MANUFACTURING FUTURES FOR EUROPE –

A SURVEY OF THE LITERATURE

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Background Report to the Study "The Future of Manufacturing in Europe" by Felix Brandes (TNO), Arjan Lejour (CPB), Gerard Verweij (CPB) and Frans van der Zee (TNO)

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1. INTRODUCTION

The future of manufacturing – renewed interest and importance

Manufacturing has made a comeback on European and national policy agendas. New questions are being raised and new dilemmas are being confronted concerning the future of manufacturing. The current wave of globalisation[1] has led to renewed discussion of how the manufacturing landscape, in terms of location, production, distribution of labour and physical appearance will manifest itself in the near and longer-term future. Will the world be an even 'flatter', 'spikier' or 'smaller' place by 2030? (Friedman, 2005; Florida, 2005; Leamer, 2006). And if so, what would this imply for manufacturing activity in Europe? What about future employment? Can Europe's future prosperity be ensured without a thriving manufacturing sector? What would a further retreat of manufacturing - a 'gravity centre' for R&D and innovation - from European soil mean for future innovation capacity?

While structural adjustment and relocation have been inextricably linked to manufacturing already for decades on end, the character and speed of adjustment and its potential longer-term consequences appear to have taken on new dimensions recently. Globalisation, new 'enabling' technologies and increased international competition have significantly altered the nature of the game, and have forced today's manufacturing firms to be even more innovative than yesterday. This review aims to highlight the most significant future trends and issues for European manufacturing in the oncoming 25 to 30 years. It does so in the form of an extensive literature survey of existing foresight and futures studies. While entirely based on the work by others, this review attempts to take a neutral, independent and unbiased view on the future of manufacturing. It includes the findings of a wide range of different studies, some of which are directly concerned with the future of manufacturing, either in Europe or in one of its major competitors (Japan, US, China). Others only deal with particular issues or aspects of that same future, such as (the impact of) climate change, future technologies or other important issues such as organisational innovation and new business models. The backbone of this literature survey is formed by three recent EU-wide foresight projects on the future of manufacturing in Europe FutMan, ManVis and Manufuture (see Box 1 for a short background).

[1] Globalization is defined as the process of economic integration with resources becoming more mobile, economies becoming increasingly interdependent, and financial markets becoming increasingly international (OECD, 2005).

Manufacturing futures – what's at stake and for whom?

The future of EU manufacturing will have different connotations to different audiences. To some EU manufacturing is first and foremost attached to a geographic notion of production location, referring to physical production and employment on European soil. To others the notion of manufacturing is typically linked to ownership (shareholders), management and (legal or financial) headquarter issues. Many European companies nowadays have a very mixed ownership in terms of size, nationality and background, and not necessarily dominantly or exclusively European. Ownership can range from institutional shareholders such as pension funds and capital investment funds to 'normal' citizens. Large European companies like Siemens, Philips, Royal Dutch Shell, Volkswagen, BASF and others are nowadays *global corporations* in various different meanings of the word: in markets, ownership, sourcing and 'own' production location. The term global also applies to at least part of the (larger) SMEs, some of which have become very successful partners in emerging regional and global production networks. With globalization, internationalization of ownership tends to increase. A series of international mergers and acquisitions (M&As), both European and globally, have changed and are changing the business landscape. At least three factors add to this development. Firstly, most larger stock exchanges nowadays have worldwide operations, co-operate and increasingly join hands (M&As). Secondly, computerization and the Internet have dramatically changed the nature of the game (speed and intensity of communication). Thirdly, (global) private equity finance has grown in importance, and increasingly influences the future of business. Yet there are still 'European' industries – most of them considered as strategic – in which national ownership (French, German, Italian, anything, but not truly 'European') is the dominant ownership form, more often than not with the state as a pivotal shareholder (the energy and aerospace sectors being classic examples).

