Those who are involved are established food firms and tend to be larger cooperatives.(Table 5.4.0)

Table 5.4.0 Food Firms' Involvement with Science and Technology Programs.

	1992		Anticipated for Future	
	No. of respondents	Percentage	No. of respondents	Percentage
Involvement with Science and Technology Programs	8	30%	12	44%
No Involvement with Science and Technology Programs	19	70%	15	56%
Total Base: All Companies	27	100%	27	100%

As many programs as companies involved were mentioned. Reasons for non-participation offered included:

"No commercial benefit". (pre-competitive research)
"Never approached."
"Lack of funding."
"No involvement with R&D."
"No need."

These findings are supported by research undertaken by Jim Fitzpatrick and Associates in a report prepared for the EC Commission DGX11. The report entitled "Review of the EC R&D Framework Program in Ireland 1984-1988" presented details of an exploration into the characteristics and attitudes of participants and non-participants in EC programs. The programs included "all signed or performed DGX11 and DGV1 Irish contracts between 1984 and 1988 and all Irish Esprit and Race contracts from DGX11 and DGX111 Sprint Irish contracts."[22] Results of this study indicated very low levels of participation generally among private sector Irish firms in EC R&D programs, particularly among manufacturing companies. (Table 5.4.1)

Table 5.4.1 Public and Private Sector Involvement in EC Framework Program (1984-1988)

Sector	Category	% of Sector	% of Total
Public	Gov dept./Agency	32%	23%
	Higher Institute	67%	48%
	State Commercial Co.	1%	0%
		100%	72%
Private	Manufacturing	32%	9%
	Services	68%	19%
		100%	28%
TOTAL			**100%**

Source: J. Fitzpatrick and Associates and B. Wafer and Associates (1990), *Review of the EC Framework Program in Ireland 1984-88,* A Report to the Commission DGX11 Science, Research and Development.p.92.

Reasons found for non application and non participation of companies aware of programs are listed in Table 5.4.2 (The food, drink and tobacco sector represented 15% of firms interviewed)

Table 5.4.2 Non-Applicants: Main Reasons for Not Applying to Participate in EC Framework Program (1984-1988)

Reasons	% of those aware
No R&D undertaken at the time	2%
R&D is done by parent name	2%
R&D is financed by other sources	2%
Co. R&D does not fall into EC programs	6%
Programs are too specific and/or criteria are hard to define	2%
The company is very small	4%
There is a bias in approving companies to take part in program	2%
Application is a slow, bureaucratic, time consuming task	8%
The company does not have the specific information needed to apply	4%
Confidentiality	2%
There is no benefit/need	2%
Other	8%
No Response	58%
Total	100%

Source: J. Fitzpatrick and Associates and B. Wafer and Associates (1990), *Review of the EC Framework Program in Ireland 1984-88,* A Report to the Commission DGX11 Science, Research and Development,p.114.

It is interesting to note that in the Fitzpatrick study the perceived deficiency of pre-competitive research was not cited as a reason for non-participation. However in exploration of public and private sector objectives in undertaking R&D, Fitzpatrick found the most important overall objectives for Public sector contractors were:

Open new scientific areas (65%)

Acquire Basic Knowledge (65%).

On the other hand the most important overall R&D objectives for non-participating Private sector firms were :

Develop new products (79%).[23]

Thus, while the issue of the deficiency of pre-competitive research may not have emerged as a specific reason for non-participation in the

Fitzpatrick research, it is reasonable to assume that the needs of pre-competitive research are better serviced through EC programs than competitive. This would explain the predominance of public sector participation in such programs.

Focusing in more detail on the research undertaken on potential early adopters of new biotechnological techniques, the findings with regard to intention to become involved with Science and Technology programs in the future divide the food firms interviewed into two groups. The first group indicated an open mind on the issue and asserted any program would be assessed on a per project basis. The second group were more sceptical and repeated objections to pre-competitive research and it's lack of relevance to day to day activities. As might be anticipated 71% of those involved with scientific programs had evidenced to the researcher a prior interest in new biotechnological techniques and 66% of those anticipating future involvement had evidenced prior interest in new biotechnological techniques.(Table 5.4.3)

Table 5.4.3 Involvement with Scientific Programs by Basis of Selection: Evidence of Prior Interest in New Biotechnological Techniques or Turnover.

	Evidence Interest	Turnover
Involved	71.4%	28.6%
Anticipated Involvement	66.7%	33.3%

Base: All Companies.

The Fitzpatrick survey did not include any investigation of possible future participation or involvement with EC R&D programs.

However a secondary finding is of interest which concerns awareness an issue unexplored in this study. The findings of the Fitzpatrick study indicated 49% of non-applicants were aware of EC programs and 25% were aware of EC assistance for R&D in Biotechnology.[24]

5.4.1 Comparison with International Food Firms.

The research undertaken in addition to secondary data accessed indicates low levels of participation among Irish food firms and the private sector generally in State run science and technology programs. In this section the purpose is to make international comparisons of the level of State support for food related industries. However, the very diversity of programs undertaken in individual countries makes comparisons and particularly financial comparisons difficult. This problem is exacerbated when trying to make comparisons between countries where institutions and statistical practice may vary enormously. In this task thus data presented by Stevens in 1987 is used.[25] The following table details the amount of government research funds which were allocated to food related research in 1981 in selected OECD countries. Using these percentages as a guide, relative support of food related industries is highlighted. As may be seen from Table 5.4.4 government expenditures on R&D in food related industries is highest as a percentage of total government expenditure on R&D in the manufacturing sector in Ireland, Denmark, Spain and Iceland. In Ireland 8.8% of government financed R&D in manufacturing was allocated to food related industries in 1981. On average the OECD governments only allocated 1% of R&D spending to the food sector compared with 20-30% to electronics. However, this information must be regarded in context. The report of the expert group on the Irish food industry asserts that the food industry should benefit from a share in public research funds in proportion to it's importance in the economy. They estimate that the sector should benefit from around 23% of public research funds.[26]

Table 5.4.4 Food Sector's Share of Government Financed R&D in Selected OECD Countries. (1981)

1981(%) Share of government financed R&D in manufacturing	
Australia	^
Austria	5.3%
Belgium	2.4%
Canada	2.9%
Denmark	15.5%
Finland	1.7%
France	0.1%
Germany	0.4%
Iceland	6.7%
Ireland	8.8%
Italy	0.3%
Japan	0.7%
Netherlands	^
Norway	0.7%
Spain	6.5%
Sweden	2.2%
UK	0.3%
US	0.1%
OECD Total	0.9%

Source: Stevens C. (1987), "Technology and the Food Processing Industry"*S .T .I. Review* , OECD, p.23.

It is also useful to note R&D expenditure in food related industries by source of funds. Data taken from Basic Science and Technology Statistics 1991 indicates highest state involvement in food related R&D in Ireland, Denmark and Italy. (Appendix D Table 5.4.5) The task of undertaking a comparison of State support for the biotechnology industry in an International context is fraught with the same difficulties encountered in the investigation of State support for the food industry. Biotechnology policy differs tremendously between countries. However, secondary information indicates Irish firms benefit from similar levels of state support for biotechnological development as other European nations. Work aimed at the exploitation of the benefits associated with new biotechnological techniques is, in many areas, at a very preliminary stage. Thus it is reasonable to assume that the majority of food firms evidenced by this survey as unconcerned with pre-competitive research would be in the main unaffected by differing levels of State support for biotechnology in a food context.

5.4.2 Technological Capacity : Allocation of Scores.

With regard to the role of State support in determining the technological capacity of food firms' to use new biotechnological techniques it is necessary to consider State support both for food related R&D and support specifically targeted at the exploitation of new biotechnological techniques.

As the unit of comparison, dedicated new biotechnology firms are awarded the maximum five points on this indicator of technological capacity. Results indicate that State support for the food industry is stronger in Ireland than other European nations and State support for biotechnology is about parity in all European nations. The support of State funding in the promotion of the Irish food industry will be an important aid in the devlopment of technological capacity for Irish firms. Important, because of the poor private sector R&D spend in Irish food. The support and funding represents an important strength for Irish food firms considering building technological capacity and for this reason Irish firms are also allocated the maximum five points on this indicator of technological capacity. European food firms gain fewer points on this indicator of capacity as, although they receive similar levels of support to the progression of new biotechnological techniques as Irish firms, they do not benefit from generous funding of the food sector. (Table 5.4.6)

Table 5.4.6 Scores Allocated for Involvement in State Science and Technology Programs.

Firms dedicated to the exploitation of new biotechnological techniques.	5 points
European food firms.	3.5 points
Irish food firms identified as potential early adopters of new biotechnological techniques.	5 points

5.5 Technological Capacity to Use New Biotechnological Techniques.

Table 5.5 presents the points allocated to Irish and European food firms reflecting their perceived performance on each indicator of technological capacity. Points have been awarded to Irish and European food firms based on the research (primary and secondary) presented indicating their performance on individual indicators. Now, through comparison of the sum of scores for each firm type, the technological capacity of Irish food firms to use new biotechnological techniques can be compared with that of dedicated new biotechnology firm and of European food firms. It may be noted that points were allocated arbitrarily and specific scores are open to discussion. However, the rationale behind each score allocation has been presented and the system's strength lies in its ability to,

1. reflect the ranked performance of firms with regard to individual indicators of technological capacity investigated as well as to
2. compare in aggregate their technological capacity to use new biotechnological techniques.

Table 5.5 Technological Capacity of Irish and European Food Firms to Use New Biotechnological Techniques.

	Size and Skill Profile of R&D staff	Use of New Biotechnol-ogical techniques	R&D Spend	Use of State Resources	Total
Irish Food Firms	2	2	0.5	5	9.5
European Food firms	3	2	1	3.5	9.5
Firms dedicated to the exploitation of new biotechnological techniques	5	5	5	5	20

Allocation of scores indicates that the technological capacity of Irish food firms is about parity with their European competitors. The size and skill profile of Irish R&D staffs are deficient when compared with that indicated in a European context as is Irish R&D spend. However, State support for the food industry in Ireland is very strong and may aid development of the techniques in the absence of strong private sector commitment. Irish food firms thus may benefit from research undertaken in the public sector without undertaking important internal technological development. Both European and Irish food firms use basic level biotechnology. Using technological capacity as a primary indicator of response indicates that European food firms are responding similarly to the emergence of new biotechnological techniques as Irish firms. Both Irish and European firms rank a weak second with regard to technological capacity to use new biotechnological techniques as compared with firms dedicated to their use. Investigation of individual indicators of technological capacity revealed a weak performance from Irish and European food firms on three of the four indicators as compared with dedicated new biotechnological companies. It is reasonable to assume that considerable upgrading of technological capacity for Irish and European food firms is necessary for them to become involved with new biotechnological techniques.

5.6 Food Firms' Strategies for Involvement with R&D.

Three aspects of food firms strategies for involvement with R&D were explored; new product sourcing activities, allocation of R&D spend and internal and external strategies used to become involved in R&D.

5.6.1 Sourcing of New Products.

Respondent firms' strategies to source new products were investigated through use of the question; What percentage of product acquisition/ line improvement is the result of the following activities? The information presented in Tables 5.6.0 and 5.6.1 would indicate that the most popular method of sourcing new products is through applied research and will remain so to the year 2000. The middle 50% of firms currently source between 30% and 90% of new products through applied research and in the year 2000 between 31% and 78% of products are anticipated to be sourced in this manner. Other methods of sourcing are important for individual firms but results show that the majority of companies source new products through applied research complemented by low levels of involvement with licensing, basic research, co.acquisition, contract R&D and joint ventures. The emerging company interviewed displayed similar sourcing methods as established incumbents, and comparison of those firms involved with high value low volume production reveals a similar importance attached to applied research. However it is noteworthy that of the six firms anticipating sourcing some new products through basic research in the year 2000 two are high value low volume ingredient supply firms. (Appendix (D) Table 5.6.2)

Table 5.6.0 Sourcing of New Products.(1992)

	Median	Range	Qu	Ql	Unanswered
Licensing	.00%	10%	.00%	.00%	6
Basic Research	.00%	100%	2.5%	.00%	6
Applied Research	50%	100%	90%	30%	6
Co. Acquisition	.00%	70%	7.5%	.00%	6
Contract R&D	.00%	100%	17.5%	.00%	6
Joint Ventures	.00%	100%	7.5%	.00%	6

Base: All Companies.

Table 5.6.1 Sourcing of New Products.(2000)

	Median	Range	Qu	Ql	Unanswered
Licensing	.00%	10%	.00%	.00%	7
Basic Research	.00%	100%	13.75%	.00%	7
Applied Research	50%	100%	77.5%	30.75%	7
Co. Acquisition	.00%	70%	7.5%	.00%	7
Contract R&D	.00%	50%	10%	.00%	7
Joint Ventures	.00%	100%	17.5%	.00%	7

Base: All Companies.

5.6.2 Allocation of R&D Spend.

Results regarding the allocation of R&D spend underline the importance of in-house development for Irish food firms identified as potential early adopters of new biotechnological techniques. (Tables 5.6.3, 5.6.4, 5.6.5) The interquartile range shows that in 1992 between 50% and 92.5% of the R&D budget was spent on in house development for the middle 50% of firms. No other R&D activity was represented in the R&D budget in equal importance. However, individual firms allocate large proportions of R&D budget to activities such as purchase of technology, licensing, contract R&D and joint programs with firms and universities.

Table 5.6.3 Allocation of R&D Spend.(1985)

	In-House Development	Joint Program Firms/Uni	Purchase of Technology	Contract R&D
Median	50%	.00%	.00%	.00%
Range	100%	90%	100%	100%
Qu	92.5%	10%	7.5%	15%
Ql	.00%	.00%	.00%	.00%
Unanswered	1	1	1	1

Base: All R&D Performing Companies.

Table 5.6.4 Allocation of R&D Spend.(1992)

	In-House Development	Joint Program Firms/Uni	Purchase of Technology	Contract R&D
Median	80%	.00%	.00%	.00%
Range	100%	50%	100%	100%
Qu	92.5%	7.5%	2.5%	15%
Ql	50%	.00%	.00%	.00%
Unanswered	2	2	2	2

Base: All R&D Performing Companies.

