The Irish Academy of Engineering

The Future of Manufacturing in Ireland
Interim Report

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Supporting Working Papers

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Chapter 1 Manufacturing – Analysis of Trends in Ireland

Introduction

The need to grow the productive side of the Economy, of which manufacturing is a major part, and in the process create employment opportunities is a key aspect of current Government policy. The challenge is to devise realistic plans that are likely to achieve this objective. In order to understand the scale and nature of this challenge the historical trends and patterns related to manufacturing in Ireland need to be analysed and compared to relevant international development. This section of the Report addresses this issue.

Manufacturing industry is a primary motor of growth in the modern economy. It comprises the main source of exported goods and directly accounts for substantial share of economic output while also having an indirect impact on the development of associated services. The rate of growth of manufacturing industry is determined by the complex interaction of international competition and the factors of production, innovation, marketing and finance along the supply chain. These include, inter alia, the cost base; productivity; the availability of staff; the links with education, design, research and development; infrastructure; information and communications technology; and a supportive climate for enterprise.

A recent report on the Future of Manufacturing for the World Economic Forum April 2012 stated that "Manufacturing has been immensely important for the prosperity of nations with over 70% of the income variations of 128 nations explained by differences in manufactured product export data alone"

The Value of Manufacturing Output

Manufacturing comprised 24% of the value of output in the Irish economy in 2009, slightly higher than in Germany . However this percentage would be reduced considerably and be closer to those in 2010 for the US 13%, Denmark 12% and the United Kingdom 11% if the output of modern sectors was adjusted to reflect US productivity levels in similar firms in the United States (see Ireland's Productivity Performance 1980-2011 Page 35 National Competitiveness Council) . Manufacturing accounted for 30% of the output of the Chinese economy in 2010.

Output growth

Between 1958 and 2001 the output of manufacturing industry increased at an average annual rate of 8% pa, and productivity (output per employee) increased at an average rate of 6% per annum resulting in an increase in manufacturing employment of 2% per annum. The sharp increase in output and productivity was due primarily to the attraction of high productivity foreign direct investment during this period.

More recently between 2002 and 2011 the rate of increase in manufacturing output reduced to 2% per annum reflecting a significant reduction in the rate of annual increase in the output of the modern industrial sectors (mainly chemicals , pharmaceutical, medical and optical appliances, computers and electrical equipment) , and an absolute fall in output of the main traditional industries with the exception of food processing.
(See Table 1)

Ireland: Growth in manufacturing output
Average Annual

(Table 1)

Modern	1995 – 2000	2000 – 2006	2005 – 2012
Reproduction media	17	15	--3
Chemicals	27	7	+5
Office and Computers	17	3	-5
Electrical Machinery & Appliances	23	10	-6
Communications Equip.	15	-1	
Medical and Optical	23	11	+3
Total Modern	23	7	3
Traditional			
Food Production	3	4	-1
Beverages	6		2
Textiles	-4	-10	-6
Clothing	-9	-16	-8
Leather Products	-5	-26	4
Wood Products	11	7	-7
Pulp and Paper	4	-2	-4
Rubber and Plastic	0	-2	-4
Other non-metallic	6	0	-7
Basic metals	-1	-1	-3
Fabricated metals	6	-1	-4
Other machinery	1	-2	1
Transport	15	-1	-2
Other Manufacturing	4	-4	5
Total Traditional	4	1	-2
Total Manufacturing	16	5	1

The rate of productivity increase in industry between 2002 and 2011 at 5% per annum was somewhat lower than in previous decades due to modest increases in output and fewer high productivity inward investments. Employment in manufacturing declined by almost 3% per annum.

Employment trends

The last decade has shown a substantial reduction in manufacturing employment in most European economies. The following table shows the trends in Ireland compared to Denmark, Germany and the United Kingdom.

Comparison of Employment Trends for selected periods

(Table 2)

	2002 - 2011	**2005 - 2011**	**2008 - 2011**
Ireland	-23%	-18%	-16%
Denmark	-24%	-15%	-16%
Germany	-6%	-2%	-3%
United Kingdom	-26%	-15%	-8%
Eurozone			-8%

Thus in the period from 2002-2011 employment in manufacturing in Ireland has declined by 23%, similar to the decline in Denmark and the United Kingdom but four times greater than in Germany. Data from Forfas shows that in Ireland over the same period employment increase in internationally traded service firms supported by the IDA, Enterprise Ireland, Udaras, and Sfadco offset about half the jobs lost in manufacturing. Forfas data also shows that in 2011, of manufacturing firms supported by the state agencies concerned, Irish owned manufacturing firms accounted for 53% or 93,000 employees (of which 38,000 were in food processing and wood products) and foreign owned companies accounted for the remaining 47% or 81,000 employees.

Manufacturing employment in Ireland accounts for a similar percentage of civilian employment to that in the United Kingdom and Denmark, but only half that in Germany.

Percentages in Manufacturing Employment

(Table 3)

Ireland	11%
Denmark	12%
Germany	21%
United Kingdom	10%

Since Germany is the strongest economy in Europe our view is that Ireland should aspire to grow the percentage of employment in manufacturing.

Sectoral issues

For most manufacturing companies, and particularly for multinational companies, the combination of globalization, trade agreements and other factors such as ICT has enabled the disaggregation of supply chains into **complex global networks**, (World Economic Forum report). A report by academics from Columbia University and Dartmouth College pointed to a trend where a single component might be exported several times, adding to trade, but with no increase in added value. This suggested an increase in supply chain fragmentation which continued from 1990 to 2008 but may now be starting to slow, and in some cases reverse.

In contrast to the trend towards lengthening supply chains, ICT improvements have also made production more nimble, capable of just in time manufacturing and frequent design changes, a trend which encourages **regional or local industrial clusters**. Timely shipments of components are indispensible. An analysis by Purdue University and the University of Tenessee estimates that a day in transit is equivalent to a tariff of between 0.6% and 2.3%. (The Economist Aug 4th 2012).

With a small production base Ireland must specialize in a limited range of manufacturing sectors with supply chains of varying lengths. The following is a classification of the main sectors in which Irish industry specializes:

Classification of Main Manufacturing Sectors

(Table 4)

	% output sold outside Ireland and UK 2005	Employees 000s 2012
Chemicals, pharma	92	25
Medical and optical	91	22
Electrical machinery	80	4
Other foods/beverages	70	5
Computers and electronics	68	22
Machinery and equipment	64	10
Transport equipment	63	4
Recorded media, printing	49	5
Food	45	39
Basic metals	38	2
Plastic products	25	8
Fabricated metal products	14	10
Non metallic minerals	10	6
Wood products	9	4

Ref: NESC report no 114 and Forfas.

Between 2005 and 2012 there was an annual increase in the output of only four of the above sectors- chemical and pharma, medical equipment, beverages and transport equipment. The greatest declines were in wood products, non metallic minerals (construction related); fabricated metal products, plastic products, computers and electrical machinery.

Seven of the fourteen sectors above sell more than half their output on the Ireland and UK markets and account for almost half of the employees . As a group these sectors are particularly vulnerable to significant changes in economic conditions in these islands, changes in competitiveness and exchange rate movements between the euro and sterling.

The above analysis focuses on the market requirements and cost competitive pressures.

However it is also appropriate to examine how sectors can be clustered in order to stimulate innovation, and in this way to improve competitiveness through product and process development. Such clusters may be horizontal as well as vertical. For example advances in ICT can have a substantial impact on the medical devices sector. Similarly transfer of technology between sectoral subdivisions can also assist the development of new products. It is useful to group firms into segments with definable operating characteristics and to build on areas of research/technological strength identified in the research prioritization exercise.

For example:

- Medical Technology
  - Implantable devices
  - Diagnostics
  - Medical electronics
  - Surgical devices

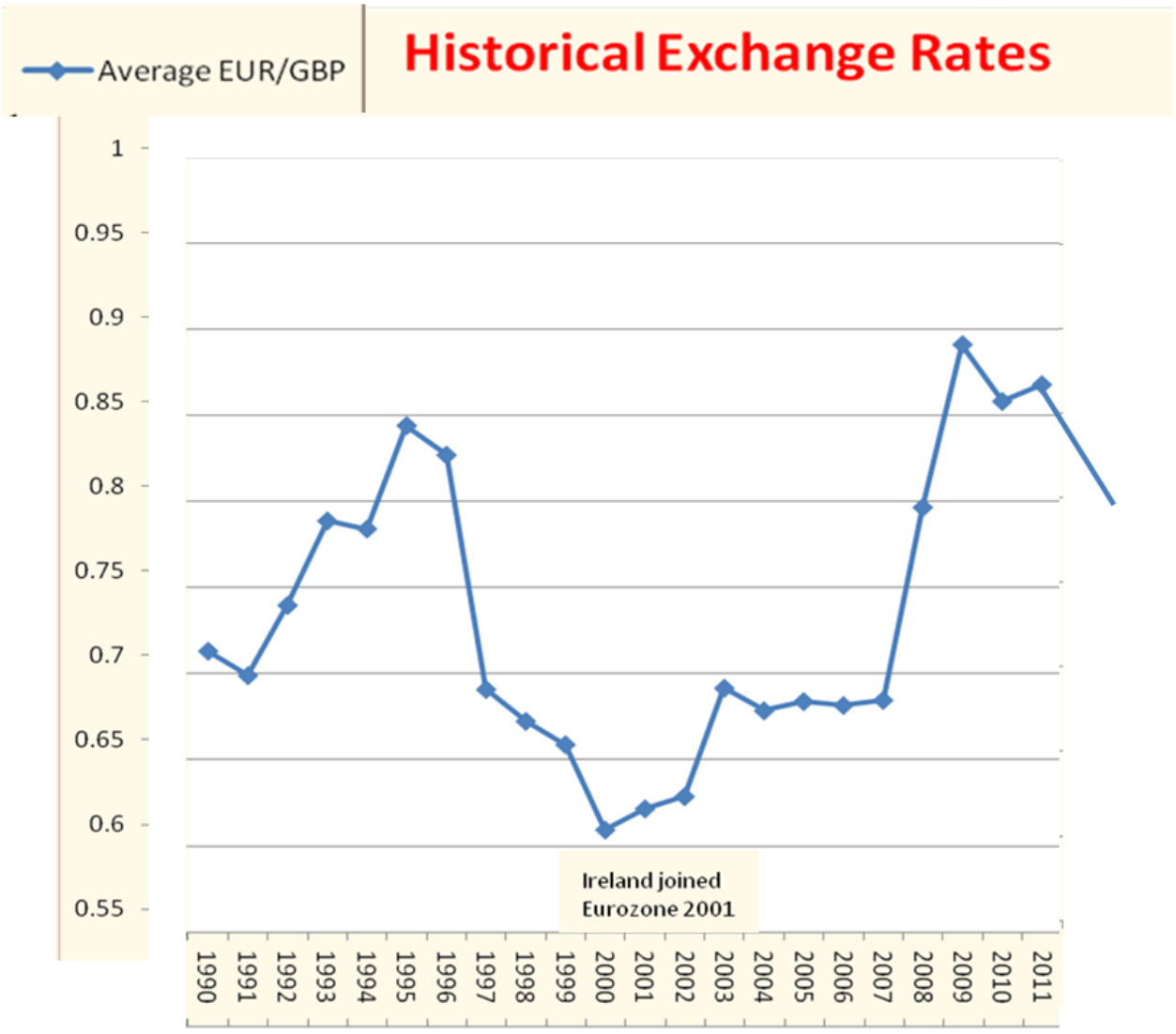
Competitiveness indicators

On a broad assessment of competitiveness Ireland's ranking in the table produced by the Institute for Management Development (IMD) in Geneva had declined to 24th of 58 countries in their 2011 report. This ranking which had been in 10th position in 2004, recovered to 17th position in 2013.

Harmonized competitive indicators estimated by the Central Bank and ECB indicate that a 24% deterioration had occurred in Irish competitiveness between 2002 and 2009. This gap was reduced to less than 10% in early 2013. (see Fig 2 page 60 Competitiveness Scorecard 2011). The deterioration vis a vis the UK was particularly severe (See Euro/ Sterling Chart 1 below).

EUR/GBP Exchange Rates – 1990 to 2011

(Chart 1)



Over 40% of manufacturing employment in Ireland is in sectors which have a heavy reliance on trade between Ireland and the United Kingdom. It is noteworthy that there has been a significant change in relative labour costs in recent years. For example, in 2006 hourly labour costs per employee for production workers in Ireland were about 26 euro per hour and were slightly lower than in the UK at 27 euro per hour. (See pages 45 and 49 NESC report no 117 June 2008). However by 2012 labour costs per hour in Ireland were 27.4 euros in 2011 compared with 20.1 euro in the United

Kingdom, due to the sharp decline in the value of sterling against the euro since 2007 (see Eurostat 63/12- 24th April 2012).The fall in costs in the United Kingdom had a particularly serious impact on those sectors which were most dependent on the British market.