When we look at the location of production, the situation is not much different: again we observe a strong trend of going global. European businesses do not limit their production operations to Europe. Offshore outsourcing of production to locations outside Europe (e.g. China, India, Latin America) has become increasingly popular. At the same time, non-European businesses have become more and more active on European soil. The car industry serves as an example in kind, with Japanese companies now having car factories in France, the Czech Republic and Britain. Foreign interest is not confined to setting up production facilities in Europe. It also covers mergers and acquisitions of European businesses, vide the recent take-overs by Indian companies in the steel sector (Mittal's take-over of European largest steelmaker Arcelor and Tata Group buying British-Dutch Corus). It is clear that international sourcing and M&As in manufacturing touch upon various medium and longer term strategic questions, relating to growth (income and wealth), competitiveness (viability and survival) and employment (jobs).

When discussing possible futures of EU manufacturing, realizing that there are indeed different ways of looking at the topic is essential. What may be in the interest of the income- and wealth-generating capacity of European firms may not necessarily coincide with the interest of European citizens. In other words, it matters whether we take a managerial, shareholder or a worker perspective, not only for our final judgement but also for the suggested policy predicament. On top of this: a too narrow focus on manufacturing may not be the best way to approach the future. What

may seem an appropriate medicine for the manufacturing sector as such may actually worsen the condition of the patient – the economy's prosperity - as a whole. Maintaining or improving growth in manufacturing and what this requires may look a credible policy objective. Keeping existing production capacity and employment in manufacturing in Europe may be another. But these objectives need not necessarily coincide with overall growth, competitiveness and welfare objectives for Europe or individual Member States. Seen from this angle, the challenge of making the European Union more dynamic and competitive, and the two principal tasks posed by the (revised) Lisbon agenda of delivering stronger, lasting growth and more and better jobs (European Commission, 2005:2) is even more ambitious than its first appreciation suggests.

A survey of future studies: structure and contents

Across the studies surveyed, a considerable degree of consensus appeared to exist on what the most important key drivers are that shape the future of manufacturing. These include:

- *Increasing international competition* involving the emergence of new competitors and the further integration of global markets.

- *Increasing pace of technological change* leading to shorter product cycles forcing firms to continuously innovate but also enabling new organizational forms and processes.

- *Socio-demographic drivers* including the 'greying' of most of the industrialized world (except for the US) and some emerging economies (e.g. China, Russia), but also further growth of the emerging economies offering new market opportunities.

- *Environmental drivers* such as climate change, the depletion of natural resources and pollution caused by industrial activity impacting how and what will be manufactured in the future.

- Additionally, some – but not all studies – outlined the importance of the *regulatory environment* and the *values of the public* as important driving factors determining future developments.

These drivers are quite broad and give rise to new challenges and issues to be solved. Understanding future challenges and issues is therefore as important as understanding the nature and background of the drivers to shed light on future development in manufacturing. This paper will hence take the classification into five major categories of drivers as a point of departure. Section 2 *globalization and international competition* discusses the key international developments expected to shape global manufacturing. These are the emergence of new competitors intensifying competition, the importance of global value networks, the influence of financialisation but also trends towards regionalism and bilateralism that might adversely affect recent trends of globalisation. Section 3 *technological aspects* outlines new key (enabling) technologies as well as knowledge skills and competencies essential to the firm of the future.

Box 1. Overview of Key Futures Studies

An obvious source for identifying trends and drivers affecting the future of European manufacturing are foresight / future studies on the subject conducted in Europe. However, as Europe's future depends on developments of its main competitors, it is essential to take into account similar projects in America, and Asia to avoid a too Europe-centric view of the future.

The key European manufacturing foresight projects conducted in the past 5 years are FutMan (2003), ManVis (2005) and Manufuture. FutMan, short for 'Future of Manufacturing', was conducted in 2003 addressing the question of how Europe can be competitive in 2015-2020 exploiting new scientific and technological developments, while responding to the needs and challenges of sustainable development (CEC, 2003). Based on a large Delphi survey involving more than 3000 manufacturing experts across Europe as well as the research results of FutMan, ManVis (2005) – short for Manufacturing Visions –developed future visions of EU manufacturing 2020. Questions also addressed how emerging economies such as China, India and Brazil impact on the location of global manufacturing production and resulting impacts for European manufacturing. These results have been fed into long-term planning for research funding in 2006 as part of the 'ManuFuture' Strategic Research Agenda. Manufuture is a European Technology Platform which mission is to develop a strategy based on research and innovation to secure high added value employment as well as a major share of world manufacturing in Europe by speeding up the industrial transformation towards a knowledge driven economy (Manufuture, no date). All three projects were financed by DG Research and feed into policy making at European but also national level.

