



The T & T Foresight Project

NIHERST

Sector Foresight Project:

NICHE MANUFACTURING

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1 EXECUTIVE SUMMARY

1.1 Introduction

This report is the NEXT contribution to Chapter 1 of a 5 Chapter sector project that has the aim of providing a briefing paper that enables policymakers, researchers, entrepreneurs and investors to understand the potential to commercialise and grow key areas of the manufacturing sector in Trinidad and Tobago.

Chapter 1 provides an overview of how the global manufacturing sector is evolving and what the key focuses might be some 10 – 20 years from now in order to provide a context for examining potential niche opportunities that TT might seek to pursue. Chapters 2 – 5 focus on the current and potential capabilities that T&T has, identifying specific niches in the future global economy that T&T could realistically aim towards based upon the capability base, and then developing the associated business cases necessary for commercialisation to ensue.

The global manufacturing sector is undergoing a period of radical restructuring as mass production commodity manufacturing increasingly moves into China, India and other developing nations. Traditional manufacturing businesses in the 'old economies' increasingly need to rapidly reconceive their businesses – or suffer the consequences of becoming uncompetitive. Technology and demographic change is also impacting. This is leading a move from 'brawn' to 'brain' at the leading edge.

1.2 Definition of Manufacturing

A classic definition from Wikipedia is that, *'Manufacturing is the transformation of raw materials into finished goods for sale, or intermediate processes involving the production or finishing of semi-manufactures'* (1).

A recent vision statement could also be a useful definition of the future of manufacturing: *'Our vision of manufacturing in 2020 is of a customer-driven, high value-added environment with an emphasis on the manufacture of individual products to meet individual requirements'* (21).

1.3 Key Trends Shaping the Future of the Manufacturing Sector

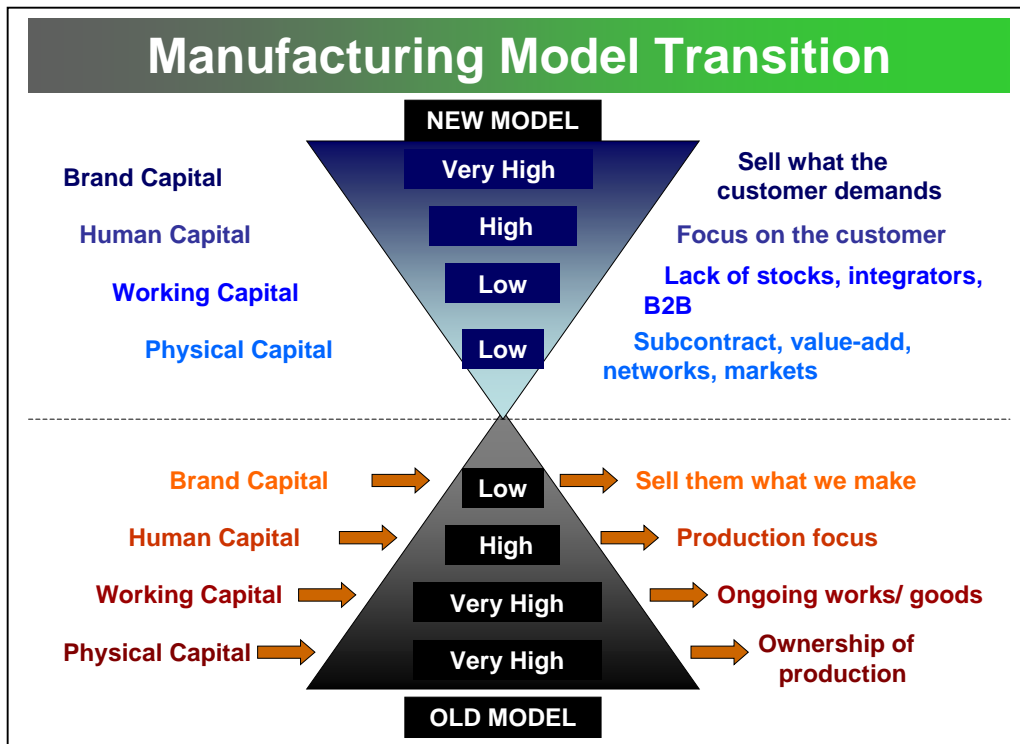
The big global shift is from the traditional input/output model to something that is driven by satisfying customer needs, as shown in Figure 1 (28)

The Japan Foresight Project (2) lists five key drivers that will shape the future of manufacturing:

- **Responses to IT** – as a way to improve competitiveness through shortening development and manufacturing times, overcoming distances, a skills development and transfer tool, the development of networked businesses which enable whole new business models, as well as database storage, knowledge management, and collaborative sharing.
- **Formation of a recycling-type society harmonious with the environment** – this will lead to the development of products which have lesser environmental effects, smart technologies to manufacture them, the development of new recycling methods, and a change from fossil fuels to other forms of more 'friendly' energy.

- **Technologies responding to low birth rates and ageing populations** – developing ways to attract a diminishing number of young people in the sector and keeping older employment working longer.
- **Education and the raising of competent workers** – only people can sustain new manufacturing activities such as the use of IT and reducing environmental impacts. This requires the acquisition of new and higher levels of skill, a more creative culture, and better integration of staff. This requires a cooperative approach between business, academic and research institutions, and government agencies.
- **Promotion of technological innovations** – there are a whole range of ICT, material science, ‘biomimicry’, energy and methodological technologies that will create whole new areas of business and greater competitiveness.

Figure 1: The shift in international manufacturing models



Additional drivers reshaping the manufacturing sector through to 2015 (17) include:

- The growing impact of multidisciplinary technology across all dimensions of life.
- The revolution in information availability and utility.
- Smart materials, agile manufacturing, and nanotechnology, all which change the way things are produced and expand their capabilities.
- Convergence in all areas of technology and technologies within the sector.
- The accelerating pace of technological change.
- The increasingly multidisciplinary nature of technology.
- The competition for technology development leadership.
- Continued globalisation (19).

Examples of more specific developments that will impact in future include:

- **Smart materials** - that have sensing and actuation capabilities.
- **Agile manufacturing** – rapid prototyping which enables accelerated and affordable design and development of complex components and systems along

with flexible manufacturing methods and equipment. An excellent example is the new DAVEX technology developed in Germany (20).

- **Nanomaterials and nanofabrication** – not only for semiconductors but also nanotubes to, for example, increase the efficiency of solar panel energy conversion (17) and create invisible structures (18). Also creating an ability to cheaply make complex devices from small to large with precise control of the arrangement of individual atoms within the device (21).
- **Integrated microsystems** – that encompass fluidic, optical, mechanical and biological components and are integrated with computation logic in commercial chip designs – which will radically reduce systems costs and expand some currently complex processing systems (19).
- **Digital manufacturing** - integrating 3D simulation tools, virtual reality and collaborative product lifecycle management software to visibly manage a product through the manufacturing process.
- **Radio Frequency ID (RFID)** – couples RFID technology with highly miniaturised computers that enable products to be identified and tracked at any point along the supply chain.

2 WHAT IS HAPPENING GLOBALLY?

In this section we look at big picture trends in the sector value growth and the growing divergence between commodities and high value niche products produced in the manufacturing sector.

2.1 Big Picture View of Sector Value & Growth

- The value of global manufacturing grew by 34% from US\$5.772 billion in 1996 to US\$7,747 billion in 2005. But the big shift is in the changing positions of different global players. The US has maintained a 20% share of the manufacturing sector over the decade. Japan has slipped from 21.1% to 17.7% and the UK from 3.8% to 3% (5).
- China accounted for 9% of the world's manufacturing in 2004 and its share is climbing fast (5). It accounted for 25% of the growth in manufactured exports from developing nations between 1990 and 2003 (10).
- China could overtake the USA as the world's largest economy within 30 years.
- China is driving down the global manufactured prices for a whole range of mainstream products e.g. in 2004 a 4.6% drop in the costs of durable goods, a 6.5% drop in telecommunications and other electronic products, and a 9.1% fall in wholesale car prices (6)
- Investments in ICT are driving growth – a rise of between 0.35 and 0.9 of a percentage point of growth in GDP between 1995 and 2003. Australia, Sweden and the USA gained the greatest boost (9).
- High technology industries now account for 50% of all manufactured exports from Ireland and 30% of exports from Switzerland, Korea, the USA, the UK, Hungary, and Netherlands.
- OECD countries accounted for almost 80% of the worldwide value added in manufacturing in 2002. China accounted for 8%, just above Germany.
- Indian manufacturing export growth may reach US\$300 billion in 2015 – an annual growth rate of 17% compared to past growth rates of 11% (13).
- The electronic equipment manufacturing sector increased production by 25% in 2005 and is expected to reach a growth rate of 50% in 2010 and 34% in 2015. These growth rates are expected to be 5.5x greater than global growth rates.

- The consumption of electronic equipment in India is also expected to grow from US\$28.2 billion in 2005 to US\$363 billion in 2015 – an annual compound growth rate of 29.8% (14).
- Nanotechnology-based chip production systems could be ready for volume manufacturing in 2015. The costs of fabrication plants could escalate from today's US\$2 – 4 billion to US\$10 – 20 billion for those using nanotechnology. These new plants are likely to disrupt and cause the collapse of the current semiconductor business model (16).
- The aerospace market is forecast to grow by at least 25% over the next 20 years and be worth US\$400 billion annually to the UK.
- The UK pharmaceutical sector has a global market worth US\$ 400 billion and growing at 4 – 5% annually.
- The UK medical equipment sector is worth US\$180 billion and likely to expand by 8 – 10% annually in the next few years.