An analysis of "Economic Relations between and within these Islands," published in March 2013 by Dr John Bradley, shows that in 2010 while 95% of the output of foreign owned companies in Ireland was exported, only 8% of these exports were to the UK. In contrast only 53% of the output of Irish owned companies was exported and 40% of these exports were to the UK.

Thus almost 70% of the output of Irish owned manufacturing companies, which accounted for more than half of the people employed in agency supported manufacturing firms, was sold on the Irish or British markets. They were particularly vulnerable to the decline in competitiveness arising from the weakening of sterling. SMEs have a particularly high dependence on the Irish and British markets.

An indication of the decline in competitiveness against British products is shown by the decline in the export /import ration of trade between Ireland and Britain from 109% in 2002 to 82% in 2012.

It is noteworthy that the rate of decline of traditional industries such as textiles, leather goods, and fabricated metal products in Northern Ireland between 2005 and 2011 was significantly less than the rate of decline in the Republic.(Manufacturing comprises 11% of employees in Northern Ireland and in the Republic).

Productivity

Since Ireland is a member of the Eurozone the main contribution to improving competitiveness which is within Irish control is to improve innovation and productivity.

The World Economic Forum (WEF) report, "The Future of Manufacturing" (April 2012), states that "the ability to innovate, at an accelerated pace, will be the most important capability differentiating the success of countries and companies."

Average productivity has increased at a similar rate to that in the US, UK and EU since 1980, though this was influenced by the faster decline in the output of low productivity traditional industries and the annual addition of higher productivity modern industries.

The value of output per hour in the "modern manufacturing sector" in Ireland in 2007 was about 100% higher than in the the Eurozone, (EU Klems 72 March 2011- Industry data base- Irelands Productivity performance 1980-2011 published by Forfas). However this relatively favourable performance was due to the proportion of the Irish industrial structure accounted for by a combination of high productivity modern industries and of pricing strategies.

In contrast the productivity (value of output per hour worked) of traditional sectors in Ireland is less than half that of the modern sectors. For example the productivity of traditional sectors in Denmark was 50% higher than in Ireland. There is clearly significant room for improvement in the productivity of these sectors in Ireland, and in this way to reverse the process of declining output. The rate of improvement in productivity in traditional industries in Ireland from 1980-2007 was similar to that in the United Kingdom.

In conclusion overall productivity in Irish manufacturing industry between 1958 and 2001 increased by an average of 6% p.a and by about 5% p.a. between 2002 and 2012. An improvement in productivity by 8% p.a. over the next decade would lead to a gradual improvement in competitiveness and increased manufacturing output.

Improvements in productivity will require increased levels of investment in machinery, greater innovation, product and process development, managerial and engineering expertise.

Research and Development

Of the total number of researchers engaged in Business R&D in 2012 only 34% were in manufacturing. In 2011 slightly less than 24% of R&D business expenditure by manufacturing firms was spent by Irish owned companies.

Contribution of engineers to productivity improvement

Professional engineers focus on improving the productivity of the resources of manpower, machinery and materials through a process of continuous innovation.

During the high economic growth period between 1991 and 2002 the number of engineers and associated technicians in the economy increased by about 8% per annum, and the output of manufacturing industry increased even more rapidly. The results of the 2011 census shows that in the period from 2002 to 2011 this rate of increase in the number of engineers reduced to 2% per annum, similar to the rate of growth of manufacturing industry. There are indications of a significant increase in the number of new engineering graduates , but though welcome this will only have a marginal impact on the total number of engineers.

The application of engineering skills will be a vital ingredient to raising the output and productivity levels in manufacturing over the coming decade.

Investment in manufacturing industry

The net value of capital assets in the manufacturing industry in Ireland in 2010 was 23bn euro. This was similar to the level at constant prices in 2005. Having allowed for depreciation of assets it is necessary to achieve an increase in investment in capital assets of about 10% per annum. Current investment rates fall well below requirement.

Conclusion

The Government has set a target of increasing employment (net) by 100,000 jobs over five years i.e. averaging 20,000 p.a.

Given that the Public Sector, Construction and Banking may be either negative or static over the five years the onus will be on the competitive market sectors, such as Manufacturing, Services, Tourism and Agriculture to generate the required increases.

In this context we estimate that a minimum target of +20,000 for Manufacturing over the five year period is necessary if the Government target is to be achieved. This equates to +4,000 jobs p.a. or annual increases of approximately 2% - 3%.

To remain competitive in the face of rapidly increasing global competition (UK, USA, China, India, Germany etc) and at a time of lower global demand, productivity increases of around +8% p.a. will be required. Hence the overall output of the Manufacturing Sector will have to increase by about +10% p.a. <u>This is a huge challenge.</u>

While output increases close to this range have been achieved before, for example from 1980 to 2000, it must be borne in mind that:

a) Special and non-recurring factors underpinned this growth, such as:
   - Taxation policy
   - EU structural funds
   - Low cost base and periods of financial discipline
   - Inward investment, EU related
   - Global market opportunities

b) Most of this growth related to the Hi-Tech, FDI sector.
   The indigenous manufacturing sector over the longer period has declined and despite the presence of a relatively small number of outstanding companies, that can compete successfully in global markets, the indigenous manufacturing base is very narrow. Despite a recent upsurge the overall position is quite precarious.

Against this background, to achieve the targets that are vital for Ireland, exceptional measures will be required:

- Within all sectors of industry by investment, productivity and innovation;
- In all areas where Public Policy impacts on industry;
- In all of the interfaces between industry, agencies, education, etc, led by the policy makers and senior management.

<u>The greatest danger would be to underestimate the scale and nature of the challenge.</u>

Note:
The following sections of this report explore and address these issues.

Chapter 2 Manufacturing – International Comparisons and Trends

1. Objective

The principal objective of the IAE study on manufacturing in Ireland is to identify and address issues which could result in an expansion of Ireland's manufacturing activity, leading to a growth in employment.

2. Manufacturing in Ireland

Output from the manufacturing sector, after many years of growth, declined between 2007 and 2009 but growth in volume resumed between 2009 and 2012. It is acknowledged that there are distortions in Irish output statistics for certain sectors which distort sectoral comparisons of output, as measured in value terms.

Employment in manufacturing stood at 250,000 in 2000, reduced to 220,000 by 2007 and reduced further to 165,000 by 2010. Apart from reductions in demand in the period, this reduction in employment numbers is primarily the result of increasing productivity. This is a condition found in all economies as they develop and will be discussed more fully in paragraph 7 below.

3. Sectoral Breakdown

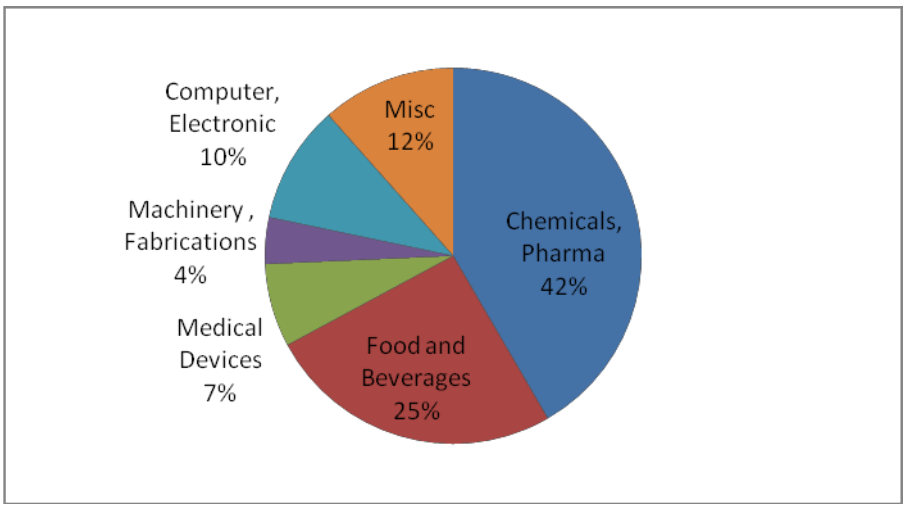


Fig 1 Sectoral breakdown by value of manufactured output, Ireland 2010. - CSO

The sectoral breakdown of manufacturing activity in Ireland by value of output is shown in Fig 1. The breakdown by numbers employed, is shown in Fig 2.

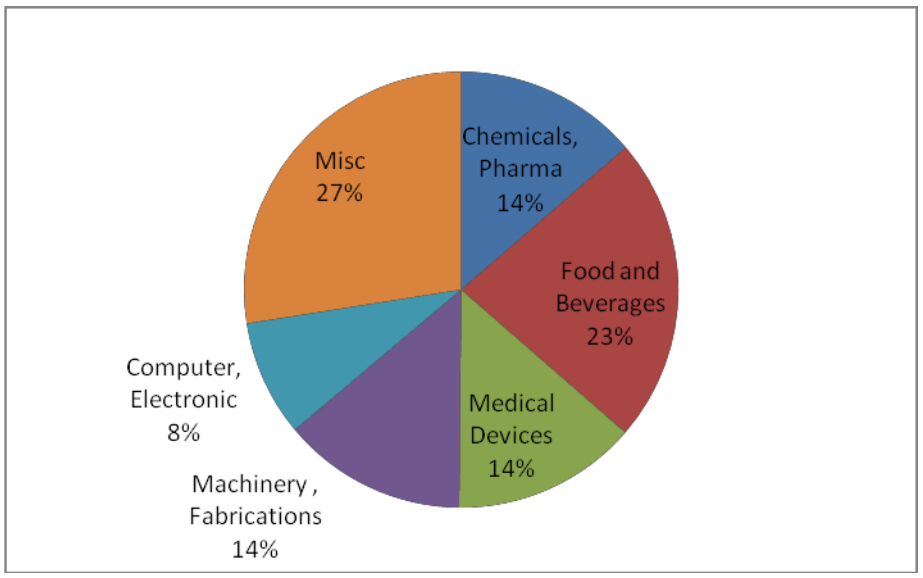


Fig 2 Sectoral breakdown by numbers employed, Ireland 2010
- CSO

4. Ireland – EU comparison

A comparison of profiles with manufacturing in the European Union is shown in Table 1.

Manufacturing output and employment. Ireland and EU, 2010 – (CSO, Eurostat)

(Table 1)

	Output Ireland %	Output EU %	Employment Irl, %	Employment EU, %
Chemical, Pharma	42	16	14	8
Food, Beverage	25	21	23	21
Medical Devices	7	1	14	2
Machinery, Fabrications	4	29	14	39
Computer, Electronic	10	7	8	6
Miscellaneous	12	26	27	24

Comparing the Irish profile with that of the European Union, it is important to note a number of key differences, as follows;

- The chemical/pharmaceutical sector has a predominant share of Ireland's manufacturing output. Pharmaceuticals formed 92 % of this grouping in 2010.
- Despite Ireland's position as an agricultural producer, food/ beverage processing is just marginally above overall EU percentages for both output and employment.
- Output of these 2 sectors is 67% of total output.
- Medical device sector in Ireland is very significantly above EU levels
- Machinery/fabrication is also very significantly below EU levels
- The Miscellaneous classification includes textiles, furniture, non metallic materials, plastics and rubber, paper, publications plus certain other categories.

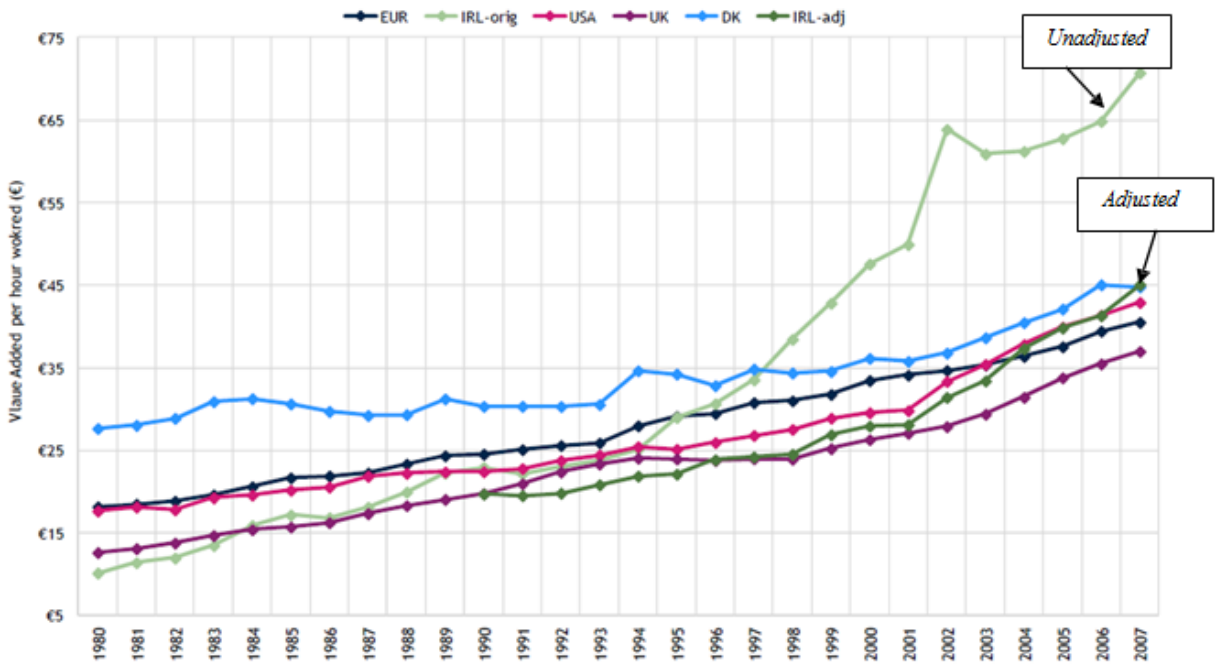
5. Manufacturing productivity

Labour productivity is an obvious key factor in assessing the competitiveness of manufacturing and its potential for expansion in employment. There has been an annual growth rate of the order of 6% between 1990 and 2007. Since then growth has slowed to approx 2% per annum. The National Competitiveness Council's publication entitled "Ireland's Productivity Performance 1980 – 2011" provides detailed statistics of Ireland's productivity and international comparisons.