The main American studies are the 1998 'Integrated Manufacturing Technology Roadmapping Initiative' (IMTI), which was created to identify and evaluate the key technology goals that would enable a competitive and capable U.S. manufacturing base in the future, while creating pathways for achieving these goals in practice (Merrell, 1999). Furthermore, in 2004 SRI – a non-profit research institute formerly part of Stanford University – conducted a series of analyses for the Manufacturing Extension Partnership (MEP) of the National Institute of Standards and Technology (NIST) to provide America's small manufacturers with reports to better understand the major shifts arising from deepening globalisation, the emergence of south-east Asian competitors and rapid advances in technology (SRI, 2007).

Asian studies on the future of manufacturing available in English language are sparse. While Japan is the country with the longest tradition of technology foresight conducting quinquennial large scale foresight exercises since the late 1970s (Cuhls, 2001), the only relevant study found was the 2005 Delphi survey (Nistep, 2005) focusing on future technologies. As broader visions of future manufacturing cannot be found in this report, government policy documents were instead the main source on future manufacturing paradigms and strategic developments in Japan. Other countries like China (NRCSTD China, 2005) and India (PC India, 2002) have just started conducting national foresight / future studies, meaning that perspectives on future manufacturing in these countries rely on mostly Western assessments found in the large European and American projects.

Additionally, key global future studies with a primarily economic focus were included as macro-economic future projections were missing from the Foresight projects presented above. These are the *Global Economic Prospects* study by the World Bank (2007) as well as the GoldmanSachs (2003) and PwC (2006) studies on emerging economies in 2050.

As competitiveness is highly influenced by organizational innovation, a separate section is dedicated to this issue. Section 4 *manufacturing paradigms and business*

models will present emerging manufacturing paradigms that have received considerable attention with the proclaimed advent of the knowledge society. Furthermore, key aspects of new business models expected to materialise in manufacturing will be discussed. Section 5 explores societal and consumer aspects likely to shape the future of manufacturing. These are in particular ageing societies impacting demand patterns and labour supply as well as changing consumer values. Lastly, the key *environmental aspects* including the availability of natural resources, but also climate change and environmental legislation will be outlined.

2. GLOBALIZATION AND INTERNATIONAL COMPETITION

2.1. Introduction

The current wave of globalisation[2] has led to renewed discussion of how the manufacturing landscape, in terms of location, production, distribution of labour and physical appearance will manifest itself in the near and longer-term future. Are we as a result witnessing a new industrial revolution? In most developed countries the potential loss of jobs associated with relocation of manufacturing and other production have become major topics of both popular and academic debate (e.g. Blinder, 2005; Kirkegaard, 2005; OECD, 2005 and 2006). Calculations show that the number of jobs that could potentially be affected through offshoring is substantial. According to recent OECD (2006) estimates, 18.1% of total employment in the US and 19.2% in the EU-15 *could* be affected (upper limit). Many if not most of these potentially affected jobs are professional or high-skilled jobs.

The unprecedented character of the current wave of globalisation has much to do with its scale and its speed. Whereas openness to trade, investment and talent are important preconditions for globalization, international competition is one of its major drivers. Much of the current discussions focus on the integration of the 'new' emerging economies in the world economy, in particular the BRICs (Brazil, Russia, India and China; see further Box 3). While sometimes perceived as an important threat to Western economies, the emergence of the BRICs and other developing countries on the world stage also offers new opportunities with new attractive and large(r) markets lying ahead, and with even more scope for specialisation for individual companies. The global competitive game is not only confined to goods and services (trade), but also applies to capital (FDI; relocation) and labour (talent and skills). There are and will be winners and losers[3], and painful adjustment processes will be required, even if the game will be most likely a positive, mutually beneficial and reinforcing, sum-game. As GoldmanSachs (2003) cautiously puts it "(b)eing invested in and involved in the right markets – and particularly the right emerging markets – may become an important strategic choice for many firms."