2.2 Views of Profitability Expectations

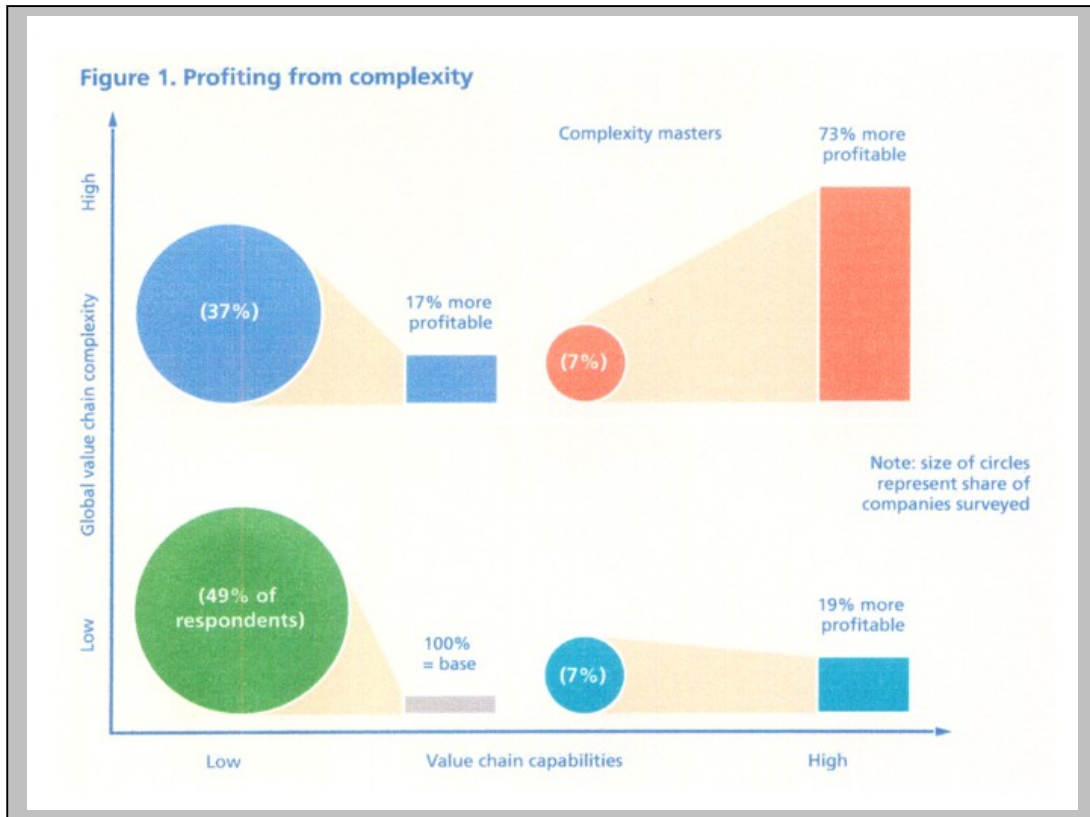
Key drivers impacting on the future profitability of manufacturing are (11):

- The continuing pressure to drive down all supply chain costs between the points of product conception through to end-customer delivery.
- The pursuit of new higher value markets and channels.
- The quickening pace of product innovation.
- Outsourcing of manufacturing and distribution activities is increasing for manufacturers in mature economies as is manufacturing in lower cost countries. Some 15% of North American and 29% of European manufacturers no longer manufacture products in home markets.
- Even product engineering is increasingly being outsourced – 62% of North American and European companies are doing this.
- There will be continuing growth in this type of outsourcing with China, India, Central and Eastern Europe, and Mexico/Central America being the leading suppliers of such manufacturing services. Egypt is an emerging player.
- 89% of top manufacturing executives see developing innovative new products and services as the main way of improving revenue – the no. 1 strategic plank.
- Developing new market channels (including online channels) also ranked as one the top 5 areas driving future profit growth.

According to a recent survey of European and North American manufacturers, those with complex global networks combined with strong value chain capabilities represented only 7% of the companies examined (12). However, they were almost **50% more profitable** and their profit margins were **73% greater** than those with weaker value chain capabilities. The areas where the 'complexity masters' excelled were in:

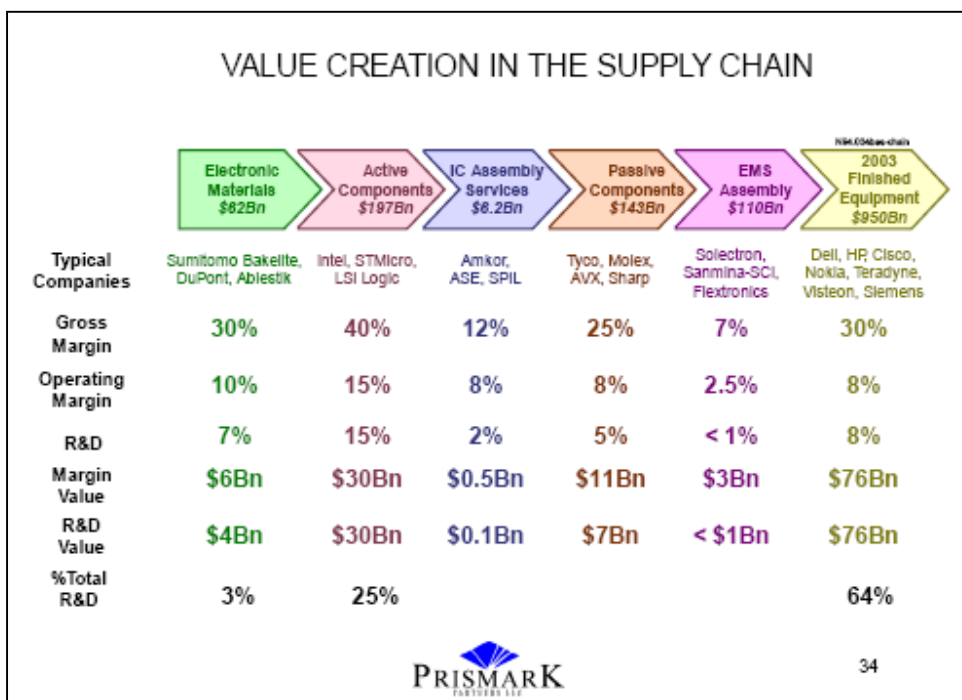
- Collaboration with customers to design and develop manufacturing processes, logistics networks, and new products that can be updated rapidly and inexpensively.
- Flexibility through design, rationalisation of components and processes, variable loading adaptability, and to be able to rapidly change production volumes and mixes.
- Visibility in conjunction with all players in the value chain, including financial, achieved through collaboration, cross-functional integration and technology.
- Technology implementation throughout the entire internal and external value chain.

Figure 2: Value chain capabilities and complexity as they relate to manufacturing profitability (12)



The gross profitability achieved by different players in the electronics components manufacturing sector, as shown in Figure 3, illustrates the margin difference between smart components/process manufacturers and basic commodity manufacturers (20)

Figure 3: Gross margins in the electronic components value chain



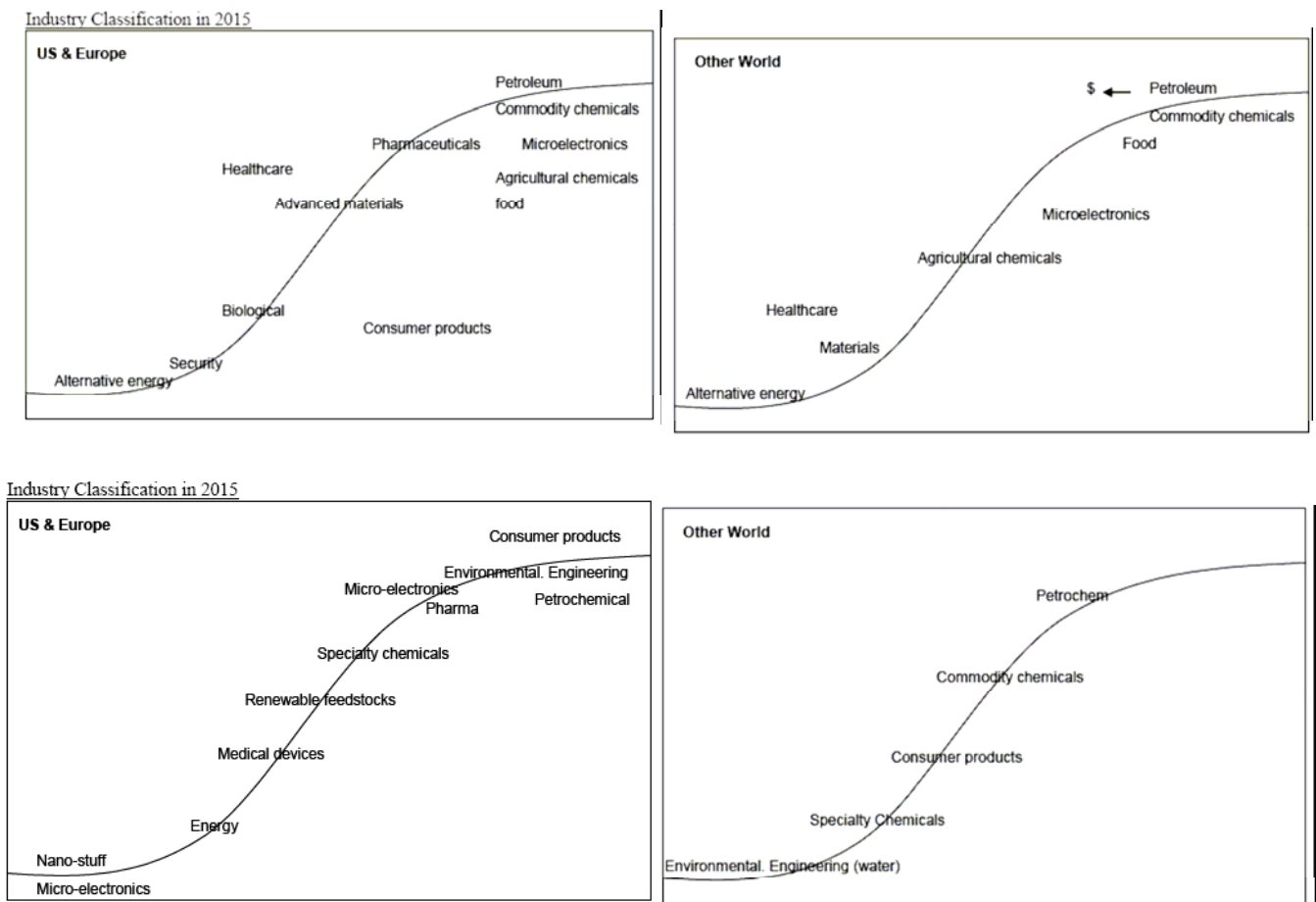
3 WHAT APPROACH ARE SECTOR PLAYERS TAKING?