Table 5.6.5 Anticipated Allocation of R&D Spend. (2000)

	In-House Development	Joint Program Firms/Uni	Purchase of Technology	Contract R&D
Median	70%	.00%	.00%	.00%
Range	100%	50%	100%	100%
Qu	90%	20%	5%	20%
Ql	50%	.00%	.00%	.00%
Unanswered	4	4	4	4

Base: All R&D Performing Companies.

The emerging firm investigated has moved from spending 100% of the R&D budget on in-house development in 1985 to now dividing the budget, 50% to in-house development and 50% to joint programs with other firms. Analysis of those firms involved with high value low volume ingredient production reveals a variety of different activities represented in importance in the R&D budget. Although in-house development is important other activities also command a high proportion of the R&D budget. Activities highlighted as commanding significant portions of the R&D budget include, purchase of technology and joint programs with firms and universities. (Appendix (D) Table 5.6.6)

5.6.3 Strategies for Involvement with R&D.

Results indicate that all strategies for involvement with R&D are popularly used with least popular strategies identified as, firm acquisition and joint programs with other firms. The percentage of companies involved or anticipating involvement in the strategies outlined are presented in Table 5.6.7 and Table 5.6.8.

Table 5.6.7 Internal and External Strategies Used to Become Involved in R&D.

Internal	%	External	%
Hire new staff	44%	Contract R&D	41%
Train staff	56%	Joint program with University	48%
Build facilities	52%	Joint program with firm	30%
Acquire firm	22%		
Base: All Companies			

Table 5.6.8 Internal and External Strategies Anticipated to Become Involved in R&D.

Internal	%	External	%
Hire new staff	30%	Contract R&D	37%
Train staff	48%	Joint program with University	37%
Build facilities	41%	Joint program with firm	26%
Acquire firm	15%		
Base: All Companies			

It is noteworthy that in discussion experts noted the importance of cost as a factor limiting their involvement with different strategies. Strategies carried out with universities were popularly with UCC and contract R&D undertaken with the research staff in Moorepark. Comparison of strategies used by those companies involved with high value low volume ingredient production does not reveal any new information. Strategies undertaken and anticipated were not unlike those indicated by established high volume food companies. The emerging firm had been involved in some novel strategies to become involved in R&D as it began life as a campus company and developed through a joint program with another firm. From the information presented it would seem to be continuing with joint type programs.

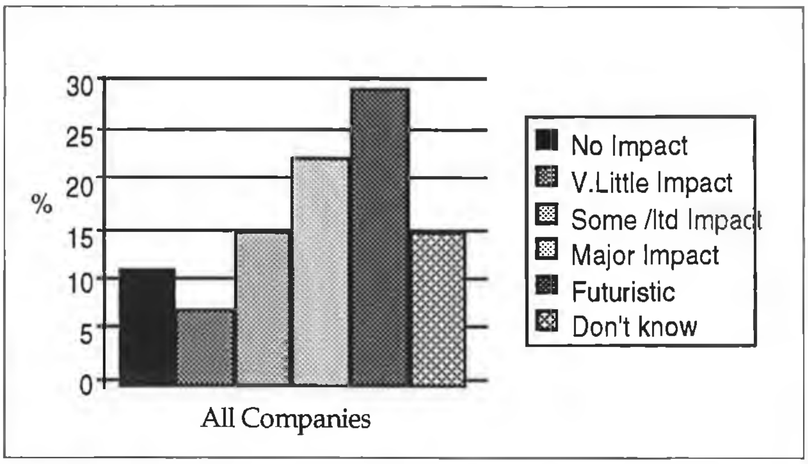
5.7 Attitudes to New Biotechnological Techniques.

Investigation of attitudes to the technological discontinuity caused by the emergence of new biotechnological techniques focused on three central issues, attitudes relating the impact of new biotechnological techniques on the Irish food industry, attitudes concerned with the regulatory environment, and attitudes regarding public perception issues.

5.7.1 Impact of New Biotechnological Techniques.

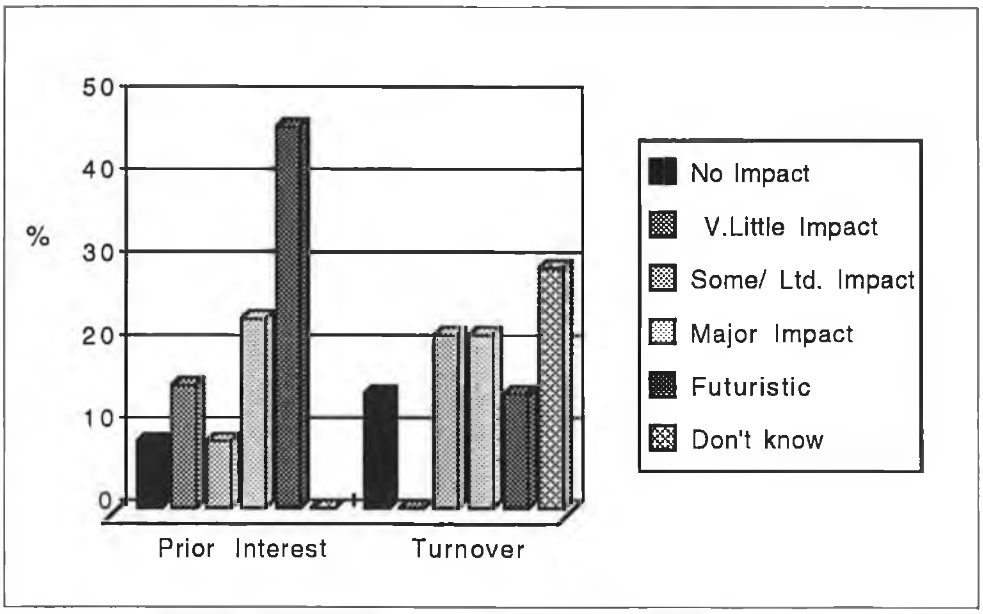
Respondents opinions were explored with regard to the impact they anticipated advanced biotechnological techniques might have on their industry, the food and drink sector of greatest impact, the greatest perceived barrier to use and their thoughts or plans concerning possible future involvement. Respondants opinions varied widely with regard to the predicted impact of advanced biotechnological techniques on the Irish food and drink industry to the year 2000.(Figure 5.4) Only 18% of those interviewed felt the techniques would have little or no impact and 66% felt the techniques would have an impact but were at variance in terms of when and to what extent. (28% felt the techniques would have an impact but futuristically well after the year 2000) No useful distinction can be made between the opinions of those involved with ingredient production and food processors. However, further analysis of the results (Figure 5.5) presents a distinction between the opinions of those respondants who had evidenced previous interest/involvement with biotechnological techniques and those who had not. Those who had been selected for interview because of their evidenced interest or involvement with new biotechnological techniques were more likely to feel that the impact of these techniques would be felt in the post 2000 years. The opinions of those firms who had not evidenced any interest or involvement to the researcher (selected for interview due to a high turnover) spanned the board. All of those who pleaded insufficient knowledge to make an impact assessment were also in the latter category

Figure 5.4 Predicted Impact of Advanced Biotechnological Techniques on the Irish Food and Drink Industry.



Discussion of predicted sector of impact, revealed varying views among respondents. From Figure 5.6 it may be noted that repondents feel the impact will be strongest in the Dairy, Brewing, Ingredients and Animal & Plant Breeding sectors. It should be noted however that in interview many respondents made the point that although advanced biotechnological techniques might offer huge potential for any particular sector the techniques might not be devloped or even used in that sector. The sector of impact might be simply using a product manufactured and developed elsewhere. They would be using the techniques "second hand". The example of genetically enginered starter cultures for use in the Dairy industry was often cited. These starter cultures would be developed and manufactured in the ingredients sector but used for production of yogurt etc in the Dairy sector.

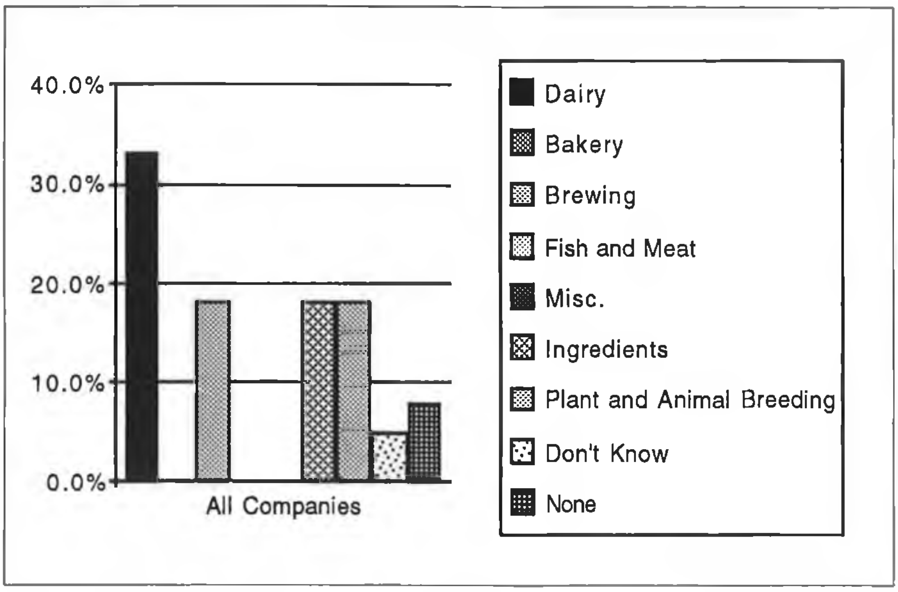
Figure 5.5 Predicted Impact of Advanced Biotechnological Techniques on the Irish Food and Drink Industry by Basis of Selection, Evidence of Prior interest or Turnover.



It may also be noted that the opinions of those with an evidenced interest in biotechnology were more likely to agree with the experts as to the sector of greatest potential impact. 38% of those selected because of evidenced prior interest in the techniques identified the Dairy sector as the sector of greatest potential impact compared with 29% of those selected due to a large turnover. It may be assumed that those who had evidenced a prior interest in/involvement with advanced biotechnological techniques are the most knowledgeable with regard to their potential.(Appendix (D) Figure 5.7)

The results from discussion of suggested barriers to adoption illustrated the importance of consumer resistance as a barrier to the continued and future use of advanced biotechnological techniques in the food and drink industry. Over 50% of all those interviewed noted consumer resisitance as a barrier to adoption and use.(Figure 5.8)

Figure 5.6 Predicted Food Sector of Impact



An interesting point to note about the next most popular barrier mentioned, 'Regulations' is that respondents discussed the regulatory environment as a barrier to the extent that it relates to labelling directives, thus underlining the importance of the public perception/ consumer resisitance question. Respondents felt if products were labelled as being genetically engineered then consumers might not accept them. Another point worth noting is that the consumer issue was not as important for those companies involved with high value low volume production as it was for those involved with high volume low value production. The most popular barrier to use for the former was a perceived lack of tangible benefits for the manufacturer inherent in the techniques. The point was made that firms would not adopt these techniques or any new technique unless the new technology offered a cost saving or other such benefit. One expert summed up the general feeling by asserting,

> "....they (advanced biotechnological techniques) will not be adopted for the sake of it".

Respondents were most vocal in discussion of this topic, and only two of those interviewed felt there were no barriers to adoption and future use. (Figure 5.8) As can be seen from Figure 5.9 no distinction can be made between the opinions of those who had evidenced prior interest in new biotechnological techniques and those who had not. Both groups clearly asserted the importance of potential consumer resistance as an issue determining the future adoption and use of advanced biotechnological techniques.

Figure 5.8 Perceived Barriers to Adoption of Advanced Biotechnological Techniques.

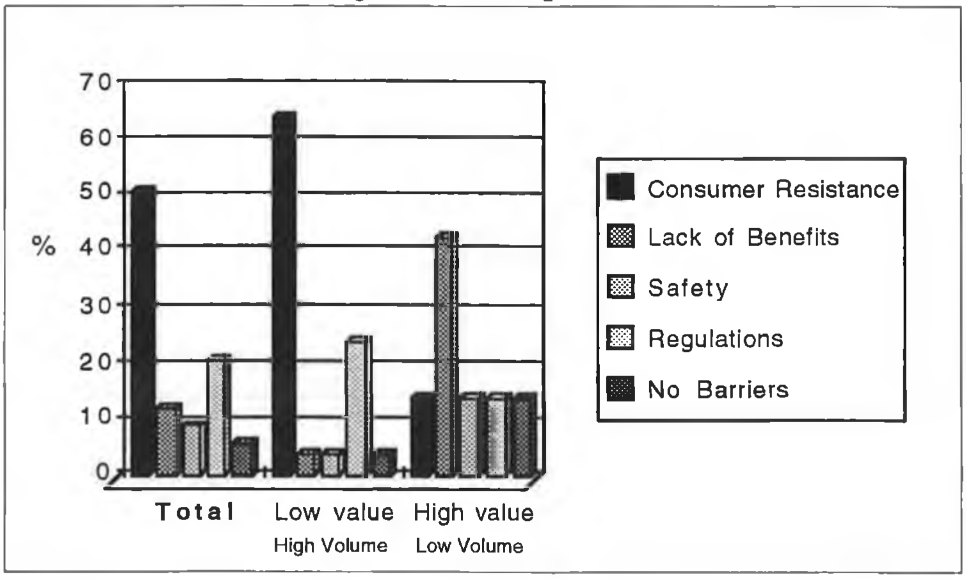


Table 5.7.0 outlines the intentions of respondents about becoming involved with advanced biotechnological techniques in the future. If all the 'positive' assertions, 'don't knows' and 'negative' assertions are amalgamated it may be seen that the majority of firms are keeping an open mind on the issue.(Figure 5.10) Over 50% of firms could envisage a scenario arising in which they would become involved. However 28% ruled out the possibility altogether.

Figure 5.9 Barriers to Use of Advanced Biotechnological Techniques by Basis for Selection, Prior interest or Turnover.