Improving competitiveness and revitalisation of manufacturing production already feature prominently on policy agendas of the US, Europe and Japan (ManVis, 2005c; see also UNCTAD, 2005). For developing economies, in particular the new emerging economies, the high growth era not only increases future expectations about income and wealth, but at the same time raises questions as to its sustainability

[2] Globalization is defined as the process of economic integration with resources becoming more mobile, economies becoming increasingly interdependent, and financial markets becoming increasingly international (OECD, 2005).

[3] Even if the losers may not outnumber the winners, they could be more politically vocal in their opposition to globalisation.

in the medium and longer run. One major challenge for the BRICs and other rapidly growing developing countries is balancing the high growth sectors and regions with the other less thriving parts of the economy (ManVis, 2005c; OECD, 2005).

2.2. Expected macro-developments: productivity, income and wealth

In a long-term scenario to 2030, the WorldBank (2007) foresees a near doubling of GDP in high-income countries and a more than tripling of GDP in developing countries. An important driver behind this process is the expansion of China and India, home to half of the population in developing countries. The world-wide rise in GDP will go hand in hand with increasing exports and energy use, with Asian levels approaching those of Europe and the US. All kinds of imaginable and unimaginable shocks may occur along the way. The longer the timeframe, the bigger the uncertainty will be.

Anchored in trends already evident and based on a number of assumptions, GoldmanSachs (2003) and PriceWaterhouseCoopers (2006) estimate that by 2050 China will be the world's biggest economy, followed by the US and India. PriceWaterhouseCoopers (2006) projects that by 2050 the 'E7' economies (BRICs plus Indonesia, Mexico and Turkey) will be around 25% larger than the current G7, and in Purchasing Power Parity (PPP) terms even 75% larger. Currently the E7 is only around 20% of the size of the G7 (75% in PPP terms). With three of the four largest economies in 2050 potentially residing in Asia, important geopolitical shifts towards Asia are to be expected. One crucial assumption behind these projections is that the BRICs maintain their growth-supportive policy settings. Not all experts share this optimism about future growth, however. Some even refer to the BRIC growth optimism as a 'marketing ploy' (Amicus, 2006). However, what holds for developed high-income economies also applies to the new emerging economies: ensuring the right conditions for growth now and in the future is vital. These conditions include macro stability (sound macroeconomic policies and a stable macro environment), strong and stable institutions (CEPII-CERIM, 2004)[4], openness to trade, and investment in new technologies, R&D and talent, and education (secondary schooling and beyond).

Both GoldmanSachs (2003) and PriceWaterhouseCoopers (2006) illustrate that – driven by demographic trends[5] – notable shifts in relative growth rates within the E7 can be expected. China and Russia are expected to face significant declines in their working age populations between now and 2050, in contrast to younger countries like India, Indonesia, Brazil, Turkey and Mexico. As a result, India is projected to have the fastest growth potential, with a GDP similar to the US in PPP terms by 2050. China, even with a marked growth slowdown, would be around 40% larger than the US economy in PPP terms. Note that as a result of demographic change, most established OECD economies are projected to lose some ground relative to the US economy by 2050. This holds for all bigger EU-15 economies as well as Japan, with Canada and Australia being notable exceptions.

[4] In the broadest sense, including the legal system, functioning markets, financial institutions, health and education systems and government bureaucracy.

[5] GDP projections of the E7 appear to be particularly sensitive to assumptions on trends in education levels, net investment rates and catch-up speeds.

PriceWaterhouseCoopers (2006) and ManVis (2005c) point out that while the BRIC might represent some of the largest markets by 2050, GDP per capita will still be lower than in the G7. By 2050 PriceWaterhouseCoopers (2006) projects India and Indonesia to be on a par with Spain and Korea today, and China, Turkey and Brazil on a par with the leading G7 in per capita GDP terms (PPP based). In a similar study, with growth stemming from labour force growth, capital accumulation and total factor productivity growth, Poncet (2006) estimates that the US does *not* lose the first rank in the world GDP hierarchy in 2050, even if China and India are expected to experience a 13-fold and 10-fold increase in GDP at current real exchange rates, respectively. Of the current G7, only the US, Japan, Germany and the UK may be among the seven largest economies in 2050 according to Poncet (2006).