3.1 The Big Players.

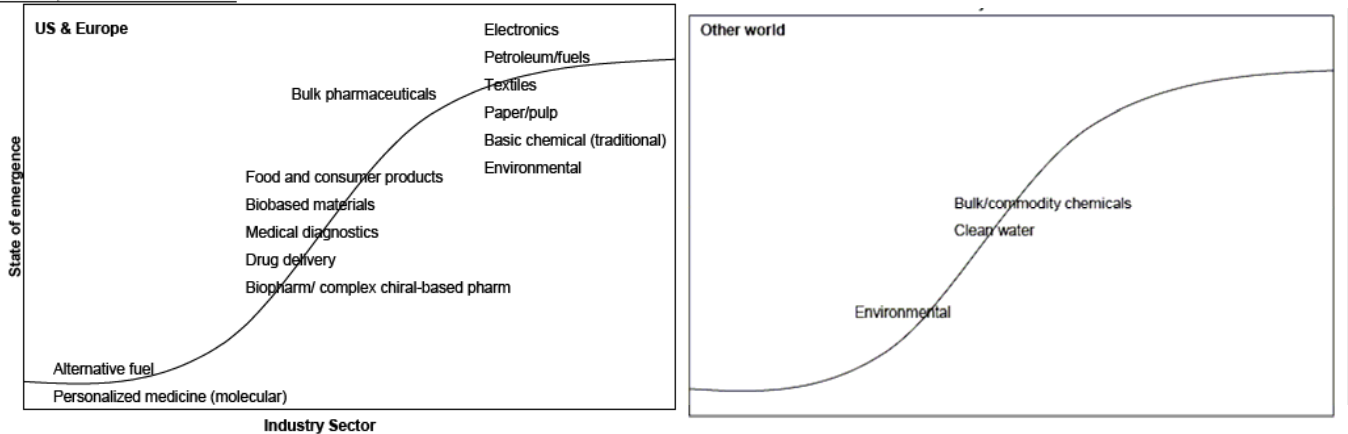
- The US manufacturing sector is in transition. The sector has ‘done a good job driving costs down and improving the efficiency of operations’. But it hasn’t done so well in the growth area because innovation is the key driver of growth.
- It is no longer possible to innovate within ‘four walls’. This is because intellectual capital, emerging technologies, and leading edge manufacturing skills are becoming increasingly dispersed around the world. This requires a different approach to succeed in future (8).
- High speed broadband is a critical component that underpins the ecosystem that drives innovation and growth.
- Market forces and changing consumer demands also mean that markets are changing continuously on a global scale.
- Manufacturing models need to become more flexible and adaptable. Companies also need to become more innovative at the Board level.

A recent workshop asked participants to develop views of the key sector areas in chemical engineers would be employed in 2015 (15). The graphs in Figure 4 represent the views of various groups for the USA & Europe as well as the rest of the world. The higher the point on the graph, the more dominant the sector.

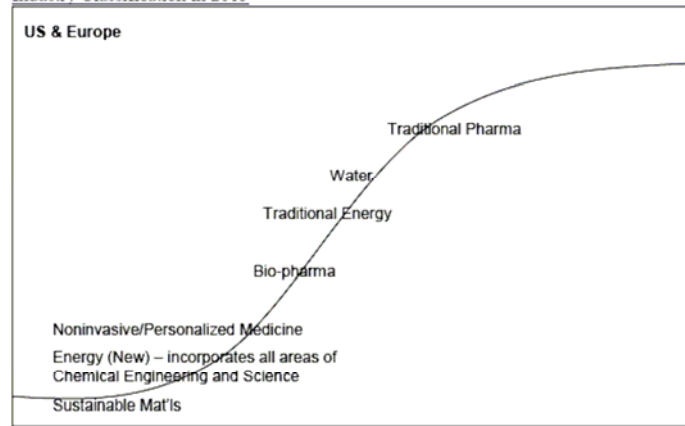
Figure 4: Views of the relative importance of traditional and emerging manufacturing sectors in 2015



Industry Classification in 2015



Industry Classification in 2015



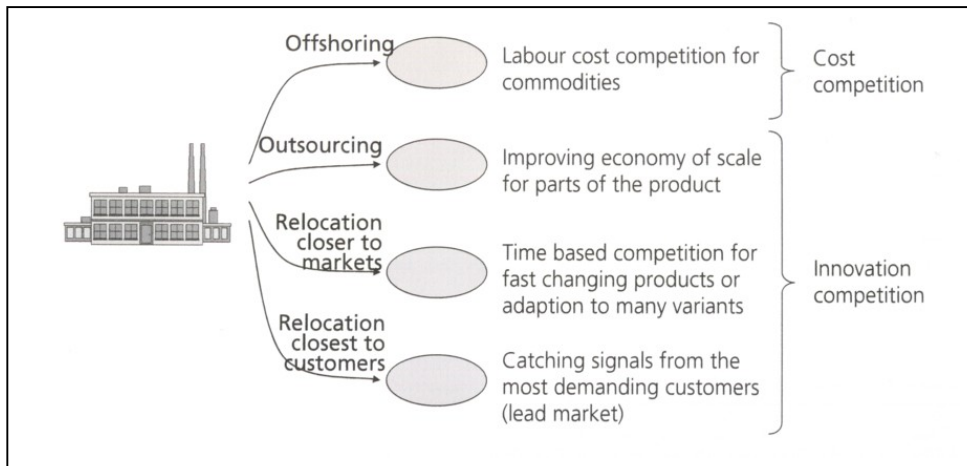
A new paradigm for manufacturing in the future from Canada is summarised in Table 1 (25).

Table 1: The new paradigm for manufacturing compared to the traditional model.

Traditional Manufacturing	New Paradigm
Domestic/North American market	Global markets
Customers sourcing locally	Customers sourcing globally
Production push	Customer pull
Higher costs are passed to customers in higher prices	Higher costs have to be absorbed – prices are falling
Prices determined by local competition	Prices set by disruptive global competition
Competing for market share	Competing for markets, investments, product mandates
Competitiveness based on cost, quality, time to market	More of a premium on time, but also on customization, service – price competitiveness is more important than ever
Value based on products	Value based on service
Mass markets	Niche markets/individual customers
Efficiency drives competitiveness	Innovation drives competitiveness
Internal performance standards	World-class benchmarks
Mass production	Customization
Growth through higher volumes	Growth through innovation
Static production processes	Flexible production systems
Stand alone discreet technologies	Integrated technologies
Mechanical processes	Automated processes
Long production runs	Short production runs
Cost cutting	Waste elimination
Sequential product development	Complex systems
Corporate organizations	Business networks
Companies compete	Supply chains compete
Purchasing & materials handling	Supply chain management
Manual skills	Knowledge based skills
Work under specifications	Problem solving
Functional materials, products, processes	Smart materials, products, processes
Production management	Life cycle management
Reactive governance	Proactive governance
Pollution control	Environmental sustainability

A European view of the future of manufacturing is that *'the innovation system is the core of global competition.'* (26). The key competitive impacts on the future of manufacturing in Europe can be summed up as shown in Figure 5.

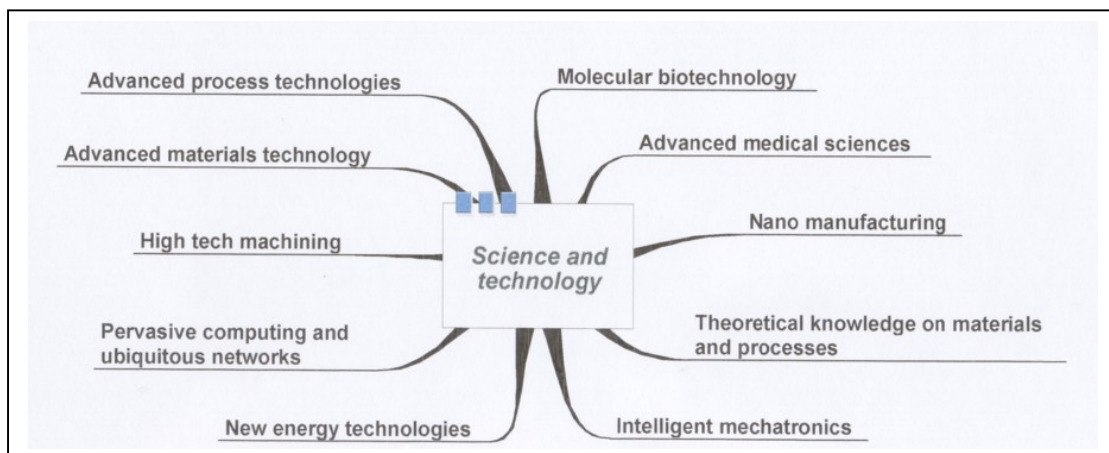
Figure 5: The key competitive impacts on manufacturing in Europe

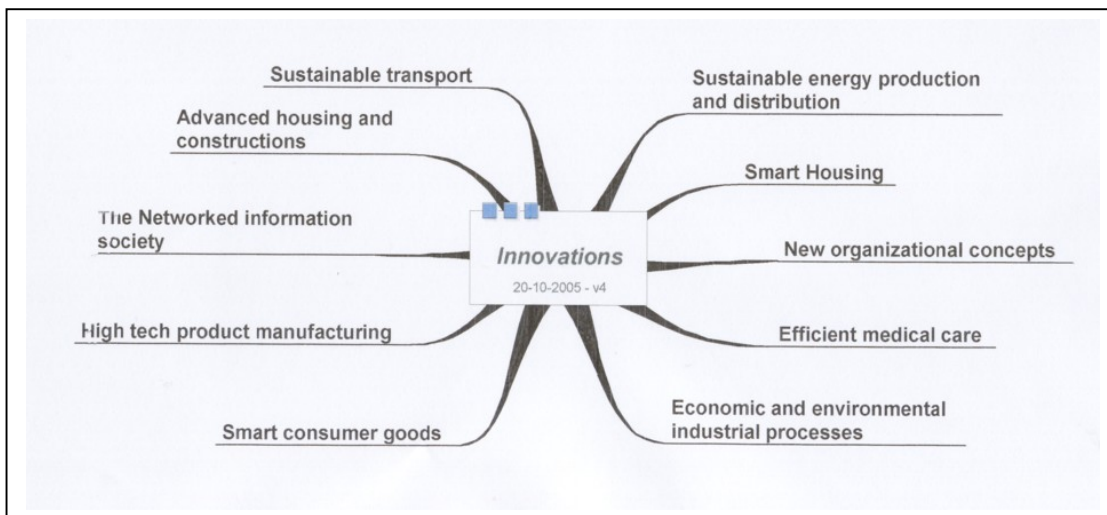
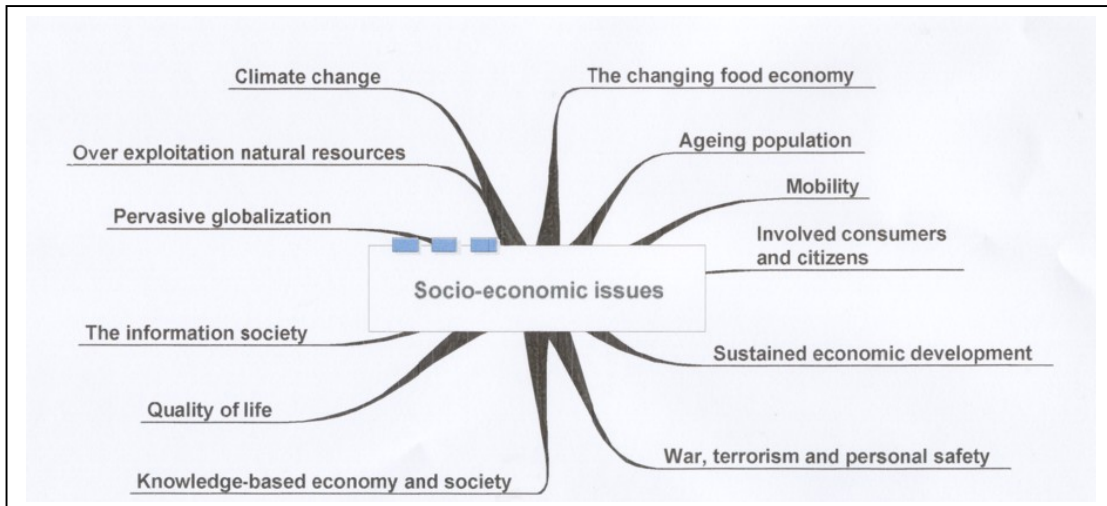


To be able to compete within this overarching framework, EU manufacturing innovation needs to focus on the opportunity areas shown in Figure 6 from three perspectives:

- Science and Technology
- Socio-economic issues
- Innovations

Figure 6: Opportunity areas for the future of manufacturing in Europe (27)





3.2 Small Country Examples

Ireland is an example of a country with a small population that has re-modelled its economy radically in recent decades. It has a long-term policy plan for the future of manufacturing and has become a net importer of human capital after being a net exporter for many decades (4).