The productivity of foreign owned companies in Ireland, as measured in value terms, far exceeds those of Irish owned enterprises. Again there are distortions due to pricing policies relating to outputs in the multinational sector. This does not conceal the fact that productivity in the indigenous sector is low.

After adjustment statistics show that, overall, the manufacturing sector in Ireland performs well in international comparison, see Fig 3

Fig 3; Output per hour worked in the manufacturing sector, with adjustments for Ireland, selected economies, 1980-2007- *"Ireland's Productivity Performance 1980 – 2011", NCC*



6. Ownership of enterprises

Ireland has a large cohort of manufacturing operations owned from outside the state.

Statistics for manufacturing enterprises in Ireland – CSO

(Table 2)

	Irish owned	Foreign owned	Total
Number of enterprises	3,737	424	4161
Turnover (€million)	20,400	76,171	96,571
Persons employed	85,205	79,801	165,006
Average employed per enterprise	22.8	188	39.6
Average turnover per enterprise (€million)	5.46	179	36
Turnover per employee (€thousands)	237	950	585

Although difficult to quantify, transfer pricing strategies may inflate the value of turnover of foreign owned companies, inflating average turnover per enterprise and per employee.

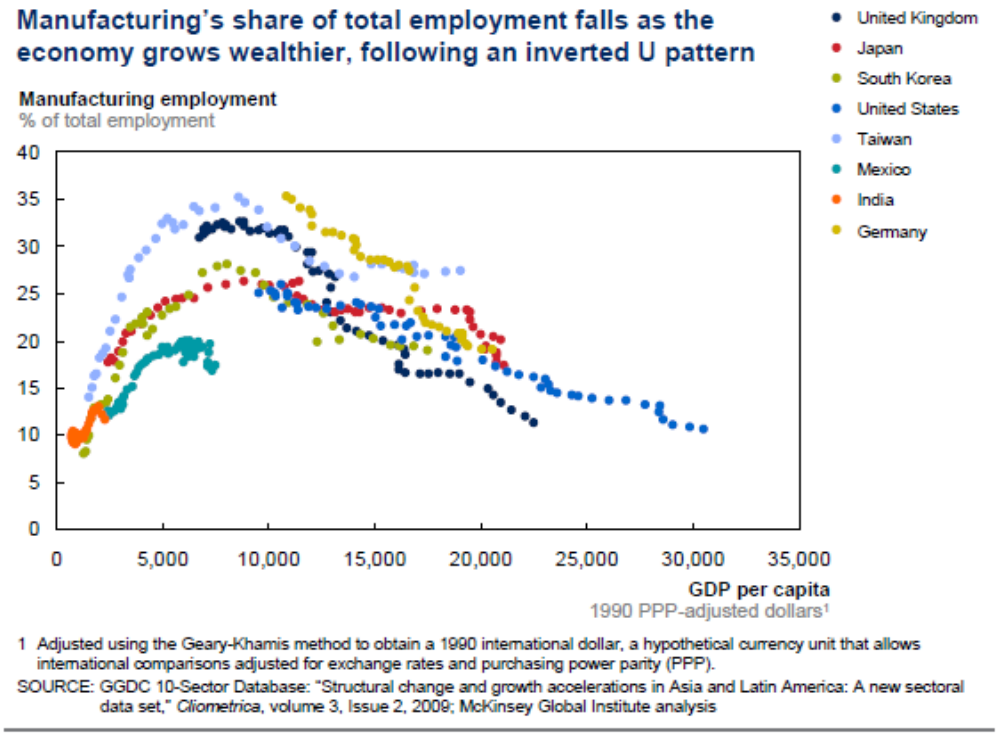
Irish owned enterprises are generally much smaller, have fewer employees, lower turnover and lower productivity than foreign owned companies. This has obvious implications for potential to develop in the future. There is an issue treated in section 11 relating to the quality and capability of the management of these enterprises.

7. Manufacturing – Global

In the production of this document, use is made of material from the McKinsey Global Institute document "Manufacturing the future: the next era of global growth and innovation"

The issue of reducing numbers involved in manufacturing is worldwide, perhaps best illustrated by Fig 4. This shows how the manufacturing share of employment has performed as the wealth of the 8 countries listed increases.

Fig 4 Manufacturing share of total employment - McKinsey



As economies develop, manufacturing is a key driver, initially producing increased employment which reduces as a proportion as the economy develops and wealth increases.
In line with this reduction, manufacturing's overall share of GDP also reduces. Table 3 below shows the share of GDP contributed by manufacturing in a selection of countries.

Manufacturing share of GDP in selected countries

(Table 3)

Country	% of GDP
UK	10
France	10
US	12
Italy	15
Germany	19
Japan	20
Ireland	22
China	33

8. Manufacturing contribution to economic development

Despite a reduction in the relative contribution of manufacturing both to employment and to GDP, it is accepted that manufacturing has and will continue to have, a key role in every country's economic development. Many service activities are directly linked to, but not classified as manufacturing, so the employment numbers are understated. For instance, in the United States, it is estimated that there are 50% extra jobs in services directly linked to manufacturing, but which are classified under the service heading. In addition manufacturing output forms up to 70% of exports in the major manufacturing countries and up to 90% of business R&D spending comes from the sector. Manufacturing is also a significant driver of productivity in all sectors of an economy.

The contribution from manufacturing is critical, despite the apparent fall off in contribution to employment and GDP growth. A vibrant manufacturing sector is vital to economic growth.

9. Manufacturing – diversity, a framework

Rather than categorising manufacturing under the traditional sectoral headings used in the beginning of this piece, the McKinsey document uses a different methodology based on classifying industries into five groups (see Fig 5), based on shared characteristics as follows:

1. Global innovation for local markets
2. Regional processing
3. Energy/resource intensive commodities
4. Global technologies/innovators
5. Labour intensive tradables

Fig 5 Suggested method of segmentation, based on 5 segments – McKinsey

Manufacturing is diverse: We identify five broad groups with very different characteristics and requirements

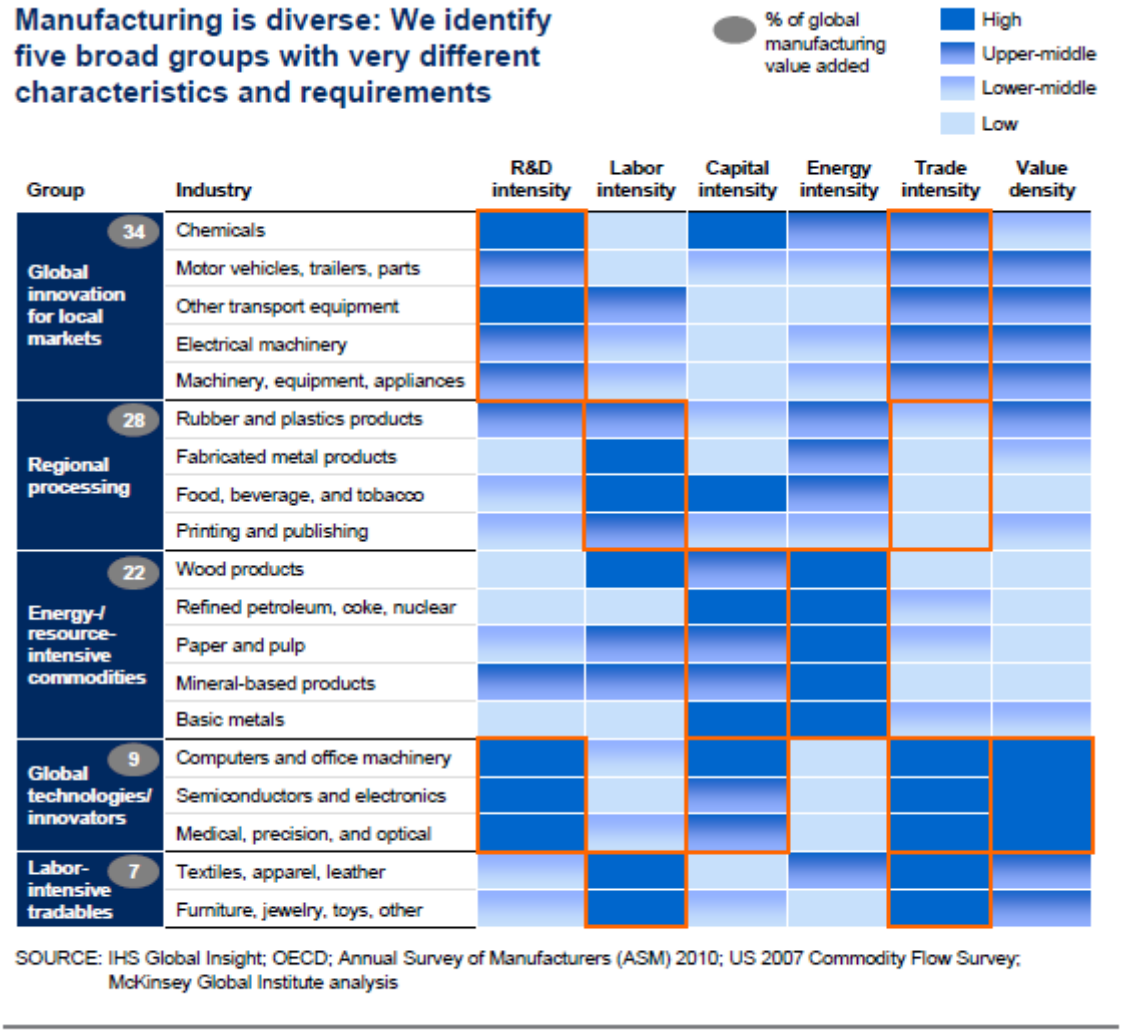
% of global manufacturing value added

Sector	Traits	Industry examples
Global innovation for local markets 34	▪ Competition based on innovation and quality; high R&D intensity[1] (5–25%) ▪ Some components traded globally (40–50% trade intensity[2]) with more regional assembly and production	▪ Chemicals and pharmaceuticals ▪ Transport equipment including automotive ▪ Machinery, electrical machinery, appliances
Regional processing 28	▪ Low tradability (5–20% trade intensity[2]) ▪ Highly complex and costly logistics ▪ Freshness requirements, and local tastes drive proximity need ▪ Relatively automated; little R&D	▪ Rubber and plastics ▪ Fabricated metals ▪ Food and beverages ▪ Printing and publishing
Energy-/resource-intensive commodities 22	▪ Provide commodity-type inputs to other sectors; low tradability ▪ Energy- and resource-intensive (energy intensity[3] 7–15%) ▪ Price competition; little differentiation	▪ Wood products ▪ Paper and pulp ▪ Basic metals ▪ Minerals-based products ▪ Refined petroleum, coke, and nuclear products
Global technologies/ innovators 9	▪ Competition based on R&D and cutting-edge technology, with high R&D intensity[1] (25–35%) ▪ Highly tradable (55–90% trade intensity[2]) in both components and final products	▪ Computers and office machinery ▪ Semiconductors and electronics ▪ Medical, precision, and optical equipment
Labor-intensive tradables 7	▪ High labor intensity[4] (30–35 hours per $1,000 value added) ▪ High exposure to price competition ▪ Globally traded (50–70% trade intensity[2]); low proximity needs	▪ Textiles, apparel, leather ▪ Furniture, jewelry, toys, and other manufactured goods not classified elsewhere

1 R&D intensity = R&D expenditure divided by value added (nominal), US, 2007.
2 Trade intensity = Exports divided by gross output (nominal), world, 2006-10 average.
3 Energy intensity = Cost of purchased fuels and electricity divided by value added (nominal), US, 2010.
4 Labor intensity = Hours worked per $1,000 value added (nominal), EU-15, 2007.
SOURCE: OECD; 2010 Annual Survey of Manufactures; US 2007 Commodity Flow Survey; IHS Global Insight; McKinsey Global Institute analysis

This approach is developed in Fig 6 which shows the development of the framework under the headings of cost (capital intensity, labour intensity, energy intensity), innovation (R&D intensity) and tradability (trade intensity, value intensity). This allows a profile to be developed which helps understanding of needs in the five segments.