Table 1: Predicted GDP and TFP growth by world region

Region	Annual GDP	Annual TFP	Annual GDP	Annual TFP
In %	2005-2050		1980-2005	
Africa	1.3	0.5	3.1	0.1
North America	3.2	1.6	3.0	1.0
South America	1.4	0.5	2.3	-0.5
China	4.5	2.6	5.4	2.2
Eastern Europe	1.5	1.5	1.9	1.1
Western Europe	1.9	1.4	2.6	0.9
India	4.1	2.1	4.9	1.5
Japan	1.5	1.5	2.5	1.2
Mediterranean	2.1	0.9	3.1	-0.5
Entire sample	2.6	1.3	3.0	0.6

Source: Poncet, 2006

If we compare the period up to 2005 and the period 2005-2050 (see Table 1), what strikes the eye is that future growth is more than in the past expected to be driven by Total Factor Productivity (TFP): almost half of GDP is expected to be fuelled by TFP growth. GDP growth, however, lies significantly below the average growth rates of the period 1980-2005. In the past productivity growth in manufacturing has been unrivalled to other sectors in the economy (see Box 2). This trend is likely to continue, although productivity in parts of the services industry, especially tradable services, could rise significantly due to the pervasive and continuing impact of ICTs.

By 2030 the per capita income gap between East Asia and other parts of the world on the one hand and the high-income countries on the other will still be considerable as projections by the WorldBank (2007) show (see Figure 1). Nevertheless, steep rises in income, like in East Asia, will clearly have implications for the types of the goods and services that consumers will demand, with patterns of demand looking much more like those of leading OECD economies today, notwithstanding cultural differences. With rises in income, income inequality is likely to rise as well, posing considerable social and public policy challenges. Larger and wealthier economies are not per se important lead markets.

Much is dependent on individual purchasing power and the willingness to buy leading-edge products and services (ManVis, 2005c). For OECD consumers, the

trend of the last decade in which low cost imports from China and other emerging economies were much to their benefit is set to continue and to even broaden to a wider range of products over time, leaving consumers with more money to spend on services (PriceWaterhouseCoopers, 2006).

Box 2: Manufacturing: past and present trends in productivity, employment, output and trade

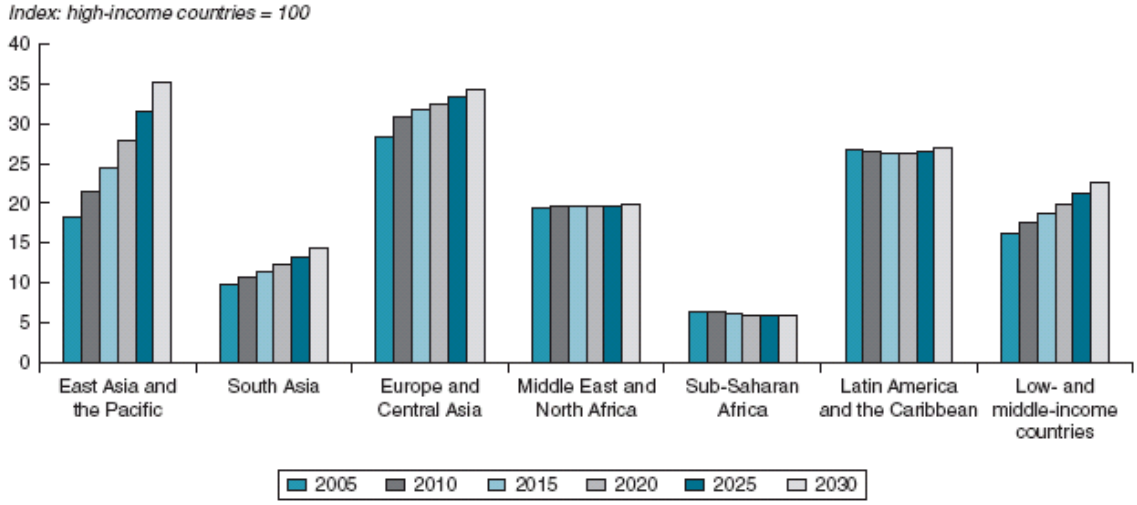
Productivity growth in manufacturing – driven by technological progress, capital accumulation and economies of scale - has been unrivalled compared to other sectors in the economy. The same productivity increases, however, can be held responsible for the continuing decline in manufacturing employment and in manufacturing's share in overall aggregate production, with services now accounting for around 70% of employment and value added in the EU[6]. Being substantially higher than the rest of the economy, in most OECD countries average productivity growth in manufacturing ranges from 2 to 4% on an annual basis. The importance of the manufacturing sector is also visible from its large share in total business expenditure on R&D (BERD).