Singapore is another small country which has developed and pursued a strong growth and innovation framework and regularly picks 'best bets' in the manufacturing and service sectors to advance the economic development of the country – now one of the wealthiest in the world. One of the areas it is backing is the biomedical sciences industry. Over the past five years compound growth rates in the sector in Singapore have been 23% annually and revenues reached S\$18 billion in 2005. The original target was to achieve a turnover of S\$25 billion by 2015 but this is now likely to be reached much sooner (21)

New Zealand has picked a number of 'best bet' niches in the manufacturing sector for future development (22). These include:

- Automotive components – specialised value-added components for export to Australia, the USA and Canada

- Aviation – niche aircraft and components
- Electronics - possible international cooperative opportunities
- High temperature superconductors – a New Zealand patented technology to be used to develop a cluster of new local industries
- Marine industry – specialised boats, yachts and components – especially in the high value leisure area
- Plastics and composites – design, technology and marketing
- Energy – innovative renewable and alternative energy technologies and solutions
- Wood – manufacturing and design initiatives to add value to New Zealand’s plantation forest timber resources (23)

The sector’s growth strategy also has strong design technology, market development and global connectedness improvement components.

New Zealand’s plastics sector is aiming to grow revenue from NZ\$2.3 billion in 2005 to NZ\$4 billion in 2015 and achieve a gross profit level of 50%. To unlock the potential of the sector, the entrepreneurial plastic firm would be modelled along the lines described in Table 2

Table 2: How to unlock potential for the New Zealand plastics sector

Required Business Processes	Required Entrepreneurial Skills
<ul style="list-style-type: none"> • Accessing new technology • Relationship management • Research, development, and design • Partnering • Risk management • Environmental scanning (awareness of customer’s strategic issues) • Financial modelling • Deal structuring • IP protection • Marketing 	<ul style="list-style-type: none"> • Ability to develop and communicate vision • Leadership • Strong people and relationship development skills • Strategic thinking • Creativity and innovativeness • Ability to build a team • Focus – ability to focus and complete deliverables (total solution focus) • Ability to ascertain the size of a commercial opportunity • Negotiation • Marketing orientation

3.3 Where Are Players Positioning Themselves?

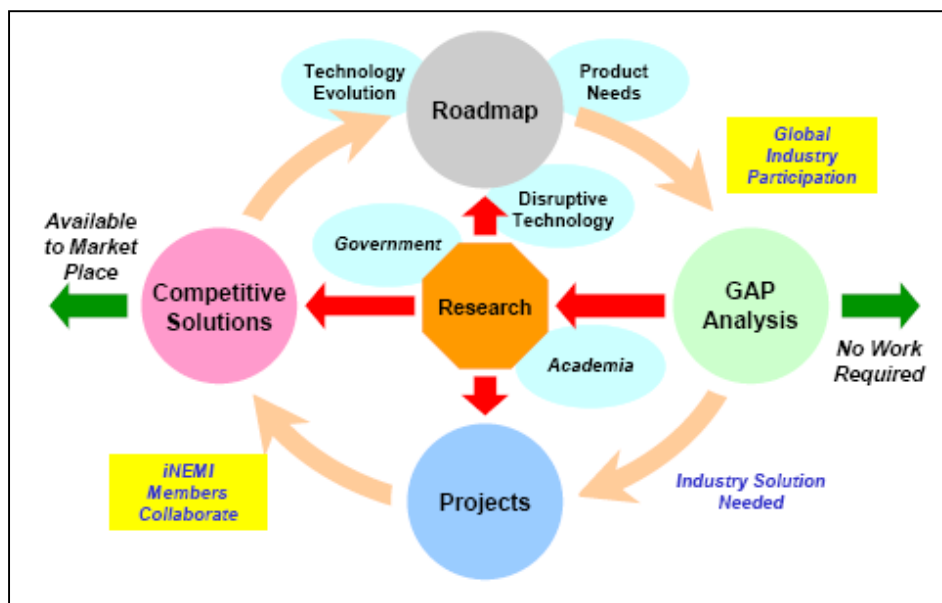
A more important and conceptual view of the future of the manufacturing sector comes from this extract out of the Japanese Foresight Project (2):

‘The future in mature economies provides a chance for manufacturing engineers and researchers to accelerate the drive for novel technological development. The strategy is for a manufacturing business to aim to establish firm superiority in leading world markets, by securing basic and fundamental technological abilities to respond to IT

and social and users' needs, and to develop innovative technologies and products, enabling qualitatively higher competitiveness to be achieved without resorting to only cost, while also making efforts to reduce costs, which is necessary for competition; to promote conversion to more proposal-oriented industries, and to raise competent workers capable of materializing these efforts. In other words, it is intended to enhance the planning and strategic abilities to further maintain and develop the excellent process innovations cultivated so far in Japan, and to promote product innovations capable of developing more attractive, higher-value-added products, and also to promote technological development abilities to implement such planning and strategy.'

The International Electronics Manufacturing Initiative (iNEMI) is looking at innovation priorities for the sector through to 2015 (20). The model they are using to evaluate future opportunities, gaps and priorities is shown in Figure 7.

Figure 7: The iNEMI model for determining sector opportunities and gaps



Technologies are not driving innovation. This is driven by customer needs. And the new model emerging to become a leader in innovation in manufacturing is shown in Figure 8.

Figure 8: The old (monolithic) and new (global) product innovation models (20)

	Monolithic Product Development	Global Product development networks
Governance	Top-down control	Symbiotic partnerships
Corporate ethos	Not invented here	Best from anywhere
Attitude toward IP	Own and protect	Share and expand
Innovation processes	Rigid	Flexible
Success metrics	Patents	Customer experience
Role of customers	Passive users	Active co-innovators

The challenges for the electronics manufacturing sector (20) through to 2015 include:

- Addressing consumer experience using the converged digital technology base.
- Adapting to changing industry structure.
- Closing technology gaps:
 - Active Device Technology.
 - Thermal Management.
 - Communications Bandwidth.
 - Next Generation Packaging Technology.
 - Design and Simulation Tools.
 - Sustainability Metrics.
- Creating new product markets with social value:
 - Energy.
 - Health Care.
 - Security.

3.4 Science & Technology Research & Development Investment

A recent OECD report described the main R & D focuses as follows:

- The development of new technologies and integrating them into productive activities is changing the economic structure and increasing productivity.
- Three areas in particular are beginning to impact – new channels for knowledge generation, diffusion, protection and application; new interactions driven by networks, linkages, partnerships and mobility; new global players from non-OECD countries.

It also noted that:

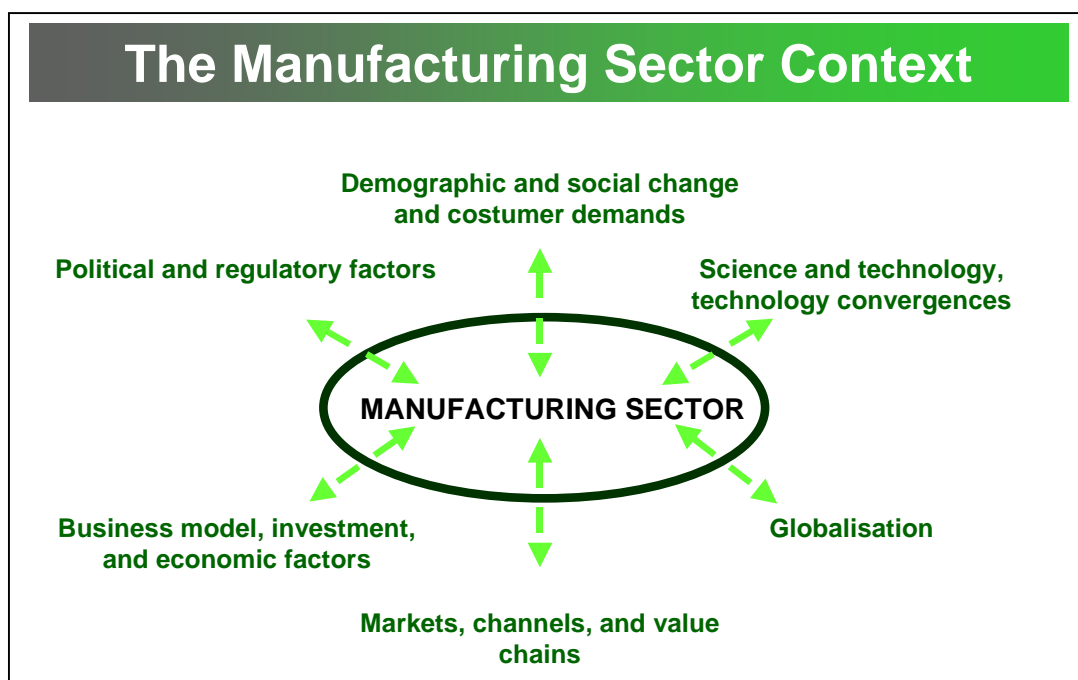
- Investment in knowledge is now almost as high as in plant and equipment.
- Sweden, Finland, Japan, and Iceland have the highest R&D intensity.
- China has become the third biggest global investor in R&D after the US and Japan.
- Professional and technical workers account for 25% - 35% of total employment in most OECD countries and over 35% in Sweden, Luxembourg, Switzerland, and Australia.
- In 2003 China had the world's second largest number of researchers (after the USA).
- The number of patents doubled from 1993 to 2002 and France, Germany, Japan, the UK, and US accounted for the vast majority of patents.
- Biotech and ICT patents are growing faster than other areas of patents.
- Co-ownership and internationalisation of patents is growing.
- Advances in and wider access to broadband are driving manufacturing growth.