Fig 6 Industry segmentation and associated cost, innovation and trade characteristics - McKinsey



10. Manufacturing, the future

The literature identifies 2 key areas, innovation and supply chain development, which will have a profound influence on the development of manufacturing in the future. These areas have been accepted in all developed economies as critical to the future development of manufacturing;

- Innovation
    - Product innovation – shortening product life cycles and technological sophistication demand increased efforts in product development and innovation.

- Process innovation – innovation in process development is critical, particularly for lower tier suppliers in a developed supply chain configuration. Many of these companies will not have a leading role in product development but will compete through the excellence of their processes

- Supply Chain Development

  - The capability to provide appropriate process capabilities and the ability to effectively manage both internally and externally within the supply chain are primary factors in successfully developing a company's competitive position.

In the context of developing the manufacturing sector in Ireland, there are some pointers, spelt out in the World Economic Forum document "The Future of Manufacturing – Opportunities to drive economic growth" (2012)

- The sophistication of an economy is based on how many products a country can export successfully and how many others can export these products.

- Sophisticated economies export large variety of exclusive products few others can make.

- The more complex the product, the more advanced the manufacturing process, the greater the resulting prosperity.

- Most manufactured goods are produced in networked hubs.

- Efficient manufacturing requires large network of connected activities.

11. Management

Developing manufacturing activity in Ireland requires managers who are capable of competing internationally, particularly in areas mentioned above, innovation and supply chain development.

There is evidence, however, that the quality of managers of locally owned enterprises in Ireland is of a low order in comparison with managers of companies in other countries. This is borne out by a joint benchmarking study in 2010 by the Irish Management Institute and the London School of Economics. This study showed overall Irish management ranking poorly compared to management of companies in other competing countries. It is not unreasonable to assume that, as managers in subsidiaries of foreign companies operate to the international standards of their parent companies, the quality of management of indigenous enterprises is generally poor and that future development of many of these enterprises will be severely constrained as a result.

Chapter 3 Manufacturing – Life Sciences

Life Sciences including Pharma and Medical Devices

Economic Status thru 2023 as it pertains to Pharma & Med Devices

1. Globally the middle class will grow from 1 billion in 2000 to 5 billion in 2030 (Source Sir Frank King in 2013, Sir Bernard Crossland Lecture).[1] This growth will impact on the commodity prices:
    a. **Water**: aquifers are being systematically depleted; alternatives are energy intensive reverse osmosis plants.
    b. **Energy**: fossil fuel prices will continue to rise; energy costs as a proportion of family budgets will rise.
    c. **Food**: continued upward price pressure due to growing population and affluent population. This will cause instability in the majority of countries where the percentage of pay spent on food is high.

2. Economic growth in the world economy will be constrained.
    a. The conditions that underpinned the thirty year growth spurt in the developed world are no longer in place, namely readily available capital, cheap imports and confidence in central banks' ability to control growth and inflation.
    b. Exponential growth in the balance sheets of Chinese banks; $14trillion additional credit in the past four years is unsustainable. The inevitable correction will see China growth constrained.
    c. China faces a looming 140m shortfall in working population. As a result China also faces a Lewisian Effect[2] change, as well as an aging population. This has implications for the medical devices & pharmaceutical industry, as well as impacting growth.
    d. Quantitative easing in the US, Japan and UK, and on a quasi basis in the Euro zone, will lead to inflation, and ultimately higher interest rates.
    e. Resistance to austerity and balanced budgets will cause bond yields to rise, thus negatively impacting GDP growth, and that of the growth of social transfers and public services.
    f. Response of ECB is unpredictable, but social resistance to austerity could possibly lead to a break-up of the Euro, impacting the wealth of the fiscally challenged Euro zone countries, constraining social spending in those countries, forcing increasing payor resistance on the cost of health outcomes in all countries.
    g. The pension crisis and growing dependency ratios in the developed world will place additional burdens on the already challenged budgets.
    h. Increased quasi protectionism, and requirements for "local dividend" from the government of large (pharma) markets, will dictate local manufacturing or licensing of local generics manufacturers of drugs.
    i. Cheap energy in the US will give the US a competitive advantage on (onshored) manufacturing.

[1] Per Irish Times editorial March 16th quoting the 2013 UN Development Program human development report: "the Rise of the South: Human Progress in a Diverse World. "Between 1990 and 2010, the South's share of the global middle class population expanded from 26% to 58%. By 2030, more than 80% of the world's middle class is expected to be residing in the South, accounting for 70% of total global consumer spending. By 2025 annual consumption in emerging market economies will rise threefold to $30trillion

[2] The point at which the excess labour in the subsistence sector is fully absorbed into the modern sector, and where further capital accumulation begins to increase wages, is sometimes called the "Lewisian turning point" (or "Lewis turning point") and has recently gained wide circulation in the context of economic development in China

Impact of Pharma amd Medical Devices Industry

1. Resistance of payors against the price of pharmaceuticals and medical devices, including the instigation of outcome based pricing, is leading to constant downward pressure on drug and medical device pricing. This includes the rejection by national purchasing authorities of new exotic treatments as not representing cost effectiveness compared with existing treatments.

2. The transition to Pharma 3.0[3] will be largely completed. Pharma 3.0 places cost effective outcomes for patients at the core of the health systems. This is accomplished by leveraging the fully integrated digitisation of the health service, combining widely accessible Electronic Health Records (EHR's), wireless monitoring of patients, remote surgery and diagnostics, integrated logistics and commercial procurement and distribution of treatments and drugs.

   This will be a highly disruptive change, affording opportunities for new entrants at multiple points. For instance Walmart's[4] experience in pharmacy, and leadership in procurement and logistics, makes them a contender.[5]

3. Qualcom is leveraging its wireless connectivity to partner with companies on a host of products such as smart bandages, innovative diagnostics. CISCO, Medtronics & Phillips are pilotting the hostpital of the future.

4. The process of drug development will evolve in response to the growing costs of developing and test a successful drug. More use will be made of genetic profiling and harvesting the growing EHR databases. This will presage the true emergence of personalised medicine[6] and the development of multiple drug combinations.

   Clarity is needed on rules for value mining from EHR's, together with new standards in meta-data analytics, and supporting studies to develop powerful search engines.

5. Health and diagnostic based apps development for smart devices will continue to grow in sophistication, culminating in remote or self monitoring or over the phone diagnosis for many ailments, so reducing doctor and hospital time demand.

6. Pharma Multi National Companies (MNC's) will look to disease state management for addressing multifaceted diseases, such as diabetes, which will grow as business segments with recurring revenue generation streams.

7. Demand for product for monitoring and enabling effective infection control will continue to grow, such as surface coatings, RTLS for personnel and real-time monitoring of infections. Hospitals will be liable for treatment of hospital acquired infections.

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[3] Concept described by E&Y in their 2010 Progressions (Pharma 3.0) Global pharma industry report

[4] "*as the focus on health outcomes increases, everybody in the system from payors to patients are seeking better value for money. Unfortunately the industry lacks companies whose core mission is to lower the cost of health care, which creates a clear opportunity for "Walmart".*

[5] Steve Osterle of Medtronic stated that he sees their future as more a service than a medical device company. The future will not be "devices" but "solutions". Medical Devices (MDs) are approximately 7% of health services costs and industry is vulnerable to price squeezes and "solutions" approach. "Orphan" drugs offer better future.

[6] The development and management of EHR's, and other aspects of health databases, are opportunities for Irish companies, but not for manufacturing.

8. The coming decade will see the introduction of SMART devices, such as the wireless monitoring of bandages and other devices, such as those being pursued by Qualcomm and Medtronic.

9. Advances can be expected in neuro-modulation as treatments for obesity, Alzheimer's, Parkinson, etc.

Threats & Opportunities

- On-shoring of MNC investment to the US and other populous markets due to government demands for local investment and tax contribution.
- Transfer pricing practices will remain under pressure as governments seek a social dividend from firms with high local revenues. This reduces the attractiveness of Ireland as an investment location.
- Pressures based on post merger rationalisation of capacity and the need to locate capacity in new growth markets, will diminish investment in locations like Ireland.
- The medical device industry in Asia, the area of greatest growth in demand, has set aggressive goals to replace all medical devices imports from the EU and US with regionally manufactured devices. The rise of generic locally manufactured drugs will continue in the (rapidly) developing locations. India and Turkey are current key examples. Eventually this lower cost capacity will back-supply developed markets.
- Increased levels of drug formulation and finishing, and the development of combination drug treatments can leverage the embedded pharma experience and existing infrastructure from MNCs working in Ireland.
- Manufacture of image guided surgery products, including those with diagnostic and biopsy sample recovery capability, represent niche opportunities that could leverage the medical device industry experience.
- Regenerative medicine (using stem cells) is an area of research, affording an opportunity for Ireland to become a world leader in the equipment needed for discrete treatment areas, and the associated adaptive manufacture of matrix components.
- Ireland has an enviable reputation for GMP in pharma manufacturing, and a backlog of redundant plants. There is a market for generic drug manufacture, and manufacture of drugs for trials, from a trustworthy and low risk location

Recommendation to support Medical Devices and Pharma Manufacturing[7]

- In a world where cost effectiveness for the supply of small molecule generics and bio-similars will be paramount to successful competition, Ireland needs to leverage the positive reputation on Good Manufacturing Practice (GMP), and experience in lean manufacturing, to establish properly capitalised Contract Manufacturing Organisation (CMO) operations, or plan for this to come online in 2018 as consolidation amongst the pharma MNC's reduce the number of players.
- Ensure that opportunities for future manufacturing opportunities be reflected in the areas supported by life science publicly funded R&D.

- The infrastructure to support the advent of personalised medicine needs to be put in place both as a service to patients, and as a basis for development of new drug combinations for CMO's.

- Big data and big computing will underpin new diagnostic and data mining techniques. It is essential that the third level colleges produce the medically trained statisticians that will have the knowledge and innovative insights to truly exploit these databases to develop new drug combinations and formulations for locally based generic and CMO manufacturers.

[7] There are obviously health related opportunities from the management of EHR's, these are not manufacturing related.

- Regenerative Medicine (RM) is an area where Ireland is at the forefront of R & D. This must be encouraged to develop into commercial enterprises.

Chapter 4 Manufacturing - ICT

1. World Economic Status in 2023

- Globally the middle class is predicted to grow from 1bn ('00) to 5bn ('30), mostly in Asia and South America.
- The conditions for a continuation of the 1980's to mid 2000's growth boom of readily available capital, cheap imports and confidence in the ability of central banks to maintain growth and control inflation will not apply in the coming decade.
  - Credit will remain constrained by banks seeking to rebuild their balance sheets and reserves to comply with more robust rules.
  - Interest rates on SME and personal borrowing will remain high.
  - The period of cheap imports, driven by low energy prices and the introduction of new low cost producers has ended, replaced by upward pressure on energy, food, commodity prices due to the demands of the growing middle class, principally in Asia.
  - Doubt about the ability of central bankers to encourage growth and manage inflation has undermined businesses confidence in investing, and led to hoarding of cash in balance sheets.
- Protectionism sentiment in challenged economies will cause the re-emergence of "social needs" type restrictions on MNC trading. (e.g Recent refusals by the Indian & Indonesian governements to recognise drug patents) The demand for local social dividends from the governments of those markets producing most MNC revenue will reshape the distribution of related employment and the attractiveness of low tax locations. (e.g. Starbucks in the UK)
- Growth in China may slow due to impending shortage of up to 140m workers and the "Lewisian turning effect"[8].
- Also the the government of the PRC will have to rein in lending / rolling over of debt to local authorities for fear of inflation and therefore unrest. (There is a masked property bubble to be resolved)
- Economic growth in the EU will be hampered by the continuing need to restrain public spending to reach sustainable debt levels.
- Divergence in the productivity and debt levels of the weaker countries in the Euro zone compared to the stronger ones, without an effective wealth redistribution process, could lead to the break-up of the currency union.
- The price of commodities will have increased marginally, impacted by the growth in consumer demand from the growing middle class, but impacted by the slowing rate of aggregated growth from the US, EU, BRIC.
- Green policies will have negatively impacted energy pricing and hence disposable income across the world.
- Increased sales of electronic computing and comms products will provide the revenue to enable the continuation of Moore's Law, and hence volume driven cost decreases, even in a slower growing global market. Sales of computing and comms products and services will continue the restrained growth of the 2008 to 2013 period.
- The pension funding crisis / number of pensioners and their health needs world-wide will intensify the payor pressure on health care and medicine providers. Investment in personalised health records will be restrained.