Manufacturing employment has declined steadily in most of the 'old' EU member states over the last thirty years, with the exception of Spain and Ireland (OECD, 2006). This gradual decline is observed both in absolute terms and as a share relative to services; but not all manufacturing sectors have declined equally (e.g. CEC, 2005; CEC, 2006; OECD, 2006). In the new Member states (EU-12) a major reshuffling of the manufacturing landscape has taken place since the early 1990s. Whereas the 1980s were characterised by a shift from low to high-tech manufacturing employment, the latest trend points to a decline in high-technology manufacturing. This is true not only for Europe, but for the OECD as a whole. The decline in manufacturing employment in OECD countries has not been accompanied by an increase in non-OECD countries (OECD, 2006). In Brazil and India manufacturing employment has been relatively stable, whereas in Russia and China manufacturing employment has been in decline, in the latter case with net job loss estimates varying from 4 to 15 million jobs in the period 1995-2002 alone (Conference Board, 2004, respectively Banister, 2005; also Pilat et al., 2006). For China this was the combined result of economic restructuring and the closing of many inefficient state-owned companies. Due to a substantial break in statistical series in 1998 and a lack of figures after 2002, an unequivocal estimate of the (decline in) manufacturing employment is lacking, however.

In contrast, manufacturing output and trade have grown significantly world-wide and are increasing. Intra-industry trade – trade occurring within the same industry, even within a firm as a result of integration of manufacturing production throughout the value chain - has risen considerably over the years, with average shares in terms of total manufacturing trade ranging from 60% (Ireland) to almost 90% (Belgium) in the period 1996-2003 (OECD, 2006).

[6] In trade, manufacturing still accounts for the bulk of of intra-EU trade, with services accounting for only 20%.

Figure 1: Development in per capita incomes over time by global regions



Source: World Bank simulations using the Linkage model.
Note: Ratio of PPP-adjusted per capita incomes relative to high-income average. PPP is fixed at base year (2001) level.

Source: WorldBank, 2007

2.3. The manufacturing sector – winner or loser from globalisation?

The longer-term impact of continued globalisation and the recent integration of new competitors in the global economy will be pervasive, even if the exact consequences in terms of productivity, income and wealth, employment and industry location are difficult to predict. Mass market manufacturers in OECD countries are likely to lose, in low-tech but increasingly also in high-tech sectors, whereas emerging economies will become increasingly competitive in tradable services sectors such as banking and wholesale financial services. Unless OECD manufacturers can find viable high value added niches, not easily copyable and involving highly firm-specific or readily patentable intellectual property, business will appear increasingly tough (PriceWaterhouseCoopers, 2006). Globalisation and increasing international competition will continue to affect our economy, with manufacturing being only one of many sectors facing the effects. Who will win and who will lose from globalisation is far from a clear-cut case. However, based on 'educated guesses', the following tentative list illustrates the possible effects from further globalisation (see Table 2).