4 HOW THE NICHE MANUFACTURING SECTOR IS EVOLVING

4.1 The Niche Manufacturing Sector Context

Figure 9 provides an overview of the factors shaping the future of manufacturing and which, in turn, manufacturing is shaping.

Figure 9: The key parameters shaping manufacturing



4.1.1 Key Sector Roadmap Issues

How the manufacturing sector evolves depends on being able to monitor and adapt to the following:

Intersections – ‘forks in the road’: Where one path becomes favoured over another e.g. outsourcing over in-house manufacturing

Interdependencies – synergy or clash? Where an opportunity e.g. microelectronics is dependent upon a manufacturing technology advance, e.g. nanotechnology, and the possible conflict with investment decisions – past and future.

Regulatory readiness – are we future-proofed? Does the country’s legislative system help or hinder emerging manufacturing opportunities?

The emergence of a possibility space: Where a convergence of technologies emerging from different market sectors can enable totally novel solutions e.g. biological manufacturing processes.

Uncertainties – the need for flexibility: Certainty is only one side of the equation. There are areas of uncertainty that can change the playing field – such as changes a new technology can make to the manufacturing playing field. The sector needs to be use foresight to be aware of potential uncertainties, develop processes to manage risk, be flexible so it can adapt, and take advantage of any opportunities that arise.

4.1.2 Sector Convergences

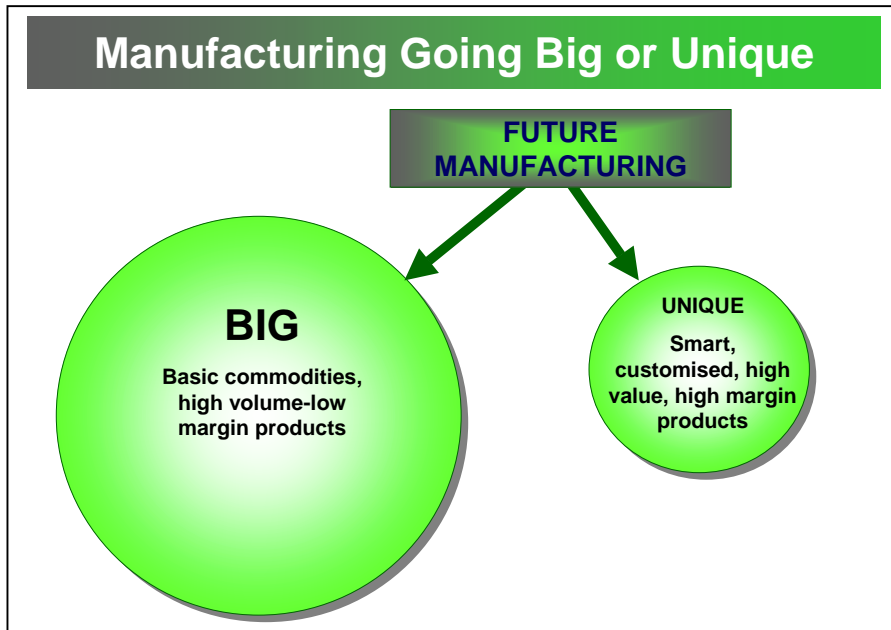
The manufacturing sector is being affected by technology convergence from almost every direction – biotechnology, materials technology, nanotechnology, ICT, systems technology, sustainability, energy, and environmental technologies.

4.2 Key Niche Manufacturing Sub-Sectors

4.2.1 Overview

Manufacturing embraces a wide range of fields. Within these fields divergence is occurring - largely between 'big' and 'unique' manufacturing - as shown in Figure 10.

Figure 10: Manufacturing – the divergence into 'big' and 'unique'



Within that overarching pattern of divergence, there are some interesting niche sector opportunities emerging that offer potentially high value adding opportunities. A summary of these is shown in Figure 11.

Figure 11: An overview of key future niche manufacturing sub-sectors

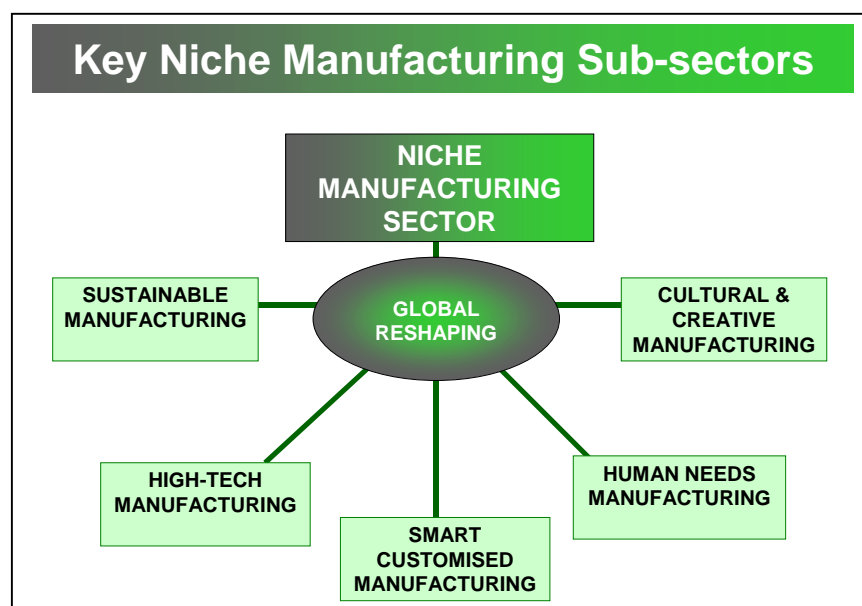
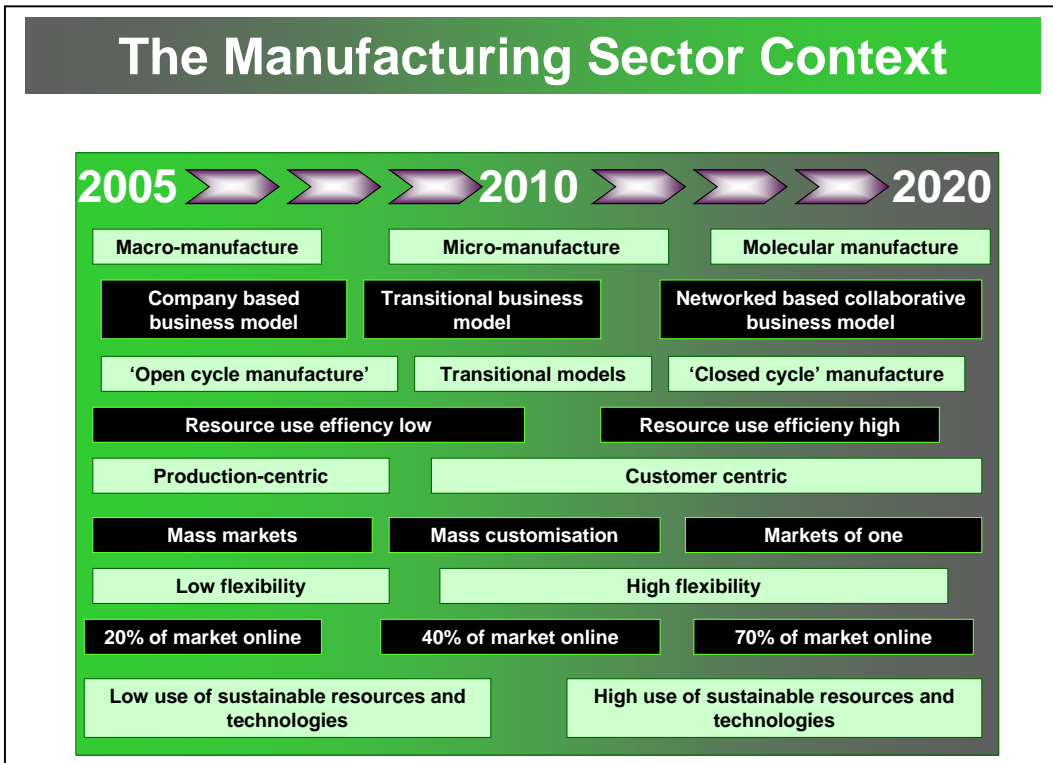


Figure 12 provides examples of trends that are likely to impact as these sub-sectors evolve.

Figure 12: Foresight-based development pathways in the manufacturing sector

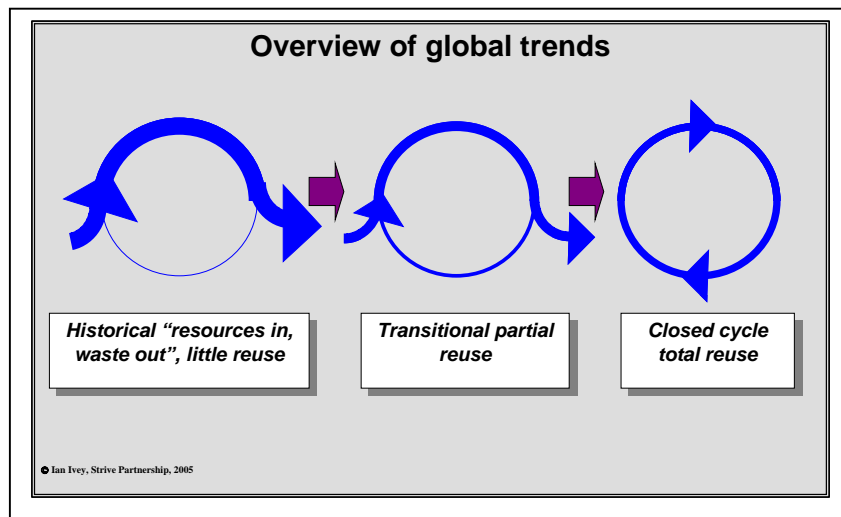


The following sections, we look at the key overarching drivers, technology trends, as they relate to each of niche manufacturing sectors

4.2.2 Sustainable Niche Manufacturing

The shift is from open cycle systems to closed cycle systems – zero energy balances, zero waste, water re-use, renewable raw materials, renewable energy, recycling laws and targets, emission charges. An overview of the transition is shown in Figure 13.

Figure 13: The trend from open cycle to closed cycle systems



This sub-sector includes areas such as renewable energy, renewable resources, manufacturing processes that not only ‘construct’ but also ‘deconstruct’ as products reach the end of their lives (e.g. the German developed Davex technology (30)), and ‘biomimicry’ (imitating natural ‘manufacturing processes’ such as ceramics produced by shellfish), which open up new opportunities.