[8] The point at which the excess labour in the subsistence sector is fully absorbed into the modern sector, and where further capital accumulation begins to increase wages, is sometimes called the "Lewisian turning point" (or "Lewis turning point") and has recently gained wide circulation in the context of economic development in China.[8] http://en.wikipedia.org/wiki/Arthur_Lewis_(economist)

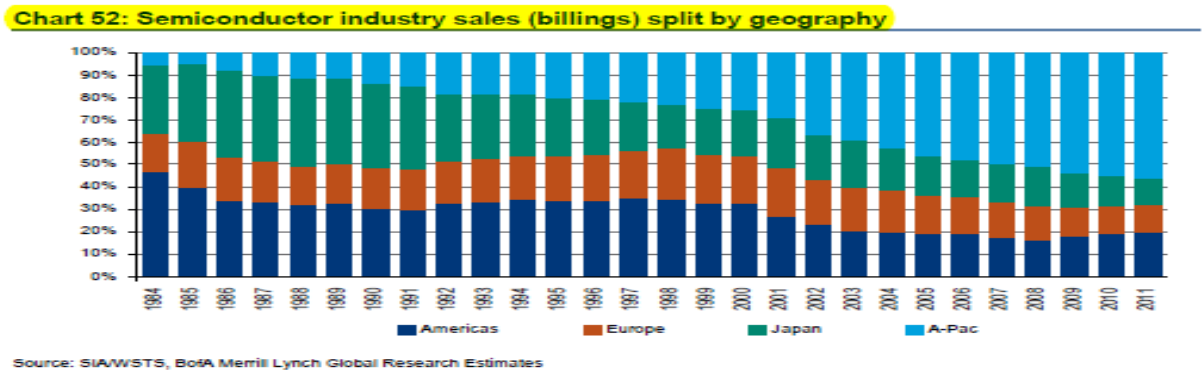
- This will be the decade of big data, as business comes to depend on the computing power, record keeping and anti hacker capability of data centres.

Impact on ICT Manufacturing

- ICT will remain a growth sector, driven by semiconductor technology development, innovative product development enabled by increasingly sophisticated design software, and demand from the growing global middle class.
- IC companies will continue to base their development plans on Moore's Law, using either feature scaling or chip stacking. FPGA & PLD manufacturers will continue to design IC's using tool sets that are three generations plus behind those for the current 30nm node.[9]
- The structure of the IC design and manufacturing industry will continue to consolidate, with only Intel and Samsung remaining as Independent Device Manufacturers (IDM's) through the 14nm and 11nm nodes.
- Leading edge foundries will be reduced to Samsung, TSMC and Global Foundries. With Intel these companies will have made the transition to 450mm wafers and EUV lithography by the end of the decade.
- Other foundries such as UMC and Renasas, and some existing IDM's such as IBM and Texas Instruments, will continue to develop lower efficiency lithography techniques to allow them to compete in the sub 30nm nodes using their existing toolsets.
- Most IC companies will continue to act as fabless companies, using the flexibility on production afforded by the foundry network, and so avoid spending on process development. This capability is being used by Irish start-up IC companies.
- Others will follow the ARM approach of licencing IP to IC development companies, letting them base their businesses on customisation of the other areas of their 'systems on a chip'. The ARM Connected Community will continue to grow above the current 1000 partners.
- Manufacture of smart phones, tablets, PC's and servers will continue to be undertaken in lower cost geographies, supporting the localisation goals of the MNC's. The anticipated onshoring of this assembly work to highly automated factories will not yet be competitive.
- Given that electronics will be "everywhere"; in controls and sensing (see Enterprise Ireland (EI) listing in Appendix to this paper), there will be multiple niche openings for small runs of electronic control systems (and therefore growth of the existing number of small companies already engaged).
- Cloud computing and SaaS (software as a service) will enable even small companies to access big computing design software, and large scale databases, to optimise all types of designs. This capability can provide design capabilities for IC's, green buildings, risk assessments, medical devices and a host of other applications.

Note also the progressive shift of semi-conductor sales volume to Asia as shown on Chart 52 abstracted from a recent Merril Lynch report. This recognises the strong assembly base in Asia, remembering that semiconductors are a component, not an end product.

[9] This is an area where legacy technology can be leveraged with 2.5D systems in a package to produce products that meet Moore's Law prediction.



Threats and Opportunities

- The accelerating digitisation of devices and processes across all sectors of economic activity will generate a stream of opportunities to develop vertical specialisations in the application of ICT.
- Ireland is best suited to the production of leading edge technology products in relatively low volumes for international niche markets, particularly where high quality is a critical requirement and/or the market is regulated.
- Opportunities must exist for leveraging the accumulated pool of experience in IC and systems manufacturing for pilot production runs of new products and subsequent tech transfers to volume contract manufacturers in lower cost locations.
- More of the IP in elecronic & comms products will be owned by non US & EU companies. This will be leveraged to grow global revenue market share for these countries like the PRC, India and Brazil.
- IC manufacturing in Ireland will eventually be limited to Intel, although market opportunities may exist for assembling and packaging small run custom Systems in a Package(SIP's) or 2.5D or 3D stacked chips. This will require an ability to etch and fill vias in the silicon interposers.
- Most ICT manufacturing operations in Ireland, both FDI and indigenous, have been in operation for 15 to 30+ years, and have had the opportunity to accumulate considerable embedded technical skills and market knowledge over this period. This will be Ireland's primary asset on which to build design and manufacturing operations.
- Many of our ICT manufacturing operations are endeavouring to add value in niche markets such as for small motherboards for medical technologies, and supplying ASIC's and FPGA's for controls and metrology systems for the medical devices and pharmaceuticals industry. They rely on close proximity to end customers to streamline their designs.
- Diminution of the value of the 12.5% corporation tax rate, (plus other R&D related reliefs), through the implemention of tax rules in the developed countries to equalise effective tax rates for indigenous companies compared with MNC's may reduce the attractiveness of Ireland as a location for major capital investment in ICT manufacturing.
- Cost competitiveness in Ireland will remain compromised, as other competing locations benefit from deliberate devaluation of their currencies against the Euro.
- Bottom line the only electronic based manufacturing categories that are likely to be competitive in Ireland are:

    a. IC manufacture (in Analog & Intel)
    b. IC design for contracted manufacture elsewhere of Programmable Logic Devices, micro-controllers and transceivers (wealth reverts to Ireland)
    c. 2.5D & 3D system packaging.
    d. Contract surface mount motherboard assembly.
    e. High capacity storage systems (EMC).

f. Small scale electronic assemblies: e.g. for medical devices, SMART controls for houses, and low cost networking equipment, security systems, specialised lighting systems, electronic functionality for mechanical deveces, Real Time Location Systems.

Recommendations

- Confirm that the goal of investment in ICT is creation of added value. The semiconductor segment will produce no additional manufacturing jobs, but will keep Ireland at the forefront of IC design, (manufactured by fabless companies.)
- Concentrate R&D funding on those areas where Irish start-ups or SME's can exploit the solid IC design training, IP rules and access to foundries to produce small comms and PLD's for niche applications. (IKON and Decawave lookalikes)
  - Given the pace of technology growth in the ICT industry, time to market of new products is vital to attract VC funding to avoid investment destroying obsolesence.
- Prepare an inventory of experience in the broad electronics manufacturing industry over the past fifteen years. Seek to direct state funded R&D towards areas that can exploit this embedded manufacturing expertise.
- Programs requiring widespread installation of socalled SMART switches, thermostats and consumption measuring devices should be leveraged to provide opportunities for local design and assembly work of electronic controls.
- Where manufacturing operations are senstive to utility costs, ensure that these costs are internationally competitive (and green where possible). US declining energy prices represent real competition for the coming decade, as will the depreciatiing dollar.
- Big computing (and big data) will enable ever more sophisticated IC, comms and electronic controller designs and performance prediction tools. The colleges training and upskilling of ICT designers need to have early access to each generation of new computing capability to maintain contact with leading edge ICT development.

The output from big data and big computing will need devices to allow its practical usage in multiple different working environments. There could be niche opportunities for such devices in manufacturing, maintenance, diagnosis, measurements.

Appendix (to Chapter 4) - Government Agencies' strategy for ICT Manufacturing

IDA Ireland

- Capital and skills intensive operations
- Production of high value products
- Pilot or short production runs
- Demand fulfilment operations

It is notable that there has been no greenfield ICT manufacturing investment in Ireland for more than a decade. There have been many significant losses from existing manufacturing plants. Only three companies (Apple, EMC and Micro Semi) have expanded manufacturing in Ireland in recent years. It is inevitable that Intel will upgrade their capacity in Leixlip to manufacture at the 22nm node so preserving jobs.

Principal existing sectors

- Semiconductors
- Power supplies
- Contract assembly
- Data processing/high capacity storage
- Instruments/controllers/sensors
- Passive components

In addition there are many semiconductor design activities.

Enterprise Ireland

Identified growth opportunities

- Microelectronic design, especially analog IC design
- Semi-conductor processing equipment
- Industrial control equipment

Principal existing sectors

- Microelectronic design, especially analog IC design
- Semi-conductor processing equipment
- Industrial control equipment
- Building management systems including
  - Lighting
  - Low voltage switchgear
  - Access control

  with emphasis on increased efficiency and the green agenda.

Principal existing sectors

- Building management systems
  - Access control
  - Lighting
  - Switchgear
  - Air conditioning
- Components
  - Electrical
  - Mechanical
  - Power supplies
  - Photonics
  - Semiconductors(design)
  - Telecoms
- Electronic Data Processing
  - Display
  - Peripherals
  - Refurbishment
  - Tracking
- Electrical equipment
  - Catering
  - Retail
  - Transport
- Industrial Control
  - Aircraft
  - CD/DVD
  - Fishing
  - Food
  - Gas
  - Pharma
  - Plastics
  - Process Control
  - Robotics
  - Semi-conductors
  - Telecoms
  - Test and Measurement
  - Transport
  - Utilities
- Sub supply
  - Assembly
  - Design
  - Harnesses
  - Hybrids
  - Materials
  - Mechanical
  - Plastics
  - Test and Measurement

Chapter 5 Manufacturing - Natural Resources including Food and Fisheries

Ireland – the Food Island of Europe

The progressive policies put in place by governments, since the 1950s, have undoubtedly created a wave of foreign direct investment that has transformed the industrial and manufacturing landscape of Ireland. Companies, particularly those involved in high value manufacturing and exporting, continue to be the cornerstone of our success in overseas markets and have created a dynamic manufacturing sector that is the mainstay of our exports. These companies have continued to put down deep roots in our economy and this is demonstrated by the numbers of companies who have significantly diversified their operations to include research and development.

Ireland is the **Food Island** of Europe. We are fortunate to have abundant natural resources that allow for the production of such a diversity of food produce. Importantly we have a tradition of farming that is based on principles that facilitate the production of quality and safe food within a strict regulatory framework that protects the consumer.

The Government report published in 2012, Food Harvest 2020, is a roadmap on how we can expand the food sector here in Ireland. It defines what is possible for this sector to achieve and it clearly does so recognising the challenges and opportunities that we face.

In 1999, the population of the world exceeded six billion. By 2025 it will exceed seven billion people and the difficulties to feed such a vast amount of people will be enormous. With the strong growth and the expectations of the middle classes in such countries as Brazil, Russia, India and China, the need for additional food output from the world's ecosystem will be problematic.

Ireland's challenge and opportunity is to establish itself as a significant player in global food production.

We sometimes overlook the major contribution the food and fisheries sectors make, which for the most part, are made up of indigenous companies that are now showing significant growth. The agri-food and fisheries sector in 2011 recorded exports of €9.13 billion which was a 12% increase over the previous year. Part of this growth can be attributed to higher commodity prices on the world market, but key elements of the sector, such as beverages, dairy and pig meat had noticeable volume growth. The entire sector was responsible for 25% of the total growth of exports in revenue terms in 2011.

No sector of the economy has such a profound impact on the rural economy as the agri-food sector, because it is so embedded into the socio-economic fabric of the country. From the production of food from the land, the support of rural communities, to the creation of added value in sophisticated manufacturing facilities, this sector plays a pivotal role in rural Ireland. The agri-food sector is predominantly indigenous manufacturing and process industry and has approximately 50,000 direct employees and importantly 128,000 families in rural Ireland are dependent on it as their main off take for farm outputs.

In 2011 the seafood sector recorded strong export growth of 10% over the previous year and BIM supported companies created 127 new jobs and additional revenues of €57 million.

The food and beverage industry would appear to be growing employment levels. The CSO national household survey estimates job numbers have increased from 43,900 in Q1 2010, 46,000 in Q1 2011 to 50,300 in 2012. This data may underestimate the levels of employment as official figures indicate over 1,700 jobs in the fishing and aquaculture sector. BIM believes there are over 6,500 full and part

time jobs that are directly employed on fisheries and aquaculture. These are, for the most part in SME operations. Data for 2010 indicates full and part time fishermen and aquaculture producers generate a further 4,070 jobs in fish processing and related activities.

Prospects for creating additional jobs in the sector

The Government's 2012 Action Plan for Jobs outlines its objectives to grow and develop the agri-food sector. In reading the report, it is apparent that the Government has expectations of major growth in the sector. There are numerous Government objectives that are planned to add value to the sector by supporting initiatives that will boost employment in both the primary and processing areas of the food industry. In food processing, Bord Bia, Enterprise Ireland and Teagasc are working together as part of the **Food Works** programme with SMEs, providing assistance to validate product under development, which involves assistance with technical expertise, research and development, pilot scale production facilities, food incubation units and product assessment. The expectation is that this initiative will support firms that are capable of salable exports.