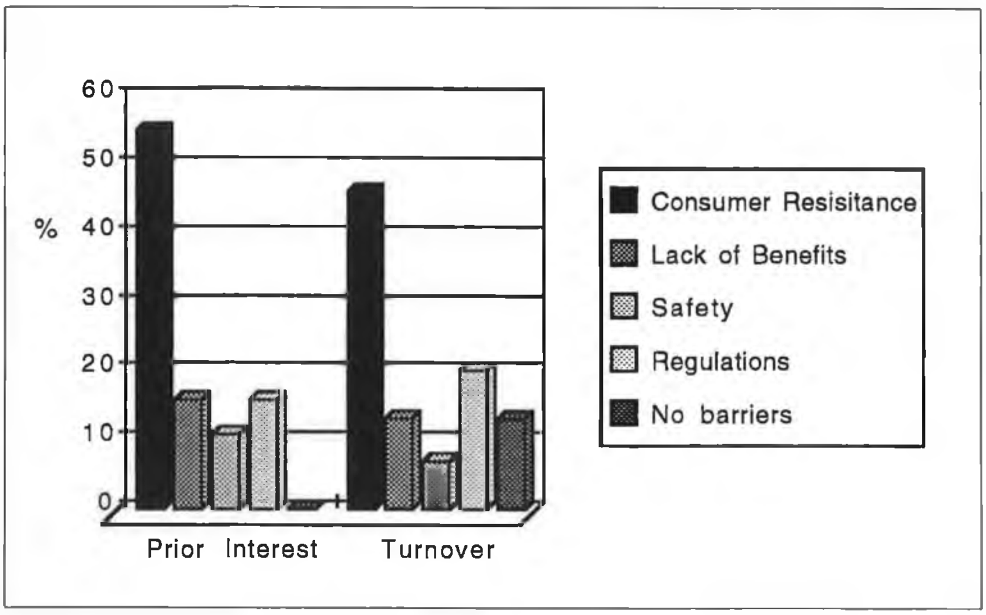


Table 5.7.0 Intention to Become Involved with Advanced Biotechnological Techniques with Reasons.

Will Become Involved - No Reason Given	4%
If Of Benefit Will Become Involved	42%
Will Become Involved through Seed Developments	8%
Will not become involved - No Resaon Given	20%
Will Not Become Involved - No Need	8%
Don't Know.	16%

As would be expected those who had evidenced to the researcher a prior interest or involvement with new biotechnological techniques were most likely to feel they might or would become involved in the future. (69% of those selected for interview due to evidence of prior interest compared with 50% selected due to a large turnover.) (Figure 5.11)

Figure 5.10 Intention to Become Involved with Advanced Biotechnological Techniques.

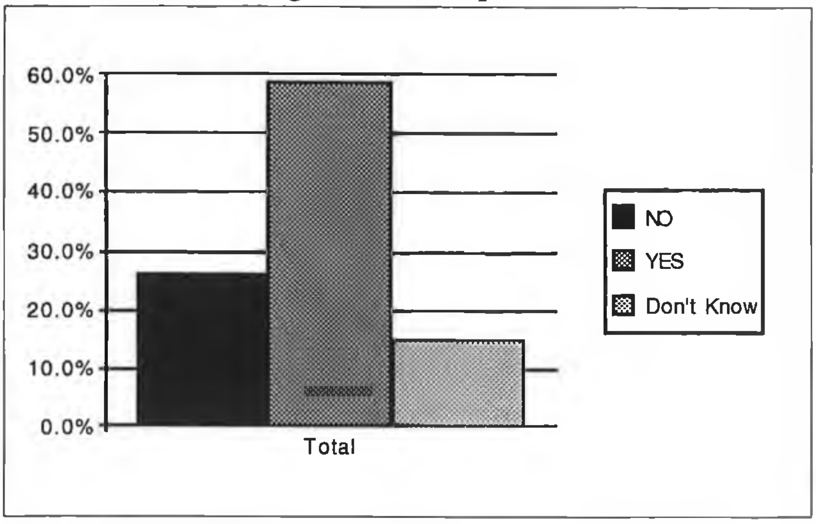
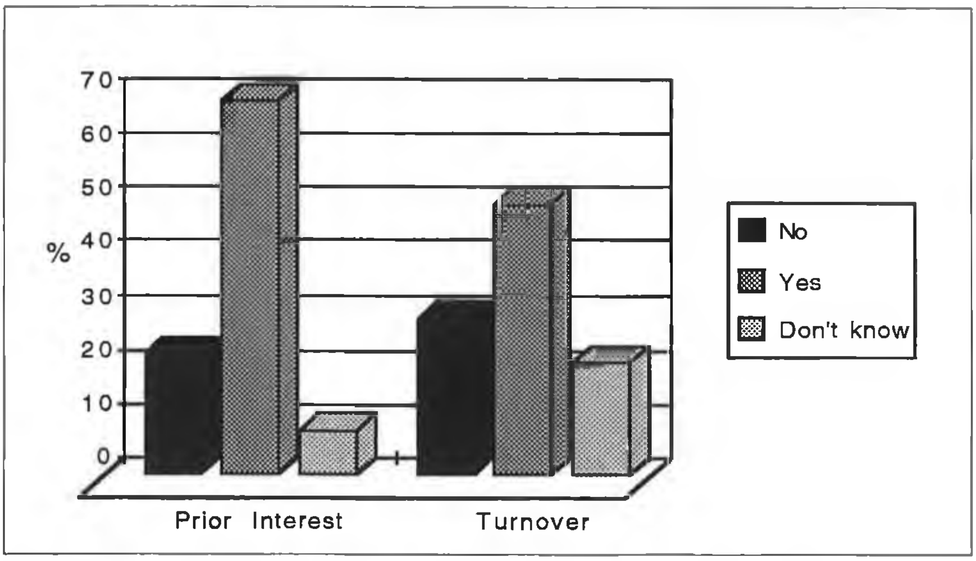


Figure 5.11 Intention to Become Involved by Basis for Selection, Evidence of Prior Interest or Turnover.

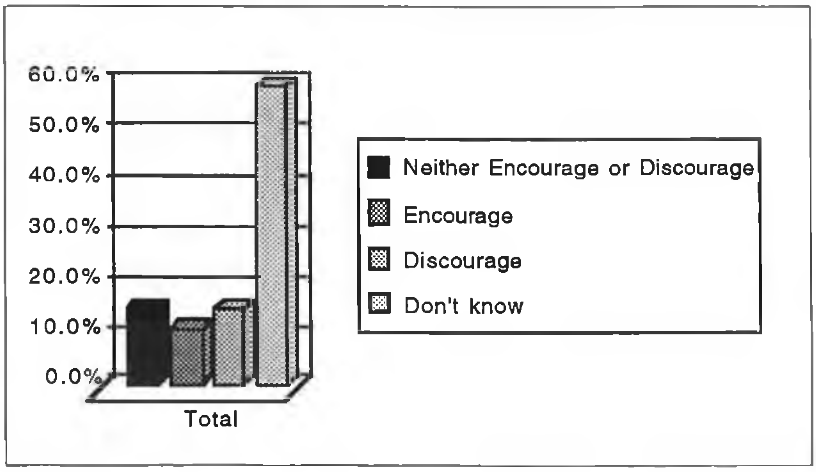


5.7.2 The Regulatory Environment.

It has been noted that the regulatory environment can affect the adoption and use of any new technology, not excepting new, biotechnological techniques. It was necessary thus to investigate the attitudes of those involved in food and drink firms with regard to the regulatory environment in Ireland. The issue of labelling was suggested for special attention by secondary sources. It has been noted as one of the more important regulations affecting the future adoption of advanced biotechnological techniques in the food and drink industry.

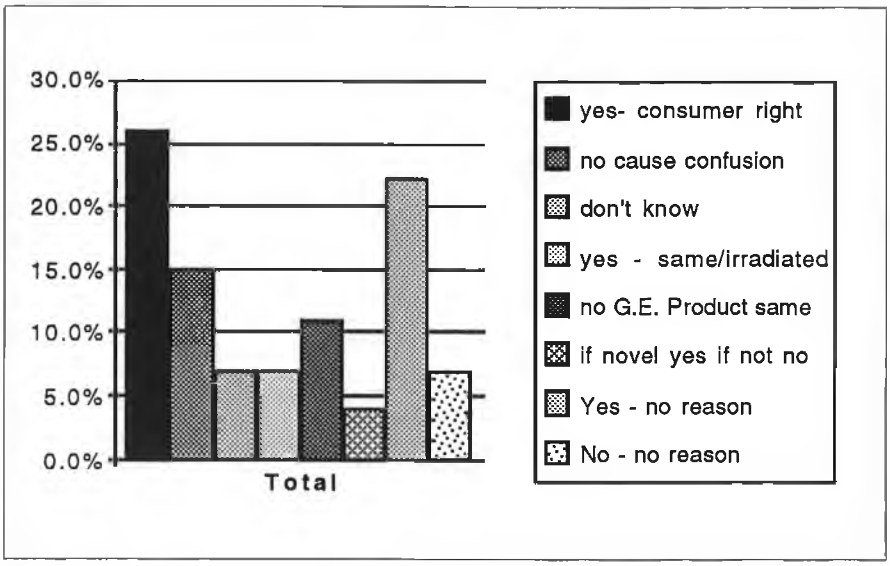
Over half of the companies interviewed have no comment to make about the regulatory environment. 58% of those interviewed either hadn't sufficient knowledge about the regulations to make an assessment, felt the regulations were not relevant to their activities and the general activities of firms in the food and drink sector or had no comment. (Figure 5.12) The common perception among those interviewed was that the regulatory environment governing the devlopment and use of new biotechnological techniques was irelevant to their work and involvement with biotechnology. In interview, it was perceived that those who expressed a view as to whether the regulations encouraged or discouraged work shared this view. It may be inferred thus from these findings that the regulatory environment does not affect the work of the majority of firms in the Irish food and drink sector. Results analysed in terms of those who had evidenced to the researcher some prior interest in biotechnology or new biotechnological techniques and those who had not did not yield any new finding

Figure 5.12 Perceived Affect of Regulations on Development and Use of New Biotechnological Techniques.



From Figure 5.13 it may be seen that there is a clear divide among the experts in the food and drink sector as to whether genetically engineered food and drink should be labelled as such.

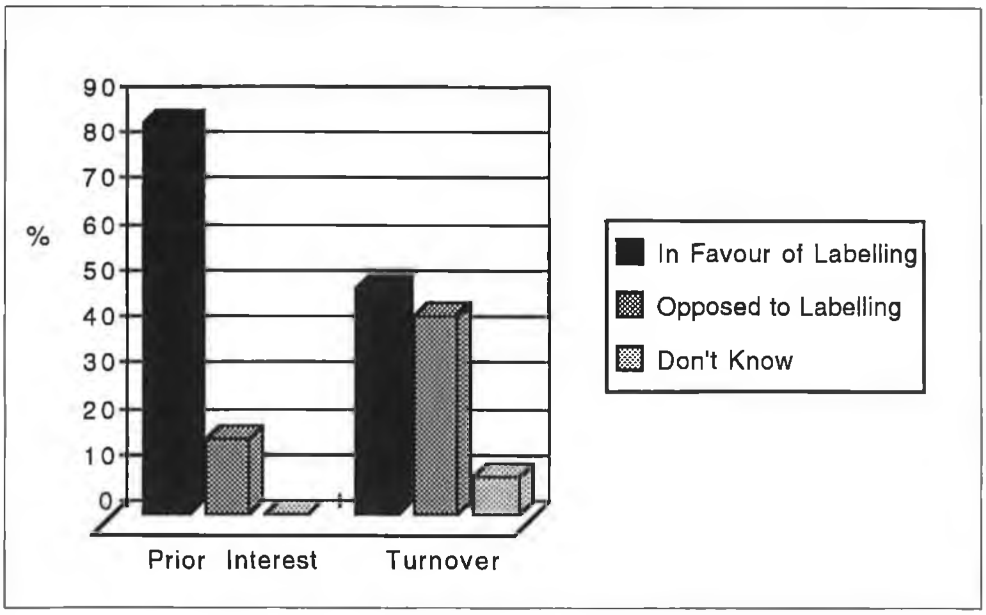
Figure 5.13 Opinions with regard to Labelling of Gene -Technology Foods.



Although the greatest percentage of respondents favour labelling as a consumer right, (26%) other reasons are given in support of non labelling such as the assertion that labelling might cause confusion among consumers. If those in favour are compared with those opposed disregarding the 'don't knows' the figures favour labelling. (59% v 33%) No useful distinction may be drawn between the opinions of those involved with high value low volume production and those involved with low volume high value production.
The results from further analysis show that those with a prior interest in advanced biotechnological techniques were the most likely to feel it was a consumer right that genetically engineered goods should be labelled as such. (46%) In total 85% of those selected for interview due to a prior interest in advanced biotechnological techniques were in favour of labelling, if for different reasons. However, the opinions of those with no evidenced prior interst were more dispersed, roughly half of these (43%) opposed labelling 49% were in favour and 8% gave

no opinion.(Figure 5.14)

Figure 5.14 Opinions with regard to Labelling of Gene-Technology Foods by Basis for Selection, Evidence of Prior Interest or Turnover.