Table 3: The key overarching drivers, technology trends, paradigm shifts and uncertainties associated with the future of sustainable manufacturing

Parameter	Sustainable manufacturing niche
<i>Overarching drivers of growth</i>	<ul style="list-style-type: none"> • Science & technology • Economic • Environment – and sustainability • Legislation • Creativity and innovation
<i>Technology trends</i>	<ul style="list-style-type: none"> • Biotechnology • Smart manufacturing technologies • Closed cycle systems • Resource efficiency
<i>Consumer trends</i>	<ul style="list-style-type: none"> • Ageing populations – legacy they leave • Quality of life • Personal health and wellness
<i>Paradigm shifts</i>	<ul style="list-style-type: none"> • From open cycle to closed cycle processes and systems • From ‘construction’ to ‘construction and deconstruction’
<i>Uncertainties</i>	<ul style="list-style-type: none"> • Environmental crises • Consumer preference • Complexity – the more we know the less we know

High tech manufacturing

This niche is evolving around material science advances, intelligent ICT technologies, nanotechnology (in particular in the medical field), ‘biomimicry’, molecular manufacturing, and digitalisation. Alone and through convergence these are expected to drive completely new business areas in the future.

Table 4: The key overarching drivers, technology trends, paradigm shifts and uncertainties associated with the future of high-tech manufacturing

Parameter	High-tech manufacturing niche
<i>Overarching drivers of growth</i>	<ul style="list-style-type: none"> • Science & technology • Convergence • Economic – competitive advantage • Creativity and innovation
<i>Technology trends</i>	<ul style="list-style-type: none"> • Micro, nano- and molecular manufacturing technologies • Smart equipment and processes • Biomimicry • ICT connectivity • Knowledge and innovation
<i>Consumer trends</i>	<ul style="list-style-type: none"> • The need for new and unique solutions
<i>Paradigm shifts</i>	<ul style="list-style-type: none"> • From macro to micro systems
<i>Uncertainties</i>	<ul style="list-style-type: none"> • Environmental impacts • Consumer preferences • Complexity – the more we know the less we know

Smart Customised Manufacturing

In mature economies there is a trend away from large factories that produce big volumes of mass products to much smaller units that provide semi-customised or fully customised solutions (3). Mass customisation is the ability to deliver mass products to markets of one. Fully customised solutions are products specifically designed for the individual. A good example of an engineering company producing fully customised solutions through the adoption of an in-house designed 'smart' laser welding technology is MontanStahl in Switzerland (31).

This niche also includes opportunities related to global shifts from macro- to micro-infrastructure systems in areas such as water, energy, and waste – the growing move towards distributed rather than centralised systems. These can be as small as individual household or factory micro-systems.

Table 5: The key overarching drivers, technology trends, paradigm shifts and uncertainties associated with the future of smart customised manufacturing

Parameter	Smart customised manufacturing niche
<i>Overarching drivers of growth</i>	<ul style="list-style-type: none"> • Science and technology • Economic – competitive advantage • Environment – sustainable industries • Flexibility and adaptability • Creativity and innovation • Convergence
<i>Technology trends</i>	<ul style="list-style-type: none"> • Flexible and adaptable manufacturing technologies • Smart systems • Material science • ICT • Design • Knowledge • Micro-infrastructure technologies – e.g. water, energy.
<i>Consumer trends</i>	<ul style="list-style-type: none"> • Individualism – markets of one • Fascination with smart solutions
<i>Paradigm shifts</i>	<ul style="list-style-type: none"> • From mass production to highly customised production • From 'brawn' to 'brains'
<i>Uncertainties</i>	<ul style="list-style-type: none"> • Systemic readiness – at all levels • The impacts of new, as yet non-commercial, technologies • Consumer preferences

Human Needs Manufacturing

This is a huge growth area and includes the health, wellness and medical areas, human fascination and experiential needs (leisure and pleasure), food and beverage, lifestyle needs, living environment needs, personal 'enhancement', items that facilitate individual differentiation, life phase needs, and things that connect people with other people.

Table 6: The key overarching drivers, technology trends, paradigm shifts and uncertainties associated with the future of human needs manufacturing

Parameter	Human needs manufacturing niche
Overarching drivers of growth	<ul style="list-style-type: none"> • Science and technology • Economic – competitive advantage • Creativity and innovation • Changing demographics • Convergence • Legislation – e.g. obesity control policies and legislation
Technology trends	<ul style="list-style-type: none"> • Bio-medical technologies • ICT technologies • Experiential technologies – holographics, virtual 3D, video interfaces • Chemical technologies – pharmaceutical, lifestyle drugs/enhancers • Human enhancement technologies • Value chains – RFID, optimisation and management of complex systems
Consumer trends	<ul style="list-style-type: none"> • Changing demographics • Ageing populations • Demands for fascination and experiences • Individualism – the egoistic society
Paradigm shifts	<ul style="list-style-type: none"> • From mass markets to markets of one • From youth dominated to over 45 year old dominated markets
Uncertainties	<ul style="list-style-type: none"> • Consumer preferences and trends • Timing – is the market ready? • New technologies that change the playing field • Migration patterns • Negative outcomes to a new technology

Cultural & Creative Manufacturing

The global trend to ‘big’ or ‘unique’, accompanied by advances in global communication networks, online marketing, and integration of global logistics systems, is opening up opportunities for ethnic and culturally based products. A person sitting in London can now order a product from a small enterprise based in Trinidad and have it delivered door to door by UPS or similar companies within several days – often faster than traditional inland mail systems can deliver internal mail.

The key drivers creating opportunities in this area are:

- The search for something different and unique by more individualistic consumers (who travel extensively) in mature markets (e.g. fans of Soca music in Germany)
- The growing expatriate communities around the world as the result of surging global immigration movements and work-based needs.

There are increasing growth opportunities for unique products that have a local, ethnic and / or cultural flavour that are being driven by advances in global connectivity.

Table 7: The key overarching drivers, technology trends, paradigm shifts and uncertainties associated with the future of human needs manufacturing

Parameter	Cultural and creative manufacturing niche
<i>Overarching drivers of growth</i>	<ul style="list-style-type: none"> • Economic – competitive advantage • Creativity and innovation • Connectivity • Convergence • Global movements of people
<i>Technology trends</i>	<ul style="list-style-type: none"> • ICT technologies • Value chains – direct supplier to consumer short cuts • Digitalisation – conversion of products into formats that are easy to deliver • Connectivity – broadband and what comes next
<i>Consumer trends</i>	<ul style="list-style-type: none"> • Changing demographics • Global immigration and career movements • Demands for fascination and experiences • Individualism – the egoistic society, customised solutions • The need for instant gratification
<i>Paradigm shifts</i>	<ul style="list-style-type: none"> • From local to global markets – even for the smallest SME • From mass market to markets of one
<i>Uncertainties</i>	<ul style="list-style-type: none"> • Consumer preferences and trends • New technologies that change the playing field • Competition from other global players – big and small

5 CONSUMER FORESIGHT

The future of any sector depends upon customers – whether they be patients in the medical sphere, purchasers of products and services, or enjoy a personal benefit – experiential, lifestyle compatible, or enhancement orientated. Understanding tomorrow’s consumers and the things they are likely to want and demand is key to mapping the future of any sector.

5.1 The Global Consumer Market

The world’s population is ageing – rapidly. Latest estimates indicate it may peak as early as 2050. There are still likely to be an extra 2 billion+ people in the world by the time that peak is reached. However, the make-up of the population in most countries is likely to vary significantly – particularly in wealthy countries.

For example, the average age of the German population is expected to be 45 years within a decade. In Japan, close to 50% of the population will be 50 years or older and in India almost 25% by 2025. China is also greying rapidly with 35.6% of the population expected to be 50 years+ by 2025.

This is a major shift – never seen before in the history of mankind. This will impact on markets in every country in a multitude of ways.

5.2 Key Consumer Groups

In tomorrow's world we believe the following consumer groups will be of growing importance and shape tomorrow's markets:

- **Cultural Creatives** – people with knowledge and skills who contribute strongly to the new economy and who also have strong personal values – especially regarding personal health and wellness, ethics, and the environment.
- **Ethnic entrepreneurs** – in both mature and emerging economies. Self-assured, successful and ready to take risks.
- **The 60s generation in their 60s** – more independent and healthier than previous generations – many wish to leave a positive legacy for their children and grand-children before they die.
- **The Baby Boomers** – a self-indulgent generation, always a bit rebellious, determined to fight ageing for as long as possible and prepared to spend on it. The oldest are now reaching 60 years of age.
- **New age women** – self-confident, independent, delaying or not having children, increasingly suffering from 'male' as well as 'female' problems – coping with life balancing and stress.
- **Generations Y & D** – the under 28 year olds. Live 50% in a 'real' and 50% in an 'unreal' (virtual) world. The boundaries between the two are blurring. They face some real personal health and wellness challenges, require constant fascination – including mind-altering substances, reshape their bodies and minds without a thought, have grown up with high-tech solutions that they don't question.
- **Global nomads** – high net worth individuals who move from country to country and contract to contract and need to support a highly mobile lifestyle.
- **Cyber tribes** – who interact through interfaces such as the Internet. They spread 'fact' and 'fiction' rapidly around the world through their networks.

5.3 Key Consumer Trends

Associated with the emerging consumer groups, we have identified a number of significant trends that are likely to impact significantly on markets over the next decade or two:

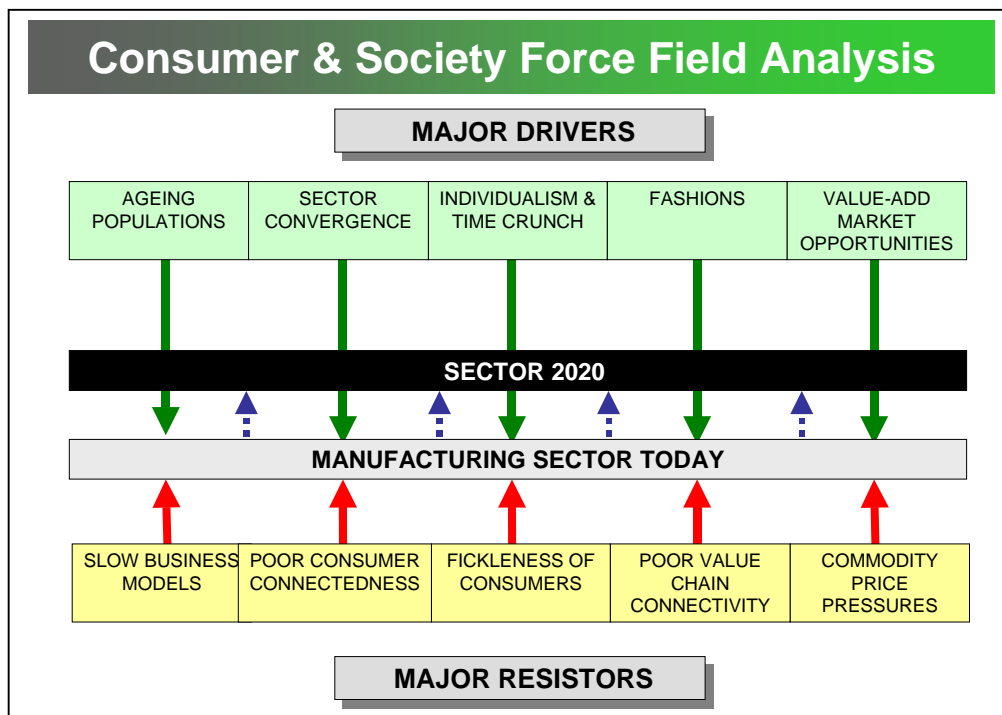
- Pursuit of pleasure, quality of life, and happiness.
- Self-enhancement -including cosmetic surgery, drug based, supplements, non-traditional therapeutic channels, and similar interventions.
- Comparative material well-being.
- 'Give me a gift of time' – so I have more time to do the things I love.
- Longevity & 'Age Defiance' – people want to defy ageing and will pay for it – particularly amongst the over 45s but also increasingly a focus of the young.
- Individualism – markets of one - more singles, the egoistic society, an interest in things that are different, ethnic, cultural, niche options
- Fascination – people are looking for '5 minute fascination' – instant gratification.
- Parents with decreased parenting skills – who need help to redress growing imbalances with the health of their children – obesity, diabetes etc.
- Global living – being able to move freely around the world with the minimum of hassles and stay healthy and fit.
- Health and wellness – particularly as the over 45s begin to realize half their lives are behind them and looking after their health and wellness is essential is they want to maximize what they get out of life.
- Being 'out' is 'in' – the death of the mass market – an aspect of growing individualism – 'I am unique'.