Recently the EU announced, as part of the CAP reforms, the scrapping of the **sugar beet** quota restrictions. Sugar Beet Ireland has been campaigning for the lifting of this restriction for some time. Plans have been drawn up to resume sugar production in 2017. An engineering design has been completed to build a modern process unit that will facilitate the efficient extraction of sugar from sugar beet and the production of industrial ethanol. This new facility will also generate energy from a CHP unit and from anaerobic digestion of beet waste. This initiative will be funded by private investment and will not need Government financial support. The project has the potential to create significant employment during the construction phase. The manufacturing unit will also afford the opportunity to create quality jobs both directly and from farms, service providers and additional ancillary manufacturing activity.

The recent announcement of the creation of 1,000 jobs by the **Kerry Group** is to be welcomed by all. It demonstrates how a basic processor of bulk milk, by innovation, can produce complex food extracts and ingredients that compete on the world market.

The **dairy sector** is poised for rapid expansion with the ending of milk quotas in the near future. The Food Harvest 2020 Government report sets an objective to increase milk output by 50% and it is estimated that this quantum leap in output will generate over €900 million in additional revenue for the dairy sector. Already milk processors are progressing plans to establish additional capacity to process this increase in output. The dairy industry has transformed itself into a highly competitive sector that can compete internationally. But we face threats. Already Ireland is under EU pressure with regard to various directives that require Government action to protect groundwater and control and reduce greenhouse gas emissions. If Ireland fails to implement these directives, we face daily fines - which are considerable. There is an urgent need to address these challenges and come up with innovative solutions.

Food Harvest 2020 recognises the need to **market our food produce** more effectively. This is a prerequisite to increasing manufacturing output. Considerable progress has been achieved with closer collaboration between the Department of Agriculture, Food and the Marine, Bord Bia, Enterprise Ireland and Teagasc. Exporting to markets, such as, China, Japan and other countries is complex and requires a coordinated approach to achieve market penetration. Likewise, we need more collaboration between the smaller producers to share marketing costs when exploring new markets.

The larger food producers are well positioned to develop new innovative products but the **smaller enterprises**, because of the constraints of financial resource, find it difficult to develop new products. There is a need to support these producers with the establishment of a limited number of small scale food production and laboratory facilities throughout the country which will allow them to develop new product offerings.

Ireland's output **of organic grade farmed salmon** lags behind Scandinavian and Scottish production. This is despite the fact that we have some of the best ocean waters in Europe around our coast. BIM and the Marine Institute have jointly proposed a major development, identified a potential site, carried out a full evaluation on this site and put in place a detailed environmental impact study. They have also lodged a formal aquaculture and companion foreshore application to the respective licencing authority. Of importance, they have fully engaged locally and nationally in an extensive transparent consultation process to promote this important project.

This project, if the license is granted, will facilitate the production of 15,000 tonnes of organic grade farmed salmon. The operation has the possibility to create 350 jobs directly plus 150 downstream jobs and €100 million in exports.

Key recommendations

- The approach by government agencies working more closely together should be extended to encourage the growth of food companies to fast-track their development. Food production necessitates the involvement of many Government and state agencies and by working together, in a more structured manner, unnecessary bureaucracy and duplication of effort can be avoided. There is an urgent need to encourage small food companies to scale up their operations and to enter new markets. **The Food Works** approach and initiative should be built upon.

- The initiative by farmers to try and restart the **sugar beet industry** is to be commended and supported. This group have already made considerable progress in advancing the project, having engaged an engineering company to carry out design work, selected a site for the plant and drawn up plans to finance the undertaking, all without recourse to Government assistance. Now that Ireland is free to process sugar in 2017, it is important that obstacles that very often hinder major new enterprises, a coordinated approach by Government and the local authority, where the plant will be constructed, should be put in place. This site for the project, because of its national socio and economic importance, should be considered under a Strategic Development Zone (SDZ). As a SDZ, the timely and orderly planning and construction of the plant should be able to proceed in a more coherent manner and it can address the possibility of ancillary developments on the site at a later date.

- With the lifting of CAP restrictions by the EU in 2015, Ireland will be able to increase its milk output and already plans are in place to ensure there is **additional capacity to process milk.** It will also afford, both national and international infant formula companies to increase their production of product. Ireland is now one of the major producers of infant formula and we should see output and market share increasing, particularly in the new emerging markets.
  This expansion in output will present major challenges to deal with the increase in the dairy herd and need to deal with the inevitable increase in both greenhouse gases and of nitrates and phosphate levels in the ecosystem. These are massive challenges and will have to be addressed. Already considerable work is being undertaken. These challenges need to be

addressed and it is important that more research and innovation take place, both at Government level, on the farm and within industry. We have seen how many companies have helped farm enterprises to improve efficiency and drive down costs and without doubt, these challenges will provide entrepreneurial firms fresh opportunities.

- Ireland, despite having some of the most advantageous coastal marine environment, has failed to capitalise on its abundant resources to produce farmed salmon, **particularly organic farmed salmon.** Other countries have achieved volume production that provides good employment without compromising the natural environment. It has been demonstrated that decisions which are based on credible facts and good science should be respected by all. It is of critical importance that a decision is reached soon on the proposed large scale organic salmon farm on our west coast. The development, if authorised by the relevant authorities, should proceed as soon as possible. The potential to create sustainable jobs, in salmon production and its processing into value added food, can bring enormous benefits to the region.

Chapter 6 Manufacturing- General Engineering including Machinery, Metals, Aviation and Plastics

1. Scale and Nature of the Sector

The companies in the Republic are supported by 3 State Agencies, i.e., Enterprise Ireland, IDA and Údaras.

The majority of firms are assisted by the Engineering Divisions in Enterprise Ireland and the IDA.

Between them they comprise approximately 800 companies and approximately 40,000 employees. There are other very small companies assisted by the local Enterprise agencies. IDA linked companies are significantly larger on average, but taking the sector as a whole:-

- Approximately 80% have less than 25 staff
- Maximum company size is ca 1000 employees but there are only a handful and companies with + 250 staff are the exception, most companies are indigenous.
- Their outputs range from product manufacturing to a range of subcontracted components and support services
- The globally competitive ones tend to sell "Technical Solutions" to clients
- A sizeable percentage of indigenous companies are engaged in supplying components, etc., to the FDI sector
- FDI/IDA supported companies, like their counterparts in other manufacturing clusters, play a role in the supply chain of the larger multinational companies.
- Smaller companies are very focussed on the Irish/UK market while the more developed companies take a wider global market perspective
- Numbers employed have dropped by approximately 25% over the last decade, in line with the fall in total manufacturing sector employment.
  The surviving companies have adopted more efficient practices and modern technology to remain competitive.
- While there are numerous examples of outstanding companies that can be classified as role models, the engineering sector as a whole is weak in Ireland. Its scale is proportionately only half the EU average, lagging well behind the medical devices sector which is well above the EU average.
- Unlike Germany (the leading EU manufacturing country) Ireland does not have a significant cohort of medium to large indigenous companies which provide the foundation for its manufacturing strength as in Germany.
- Productivity in the sector appears to be less than 75% of German/Danish indigenous companies.

2. Perceived Problems and issues in the sector

- Indigenous manufacturing policy/prioritisation has received limited attention over the last twenty years compared to the FDI sector.
- The sector has an "image" problem which inhibits investment and in particular recruitment of first class engineers/technologists who could underpin innovation and improve productivity.

- Mainly for cost competitiveness reasons Irish companies have turned to overseas producers or locations to manufacture products or components that could be made in Ireland.
- For smaller companies marketing into the UK and EU can be a major problem, particularly if domestic demand is weak.
- Overhead costs and related procedures/regulations impinge severely on smaller companies who are trying to expand.
- Accessing expert R & D support to help product development appears to be a real problem.
- IMI survey pinpointed weak management as an issue in the sector.
- Owners tend to be conservative/risk averse and may have reservations about using venture capital funding.

Note: Much deeper analysis will be required to pinpoint the factors that give rise to both successes and failures in this diverse sector.

3. **Opportunities and Related Initiatives**

Apparent opportunities fall under 5 general headings:-

a) FDI companies in Ireland import very large quantities of materials, components, etc. A comprehensive in depth analysis should reveal more opportunities for manufacturing in Ireland and the standards that indigenous companies must achieve.
b) Further exploitation of FDI sub-contracting opportunities within Ireland
c) Deeper penetration of the UK market
d) New start-ups or diversifications into technically advanced products aimed at a global market
e) More cross-border interactions: the sector is relatively vibrant in the Northern Ireland and synergy between firms in the two jurisdictions can provide a stronger foundation for growth.

4. The initiatives to support a programme of sustained growth over the next decade include:-

- Appropriate capital investment into the sector.
- Supply of qualified/trained people to match the current emerging needs of the sector, e.g. industrial engineers, toolmakers, etc.
- A supportive economic environment in Ireland.
- A competitive cost framework.
- A first class networking and intelligence system to identify opportunities, driven by the relevant agencies
- A clear cut and integrated Government policy that emphasises indigenous manufacturing.
- A sustained programme to enhance the image and attractiveness of the sector.

Chapter 7 Manufacturing - Cleantech and Energy Efficiency

Opportunities for Growth and employment

Cleantech Manufacturing: Current Status

The cleantech industry is quite broad and includes sectors such as recycling, renewable energy, waste to energy, energy efficiency, water efficiency and sustainable transport. The sector employed 5,900 people across 240 companies in 2010 (could be estimated at circa 7,000 employees today). The sector is thus significant, but relatively small. The cleantech sector in Ireland includes a significant amount of services companies (e.g. consultancy, transport services, legal services and operation and maintenance), hence the manufacturing sector (which produces clean-technology products) is an even smaller niche subsector, with an estimated 4,000 direct employees across some 40-odd companies. Existing cleantech companies include the following:

Energy Efficiency

- Glen Dimplex (solar thermal and heat pump renewable technology, smart storage heating)
- Kingspan (renewables and insulation)
- Nualight (LED lighting)
- Patina (high efficiency lighting with integrated controls)
- HDS Energy (biomass boilers)
- Comeragh Controls (heating zone control products)
- Cylon Controls (building management systems)
- Episensor (wireless sensors for environment control)
- Climote (heating controls)
- Owl Ireland (wireless metering)
- IKON Semiconductor (solution provider for LED industry)
- LED Group (LED lighting products)

Smartgrids

- Meterlogix (energy Metering)
- Wattics (smart metering)

Renewables

- BHSL (biomass boilers)
- OpenHydro (tidal energy)
- Solarprint (dye-sensitised solar cells photo voltaics)
- C&F Green Energy (wind turbines)
- Grant engineering (biomass boilers)

Water

- Aqua-sol engineering (water filter technology)
- Bio-Cycle Ltd (commercial and domestic water-water treatment)
- Biotector Analytical Systems Ltd. (water analysis equipment)
- Bord na Mona (wastewater treatment, water harvesting and recycling)
- Butler Manufacturing (packaged water / wastewater solutions)

- SCFI (super critical water oxidization)
- Solids Technology (products for water and wastewater industries)
- Trustwater (electrochemical cleaning and disinfecting)
- Hydro International (water and wastewater solutions)

Ireland has a relatively low profile in the international Cleantech manufacturing. Nualight, a company specializing in the design of manufacture of specialist LED lighting for the retail, car parks and airport sectors among other was included in the Global Cleantech 100 Report for 2012. Cylon Controls, a manufacturer of building management systems solutions was the winner of the Global Cleantech Cluster Association's 2012 award, both of which are notable exceptions. Four Cleantech manufacturing companies are represented in the Irish Times Top 1,000 (C&F Group, Glen Dimplex, Kingspan and Grant Engineering). These companies have substantial operations outside of what would be considered Cleantech manufacturing, and together make up an estimated half of the total employment in the Cleantech sector overall in Ireland.

Findings and Recommendations

Risk

The recent liquidation of Wavebob (ocean wave energy development and manufacture) and in the past Bioverda's biofuels productions plants are example of the risky nature of manufacturing in this sector. Taking due account of this risk, a deliberate policy should be to avoid government selecting particular technologies – instead letting the market drive and support the technologies with the best opportunities

Leveraging Manufacturing Competencies

Ireland already has strong competencies in certain manufacturing / production areas, e.g. the pharmaceutical industry in Ireland. A strong and vibrant Cleantech water processing and treatment manufacturing industry has emerged to meet the needs of this sector. This experience should be replicated for other manufacturing / production areas: for example, with the anticipated impact of Harvest 2020 on in dairy sector, the opportunities for process and utilities efficiency improvements are very considerable and thus far, untapped

Clustering

The challenges to resource efficiency and climate change are often interdependent – for example the interaction between water use and energy, the usefulness of "waste" as an energy source. There are significant benefits in cross-fertilisation of ideas across these sectors and one proven way of achieving this is through start-up clustering. One good example of clustering is DCU's Cleantech innovation campus in Glasnevin. This should be replicated.