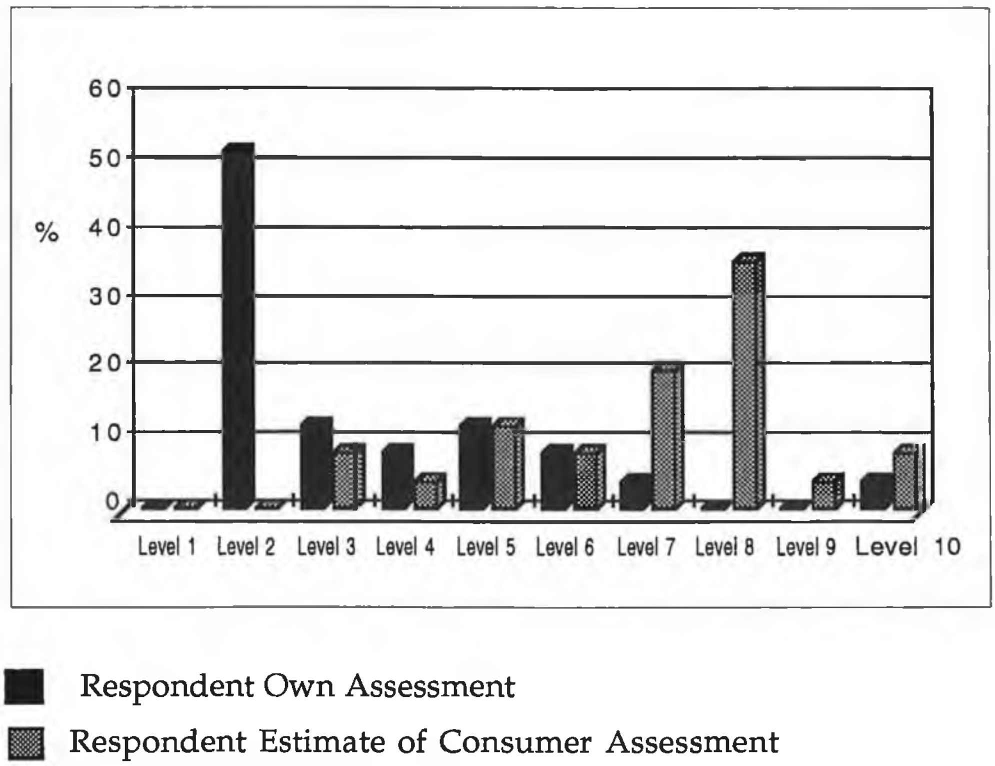


5.7.3 Public Perception of Gene-Technology Food and Drink.

Four questions were generated in order to investigate this topic. The questions explored experts' perceptions of consumers risk assessment of food and drink produced through use of advanced biotechnological methods and by comparison their own assessment of food and drink produced in this way. Exploration was also made of expert opinion with regard to expected consumer reaction to genetically engineered food and drink and contingency plans to deal with possible adverse reactions.

Respondents were asked to indicate on a scale of 1 to 10 (with 1=no risk, up to 10= very high risk) both their own numerical risk assessment of food and drink produced through advanced biotechnological techniques including genetic engineering and that of consumers. Two ingredient supply firms refused to give a risk assessment on the grounds that each new food would necessitate individual assessment. However, the results show a consensus emerging among those who did respond. All save two estimated the consumer risk assessment as higher than their own. Risk assessment scores are presented in Figure 5.15. Respondents' more ususal numerical risk assessment of food and drink produced through advanced biotechnological methods was 2(low risk) and their estimate of the consumers' risk assessment was 8 (high risk). Use of the interquartile range indicates that the middle 50% of firms numerical risk assessment of gene-technoloy foods was between 2 and 5 and their estimate of consumers' risk assessment was between 5.5 and 8. The findings here further support the argument that experts working in the food industry anticipate adverse cosumer reaction to gene-technology food and drinks. Comparison of the risk assessments of those involved with low value high volume production and those involved with high value low volume production does not reveal any significant findings.

Figure 5.15 Respondent Risk Assessment of Gene-Technology Foods and Estimates of Consumer Risk Assessment.



Almost complete agreement among those interviewed was noted as to the expected adverse reaction consumers will have to genetically engineered food and drink. 78% of those interviewed anticipated future adverse consumer reaction. Six experts however felt that consumers might not have an adverse reaction and their opinions were variously:

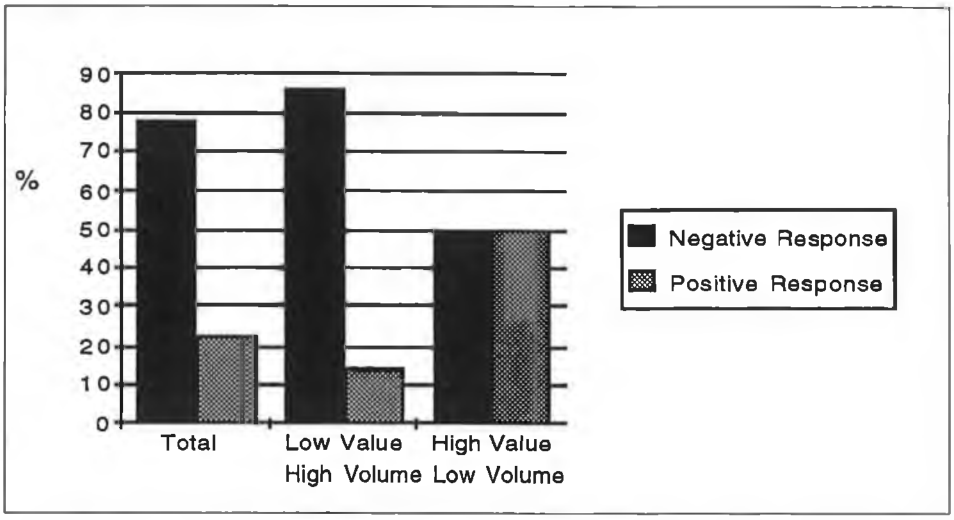
> "If the customer is ok (following consumption) then the response will be ok.. it will find its place."
> "Consumer reaction is lead by press reaction..."
> "If it's cheap enough they will eat it"
> "If it is properly advertised and promoted then no problem"

Due the the overwhelming response indicating an expected negative consumer response some of the comments are presented below.

> "with mistrust if presented as such"
> "Brutal"
> "With Doubt"
> "Conservatively"
> "Slow to accept... traditional consumers"
> "With confusion"
> "Strong bias against initially... if realised"
> "....ignorance...sceptical"
> "Poorly"
> "Badly"
> "Cautiously"
> "Hard to say...adverse reaction"
> "Badly ..lack of understanding .. genetically engineering whips up emotion but if explained....no difficulty"
> "Consumer might not realise, additives might be a bigger problem... wary, this is a worldwide phenomenon."
> "Unless parcelled properly ...will find objection"
> "Not Great" (sarcastically)

Ingredient supply firms were not as likely to anticipate an adverse consumer reaction to gene-technology food and drinks as high volume food processors. (Figure 5.16) Analysis of the responses in terms of those who had evidenced prior interest in biotechnology and those who had not, showed that a negative reaction was predicted equally by both groups.

Figure 5.16 Anticipated Consumer Response to Gene Technology Foods.

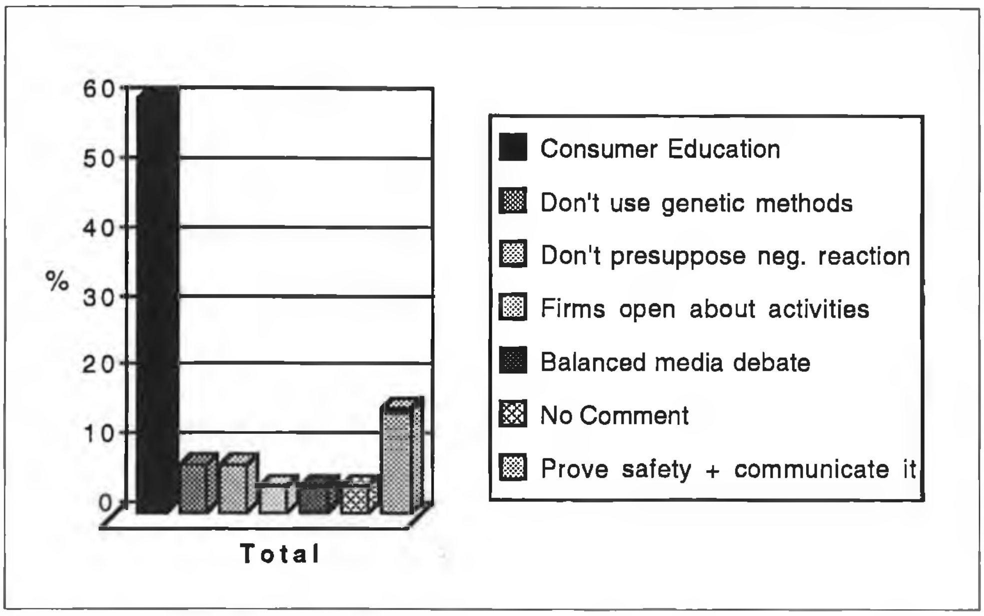


The most popular remedy suggested to combat possible adverse consumer reaction to genetically engineered food and drink was consumer education. (Figure 5.17) 60% of the total sample suggested this general remedy, and another 23% focused on particular aspects of consumer education such as balanced media debates, proof of safety and communicating this proof and the importance of food and drink firms becoming open about their development activitities. It is noteworthy however that two respondents felt that the situation could not be remedied through education, rather they felt the techniques should be dropped. Also, another two experts notably in the ingredient supply sample felt that adverse consumer reaction had not been noted and and should not be expected. As one respondent asserted;

"If it's not broken don't fix it".

Analysis of responses by basis for selection, evidence of prior interest new biotechnological techniques or large turnover did not yield any new information. The response of both groups were broadly similar.

Figure 5.17 Suggested Remedies to Anticipated Adverse Consumer Reaction.



5.8 Trends of Response Relating to Each Identified Determinant.

Findings indicated that the technological capacity of Irish firms was about parity with their European competitors. The technological capacity of Irish and European food firms to use new biotechnological techniques was indicated as deficient compared with dedicated companies. The scoring system used to draw together the four indicators of technological capacity resulted in the allocation of 9.5 points to identified potential adopting Irish food firms and European food firms respectively. Companies created to exploit the potential of new biotechnological techniques were allocated a maximum of 20 points. Using technological capacity as a primary indicator of response it may be assumed European firms as Irish firms investigated have not yet responded in any meaningful manner.

Exploration of the strategies used to become involved in R&D revealed an emphasis on in-house applied research among companies interviewed. Other strategies were used but only to complement this general thrust of R&D effort. Results of the exploration of attitudes to the emergence of new biotechnological techniques may be presented in three parts. With regard to the investigation of perceived future impact new biotechnological techniques might have on the food industry respondents were divided. Those who had evidenced to the researcher a prior interest in the techniques were most likely to feel the techniques would have an impact but futuristically - post 2000 and that the sector of greatest potential impact was the Dairy sector. These experts were also most likely to assert they could envisage a scenario emerging which might result in them becoming involved. The opinions of those who had not evidenced any prior interest were less defined and a consensus was not reached on any aspect of impact. Public perception issues were indicated as of paramount importance to the future adoption and use of new biotechnological techniques and an overwhelming majority anticipated adverse consumer reaction to gene-technology food and drinks. The regulatory environment was indicated as of importance solely as it related to possible compulsary labelling of gene-technology food and drinks.

Preceding results summarize the findings for the total sample in aggregate. Obviously individual firms and groups of firms performed differently on individual and all determinants of response.

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Chapter 6 Patterns of Response Inferred.

6.0 Introduction.

In this chapter trends of response to the technological discontinuity caused by the emergence of new biotechnological techniques are inferred through an appreciation of the three identified determinants of response:

Technological capacity to use new biotechnological techniques.
Strategies used to become involved in R&D.
Attitudes to the emergence of new biotechnological techniques.

Trends of response inferred are presented in the following manner. To begin, the general response noted of all potential early adopters of new biotechnological techniques interviewed is presented. Analysis is then made of the differences and similarities noted in the responses of;

Established incumbent firms investigated and the emerging firm investigated,

Firms involved with high volume low value production and firms involved with low volume high value food production, and

Firms selected for interview due to evidenced prior interest in new biotechnological techniques and those selected because of a large turnover.

6.1 General Pattern of Response Inferred for all Firms Investigated.

Thirty seven potential early adopters of new biotechnological techniques were identified in the Irish food industry. 73% of those identified responded to the investigation. These firms included established firms, and an emerging firm, firms involved with high value low volume production, and those involved with high volume low value production, firms who had evidenced to the researcher a prior interest in new biotechnological techniques and some who had not. They represented Dairy, Fish and Meat, Bakery, Brewing, Miscellaneous food production, Ingredients and Animal and Plant Breeding sectors of the Irish food industry. The aggregate response of these firms to the technological discontinuity caused by the emergence of new biotechnological techniques is inferred through an appreciation of their performance on the three identified determinants of response.

6.1.1 Analysis of Determinants of Response.

(i) Technological Capacity to use techniques: Analysis of firms' capacity to use new biotechnological techniques is included in Chapter 5. Results indicated that the capacity of firms interviewed to use new biotechnological techniques was deficient when compared with firms dedicated to their use. Taking each indicator separately:

R&D staffs employed, although better qualified than those present in European food firms were not of the same standard academically as those employed by firms dedicated to the exploitation of new biotechnological techniques. Doctorate level staff, most popularly employed by such firms are barely represented in the R&D departments of firms interviewed. R&D spends taken as a percentage of sales and in absolute figures were also indicated as deficient compared with that spent by dedicated firms. Results indicated use and intended use of biotechnology was at a basic level and did not include the exploitation of advanced biotechnological techniques. Use sophistication was indicated as in-line with that normally used by high volume low value food processors internationally. The single factor which indicated a possible future increase in technological capacity to use new biotechnological techniques is the significant government support which the Irish food industry enjoys.

In order to appreciate the wide chasm between the technological capacity of firms interviewed and those dedicated to the use of new biotechnological techniques it is useful to note that the scoring system developed to draw together the four indicators of technological capacity resulted in the allocation of 9.5 points to Irish food firms compared with a maximum of 20 points allocated to firms dedicated to their use. Results did indicate however that the technological capacity of Irish food firms interviewed is comparable to that of their European competitors. Both groups of firms were allocated 9.5 points respectively.

(ii) Strategies for involvement in R&D: Strategies for involvement with R&D indicated an overwhelming concentration on in-house applied research. Other strategies and methods to source new products and further research and development are used but only to complement this general thrust of R&D effort.

(iii) Attitudes to the emergence of new biotechnological techniques: Investigation of attitudes to the emergence of new biotechnological techniques revealed two important beliefs of firms interviewed.
On the one hand experts acknowledged and appreciated the potential offered by new biotechnological techniques to the food industry. 59% of those interviewed could envisage a scenario evolving which might result in them becoming involved, and sectors of greatest potential impact were identified as Dairy, Brewing, Ingredients and Animal and Plant breeding. On the other hand experts indicated that possible consumer rejection of gene-technology food and drinks represented a major deterrent to use. The salience of this issue for experts interviewed may not be over emphasised. The regulatory environment was discussed as a problem only as it related to possible compulsory labelling of gene-technology foods. Experts estimated consumer risk assessments of gene-technology foods as much higher than their own and an adverse consumer reaction to food produced through advanced biotechnological methods was anticipated by almost all respondents.