Important parts of the low- and medium-skilled labour segment are expected to come under considerable stress. The logical long-term trend for manufacturing across the OECD will account for an even smaller proportion of GNP, possibly at an accelerated pace (PriceWaterhouseCoopers, 2006). The fact that manufacturing productivity is generally higher than services productivity, as well as the continued trend of 'tertiarisation' (i.e. shifting demand from goods to services) in developed economies all contribute to this.

Table 2: Potential winners and losers in OECD economies over the next 10 years

	Potential winners	Potential losers

Companies	• Retailers • Leading global brand owners • Business services • Media companies • Niche high value added manufacturers • Health care and education providers • Financial services companies able to penetrate E7 markets • Energy and utilities companies	• Mass market manufacturers (both low tech and hi tech) • Financial services companies not able to penetrate E7 markets who may become vulnerable in their home markets • Companies that over-commit to key emerging markets without the right local partners and business strategies
Individuals	• Global 'star performers'* • Consumers of low cost imports • Providers of high value personal services with cultural barriers to migrant labour • Individuals with strong cross-cultural skills	• Low and medium-skilled workers in tradable sectors (including those open to offshoring) • Low and medium- skilled workers in non-tradable sectors open to migrant labour

Source: PriceWaterhouseCoopers, 2006. * Ranging from chief executives and financial market traders to footballers and film stars.

2.4. Relocation and international sourcing

One of the manifestations of globalization is the growing trend in international sourcing. The term sourcing applies to firms that contract out (parts of their) production to other firms (i.e. outsourcing) or other production locations within the firm itself (i.e. insourcing), either domestically or abroad. In the latter case we speak of offshoring. International sourcing in manufacturing is not new, with original equipment manufacturing (OEM) in electronics and ICTs in East Asia in the 1970s being the prime example of offshore outsourcing *avant la lettre*. Yet the scale and the pace at which relocation of production has occurred over the last decade appears to have increased.

Relatively new phenomena are the take-off of international sourcing in services (including R&D) and the emergence of global production networks. A crucial enabling factor behind both developments is the increased ability to fragment or divide production processes into increasingly smaller components (Krugman, 1995; OECD, 2005a; Evans et al., 2006). Recent technological developments, which have resulted in important decreases in communication, computing and transport costs and an increased ability to monitor, manage and control have enabled firms to fragment and spatially separate various stages of production at different locations. ICTs play a key role in the increased possibilities for sourcing, by offering new and cheaper ways of communicating (Internet, videoconferencing) and delivery (B2B, B2C). According to BoozAllenHamilton (2004) a new wave of (international) sourcing is occurring now also including white collar work and business services. At the same time, the quality and cost of sourcing services has reached unprecedented levels (ditto).

One major argument for the relocation of production to other parts of the world, mostly emerging economies, is low labour cost (KPMG, 2004) or – more general - lower production costs. Key are total landed (i.e. integral) costs, including energy, transport and other costs. With important changes in relative prices, and with falling levels of labour content in total production, the relative importance of labour costs may well shift in the longer run. While China may be a low cost labour location now, its future landed cost may appear to be relatively similar to countries in the EU or the

US. In some sectors, cost differentials can be substantial, however. To take the example of IT-enabled services, the reported cost savings of offshoring amount up to 40%. In 2004 US companies alone saved approximately US$11 billion by outsourcing to India (Erber and Sayed-Ahmed, 2005: 102). Yet the evidence is not all-conclusive. Other surveys give a more mixed picture, with some companies even losing from offshore outsourcing (OECD, 2006). Increasingly other arguments for offshoring are voiced, including the search for new markets and customers and the availability of a talented and skilled labour force. Surveys among CEOs of major international companies point out that market potential and business opportunities are a major driver of doing business and investing in emerging economies.