Innovation/Applied Research as a Key Driver

The Cleantech sector is a highly competitive, fast evolving, knowledge driver sector. Countries that have thriving Cleantech sectors have also developed national competencies in innovation and intellectual property development, such as Israel and the United States. Existing R&D tax credits are a very useful instrument for stimulating innovation in this sector, however support from the academic sector on the use of tools and processes (such as NUI Maynooth's promotion of System Design Thinking as an innovation methodology) should be promoted and offered to the businesses community as post graduate courses, or through Enterprise Ireland, IDA or other organisations. General entrepreneurship needs to be taught at under graduate level also.

Increased Primary Research

The International Energy Agency in its Energy technology Perspectives 2012 report identified a sharp decline in global R&D in energy as the economic crisis deepened. It also calls for a marked increase in Government sponsored primary R&D in this sector, which on a global scale only accounts for 4% of overall government R&D spending. It is recommended to replicate the investment in ocean energy R&D to other areas of the Cleantech sector, in particular the energy efficiency sector due to its worldwide applicability.

Skills

The competencies and skills identified in the report "Future Skills Needs of Enterprise within the Green Economy" (see References below) are valid for Cleantech Manufacturing. While the Green Economy is a wider business sector and includes for example renewable energy production, the same skills are valid and they are in short supply in some sectors. Required skills range from basic engineering, to computer science, but include new fields such as data analytics and cutting edge communications technologies. Some of the skills of which there is a shortage of in the market are not being adequately addressed by the academic communities. Examples are thermodynamics and industrial energy efficiency.

Growth Opportunities

The global Market is worth an estimated €2-5 trillion, so the opportunities for growth in Ireland are staggering. Ernst & Young, in their Cleantech Ireland Report estimated that employment in the Cleantech sector in Ireland could grow to 80,000 by 2020. As this includes both services and manufacturing, an estimate for the manufacturing sector alone could be 10,000 – 15,000 employees. As a high cost economy, Ireland can only be successful in developing and manufacturing Cleantech products which have a high intellectual property content. While that rules out some high volume – low cost products, such as some components of wind turbines, it directly applies to the vast majority of Cleantech products

References

	Reference	Link
1	Cleantech Ireland – An assessment of the sector and the Impact on the National Economy – Ernst & Young	http://www.ey.com/Publication/vwLUAssets/Cleantech_Ireland_report/$FILE/Cleantech%20FINAL%20low%20res.pdf
2	Cleantech Ireland - Irish Exporters of Cleantech Products and Services Directory , Enterprise Ireland	http://www.envirocentre.ie/includes/documents/Cleantech_web.pdf
3	Future Skills Needs of Enterprise within the Green Economy in Ireland	http://www.skillsireland.ie/media/egfsn101129-green_skills_report.pdf
4	Enterprise Ireland – A guide to Irish Suppliers for Low Carbon buildings	http://company-profiles.enterprise-ireland.com/files/2013/02/Better-Building-Directory_2013.pdf

Chapter 8 Manufacturing - Construction

Policy Derivation to Maximise Employment in Construction Manufacturing through 2023.

Economic Perspective from 2023

1. The construction industry will be fully digitised by 2023. This will increase pre-fabrication and quality, while reducing costs.
2. Tensions within the Euro membership between high productivity countries and those with consistently lagging competitiveness will be managed through minor conditional wealth transfers between members.
3. Ireland's relatively flexible labour market, and its manufacturing experience acquired from the large base of MNC companies, will enable Ireland to maintain a rough parity in productivity with the UK in any pre-fabrication work.
4. Banking recovery in Ireland to sustainable levels of lending and costs of borrowing will be achieved in the latter half of the decade. Bank recovery in the UK will happen earlier.
5. Recovery in annual construction spending will be subdued, driven by modest rates of growth, but constrained by the cost of capital for commercial and domestic property investment, and the reduced disposable incomes of end users.
6. Capital availability for new investment by SME's will remain tight and interest rates high. This puts start-up companies at a disadvantage, when competing with larger companies with accumulated reserves of free cash, in exploiting the digitisation of the construction industry.
7. Investment in capital plant by indigenous and MNC's will recover in the later years of the coming decade, driven by growth in their traditional markets and the competitiveness delivered by newly emerging technologies and products.
   Investment by pharma MNC's in Ireland will continue on a downwards trend, as a consequence of their increased investment in growth markets.
8. Major spending on utility infrastructures in Ireland will occur, driven by the requirements of the EU Water Directive and the opening of zonal energy markets.

Manufactured Construction Products that will have grown in the upcoming decade

1. High resolution digital Building Information Models (BIM) will form the basis of the digitised industry. As building designs are being generated, cloud based computing power and "big data" will both design to specified constraints and report on energy performance, cost, occupancy behaviour, lifecycle use of water, or any other characteristics.
   a. Embedded sensors will allow a project to "feel" how it is operating and respond to specific conditions of occupancy, weather, energy availability, even maintenance state.
   b. Connected to the cloud, a host of such sensors will help the building accumulate knowledge about itself and "learn" to optimize its performance. Access to the sensor data is critical to optimising the design of future modules.
2. The market for Irish construction related manufactured products and prefabricated modules will be largely confined by, logistics considerations, to the traditional markets of Ireland and the UK.
3. Growing energy prices will prompt increased investment in products for conservation of energy. An opportunity exists for developing tailored products for retrofitting existing buildings constructed to local Irish norms.

4. Successive generations of heating units will be manufactured to exploit incentives in the energy market tariffs. This included the development of easily programmable and integratable local Smart controls systems suitable for smaller and medium building sizes, and hot water solar panels optimised for Irish conditions.
5. The opportunities afforded by the compact all-island distribution utility networks for prototyping and optimising the design and manufacture of controls and switching systems can be exploited to create new niche products for Irish start-up companies.
6. Investment in utilities infrastructures will increase significantly, prompted by technical developments in communications systems, extension of gas grids to connect new sources, and by the dictates of EU wide requirements, such as the Water Directives. This will enable the growth in pre-fabrication of control and pumping modules, exploiting the embedded experience of designing and fabricating systems for MNC manufacturing plants.
7. The mandatory adoption in 2016 of building information modelling (BIM) on public construction contracts in the UK, coupled with the increased sophistication of laser scanning measurement systems, will have enabled a rapid growth in UK off-site pre-fabrication, driven by higher quality and productivity considerations.
   Ireland's slower rate of adoption will have created an opportunity for UK pre-fabrication suppliers to compete successfully in the Irish market.
8. Growing investment in the incorporation of recycled materials in new products will occur, driven by increased abstraction and commodities prices.
   Areas with potential included asphalt and tyre recycling into quieter urban pavements, glass recycled into hygienic kitchen counters, plastics into longer life replacements for timber building components, and the development of simple systems for treatment of recovered grey water for non consumption domestic uses.

Threats to and Opportunities for Construction Manufacturing

1. Failure to remain in echelon with developments in the digitisation of the UK construction market could limit the size of the local start-up markets for Irish pre-fabrication companies, and, as a consequence, facilitate greater penetration of the Irish construction market by overseas suppliers of pre-fabricated components and modules.
2. The upcoming investment programs in the island's utility distribution systems, represent real opportunities for supply of modules for control and operation of these networks, which will also act as acting as laboratories for optimising the design of such products. The export growth potential is obvious.
3. The recovery of the construction market, and hence the market for construction related manufactured products will occur earlier in the UK than in Ireland. Investment in new product development and commercialisation should inherently consider this market as a natural extension of that on the island of Ireland.
4. The detailed knowledge of the UK market, and those further afield, that has developed as a result of the high levels of emigration of experienced construction personnel, and the market diversification by Irish construction companies, should be exploited in developing construction related products that would be marketable in those markets.

Recommended Government Policy Changes

1. The software supporting the digitisation of the construction industry will become ever more sophisticated. The need to stay ahead of these developments should be reflected in the curriculum of all third level colleges educating professionals for the construction industry.

2. Specifically the curriculum for all Level 6 through 10 manufacturing course syllabi should cover the leading edge emerging technologies, such as 3D metal printing, graphene fabrication, CNC machines, site robotic machines etc.

3. All other industries that digitised their design processes have exploited the ability to pre-fabricate sub-assemblies, for obvious efficiency reasons. The same trend will happen with the digitisation of the construction industry.

   A government roadmap is needed to ensure that the depressed construction market here does not result in Ireland ceding the development of prefabrication capability to other countries which are more advanced on the construction industry digitisation process.

4. To maximise the volume of indigenous investment in construction pre-fabrication for infrastructure projects, and encourage private sector investment, the scale of total annual capital spending in the country should be maintained at relatively stable levels to allow the invested capital in pre-fabrication to be predictably amortised. Increased levels of counter cyclical public capital spending could offset reduced levels of private sector investments during business cycle downturns in the coming decade, which hopefully will have a shorter period cycle and amplitude than previously.

5. Any offsite fabrication should be afforded access to low interest funding. This funding should be put in place to support the deepening of indigenous investment and output in all aspects of manufacturing.

6. With a relatively small local market for construction related products, it is vital that the quantum of investment for developing new commercial construction products be aggressively managed to concentrate resources on the most promising opportunities.

7. The high level of emigration of Irish construction professionals and tradesmen could act as a market intelligence source on emerging demands and niche construction product opportunities, if a consistent process of keeping in contact with the construction diaspora could be established.

[Useful Reference: Predictions for the Building Industry, 2030 (ENR), 02/06/2013, by Philip G. Bernstein]

Chapter 9 Manufacturing – Education, Research and Innovation

The changing ecosystem for education, research and innovation in Ireland can only be considered in the light of the rapid and significant changes which are taking place in the European and Global Ecosystem. Our paradigm shift to date had been from "*Thinking Local, acting Local*" to "*Thinking Global, acting Local*". The next paradigm shift is different: "*Thinking Global, acting Global*". This is new business for Ireland's Higher Education [HE] sector. It is fundamental to the competitiveness of the Irish nation going forward. New trends in clustering of Higher Education institutions are evident. We see groupings forming across the EU with strong universities coming together to form excellence clusters e.g the IDEA League with Imperial College (UK), TU Delft (Holland), RWTH Aachen (Germany), ETH Zurich (Switzerland), ParisTech (France) and also the EUROTECH Alliance with DTU (Denmark), EPFL (Switzerland), TU/e (Holland) and TUM (Germany). Similarily there are numerous national and international alliances being formed (such as the TU-Austria and ParisTech at the national level, more detail below). As we progress, it will be important that institutions in Ireland are associated with the key hubs of excellence in the international HE sector. Changing the Irish HE sector in the absence of a detailed understanding of the dynamic global developments could result in damage and potential disaster for the longer term economic development of the country. On-going, continuous monitoring of international trends and developments is thus of the highest priority. Powerful clusters of leading universities are emerging. They will likely set the primary elements of the agenda and the standards for international education and research. They will form global knowledge clusters.

In addition to the partnering and clustering activities, the development linked to the use of the internet in the provision of educational programmes will also have a quite a disruptive effect on the traditional, localised approach to education. Massive Online Open Courses (MOOC's) and online courseware (OCW) are now making a strong impact and are maturing rapidly. They will transcent the geographical boundaries of the world and will have thousands of enrolled students. We already have examples of this, e.g. at Georgia Tech. The online offerings will change the dynamics of taught programmes right around the globe.

In summary, the smaller countries of the EU such as Ireland are challenged in this new operating environment for higher education. Judicious decision making is imperative where budgets are limited and international competition is fierce.

It is interesting to observe that, in a similar manner to the international dynamic taking place in global industrial development (recently classified for example in Germany as the 4th Industrial Revolution, Industrie 4.0) it seems reasonable to argue that there is an equivalent international revolution taking place in global education in general. The Science, Technology, Engineering and Mathematics areas [STEM] are particularly impacted. The opportunities are great, the challenges enormous.

The ecosystems for global education, research and innovation have developed almost beyond recognition when compared to the situation only 5 years ago. This ecosystem development includes the member states of the EU. Ireland must recognise the true extent of the significant change which

is taking place and we must develop our HE policies and strategies to ensure that we hone our own particular attributes to strengthen our success trajectory in this new open, global operating environment.

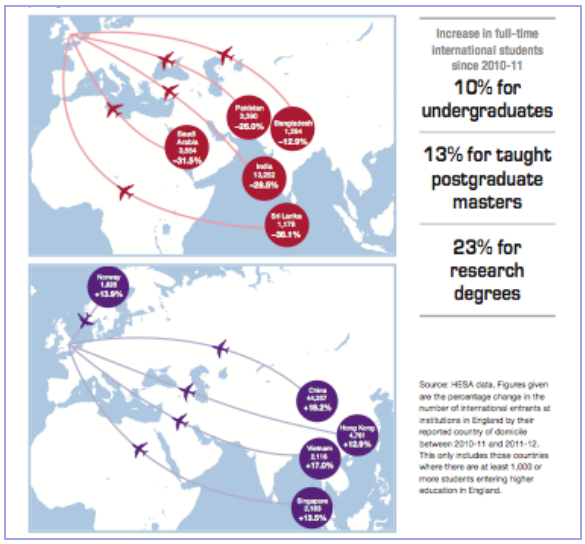
The Higher Education Authority is currently centrally involved in new policy development and is planning for significant change in the future HE landscape in Ireland. "*Higher Education Research (in Ireland) will need to connect to enterprise and society in new and imaginative ways to harness its potential for economic and social well being, including a more effective approach to knowledge transfer and commercialisation* – National Strategy for Higher Education to 2030. – Report of the Strategy Group (Irish Government) January 2011 (Hunt Report). Engineering has been selected by the HEA for particular attention. Herein lies a particular opportunity for accurate assessment to ensure that we continue to strengthen our HE system such that STEM as well as our business schools and other disciplines can take a leadership role in selected aspects of the EU's drive for innovation and entrepreneurship through for example the European Institute of Technology [EIT].