6.1.2 Inferred Response.

Analysis of the three determinants of response would not indicate any significant involvement of potential early adopters interviewed with new biotechnological techniques. The primary indicator of response investigated was technological capacity and results indicate firms interviewed have not the capacity to use the techniques, nor are any significant increases in technological capacity anticipated in the future. Strategies for involvement in R&D are centred on in-house applied research. Involvement with basic research, critical for the development of emerging technologies is minimal to zero. Attitudes reflect an appreciation of the techniques potential but also a realisation of public perception problems possible through use. Using Daly's description of options available to firms following a technological discontinuity, firms interviewed are indicated as availing of options,

> " Do Nothing or
> Monitor only."[1]

Analysis of identified determinants of response did not indicate any first hand involvement with the techniques thus supporting the hypothesis that firms interviewed following the technological discontinuity caused by the emergence of new biotechnological techniques are 'doing nothing'. However approximately half of those interviewed were included in the judgemental census of potential early adopters of new biotechnological techniques because they had evidenced to the researcher a previous interest in new biotechnological techniques. (Table 4.2) It is reasonable therefore to assume that some firms although remaining uninvolved with the techniques are undertaking a monitoring strategy. Using Hamilton's typology of strategy available following a technological discontinuity firms interviewed may be categorised as using the 'Opening Windows' strategy.[2] This involves monitoring and identification of important technologies.

The inferred 'Do nothing' or 'Monitor only' response to the emergence of new biotechnological techniques contrasts with research undertaken in 1990 which indicated 11 Irish food and drink firms were involved with biotechnology R&D. These companies were in the Dairy, Ingredients and Alcoholic Beverage sectors. However the definition of biotechnology used in that piece of research was very broad and did not necessarily encompass new biotechnological techniques.(Appendix (E)) The screening criteria required only that the company be actively involved in biotechnology research and development in Ireland as a means towards innovation, either through in-house or contracted R&D activi]ties.[3]

The rationale suggested for potential early adopters of new biotechnological techniques interviewed availing of identified options and strategies following the emergence of new biotechnological techniques is as follows:

1. A factor identified as important, by the literature accessed, in the process of diffusion of a new technology in industry is the perceived risk associated with adoption.[4] For firms interviewed, results show the risk associated with adoption of new biotechnological techniques is enormous. Food firms highlighted the salience of public perception issues as affecting adoption. They pointed out they do not wish to be associated with any technology however powerful if consumers regard the products possible through use as potentially harmful. Perceived risk associated with adoption and use thus has resulted in firms remaining uninvolved and in some cases 'monitoring only'.

2. Mansfield has noted the probability of diffusion and adoption of an innovation is a decreasing function of the size of investment required.[5] Comparison of the technological capacity of potential early adopters interviewed with that of firms dedicated to use of the techniques has highlighted the huge investment necessary for firms interviewed to

become involved. This is another factor which has lead firms interviewed to 'Do nothing' or 'Monitor only'.

3. Webster has indicated that a factor which tends to retard diffusion includes the degree to which increased technical skills are required to use the innovation.[6] Analysis of the size and skill profile of R&D workforces of firms interviewed highlighted the considerable upgrading necessary for firms to use new biotechnological techniques. This has also supported the continuing non-involvement strategy of firms interviewed.

4. Finally, literature accessed indicated that the relative advantage afforded by an innovation has been identified as a primary determinant of whether it is adopted in an industrial market.[7] For firms interviewed results indicate the relative advantage to be gained through use of new biotechnological techniques is not clear. The techniques as noted in literature accessed have been slow to realise their potential and as yet it is difficult to identify in a food context an immediate relative advantage afforded through use. In sum examination of results would indicate firms interviewed are responding to the emergence of new biotechnological techniques by 'Doing nothing' or 'Monitoring only'.

6.2 The Inferred Response of Established and Emerging Firms.

The distinction between established and emerging firms is an important one in the development of a new technology. In this survey the judgemental census of food firms identified as potential early adopters of new biotechnological techniques included two emerging firms and thirty five established incumbents. This sample reflected trends of interest in new biotechnological techniques noted in the Irish food industry. The sample achieved contained one emerging firm and twenty six established incumbents.

Table 6.0 Sample Achieved - Emerging and Established Firms.

	No. of firms
Emerging firms	1
Established Incumbents	26
Total	27

The bulk of firms interviewed thus were established incumbents. Such firms as defined by Hamilton have positions in a particular industry or market to which applications of a new technology may be directed.[8] In this survey established incumbents interviewed included food co-operatives, brewing, baking, and miscellaneous food firms as well as food ingredient firms. For all of these firms new biotechnological techniques represent another, albeit powerful, tool which may or may not be adopted for use in manufacture and/or research and development work. An emerging firm however is defined as one

> "created to exploit a new technology."[9]

For the purposes of this survey the emerging firm identified and interviewed was a high technology plant breeder. Detailed examination of findings however raised the question whether this firm was mis-classified as an emerging new biotechnology firm but rather is an emerging firm based on biotechnological techniques available prior to the advances referred to as new biotechnological techniques.

6.2.1 Analysis of Determinants of Response.

Analysis of results revealed the response of established incumbent firms, due to their dominance in sample reflected the aggregate response of all potential early adopters interviewed. However, a slightly different pattern of response was indicated from examination of findings relating to the emerging firm interviewed. Focus on the results relating to the performance of the emerging firm reveals the following trends:

(i) Technological Capacity to use techniques: The primary factor of note was the primacy of the R&D department and R&D activities to the general functioning of the emerging firm as compared with established incumbents. Almost half of those employed in the emerging firm were employed in the R&D department and half of these were educated to higher degree level. Trends of R&D staff employment thus were similar to R&D staff employed in all dedicated new biotechnological firms. Degree level staff were most popularly employed in the R&D departments of established incumbents. R&D spend as a percentage of sales for the emerging firm was also indicated as high at 30% in 1992 and anticipated to remain so. The percentage had formally been 100%. Secondary data accessed indicated that R&D spend taken as a percentage of sales is normally high for dedicated companies. The R&D spend as a percentage of sales for established incumbents was popularly indicated as between 0.1% and 5%.

In terms of use sophistication of biotechnology the results were perhaps surprising. The emerging firm interviewed asserted that it used Level 1 or most basic biotechnology in manufacture and R&D and intended to continue use at this level into the future. The most popular level of use for established incumbents was Level 2 in manufacture and R&D. Similar to established incumbents the emerging firm benefits from significant government support of the Irish food industry, although results indicate it had not been involved with State science and technology programs in the past.

Overall the technological capacity of the emerging firm was indicated as superior to that established incumbents. Results indicated it undertook similar trends of R&D employment to dedicated firms and also spent similar amounts taken as a percentage of sales as such firms. However, it did not use biotechnology at an advanced level and it is for this reason that this firm's classification as an emerging firm, created to exploit new biotechnological techniques, is questioned. It's staff, size and skill profile and R&D spend would indicate it is such a firm. However, it does not use biotechnology at an advanced level and is not involved with State science and technology programs directed towards the development of these emerging technologies. Because of this the firm perhaps might be more correctly classified as a high technology firm based on use of biotechnology in general rather than new biotechnological techniques.

(ii) Strategies for involvement in R&D: Strategies used to become involved in R&D were very similar to those reported used by established incumbents. Applied in-house research and development was indicated as important, although novel strategies had been used in previous years. The company started life as a campus company and used classic strategic alliances to combine it's core technical assets with innovation-specific complementary assets of an established firm to develop new plant products.

(iii) Attitudes to the emergence of new biotechnological techniques: Attitudes to the emergence of new biotechnological techniques were very similar to those expressed by established incumbents. The emerging firm appreciated the potential of advanced biotechnological techniques but emphasised the salience of public perception issues in dictating their use and adoption in the food industry.

6.2.2 Inferred Response.

Results indicate that the response of established incumbent firms is very similar to the aggregate response of all firms interviewed. It may

be assumed thus that following the technological discontinuity caused by the emergence of new biotechnological techniques these firms are 'Doing nothing' or 'Monitoring only'. Analysis of results regarding the identified emerging firm however indicated a firm with a superior technological capacity to use the techniques to that of established incumbents but yet not as advanced as dedicated companies. Strategies used to become involved in R&D were similar to those used by established incumbents, if formally more novel, as were attitudes.
If we accept that this company has been misclassified as an emerging company as defined by Hamilton - created to exploit new biotechnological techniques, and is more correctly defined as a high technology company based on biotechnology (for reasons outlined in the preceding section) it is easier to analyse it's response to the emergence of new biotechnological techniques. The firm is not yet involved with new biotechnological techniques, yet it has the technological capacity to use them, it has used novel strategies in the past to become involved in R&D and expresses similar attitudes to the emergence of new biotechnological techniques as established incumbents. From this information it is reasonable to assume that this firm is also monitoring the techniques following their emergence and may or may not become involved in the future. If however a decision was made to become involved adoption might be more expedient in this firm compared with established incumbents due to it's superior technological capacity. Results show the company can envisage a scenario emerging where it might become involved if the technologies afforded advantage to activities.

6.3 The Inferred Response of Firms Involved with High Volume Low Value Production and those Involved with Low Volume High Value Production.

Literature accessed has highlighted the applicability of new biotechnological techniques to the work of low volume high value food ingredient suppliers as compared with high volume low value food processors who may use the techniques second hand in the purchase of genetically engineered ingredients for use. In the judgemental census of food firms identified as potential early adopters of new biotechnological techniques, 28 high volume low value food processors were identified and 9 low volume high value ingredient supply firms. The sample achieved included 6 low volume high value supply firms and 21 high volume low value food processors.

Table 6.1 Sample Achieved - High Volume Low Value Food Processors and Low Volume High Value Supply Firms.

	No. of Firms
High volume Low value Food Processors	*21*
Dairy	10
Brewing	2
Fish and Meat	2
Bakery	3
Miscellaneous	4
Low Volume, High Value Supply Firms	*6*
Ingredients	5
Plant breeding	1
Total	27

6.3.1 Analysis of Determinants of Response.

In this section presentation is made of the similarities and differences noted in the trends of response of firms involved with high volume low value production and those involved with high value low volume production. Analysis of results pertaining to the latter is hampered due to the poor response rate among such companies and findings should be treated with caution.

(i) Technological capacity to use techniques: Crosstabulation analysis revealed the technological capacity of high volume low value food processors was not significantly different to that indicated by all firms interviewed. On the other hand only two high value low volume ingredient firms indicated that they operate a formalised R&D department in Ireland, two undertake R&D overseas, one is uninvolved in R&D and one refused to give details of R&D staff. (Appendix (D) Table 5.1.1) Those who operated R&D departments in Ireland employed similar numbers of scientific staff as high volume low value processors. Staff were indicated to be more academically qualified in the R&D departments of high value low volume ingredient firms. Details were not recorded of overseas R&D departments although, as noted respondents indicated overseas departments tended to be large and well staffed. Literature has indicated the applicability of new biotechnological techniques or Level 3 use to such firms. Findings indicated however, similar use sophistication among high value low volume supply firms as high volume low value food processors. (Level 2) No difference was noted between the R&D spend of high volume low value processors and high value low volume supply firms. Both groups benefit from government support to the Irish food industry. Results show supply firms remain uninvolved with State science and technology programs whereas considerable involvement was indicated among high volume low value processors.

The technological capacity of high value low volume supply firms was indicated thus as very similar to that of high volume low value processors. The former tended to employ a greater proportion of more academically qualified staff but indicated less involvement with State science and technology programs to the latter.

(ii) Strategies for involvement in R&D: Findings indicated high volume low value supply firms used slightly more novel strategies for involvement in R&D than high volume low value food processors.

Supply firms tended to indicate more involvement with strategies such as purchase of technology and joint programs with firms and universities. High value low volume supply firms also represented one third of those who anticipated sourcing future products through basic research.

(iii) Attitudes to the emergence of new biotechnological techniques: It was in the exploration of this the last identified determinant of food firms' response to the technological discontinuity caused by the emergence of new biotechnological techniques that the greatest differences were noted between the response of high volume low value processors and high value low volume ingredient supply firms. Low volume high value supply firms did not attach the equal importance to the public perception issues dictating future adoption and use of new biotechnological techniques as high volume low value processors. This difference in attitude was particularly evident in the exploration of attitudes with regard to the greatest perceived barrier to use of new biotechnological techniques and suggestions for remedies to possible adverse consumer reaction to gene-technology foods. For supply companies the greatest barrier to use was not as indicated for processors the possible adverse reaction of consumers to gene-technology foods but rather the perceived lack of benefits inherent in the techniques use. Also when asked for suggestions to possible adverse consumer reaction supply firms gave answers such as

> "if its not broken don't fix it."

Two high value low volume supply firms maintained that adverse consumer reaction had not been noted and should not be anticipated. Analysis of findings would indicate that the attitudes of high value low volume supply firms towards the emergence of new biotechnological techniques tend to stem from the functional aspects of these technologies and the relative advantages of use. The potential of the techniques was appreciated as by high volume low value processors but a comparable emphasis not attached to public perception issues affecting adoption.

6.3.2 Inferred Response.

Inferring a response to the technological discontinuity caused by the emergence of new biotechnological techniques through an appreciation of the three identified determinants of response is difficult for high value low volume supply firms due to the poor response rate to questions posed. In particular the response to questions concerned with measurement of technological capacity was poor. However, the findings indicate respondent firms, have similar technological capacity to high volume low value processors, use slightly more novel strategies for involvement in R&D and are more involved with basic research than processors. Such firms also express a more functional attitude to new biotechnological techniques and do not attach equal importance to public perception issues as dictating use. Without further investigation of the technological capacity of such firms it is difficult to state conclusively their response to the emergence of new biotechnological techniques. In particular research needs to conducted on the capacity of R&D departments overseas to use new biotechnological techniques as many firms indicated they benefit from the work of these departments.