- ‘Technology for dummies’ – make it simple please

5.4 How Do These Relate to Future Sector Prospects?

How consumers are likely to influence the future of the manufacturing sector can be illustrated by separating impacts into drivers (characteristics that will favour the sector) and resistors (characteristics that will hold back progress) as shown in Figure 14.

Figure 14: Consumer and society force field analysis



Consumer drivers that favour growth of niches in the manufacturing sector include:

- Ageing populations – and associated needs.
- Personal and global sustainability – health and wellness of the individual and the environment within which they live.
- Anything that gives consumers a ‘gift of time’
- Especially for generations Y and D – anything that is cool, experimental, technological, and helps them be different.
- Individualism and a desire to be different.
- They will pay a premium for something they really want.

Resistors holding back manufacturing include:

- Traditional production and delivery business models – too slow. I want it and I want it now!
- A lack of connectedness with consumers.
- Fickle consumer demands – ever changing dynamics of the market
- Poor value chain connectivity between manufacturer and end-user.
- They will pay as little as possible for ordinary everyday commodity products

6 SECTOR FORESIGHT – SHAPING THE MANUFACTURING OVER THE NEXT 10 – 20 YEARS

How manufacturing evolves over the next 10 – 20 years can be viewed using several different tools. These include PESTE (an analysis from the Political, Economic, Social, Technological, and Environmental perspectives), SWOT (strengths and weaknesses – as seen today; opportunities and threats – in the future), and global scenarios.

6.1 Sector PESTE

A PESTE perspective of the major future influences on manufacturing is shown in Table 8.

Table 8: Major future influences on the manufacturing sector from a PESTE perspective

Parameter	Influences
<i>Political</i>	<ul style="list-style-type: none"> • Legislation impacts – positive and negative • Funding of S & T • Incentives to the private sector • Security – intellectual property protection
<i>Economic</i>	<ul style="list-style-type: none"> • Returns on investment – how the sector performs relative to other sectors • Tipping points in the balance between costs of finite versus renewable resources
<i>Social</i>	<ul style="list-style-type: none"> • Changing consumer demands and needs • Changing demographics • Fashion trends • Attitudes towards business
<i>Technological</i>	<ul style="list-style-type: none"> • Developing ways of dealing with complexity • New breakthroughs • Convergence of technologies
<i>Environmental</i>	<ul style="list-style-type: none"> • Sustainability • Closed cycle systems

6.2 Sector SWOT

The SWOT tool provides a simple matrix analysis of key areas that are fundamental to scenario development. Table 9 lists some of the more important areas.

Table 9: Manufacturing sector SWOT analysis

Strengths	Weaknesses
<ul style="list-style-type: none"> • A wealth of experience • A tradition of investment in R&D • A diversity of markets • Established value chains • Multiple channels for delivering to consumers • Increasing wealth of consumers 	<ul style="list-style-type: none"> • Price pressures in commodity areas • Lack of flexibility and adaptability • Production rather than customer centric • Long lead times • Old business and value chain models • Foresight capabilities
Opportunities	Threats
<ul style="list-style-type: none"> • Growing niche opportunities such as health and wellness, experiential, ethnic and cultural • Changing demographics • Sustainable and renewable energy • Micro-systems • Individual customisation • Smart manufacturing systems • Creativity and design value-add • Convergence with other sectors offers new product options 	<ul style="list-style-type: none"> • Changing global dynamics in where manufacturing is taking place • Failing to adopt new business models • Being blindsided by technological and consumer changes • Unable to manage complexity • What's in today is out tomorrow • What happens when markets begin to shrink (as in Germany today)?

6.3 Global Scenarios

How manufacturing evolves is very dependent upon how the world evolves over the coming decades. Using scenarios can be useful for developing a picture of alternative futures and developing an understanding of how to develop a flexible approach to future markets and opportunities. The following European scenarios to 2020 are useful in that many of the competitive issues they face are very similar to small countries – how to find the appropriate niches in the world economy which offer a viable long term future (29).

6.3.1 Global Economy 2020

Consumers have pursued their personal utility without paying too much attention to environmental and social impacts of production and consumption. The free market has been considered the most effective way to allocate resources efficiently and to achieve sustainable development.

Policy-making has been based on a ‘small government’ rationale. It principally has aimed to strengthen market mechanisms and competition. Policy objectives have been set on sector levels with little emphasis for integration across institutions or policy fields.

Compared to its global competitors, Europe is under heavy pressure. Technology progress has been uneven. In particular, nanotechnology has not fully delivered yet on its more ambitious promises due to a lack of concerted policy action. The private car has retained its principal roles as status symbol and means of individual mobility.

Manufacturers have focused on the customisation and individualisation of products. New ICT tools have increased the efficiency of product and process design. Environmental progress has been made incrementally as companies aim to cut costs by making more efficient use of resources.

6.3.2 Local Standard 2020

Local authorities and regional governments have gained new powers. The new European regionalism puts limits on policy co-ordination in Europe. European institutions face severe difficulties to co-ordinate the interests of regions and Member States. The civil society has become an important player in policy-making, especially at local level. Consumer and citizen groups push their agendas on local and environmental issues.

The transport network has been suffering from bottlenecks due to shortfalls in investment and local opposition to new projects. The economic and social disparities between European regions and between Europe and its neighbours have not lessened.

Whereas in some regions the society has shown a high level of awareness to environmental and social issues, in other regions economic and employment considerations have attained more attention.

At local levels some very creative environments – new sources of innovation – have emerged. Complex systems management tools have helped industry cope with a challenging business environment. Strict environmental regulation in certain regions has partly led to the concentration of production sites which offer favourable regulatory conditions, partly to the adoption of radically new manufacturing approaches to retain production, and partly to the relocation of production abroad.

6.3.3 Sustainable times 2020

European citizens support the government's coordinating and regulating role to reconcile the economic, environmental, and social dimensions of sustainability. A global governance system has emerged that promotes sustainable economic development. Industry has been an active partner in sustainable development, closely collaborating with governments and the civil society.

European manufacturing has been able to break the links between economic growth and resource use. Socio-economic change has been occurring at a fast pace, enabled by successfully linking technological opportunities with organizational innovation.

The energy supply system is in transformation towards renewable resources and fuels. Bio-resources have started to replace nonrenewable materials. The material design for low resource intensive production processes takes into account recycling, de-composition, and after-use treatment. New forms of mobility systems have emerged and the internal combustion engine's dominance in vehicles has been challenged by fuel cell technology.

Manufacturing companies have increasingly focused on the provision of services rather than selling products. Novel applications of information and communication technology have supported the transition towards the service economy.

6.3.4 Focus Europe 2020

Citizens see governments being principally responsible to achieve sustainable development. Individualist values and behaviours prevail among European consumers. The European Commission has emerged as a powerful actor to guide society towards sustainability. Its policies are guided by the principle of integrated utility of policy measures (i.e. balance economic, environmental, and social utility). European policies have increasingly introduced fiscal instruments to create incentives for sustainable production in industry.

Europe has pursued a strategically targeted industrial policy to facilitate the development of environmentally benign products and services. As a result new business opportunities emerged for European manufacturers in international markets. At the international level, Europe has been confronted with new competitors, especially in Asia (e.g. China and India). International trade has been facilitated through the WTO, though there has been little international support for European demands to take environmental and social issues on board.

Since behaviour patterns of consumption have not changed significantly, the scope for broader socio-technical innovations have been limited. New technology has not been able to break socio-technical lock-in situations and innovation has followed rather traditional trajectories: For example, the near zero-emission car based on the internal combustion engine has become reality. However, the shortcomings associated with individual mass mobility and freight transport prevail. Ambient intelligence has been widely implemented in both the public (e.g. intelligent transport systems) and the private and industrial sphere (e.g. for control and surveillance applications).

7 FINAL COMMENT

We have developed a global view of the manufacturing sector and key niches that provides a context for looking at potential opportunities which T&T can choose as 'best bet' opportunities.

The challenge is to identify areas that are going to be of the greatest relevance in markets 10 – 20 years from now rather than in today's context as the whole sector is changing rapidly.

As the scenarios demonstrate, how the sector evolves will depend upon how the sector responds various global scenarios. The manufacturing sector is at a point where it needs to use foresight and innovation to move into the future, especially in mature and small economies.