Several major drivers of change can be identified in the HE landscape in the EU and Ireland. These include:

1) Internationalisation of the student body,
2) New forms of national and international partnerships and collaborations,
3) The use of the Internet in support of online education (e.g. MOOC's) and
4) The increasing utilisation and development of international rankings of universities and institutes of technology.

At first sight it may be considered that internationalisation of the student body and partnerships and collaborations between HE institutions is something that is already happening and that this will continue to develop in an incremental manner. It is true that academics have been collaborating internationally since the very early years of universities. This is a fundamental aspect of the role of the individual academics in leading academic institutions and this will and should continue. Figure 1 refers to a recent report from the HEFCO (UK) where the significant increase in international student activity in England is reported.

Figure 1: Growth in International Students to England [Higher Education Funding Council for England (HEFCE), Report: Higher Education in England – Impact of the 2012 Reforms]



However, very recent examples show that extreme effort is currently being invested in developing new, long term ambitious partnerships between HE institutions both globally and also very strongly within the EU. It is valuable to consider some examples here:

Example 1: In Austria one of the most recent developments has been the strategic alliance of Austrian Universities of Technology. In 2010, the Vienna University of Technology, the Graz University of Technology, and the Montanuniversität Leoben founded the "TU Austria", producing an association in the field of science and engineering with more than 43,000 students, €440million total assests and 8,600 employees. Again the key objective is strengthening the position of each of the partner universities in international Education, Research and Innovation. Strong competence centres for excellence are integrated into this model.

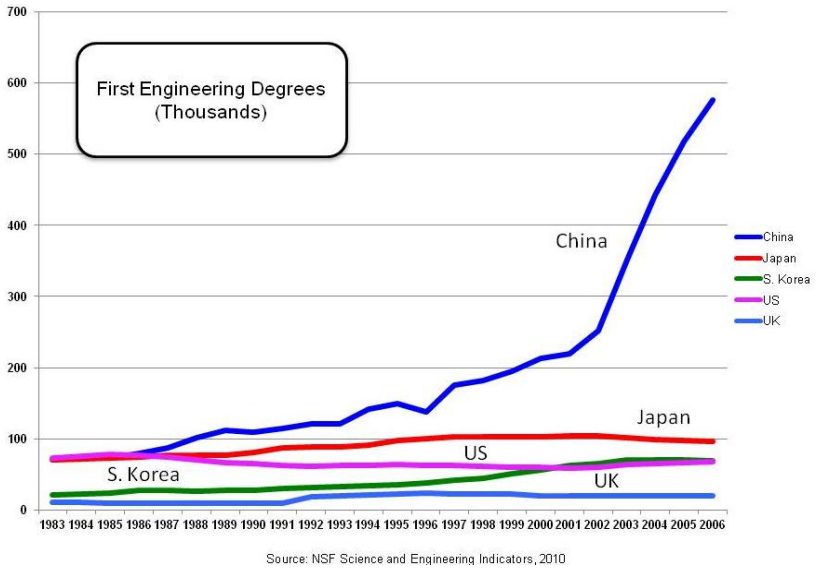
Example 2: Another example is from the city of Paris "*ParisTech*". Here developments are happening which we could hardly have conceived would be possible just a few years ago. The French HE system has been undergoing significant restructuring over the last 10 years. There are numerous examples of universities merging in France as a result. In Paris it was decided to develop an organisation equivalent in strength to MIT in the USA. – the Paris Institute of Technology (*ParisTech*). ParisTech is a consortium gathering twelve of the most famous French Grandes Écoles in Engineering and Management. In both fields, its aim is to be a major player at the forefront of higher education and research centers. Paris-Saclay has been selected for the location of this €5billion investment in this new Institute.

Example 3: In the City of Dresden, Germany, numerous research organisations and the TU Dresden have amalgamated onto an organisation called the "*Dresden Concept*". Here we have the TU in formal partnership with the Max Planck Institutes, Helmholz Institutes, Leibniz Institutes, Fraunhofer Institutes and other large scale research institutes. The vision is to make excellence happen and to make it visible in Dresden. The strategy is collaboration rather than coexistence. This new amalgamation was the primary reason behind Dresden winning its recent bid to become one of

the 11 excellence universities in Germany. In particular, the co-operation of all DRESDEN-concept partners is aimed at the development and use of synergies in research, education, infrastructure, and administration. Partners co-ordinate strategies to support Dresden's leading areas and identify new emerging scientific areas. The DRESDEN-concept alliance also works on a joint initiative to attract top talents and to convince the best to come to Dresden. This is an outstanding example of the German Infrastructure for Education, Research and Innvoation coming together to create a new powerhouse in Education, Research and Innovation in Central Europe. An equivalent scenario could hardly be achieved in Ireland.

Looking at these developments at our EU doorstep and considering the situation in the leading countries outside Europe we can start to appreciate the enormous challenges facing us in Ireland in the HE sector just to keep pace with these great drives for excellence. It is valid to state that the educational and research excellence in Ireland has earned a strong international reputation (e.g. through individual top level academics and through centres of excellence such as CRANN, CONWAY, REMEDY and TYNDALL). It is also valid to state that when we review the investment taking place in other regions in the EU, transformational change is without doubt necessary to strengthen our Irish ecosystem and to secure our competitiveness into the future.

Figure 2: First Engineering Degrees (NSF)



As is well known, one of the major motors for change will be the on-going rapid developments in China. An example of the situation in engineering in China is shown in Figure 2 above. The widening gap is self evident. In parallel with such developments, the investment in research and research infrastructure in China is enormous. Many universities in the EU have been developing new strategies for internationalisation and these strategies have (and must have) a strong focus on China. In addition, we see significance and strong initiatives in other regions such as India, Brazil etc.

The Strategic Policy for Education, Research and Innovation in Ireland is being addressed by bodies such as the HEA and Forfas. It is clear that the STEM areas are of fundamental and critical importance to the next stages of economic development in Ireland. For a small open economy such as Ireland, it is truly difficult in a current climate of econmic downturn to develop a robust and sustainable strategy for the next 10 years. We must use every resource available to us, our international networks (e.g. through bodies such as the Conference of European Schools for Advanced Engineering Education and Research (CESAER), the UNITECH Network, the Conference of Rectors of Universities of Technology (CRP) and various other HE and industry networks.

There is no doubt but that the challenges facing Ireland in innovation development are great, indeed the challenges facing the EU are also truly significant. When compared with the USA it is evident that the EU has slipped in relative terms. Several examples can be cited supporting this claim (such as social media). Greater emphasis needs to be placed on entrepreneurship. The researcher has the potential to be an entrepreneur but proactive support is required.

In addition to the above developments, very serious consideration must be given to the university-industry partnerships. This is a complex area and it is evident that there are numerous models within the EU (e.g in Norway, Holland, Germany, UK). One of the most mature models is that of the Fraunhofer. Fraunhofer, founded in 1949, currently has 68 Institutes and has been developing a strong international presence over the last 10 years (e.g in the USA). It is widely recognised as being one of the best models. Fraunhofer was the top performing research organisation in the FP7 Framework Programme (top overall score and top networking rank as reported in www.researchranking.org) of the EU. However, it must be recognised that it functions most effectively in the German system where the infrastructure from basic research to applied research through organisations such as Fraunhofer, Max Planck, Helmholz, Leibniz. Fraunhofer is inextricably linked to the university structure. The Fraunhofer institute directors are also professors in the universities.

At the EU level, the work of the European Institute of Technology (EIT), which represents a new type of university-industry partnership is seen to be of central importance in reversing the decline in innovation in the EU. The €2.7bn being invested in the development of Knowledge and Innovation Communities (KIC's) has this objective. Three inaugural KICS have already been launched (Climate Change, ICT and Sustainable Energy) and several more are in the planning stage (2014 and 2016).

A strengthening of the university-industry partnership models to meet the needs of the open innovation models of industry is urgently needed in Ireland in order to secure competitive advantage, to develop a sustainable manufacturing ecosystem in the country and to strengthen our manufacturing base. In the Irish context the interface between the universities/institutes of technology and industry is still at an early stage of development and is being progressed through the Technology Centres programme of Enterprise Ireland. Of particular significance is the strengthening of partnerships between the HE sector and the Small, Medium Sized Enterprises (SME's).

Engineering and Manufacturing Skills and Competencies

In relation to the manufacturing industry in Ireland, it is clearly evident that we are currently heavily challenged by international competition. Our cost base represents one challenge, our skills base and projected skills shortages is another major challenge. Skills development is strongly dependent on the educational bodies delivering adequate numbers of persons having the appropriate skills and competencies. For the case of manufacturing engineering we face very severe challenges. These challenges have been identified and accepted by Irish Government. The Manufacturing Development Forum (MDF) was set up by the Government to identify the real challenges and to focus on addressing them. When we review the situation today in the Universities and Institutes of Technology we find that manufacturing programmes are in a state of crisis. A review of programmes classified under the heading "*Manufacturing*" at Engineers Ireland yielded the following results: Of the 21 courses *dedicated to manufacturing*, there were no students enrolled in 13 of them in 2012. A total of 226 students registered for Manufacturing courses in 2012 [Level 6 : 0; Level 7 : 81; Level 8 : 145; Level 9 : 0]. Only 7% of students enrolled were female. A large number of courses are not attracting entrants. It is accepted that there is a negative image of manufacturing engineering and that students do not see satisfactory career opportunities in manufacturing. [However, it should be noted that these numbers are somewhat misleading as the manufacturing industry takes graduates from programmes which are not classified as manufacturing e.g. mechanical engineering]. Even taking this into account there is a serious job of work to do to remedy the situation.

The global paradigms for manufacturing are changing and indeed are changing rapidly. Central to the future of manufacturing in Ireland is a strong infrastructure for Education, Research and Innovation. An adequate infrastructure to meet the transformational changes needed does not currently exist. There is a strong need to focus on centres of excellence in manufacturing and to back such centres financially. In a broader global context, innovation, design and manufacturing paradigms are shifting. This means that both universities and industry must adopt a different approach in order to meet the emerging challenges. The identification of manufacturing competitiveness as a national priority in the recent national research prioritisation exercise is most positive. However, serious gaps still exist in policy development exist in this area.

The last decade has been disappointing in relation to the investment in training programmes for the development of skills and competencies at all levels in Ireland – from apprentice to PhD levels.

In conclusion, the EU is currently faced with very serious societal problems. We have extreme levels of youth unemployment. We are operating in a relatively unstable political environment. There is universal acceptance that Education, Research and Innovation can provide the platform for economic success, for next generation jobs in key areas such as advanced manufacturing and for success in a globally competitive environment. However, this can only happen if robust strategic planning is accompanied by appropriate investment in the strive towards excellence in our HE institutions. The HE landscape is in a state of flux in the EU and in Ireland. The total undergraduate enrolment for HEA funded institutions increased from 140,000 in 07/08 to 162,000 in 11/12 – a 15% increase. The overall total enrolment rose from 170,000 in 07/08 to 196,000 in 11/12, also a 15% increase. Overall the recurrent grant funding decreased from €1.4 bn in 2008 to €1.2 bn in 2011

(source HEA financial statements). Significant challenges lie ahead to adequately fund higher education in the light of growing demand and diminishing overall funding. Institutions will need to significantly reduce their reliance on HEA funding and must identify alternative funding sources such that strategic priorities can be met. The excellence trajectory of our educational programmes must continue in an upwards direction and it must as least be in line with the standards of the excellence clusters described above. This is a real challenge.

Recommendations regarding Education, Research and Innovation

1. Draw on the top level expertise of bodies such as the Irish Academy of Engineering (IAE) to monitor international developments (IAE has strong links to other Academies of Engineering (e.g. Germany, UK, China, USA),
2. Undertake a review of international developments in the STEM subjects of the HE Sector, focussing on (1) partnership developments in the HE Sector itself and (2) on the partnerships between the HE sector with Industry,
3. Undertake a review of the medium and long term implications of the ongoing cuts to HE funding in Ireland (e.g. Block Grant cuts to the HE Colleges, the 1.7 factor to HE colleges for laboratory based disciplines, capital equipment funding for undergraduate levels 7 and 8 laboratories),
4. Strengthen the support for research in engineering through Science Foundation Ireland (report from IAE showed that it was at only 8% for engineering in initial 10 years of SFI activity),
5. Carefully assess best practice models for university-industry partnerships and collaborations.