With the limited information available it is hypothesised high value low volume supply firms have more involvement with new biotechnological techniques than food processors. The determinants of response indicate such firms are involved with basic research an important prerequisite for the development of an emerging technology, R&D personnel tend to be more academically qualified then those employed by processors, the perceived risk associated with involvement is not as great for these firms as processors due to the lack of importance attached to issues of public perception and finally results presented earlier indicated many food processors believe ingredient supply firms are using advanced gene-technologies. Using Daly's framework of options available to firms following a technological discontinuity it may be hypothesised that low volume high value ingredient supply firms are moving from a strategy of 'Monitoring only' to 'Participation in some manner'. However, in the absence of more detailed information it is impossible to state what level of participation individual firms are pursuing. Analysis of results pertaining to high volume low value processors indicates a similar response to that noted for all firms interviewed. Using Daly's options such firms may be categorised as 'Doing nothing' or 'Monitoring only'. It is interesting to note that many high volume low value processors indicated they felt they might be using new biotechnological techniques second hand in ingredients purchased. In total 86% of processors asserted that they purchase high value low volume ingredients, thus the response of such supply firms will directly affect the response of low value high volume processors.

6.4 The Inferred Response of Those Selected for Interview Because of Evidenced Prior Interest and Those Selected Due to a Large Turnover.

The researcher's objective in choosing the sample was to obtain a judgemental census of potential early adopters of new biotechnological techniques in the Irish food industry. To achieve this the sample was chosen using three lists. Two of the lists identified food firms with a previous interest in new biotechnological techniques, the third identified food firms in decreasing order of turnover. In this section presentation is made of the differences and similarities in the inferred response noted between firms who had evidenced to the researcher a prior interest in new biotechnological techniques and those chosen for interview solely by virtue of a large turnover. The sample achieved included 12 firms who had evidenced to the researcher a prior interest in new biotechnological techniques and 15 firms chosen solely by virtue of turnover.(Table 4.2)

6.4.1 Analysis of Determinants of Response.

(i) Technological capacity to use techniques: Crosstabulation of evidence of interest in new biotechnological techniques by the various indicators of technological capacity reveals few significant findings. Those who had evidenced to the researcher a prior interest in the techniques indicated similar R&D staffs employed, similar use sophistication of biotechnology and similar R&D spends as those who were chosen for interview solely by virtue of their turnover. However, in analysis of firms' current and intended involvement with State science and technology programs, results indicated, as might be anticipated, firms most involved were those who had evidenced an interest in the techniques. 71% of those involved in State science and technology programs had evidenced a prior interest in new biotechnological techniques and these firms represented 66% of those who anticipated future involvement. Apart from increased involvement in science and technology programs noted with regard to those firms who had evidenced a prior interest in new biotechnological techniques, a relationship was not indicated between evidence of interest in the techniques and technological capacity to use them.

(ii) Strategies for involvement in R&D: Analysis of strategies for involvement in R&D by evidence of interest in new biotechnological techniques did not reveal any new findings. Similar strategies, sourcing methods and R&D spend allocations were indicated by both groups of respondent firms.

(iii) Attitudes to the emergence of new biotechnological techniques: Analysis of firms attitudes to the emergence of new biotechnological techniques did reveal some interesting findings with regard to the differences of opinion held by those who had evidenced a prior interest in new biotechnological techniques and those who had not. As noted in Chapter 5 those companies who had evidenced to the researcher a prior interest in new biotechnological techniques were more likely to feel that; advanced biotechnological techniques will impact on the food industry but futuristically (post 2000), the sector of greatest potential impact will be the Dairy sector and that gene-technology food and drinks should be labelled as such. (85%) On the other hand companies identified as potential early adopters but which had not evidenced a prior interest in new biotechnological techniques did not reach a consensus as to the predicted impact of advanced biotechnological techniques on the food industry, did not identify a single most important sector of impact and were divided as to the merit of labelling gene-technology foods. Those who had evidenced a prior interest were also most likely to envisage a scenario presenting itself which might result in them becoming involved with the techniques (76%) compared with 50% of those chosen for interview solely by virtue of a large turnover. If one assumes that those who evidenced to the researcher a prior interest in new biotechnological techniques are the most knowledgeable it is evident that the informed view is that new biotechnological techniques will have an impact on the Irish food industry but futuristically - post 2000, that the sector of greatest potential impact is the Dairy sector and gene-technology food and drinks should be labelled as such. Crosstabulation of evidence of interest in new biotechnological techniques by other attitudes measured did not reveal any new findings. Similar attitudes were expressed by both groups.

6.4.2 Inferred Response.

Analysis of determinants of response to the technological discontinuity caused by the emergence of new biotechnological techniques revealed significant differences in the response of firms who had evidenced a prior interest in the techniques and those who had not. Results showed that those who had evidenced a prior interest were most likely to be involved with State science and technology programs and were most likely to agree as a group that the techniques would impact on the food industry but futuristically - post 2000, that the sector of greatest potential impact will be the Dairy sector and that gene-technology food an drinks should be labelled as such. These firms were also indicated as most likely to become involved in the future. Those chosen for interview solely by virtue of turnover on the other hand were unlikely to be involved in State science and technology programs and could not reach a consensus regarding any issue concerned with the future use of new biotechnological techniques in the food industry. Using Daly's series of options available to firms following a technological discontinuity it is reasonable to assume firms who had evidenced to the researcher a prior interest in new biotechnological techniques are 'Monitoring only'. They are most knowledgeable about the techniques and have become involved in State science and technology programs. Those firms chosen for interview by virtue of turnover are indicated as 'Doing nothing'. Results indicate these firms are less knowledgeable about the techniques and remain uninvolved in basic state sponsored science and technology programs.

6.4 Summary of Findings.

Findings indicate that the aggregate response of all identified potential early adopters interviewed to the technological discontinuity caused by the emergence of new biotechnological techniques may be inferred as 'Doing nothing' or 'Monitoring only'. Explanations for food firms' continuing uninvolvement with the techniques were taken from the literature accessed. Research has shown adoption and diffusion of new technologies in industry is a decreasing function of the perceived risk of involvement, the size of investment required for involvement and the increased technical skills necessary for use. Findings indicated all of the above factors have contributed to retarded diffusion of new biotechnological techniques in the Irish food industry. Findings also indicated the relative advantage afforded through use of new biotechnological techniques was not apparent to food firms interviewed and this had also contributed to retarded diffusion and adoption of the techniques. Analysis of the response of established incumbents and the emerging firm interviewed resulted in the recategorisation of the emerging firm as a high technology company. Detailed exploration of this firm's technological capacity to use the techniques highlighted the fact that it could not be accurately described as an emerging firm as defined by Hamilton - created to exploit new biotechnological techniques. The inferred response of established incumbents was 'Do nothing' or 'Monitor only' and the high technology company interviewed was indicated as 'Monitoring only'.

Exploration of the response of high value low volume supply firms was hampered due to the poor response rate to questions posed. However, through an appreciation of the determinants of response, and other background information it was hypothesised that such firms may be moving from a monitoring strategy to 'Participation in some manner'. The response of high volume low value food processors was indicated as 'Do nothing' or 'Monitoring only'. Findings highlighted the fact that 86% of such companies use high value low volume ingredients in manufacture, therefore the response of low volume, high value ingredient supply firms has a direct impact on the response of processors. Analysis of the difference and similarities in the responses of those who had evidenced to the researcher a prior interest in new biotechnological techniques and those who had not indicated that those who had evidenced an interest were most correctly categorised as 'Monitoring only'. Those chosen for interview solely by virtue of a large turnover were most accurately categorised as 'Doing nothing'.

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Chapter 7 Conclusions and Recommendations.

7.0 Introduction.

Conclusions and recommendations are presented under four headings. Initially conclusions are presented specific to each of the three determinants investigated; technological capacity to use new biotechnological techniques, strategies for involvement with R&D, and attitudes to the emergence of new biotechnological techniques. Finally, conclusions and recommendations are presented relating to responses inferred for firms interviewed.

In analysing the following conclusions it must be acknowledged that they were reached through the investigation of firms identified as potential early adopters of new biotechnological techniques. The extent to which the conclusions can be generalised or said to apply to the 800 remaining firms in the Irish food sector is unknown. Respondents represent the leading edge and are identified potential innovators with regard to use of new biotechnological techniques in the Irish food sector. Other firms particularly non-technology performing companies might perform very differently in response to the emergence of new biotechnological techniques.

It is recommended that non-technology performing firms be included in any future investigations. As ingredients produced through advanced biotechnological techniques become increasingly available the techniques' impact will no longer be confined to technology performing companies. Firms will not have to use the techniques to become involved. Technology and non-technology performing companies alike will be obliged to make a decision regarding inclusion of genetically engineered components in their food products. Research is recommended to investigate possible similarities and differences in the decision processes of those considering involvement through use and, alternatively, those considering involvement through inclusion of genetically engineered ingredients in production. Technology performing firms identified as potential early adopters through use were the focus of this research.

7.1 Technological Capacity to Use New Biotechnological Techniques.

Technological capacity was identified as the primary determinant of response. Food firms' performance on this determinant indicated their ability to use the techniques. Indicators of technological capacity used in the study were; size and skill profile of R&D staff, use sophistication of biotechnology in manufacture and R&D, R&D spend as a percentage of sales and current and intended involvement with State science and technology programs. From the investigation of size and skill profile of R&D departments it may be concluded:

> Identified potential early adopters of new biotechnological techniques have similar R&D staff profiles as all technology performing Irish food firms.
>
> R&D staffing levels per unit of production are similar in Irish food firms as European food firms.
>
> Taken in absolute figures Irish food firms do not employ sufficient R&D personnel to create a 'critical mass' necessary for the development of new biotechnological techniques.
>
> R&D personnel employed by Irish and European food firms are severely underqualified compared with those employed by dedicated new biotechnology firms.

Use of the scoring system revealed that Irish identified early adopters were ranked third on this indicator of technological capacity. (Table 7.0)

The size and skill profile of R&D staffs employed by Irish food firms are insufficient to use advanced biotechnological techniques.

Table 7.0 Performance Rankings on First Indicator of Technological Capacity: R&D Staff, Size and Skill Profile.

1. Firms dedicated to the exploitation of new biotechnological techniques.	5 points
2. European food firms.	3 points
3. Irish food firms identified as potential early adopters of new biotechnological techniques.	2 points.

Conclusions relating to the investigation of use sophistication of new biotechnological techniques are as follows:

The most popular level of biotechnology use in manufacture among Irish food firms identified as potential early adopters of new biotechnological techniques is Level 2. This level of use corresponds loosely to techniques available in advance of the developments associated with new biotechnological techniques.

The majority of firms interviewed anticipate using Level 2 in manufacture to the year 2000. Use of more advanced techniques is not anticipated.

Level 2 is most commonly used in manufacture by the

International food processing sector.

Level 1 (use of basic or classical biotechnological techniques) and Level 2 use is most favoured in R&D although three firms anticipate using Level 3 or advanced biotechnological techniques in R&D in the year 2000.

A belief exists in the food industry that selected ingredients purchased may be produced using advanced biotechnological methods or Level 3.

Firms dedicated to the exploitation of new biotechnological techniques are by definition using advanced biotechnological techniques or Level 3 in manufacture and R&D.

Biotechnology use sophistication of Irish and European food firms is equal although basic compared with that used by new biotechnology firms.(Table 7.1)

Table 7.1 Performance Rankings on Second Indicator of Technological Capacity: Use Sophistication of Biotechnology.

1.Firms dedicated to the exploitation of new biotechnological techniques.	5 points
2.European food firms.	2 points
2.Irish food firms identified as potential early adopters of new biotechnological techniques.	2 points

From the investigation of R&D spend it may be concluded:

The median R&D spend for Irish firms is 0.3% taken as a percentage of sales.

The R&D spend of European food firms is indicated as twice that of Irish food firms.

The R&D spend for dedicated new biotechnological companies ranges from 46.3% to 126.7% taken as a percentage of sales.

The R&D spend of Irish firms identified as potential early adopters is low compared with European firms but minimal compared with dedicated new biotechnology firms.(Table 7.2)

Table 7.2 Performance Rankings on Third Indicator of Technological Capacity: R&D Spend.

1. Firms dedicated to the exploitation of new biotechnological techniques.	5 points
2. European food firms.	1 point
3. Irish food firms identified as potential early adopters of new biotechnological techniques.	0.5 points.

The following conclusions emerged from investigation of firms' current and intended involvement with State science and technology programs:

State support for the Irish food industry is high compared with other European countries.

Low levels of participation are indicated among food firms in particular and the Irish private sector in general with State science and technology programs.

Irish firms benefit from similar levels of State support for the development of new biotechnological techniques as their European competitors.

Generous government support of the Irish food industry coupled with uniform European support to the development of new biotechnological techniques resulted in the maximum allocation of 5 points to identified potential early adopters on this indicator of technological capacity.(Table 7.3)

State support is an important factor contributing to increased technological capacity for potential early adopters of new biotechnological techniques in the Irish food industry.

Table 7.3 Performance Rankings on Fourth Indicator of Technological Capacity: Use of State Science and Technology Programs.

1. Firms dedicated to the exploitation of new biotechnological techniques.	5 points
1. Irish food firms identified as potential early adopters of new biotechnological techniques.	5 points.
2. European food firms.	3.5 point

It is recommended that research should be undertaken to explore methods of increasing the participation rate of private companies in State science and technology programs. In the progression of new biotechnological techniques, involvement in State science and technology programs could be an invaluable asset for food firms. Research which identified methods of increasing participation and satisfaction with State run programs may be instrumental in the future development and use of new biotechnological techniques. For the purposes of comparison participation rates in State science and technology programs were assumed equal among European and Irish food firms.

Assimilation of scores and rankings on individual indicators presented in Table 7.4 lead to the following overall conclusions regarding technological capacity:

Table 7.4 Technological Capacity of Irish and European Food Firms to Use New Biotechnological Techniques.

	Size and Skill Profile of R&D staff	Use of New Biotechnological techniques	R&D Spend	Use of State Resources	Total
Irish food firms.	2	2	0.5	5	9.5
European food firms.	3	2	1	3.5	9.5
Firms dedicated to the exploitation of new biotechnological techniques.	5	5	5	5	20

European food firms command similar technological capacity to use new biotechnology firms as Irish food firms identified as potential early adopters of the techniques.