8 APPENDIX 1: KEY REFERENCES

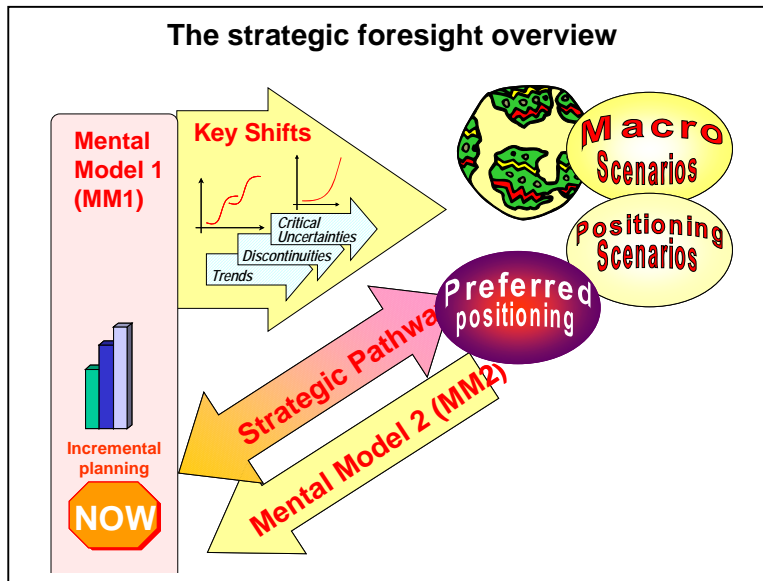
1. Manufacturing, Wikipedia [Link](#)
2. Survey Results in “Manufacturing”, The Seventh Technology Foresight, NISTEP Report No. 71, Science & Technology Foresight Centre, Japan, July 2001 [Link](#)
3. Advanced Technology and the Future of US Manufacturing, Georgia Tech Policy Project on Industrial Modernisation, Centre for Science Technology and Economic Development, USA, May 2004 [Link](#)
4. The Future of Manufacturing in Northern Ireland, Department of Enterprise, Trade and Investment, Ireland, March 2006 [Link](#)
5. Share of world production falls as China surges, Financial Times, 22/05/06 [Link](#)
6. China, India Superpower? Not so Fast! Yale Global Online, 25/10/05 [Link](#)
7. Durable Price Decreases Due to China, Strive Archives
8. American Manufacturing; A Vital National Asset, Executive Current, Capgemini, February 2006. [Link](#)
9. Executive Summary, OECD Science, Technology and Industry Scoreboard 2005 [Link](#)
10. Who's Ahead in Global Manufacturing? The Globalist, 06/09/05 [Link](#)
11. The Challenge of Complexity in Global Manufacturing, Deloitte Touche Tohmatsu, 2003. [Link](#)
12. Mastering Complexity in Global Manufacturing, Deloitte, 2003 [Link](#)
13. Manufacturing Exports to Touch \$300 b. by 2015; Study – The Tribune, India, 24/10/04 [Link](#)
14. India Eyes High-tech Manufacturing, United Press International, 23/02/06 [Link](#)
15. Speculation on 2015, Frontiers in Chemical Engineering Education, Massachusetts Institute of Technology, USA, June 2005 [Link](#)
16. Nanotech Manufacturing Could Break Semiconductor Biz Models – Analyst, TG Daily, 19/07/05 [Link](#)
17. Nanotube-enhanced Solar Cells Improve Efficiency by 18%, Smart Economy, 28/04/06 [Link](#)
18. Harry Potter Invisibility Cloak ‘within five years’, The Telegraph, UK 26/05/06 [Link](#)
19. Global Technology 2015, National Intelligence Council, US Government, 06/11/03 [Link](#)
20. Innovation Priorities for 2015, iNEMI, 2005. [Link](#)
21. Biomedical Sciences Industry May Exceed Government’s 2015 Target, Channelnewsasia.com, 27/01/06 [Link](#)
22. Manufacturing: As it Will Be, Prospects.ac.uk, UK, Spring 2005. [Link](#)
23. Specialised Manufacturing, Sector Engagement Strategy 2005-6, NZTE, 2005 [Link](#)
24. Wood, Buildings and Interiors, Sector Engagement Strategy 2005-6, NZTE, 2005 [Link](#)
25. Canadian Manufacturing: Critical Factors for Business Success to 2020, Canadian Manufacturers and Exporters, 2004 [Link](#)
26. European Manufacturing in a Global Environment, European Manufacturing Quo Vadis?, Manufacturing Visions, Bled, October 2005 [Link](#)
27. Future Product Innovation. The Challenge of Matching New Technologies to New Demands, European Manufacturing Quo Vadis? Manufacturing Visions, Bled, October 2005 [Link](#)

28. New Business Concepts – Networking, European Manufacturing Quo Vadis? Manufacturing Visions, Bled, October 2005 [Link](#)
29. The Future of Manufacturing in Europe 2015-2020. The Challenge for Sustainability, Institute for Prospective Technological Studies, European Commission, March 2003. [Link](#)
30. Davex Technology www.davex.de
31. MontanStahl, Switzerland www.montanstahl.com

9 APPENDIX 2: GLOBAL FORESIGHT OVERVIEW

To develop a context for the manufacturing sector and the opportunities it may offer to T&T economically and socially, we first need to look at the global picture of the sector – the trends, players and positioning, then develop scenarios which relate to the T&T situation within that global picture, and then a way of determining the strategic positioning T&T might take to exploit opportunities the sector offers.

Figure 15: The overarching strategic foresight framework



A key part of developing an understanding of how the global picture is being shaped is knowing the meta-trends that are driving change. We call these the 7 Tsunamis of Change. These global drivers are shaping the future of our lives, of markets, of business, of the world we live in. The Tsunamis are changing the landscape within we will operate – destroying some things, changing other things, causing new things to be build in their aftermath.

Figure 16: Meta-trends – The 7 Tsunamis of Change

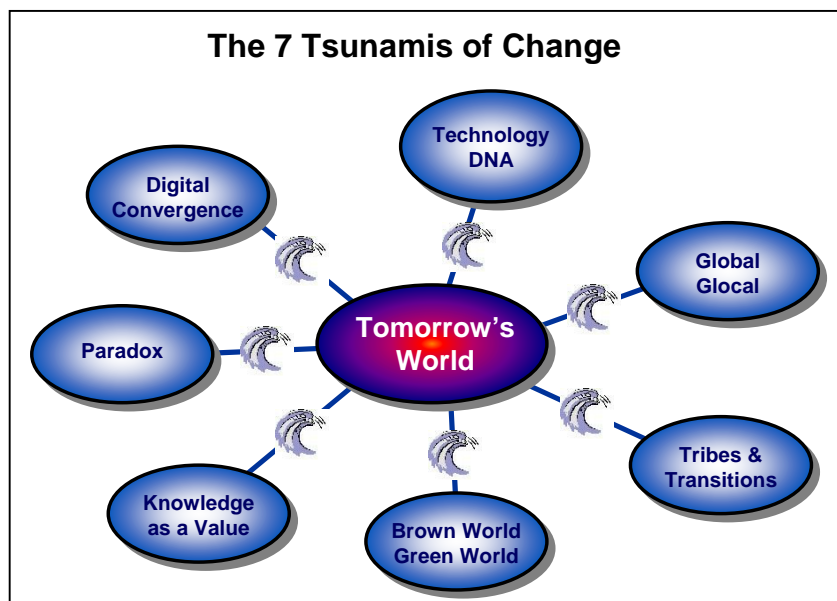


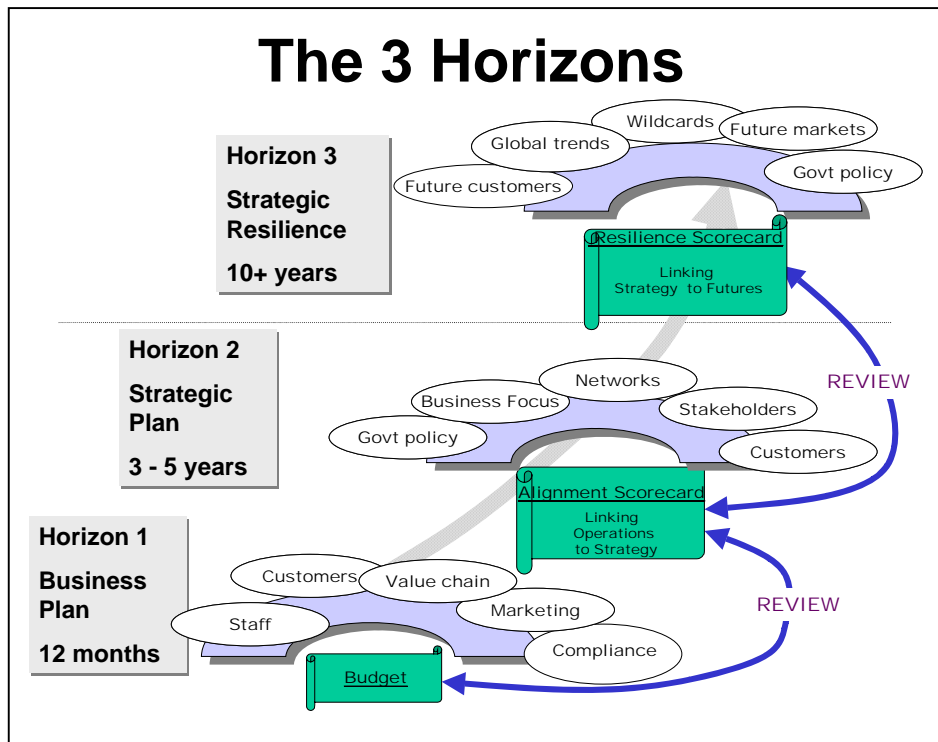
Table 10 provides a brief overview of the areas each Tsunami is driving.

Table 10: Areas where each Tsunami of Change is impacting

TSUNAMI	CHARACTERISTICS
<i>Digital Convergence</i>	<ul style="list-style-type: none"> • Chips in everything • Total interconnectivity • Virtuality
<i>Technology DNA</i>	<ul style="list-style-type: none"> • Biological/technological convergence • Cumulative innovations • Re-shaping of life itself
<i>Global Glocal</i>	<ul style="list-style-type: none"> • Global village • Cultural convergence • Biggest or most unique
<i>Tribes & Tribulations</i>	<ul style="list-style-type: none"> • The digital divide • Tribalism • Changing lifestyles / work styles
<i>Brown World, Green World</i>	<ul style="list-style-type: none"> • Climate change • Resource productivity • Water, air, energy
<i>Knowledge as a Value</i>	<ul style="list-style-type: none"> • Hierarchy of knowledge and value • Knowledge management • Consumer Power
<i>Paradox</i>	<ul style="list-style-type: none"> • Unexpected effects • Living with degrees of grey versus black and white • Solutions take opposites into consideration

The long-term views we develop by using foresight help us develop a picture of how a business Horizon 3 may look 10 – 20 years from now – which is often quite different to how it looks today. This horizon helps us understand the future destination we wish to aim for – the desired scenario. By backcasting from Horizon 3 we can then develop a 3 – 5 year strategic plan (Horizon 2) and then a short- term business or implementation plan (Horizon 1) – see Figure 17. By taking this approach, commercialisation of opportunities discovered during the research and evaluation process is made within a long-term context.

Figure 17: The three business Horizons



There are a number of tools and processes that can be used to help shape Horizon 3. These include foresight research, the PESTE analysis, scenario development (for the global sector), developing a view of the long-term destination for the sector and country, and then local scenarios that provide a framework for decision making.

Figure 18: Tools and processes for developing a Horizon 3 perspective