European and Irish food firms need considerable upgrading of their respective capacities in order to use new biotechnological techniques.

Dedicated new biotechnological firms record far superior performance on three of the four indicators of technological capacity as compared with Irish and European food firms.

> In using technological capacity as a primary indicator of response, it may be concluded that both Irish and European food firms are incapable of using the techniques and have not yet responded in any positive sense.

That European firms are similarly indicated as incapable of using the techniques implies that an opportunity exists for Irish firms to build technological capacity in tandem, if not in advance, of such firms and perhaps benefit from first mover advantages. However, results indicate a significant increase in technological capacity is not anticipated by firms interviewed thus it may be presumed identified potential early adopters do not anticipate using the techniques in the future. On the other hand factors which may influence their decision on possible future direct involvement, or more probable indirect involvement include the regulatory environment and public perception issues. Conclusions reached relating to the investigation of these issues are presented in the following sections.

Future research is recommended to involve primary investigation of identified potential early adopters of new biotechnological techniques in the European food industry. Secondary data used in this study which described the activities of European food related industries in general may have diluted the performance of potential early adopter European food firms on individual indicators.

7.2 Strategies for Involvement with R&D.

The second identified determinant of response investigated was strategies for involvement with R&D. The following conclusions emerged:

The most popular method of sourcing new products is applied research and will remain so to the year 2000.

The vast majority of the research budget is spent on in-house development.

A diverse range of strategies have been used and are anticipated to become involved with R&D.

Strategies outlined for involvement with R&D indicate an emphasis on in-house applied research which precludes any involvement with advanced biotechnological techniques. R&D undertaken owes more to product testing procedures than fundamental or basic research with food. Strategies explored in this study were those used to become involved with R&D generally. Literature outlined the particular strategy patterns associated with involvement with new biotechnological techniques. It is recommended that future research is undertaken which investigates this phenomenon in an Irish context. Anticipated adverse consumer reaction however may create difficulties in the recruitment of firms willing to speak about strategies specific to potential involvement with new biotechnological techniques.

7.3 Attitudes to the Emergence of New Biotechnological Techniques.

This was the final determinant of response investigated, conclusions are presented below.

66% of respondents felt new biotechnological techniques would have an impact on the food industry but were at variance in terms of when and to what extent. 28% felt the techniques would have no impact on their industry.

Sectors of greatest potential impact were identified as Dairy, Brewing, Ingredients and Animal and Plant breeding.

The greatest barrier to use was identified as anticipated consumer resistance.

54% of respondents could envisage a scenario arising in which they would become involved with the techniques. 28% ruled out the possibility of becoming involved.

The regulatory environment governing development and use of new biotechnological techniques was indicated as irrelevant to the work of Irish food firms.

Respondents were divided as to the merit of labelling gene - technology foods. 58% were in favour, 33% against.

Respondents indicated a numerical risk assessment of food and drink produced through advanced biotechnological techniques as 2 (low risk) and their estimate of consumers' risk assessment was 8 (high risk).

78% of those interviewed anticipated an adverse consumer reaction to gene-technology food and drink.

The most popular remedy suggested to combat possible adverse reaction was education.

Respondents appreciate the potential of new biotechnological techniques for their industry but are also aware of the possible public perception problems use of the techniques might incur.

Investigation of attitudes indicated the uncertainty which surrounds future use of new biotechnological techniques. Research is recommended to track consumer attitudes to gene-technology food and drink into the future. This is of particular importance as products become more available and the public is made more aware of the implications of use. Research will indicate whether experts' anticipation of adverse reaction is accurate. Consumer response to gene-technology food and drinks is of equal importance both to those firms considering involvement through use and those considering indirect involvement by purchase of gene-technology ingredients. Research is also recommended to investigate consumer attitudes to labelling of gene-technology foods. Experts are divided as to the merits of labelling. Detailed exploration of consumers views may aid generation of appropriate regulations.

Literature accessed indicated that with increasing awareness of new technologies comes increasing concern.[1] In 1989 awareness of biotechnology was found to be very low among Irish adults.[2] In the absence of widespread media debate it is reasonable to assume this level of awareness remains. Ireland thus is the perfect setting in which to investigate this phenomenon through the implementation of a longitudinal study tracking awareness and concern into the future.

A final recommendation for research stems from an identified strength of the Irish food industry; our green and environmentally clean image.[3] Research is recommended to investigate whether future involvement with new biotechnological techniques might enhance or discredit this perception of Irish produced food and drinks. The results of this research would be of particular interest to food firms developing into new competitive markets and increased value-added production. Although, literature accessed indicated the existence of a trend towards increased technological input in food products [4] the merits of the techniques' use must be weighed against possible attendant public perception problems. It is recommended that responsibility for this research might be taken by the State and results used to develop a comprehensive policy for future industry-wide involvement with new biotechnological techniques. An agreed policy regarding involvement, whether through use or second hand through ingredients purchased, must be put in place if the green and environmentally clean image of Irish products is in any danger. The pace with which products are being developed through use of new biotechnological techniques necessitates that this research be undertaken as soon as possible. Decisions on the inclusion of genetically engineered components in food products which may have far reaching consumer perception consequences are been taken in the present time dimension.

7.4 Responses Inferred.

Through an appreciation of firms' performance with regard to the three identified determinants of response examined a pattern of response was inferred for those firms interviewed. Patterns of response were categorised according to Daly and Hamilton frameworks of strategy available following a technological discontinuity.[5] It may be concluded:

> The general response of food firms interviewed to the emergence of new biotechnological techniques has been to 'Do Nothing' or 'Monitor only'.

Firms have not the technological capacity to use the techniques and use applied research for involvement in R&D. Although they are aware of the potential of new biotechnological techniques for their industry, anticipation of adverse public reaction discourages involvement. Factors identified as retarding involvement and use are the perceived risk associated with adoption due to anticipated adverse consumer reaction, the size of investment required to build technological capacity to use new biotechnological techniques, and the fact that relative advantage afforded through use for many is as yet unclear.

Particular groups of firms were identified as pursuing slight modifications on this general pattern of response. Evidence of prior interest in the techniques was indicated as an important factor discriminating between 'Monitoring' or 'Do nothing' strategies. Results indicated those who had evidenced a prior interest were more knowledgeable about the techniques and also most likely to be involved in State science and technology programs thus indicating a 'Monitoring' strategy. On the other hand those who had not evidenced any prior interest in the techniques tended to be uninvolved with State science and technology programs and were often confused regarding the potential applications of new biotechnological techniques in the food sector. Such firms were indicated thus as 'Doing nothing'. It may be concluded thus:

> Firms who had evidenced to the researcher a prior interest in the techniques are pursuing a 'Monitoring' strategy and those who had not are 'Doing nothing'.

Production activities were also hypothesised as a discriminating factor dictating response. Findings indicate high value low volume supply firms have similar technological capacity as high volume low value processors, use slightly more novel strategies for involvement with R&D and are more involved with basic research than processors. Most importantly however, they express a more functional attitude to new biotechnological techniques than processors and do not attach equal importance to public perception issues discouraging use. Due to the poor response rate among this sector it is impossible to state with any degree of accuracy their response to new biotechnological techniques. However it is hypothesised that these firms are moving from a 'Monitoring' strategy to 'Participation in some manner'. The following indicators of increasing involvement form the basis for this hypothesis:

(i) Processors feel such firms may be involved.

(ii) The techniques have primary application in the ingredient sector.

(iii) R&D personnel employed in low volume high value firms tend to be more skilled than those employed in other Irish food firms.

(iv) Findings indicated more involvement with basic research necessary for the development of an emerging technology and less importance attached to public perception issues discouraging use among these firms. It is hypothesised thus that:

> High value low volume ingredient supply firms are moving from monitoring to a strategy of 'Participation in some manner'. Low value high volume processors are indicated as 'Doing nothing' or 'Monitoring only'.

Firm status was not indicated as a discriminating factor dictating response. Established incumbents were indicated as involved with 'Monitoring 'and 'Doing nothing' strategies and the emerging firm based on technologies available in advance of new biotechnological techniques was indicated as 'Monitoring'. Research is recommended to identify an emerging new biotechnology firm in the Irish food industry and to track it's development.

> Established incumbent firms are undertaking 'Monitoring' or 'Do nothing' strategies and the emerging firm interviewed although better qualified to use the techniques than established firms is also involved in a 'Monitoring' strategy.

It may be concluded thus responses of identified potential early adopting food firms may be divided in to three broad categories. Those who are 'Doing nothing' in response to the techniques, those who are 'Monitoring only' and those which are hypothesised as moving from a 'Monitoring' strategy to 'Participation in some manner'.

Conclusions indicate that for most potential early adopters identified in the Irish food industry use of new biotechnological techniques is neither anticipated nor desired. Such firms only anticipate possible future involvement 'second hand' through the use of genetically engineered ingredients. The sole group for which possible future direct use was indicated were high value low volume ingredient supply firms. It is recommended that future research studies are tailored to the individual requirements of direct or indirect use. The research requirements of direct users which include high value low volume ingredient suppliers are estimated as greater than those anticipating indirect involvement. In addition to consumer reaction to gene-technology food and drinks which may influence their derived demand curve, such firms need to be aware of the optimum strategies to become involved with new biotechnological techniques and methods to increase technological capacity. In an Irish context research is recommended to investigate the potential market for gene-technology ingredients. Recently the report of the expert food group highlighted the potential of the ingredient industry for the Irish food sector.[6] Detailed exploration of this market characterised by derived demand may indicate the profitability of involvement with and use of new biotechnological techniques for such firms. Subject to a finding indicating growing demand for gene-technology ingredients research is recommended to undertake a detailed investigation of the technological capacity of low volume high value ingredient firms and their strategies to become involved in R&D compared with dedicated firms and similar firms active overseas. Exploration of technological capacity and optimum strategies used to become involved with new biotechnological techniques would also be of interest to emerging new biotechnology firms.

The research interests of indirect users however are more basic as these firms are primarily concerned with consumer reaction to food products containing genetically engineered components. Relevant research studies have been recommended previously and include investigations of consumer awareness and response and the implications for the perceived image of Irish produced food products.

Research undertaken in this study outlined an industry to which new biotechnological techniques may be applied. It may be concluded that, if the products of biotechnology are to be used in this industry they will be produced elsewhere. Possible future direct involvement is only anticipated by low volume, high value ingredient firms. The majority of Irish food firms remain uninvolved with the techniques and do not foresee direct involvement in the future. Irish food firms are indicated as market rather than technology driven.

References.

1. Office of Technology Assessment, U.S. Congress (1987), *New Developments in Biotechnology: Public Perceptions of Biotechnology,* OTA-BP-BA-45, US. Government Printing Office, Washington D.C.

2. *Attitudes to Biotechnology* (1989), An Omnibus Survey prepared for BioResearch Ireland Ltd., by Lansdowne Market Research.

3. P.A. Consulting Group (1992), *The Food Industry - a Report by the P.A. Consulting Group to the Industrial Policy Review Group.* Stationery Office, Dublin.p.6.

4. Young J.N. (1991), *The Food Industry of the Future,* Leatherhead Food R.A. London. p.12.

5. Daly P. (1985), *The Biotechnology Business - A Strategic Analysis,* Frances Pinter Ltd., London pp.107-108 and Hamilton W.F. (1990) "The Dynamics of technology and Strategy" *European Journal of Operational Research,* vol.47, pp.141-152.

6. *Report of the Expert Group on the Food Industry* (1993), Dept.of Agriculture, Food and Forestry. Dublin. p.6.

Appendices.

Appendix (A)

Theme Sheet.

Topic 1. **Current use of advanced biotechnological techniques in the Irish food industry.**

Probes:
Use in food processing.
Use in primary food production - animal & plant.
Own Company involvement.
Specific instances of use known.
Industry use/use in industry support lab.s.

Topic 2. **Potential of new biotechnological techniques for the Irish food industry.**

Probes:
Time frame of potential use.
Sector's of greatest potential.
(i) Food ingredients.
(ii) Primary food production.
(iii) Food processing sectors.
Potential for industry.
Potential for industry support lab.s.
Own company potential use.

Topic 3. **Consumer issues.**

Probes:
Food companies market or technology driven.
Importance of consumer issues.
Labelling.
Methods to combat adverse reaction.
Issues involved with medical and food use.
Ethical issues.

Topic 4. **Regulatory environment.**

Probes:
Directives 219/220.
Importance of regulations for development and use.
Labelling.
Intellectual property law (Europe and the US).

Topic 5. **Food industry personnel**

Probes:
Skills and education profile of scientific staff.
(i) in industry
(ii) in industry support lab.s
Motivation of scientific staff in industry and in industry support lab.s.
Availability of highly skilled scientific personnel.

Topic 6. **Research and development activities.**

Probes:
Industry R&D facilities.
State support R&D facilities.
Spending on R&D in food industry.
Industry involvement in State science and technology programs.
Importance of R&D for food industry.
State funding of basic and applied research.
Industry use of State support R&D facilities.

Appendix (B)

Strategic Research & Development

college of marketing & design, dublin 1. phone (01) 363000 ext. 65.

FOR THE ATTENTION OF THE R&D DIRECTOR, THE QUALITY CONTROL MANAGER OR THE TECHNICAL MANAGER.

address

08:10:1992

Dear Mr. X,

The food sector is very important to Irish industry. This fact has recently been publicly recognised by the Industrial Policy Review Group headed by Mr. Jim Culliton. For food firms to retain the Natural Advantage they now possess many experts recommend growth through technology development, particularly in the area of food science and technology.

A survey is proposed. The objective of this survey will be to assess leading food firms current involvement with Technology Development and their future plans if any, to become involved. I wish to invite you to participate in this research. Learning of your experiences with, and opinions on technology development would greatly benefit my studies. The investigation will be undertaken through use of a telephone survey. The topics for discussion are detailed in the questionnaire enclosed. I would appreciate if you could scan this document, in preperation for my call.

The information which you provide will be treated as confidential and no effort will be made to trace details to particular respondents. Trend data only will be recorded. Participating firms will be forwarded a copy of the results when available. The research will be presented in fulfillment of the requirements of an M.B.S. degree.

I look forward to speaking to you. Please expect a telephone call from me in the next few days.

Yours sincerely,

Clare Kavanagh

Post-Graduate Research Room, C.O.M.A.D., Mountjoy Sq., Dublin 1.

QUESTIONNAIRE.

SECTION 1. PRODUCTS AND R&D

Que.1 In the food sector, what products and/or services do you produce?

Dairy Foods ☐

Meat and Fish Products ☐

Bakery Products ☐

Brewed and Distilled Products ☐

Confectionary and Other Food Products ☐

Que. 2 How do you normally source your products? Please indicate the percentage of product acquisition / line improvement which is currently the result of each of the following activities. Please also record, in the space provided, the expected situation in the year 2000.

	NOW	YEAR 2000
1. licensing		
2.Basic Research		
3.Applied Research		
4.Company Acquisition		
5.Contract R&D		
6.Joint Ventures		

Que. 3 Please complete the following table indicating an approximate of the percentage of turn-over which is currently spent on Resesarch and Development, the proposed spend in 2000 and the spend in 1985.

	1985	Now	2000
% of Turnover			

Que. 4 Please divide this R&D spend, in terms of the proportion allocated to In-House Development, Joint programs with Firms or Universities, Purchase of Technology /licensing and Contract R&D.

	1985	Now	2000
In-House Development			
Joint Program with Firms/Universities			
Purchase of Technology/licensing			
Contract R&D			

Que.5 Please complete the following table indicating the size and skill profile of your Irish R&D work force now, in 1985 and in the year 2000.

Base Country_______________	NUMBERS		
R&D DEPT. SCIENTIFIC HIGHER DEGREE GRADUATES	**1985**	**NOW**	**2000**
MARKETING GRADUATES			
SCIENTIFIC DEGREE GRADUATES			
CHEESE MAKERS -(SKILLED)			
SCIENTIFIC DIPLOMA GRADUATES			
TOTAL R&D STAFF			
TOTAL COMPANY STAFF NUMBERS.			

Que.6 The following two tables list internal and external corporate strategies that you may have used in order to become involved in R&D. Please indicate those with which you have been involved and those which you intend becoming involved and your reasons for selection of these strategies.

INTERNAL STRATEGIES:	Strategies undertaken	Intended Strategies
HIRE NEW STAFF		
TRAIN EXISTING STAFF		
BUILD FACILITIES		
ACQUIRE FIRM		
OTHER		

EXTERNAL STRATEGIES:	Strategies Undertaken	Intended Strategies
CONTRACT R&D		
JOINT PROGRAMME WITH ACADEMIC LAB.		
JOINT PROGRAMME WITH OTHER FIRM		

Que.7 Have you ever been involved in any Science Development programs?
YES - Give Details - (State Agency involved, Benefit - monetary or otherwise)
No - Give Reasons.

Que.8 Do you intend becoming involved in any Science Development Programs in the future?
Give Details.

Que.9 Do you purchase food additives or ingredients for manufacture?

YES goto Que.10
NO goto Que.11

Que.10 What technologies are used in the production of these products?

SECTION 2. BIOTECHNOLOGY

Que. 11 Thinking of the advances made in biotechnology recently, what level of this technology are you currently using in manufacture and in research and development, (if any) and where do you envisage working in the year 2,000.
I have divided the continum of progress into three general areas. Please tick the boxes which you feel best describe the level at which you work with biotechnology.

	MANUFACTURE		R &D(if any)	
	NOW	**YEAR 2000**	**NOW**	**YEAR 2000**
1.TRADITIONAL BIOTECHNOLOGY:BREWING WINE, YOGURT, FERMENTED MILKS, CHEESES BIOYOGURTS(USE OF PROBIOTICS) COTTAGE CHEESES AND ORGANIC FOODS. BASICALLY, BIOTECHNOLOGICAL TECHNIQUES FOR DEVELOPING USEFUL PRODUCTS BY TAKING ADVANTAGE OF NATURAL BIOLOGICAL ACTIVITIES	☐	☐	☐	☐
2.FUNCTIONAL FOOD INGREDIENTS -- USING CHARACTERISED INGREDIENTS TO CONTROL PROPERTIES OF FOOD PRODUCT eg flavours, fat substitutes, low calorie options.etc ALSO INCLUDED HERE ARE TRADITIONAL PRODUCTS WHICH ARE PRODUCED WITH A BETTER UNDERSTANDING NOW OF THE PROCESS OF MANUACTURE ESPECIALLY FERMENTATION TECHNIQUES AND DOWNSTREAM PROCESSING.	☐	☐	☐	☐
3.MODERN BIOTECHNOLOGY WHICH WITH THE DISCOVERY OF RECOMBINANT DNA TECHNIQUES AND OF CELL FUSION HAS LEAD TO A RADICAL ACCELERATION OF PROGRESS AND TO A MULTIPLICATION OF BOTH TOOLS AND APPLICATIONS. TECHNIQUES USED HERE MIGHT BE: (I).GENETIC ENGINEERING (II).HYBRIDOMA TECHNOLOGY-CELL FUSION (III).BIOPROCESS TECHNOLOGY (IV).PROTEIN ENGINEERING (V).BIOINFORMATICS EXAMPLES INCLUDE THE USE OF BIOLOGICAL PRIODUCTS AS NATURAL FOOD PRESERVATIVES (BACTERIOCINS), DIAGNOSTICS FOR CONTAMINANTS AND FOOD SPOILAGE ORGANISMS,-- THESE CAN BE DNA PROBE BASED OR MONOCLONAL ANTIBODY BASED-, GENETIC ENGINEERING FOR STRAIN IMPROVEMENT AND PRODUCTION OF CROPS WITH NEW CHARACTERISTICS- eg bruise resistant tomatoes.	☐	☐	☐	☐

SECTION 3. ATTITUDES

Que. 12 What do you think the impact of advanced biotechnological techniques such as genetic engineering will have on the Irish food and Drink industry to the year 2000?

Que.13 On which sector in the Food and Drink industry will the impact of these techniques be the strongest?

Que. 14 In terms of the barriers preventing the continued and future use of genetically engineered food and drink, what for you would be the most important barriers?

Que. 15 Do you feel the regulations in Ireland encourage or disencourage work in this area?

Que. 16 How do you feel consumers will react to genetically engineered food and drink products?

Que.17 On a scale of one to ten , where one denotes no risk and ten denotes unacceptably high risk please indicate your risk assessment of food and drink produced through advanced biotechnological methods, including genetic engineering.

[ ]

Que. 18 On the same scale of risk, using your experience in the marketplace please estimate consumers risk assessment of food and drink produced through advanced biotechnological techniques.

[ ]

Que. 19 Do you feel genetically engineered food and drink products should be labelled as such?

Que. 20 How do you feel possible adverse consumer reaction to genetically manufactured food and drinks should be dealt with?

Que. 21 Do you intend becoming involved with genetically engineered food and drink in the future?

Appendix (C)

Questions taken from Cogan&McGovern study. (1984)

Que. 5. Indicate the size and skill profile of your workforce at startup and at the end of your last trading year.

	Start - up	Present
Professional		
Technical		
Non Technical		
Technician		
Production		
Other		

Que. 7. Indicate the expenditure that has been made (in man years/£) in the development of high technology based products/services.*

	Year 1	Year 2	Year 3	Year 4
In house product development				
In house process development				
Purchase of technology				
Other				

*Give approximate proportions if absolute values are not available.

Que. 8. Indicate revenues derived from high technology based products/services.*

	Year 1	Year 2	Year 3	Year 4
In house product development				
In house process development				
Purchase of technology				
Other				

*Give approximate proportions if absolute values are not available

Source: Cogan D.J. and McGovern B. (1984), *The Nature and Needs of High Technology Industry*. Education, Innovation and Entrepreneurship Research Programme, Dublin.

List of Strategies for Involvement with Biotechnology compiled by Dibner.(1987)

TABLE 1 - THE PROS AND CONS OF VARIOUS CORPORATE STRATEGIES

Strategy	Pros	Cons
A. Internal		
1. Hire new staff	Gets expertise in-house	Slow
2. Train existing staff	Familiar with corporation	May not be easy to train; slow
3. Build facilities	Necessary step for internal development.	Costly; slow
4. Acquire biotech firm	Gets expertise in-house	Very costly;limited to firm's focus
B External		
1. Joint program with academic lab	Gets patent rights; Training:Inexpensive	Key people can leave. Proprietary risk
2.Joint program with biotech firm ("partnering")	Multiple partners; Project focus;Products to market;Shared risk	Limit to profits; Limit to agreements

Source: Dibner M.D. (1987) "Corporate Strategies for involvement with Biotechnology", *Biofutur*, Juillet, Aout, p.47.

Appendix (D)

Table 5.1.1 Type of Company by Number of Persons Employed in R&D Department. (1992)

STAFF NUMBERS

FIRM TYPE	1	2	4	5	6	8	10	12	16	20	R&D ELSE WHERE	NO R&D	NO ANS	TOTAL
ESTABLISHED FIRMS	1 4.8%	2 9.5%	3 14.3%	1 4.8%	1 4.8% 50%	1 4.8% 50%	1 4.8%	1 4.8%	2 9.5%	2 9.5%	3 14.3% 60%	3 14.3% 75%		21 77.8%
EMERGING FIRMS						1 100% 50%								1 4%
INGREDIENT FIRMS					1 20% 50%						2 40% 40%	1 20% 25%	1 20% 100%	5 18.5%

Table 5.4.5 R&D Expenditure in Food Related Industries by Source of Funds. (1987)

	Business Enterprise	Government	Other National	Funds From Abroad	Total
Belgium	1480.5(96%)	58.6(4%)	^	^	1539.1
Denmark	293.0(92%)	14.0(4%)	6.9(3%)	4.2(2%)	318
France	1019.2(87%)	33.5(3%)	4.1(.5%)	118.0(10%)	1174.8
Germany	322.0(97%)	11.0(3%)	^	^	333
Greece	215.8(99%)	1.8(1%)	^	^	217.6
Ireland	12.411(89%)	1.490(11%)	.002(0%)	.027(0%)	13.93
Italy	60427.0(94%)	3691.0(6%)	^	^	64118
Japan	192248(99%)	1028.0(1%)	^	^	193276
Spain	3796.4(99%)	31.0(1%)	^	^	3827.4
UK(1985)	109.9(89%)	4.1(3%)	^	9.2(8%)	123.2

Source: *Basic Science and Tecnology Statistics* (1991), OECD.

Table 5.6.2 Sourcing of new Products - Companies involved with High Value Low Volume Production. (1992, 2000)

	Licensing		Basic Research		Applied Research		Contract R&D		Joint Venture	
	1992	2000	1992	2000	1992	2000	1992	2000	1992	2000
Firm 1	No R&D currently or anticipated in the year 2000									
Firm 2					100%	100%				
Firm 3	R&D currently and anticipated overseas.									
Firm 4			15%	15%	70%	50%	15%	35%		
Firm 5					100%	70%		10%		20%
Firm 6				20%	100%	80%				

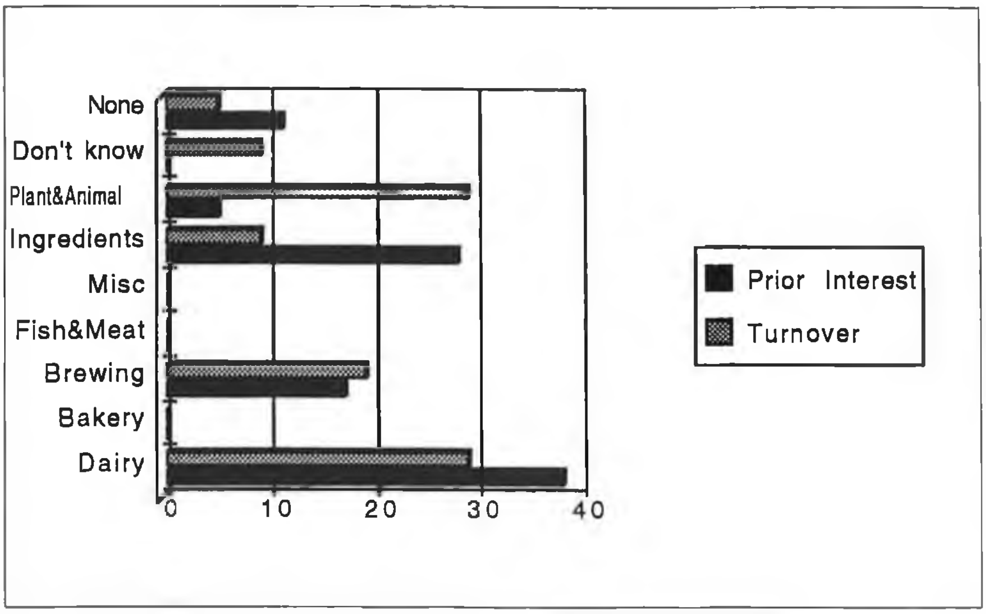
Base: All Companies involved with high value low volume production.

Table 5.6.6 Allocation of R&D spend - Companies involved with High Value Low Volume Production. (1985, 1992, 2000)

	In-House Development			Joint Program Firm/Uni			Purchase of Technology			Contract R&D		
	1985	1992	2000$^{\Delta}$	**1985**	1992	2000$^{\Delta}$	**1985**	1992	2000$^{\Delta}$	**1985**	1992	2000$^{\Delta}$
Firm 1	No R&D currently or anticpated in the year 2000.											
Firm 2							**100%**	100% (overseas)	100%$^{\Delta}$			
Firm 3	R&D currently and anticipated overseas.											
Firm 4	**10%**	100%	70%$^{\Delta}$	**90%**		30%$^{\Delta}$						
Firm 5	**100%**	50%	50%$^{\Delta}$		50%	50%$^{\Delta}$						
Firm 6	**100%**	100%	100%$^{\Delta}$									

Base:All Companies involved with high value low volume production.

Figure 5.7 **Predicted Food Sector of Impact by Basis for Selection, Evidence of Interest in New Biotechnological Techniques or Turnover.**



Appendix (E)

"Biotechnology refers to the application of scientific and engineering principles to the processing of materials by biological agents to provide goods and services. This term is understood to exclude biomedicine and agriculture excepting those areas which now involve the application of cellular or molecular biology."

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