Figure 2: CEOs of major international companies and their plans in emerging economies

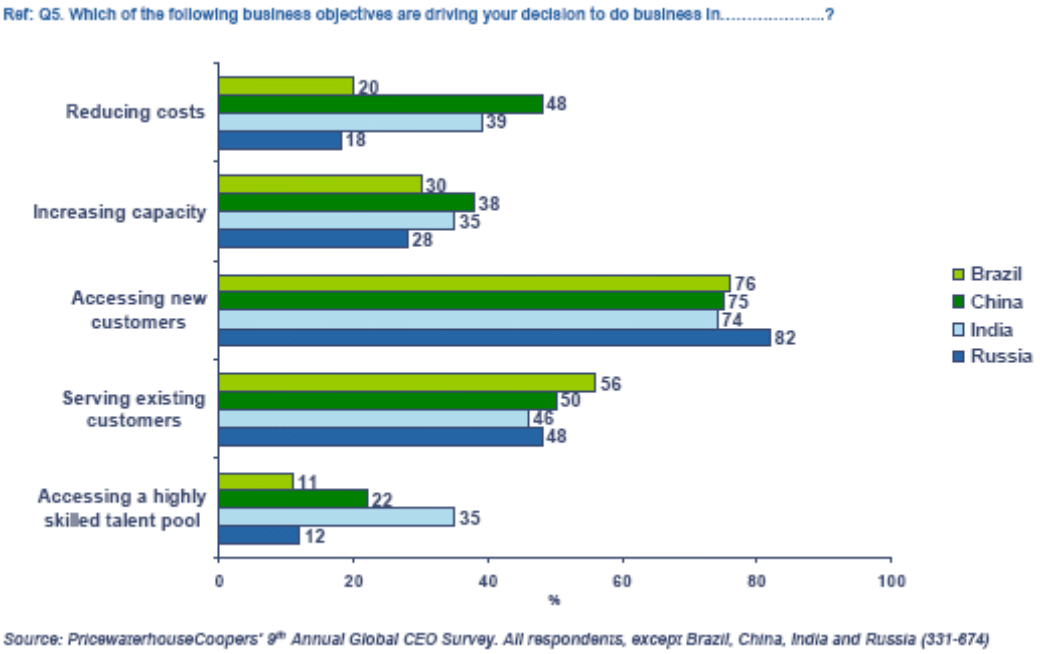
In a recent survey by PricewaterhouseCoopers[7], business leaders were rather unanimous in that emerging markets offer significant business opportunities: 78% believed this of China, 64% of India, 48% of Russia and 46% of Brazil. Yet offshoring was but one of many actions CEOs of major international companies were intending to do. The most important one notably was forming alliances with partners (see Figure 2). Accessing new customers is the key driver for doing business in emerging economies, as is shown in the next figure.

While accessing a highly skilled pool of talent is not yet among the most important drivers for business presence in emerging economies (see Figure 3) , the longer-term future will most certainly look very different. FutMan (2003e) emphasizes that the recruitment of skilled workers and the training of the workforce will become a major competitive factor for manufacturing companies in the post-industrial area. A major challenge is to close the mismatch between supply and demand of skilled labour in Europe and to improve computer literacy, scientific literacy, and environmental literacy. (see section 3.5.1: 'Skilled workforce' for details) Setting incentives and

[7] 9th Annual Global CEO Survey based on interviews with 1,410 CEOs between September and December 2005.

motivate the (potential) workforce will become more dominant. At the same time, as the high-skill labour market becomes increasingly global, international mobility of skilled professionals will rise. Knowledge, technological capabilities and other complementary assets matter, for both individuals and companies.

Figure 3: Motives of CEOs for doing business in emerging economies



Globalization and the increased use of sourcing by manufacturing and services firms can have important effects on productivity. However, the direction and extent of these effects has not been studied in depth (Olsen, 2006). Several studies have focused on the negative effects of outsourcing on wages and labour skills, while other studies have tried to establish whether positive effects on productivity can be observed. In particular, it has been argued that contracting out by manufacturing firms to foreign providers of service activities, a phenomenon that began in the 1980s in customer services and extended to engineering and software development, increases productivity. However, empirical studies of the existence of a positive effect have not found sufficient evidence to support these claims. Indeed, the effect on productivity of outsourcing seems to be conditional on the industrial sector (Olsen, 2006).

2.5. Relocation and the future: possible consequences for Europe

Confronted with the statement that "80% of traditional production in the EU will be relocated to low wage world regions", 81% of the ManVis Delphi respondents judged the statement to be important, whereas 63% expected this to happen within the next 10 years (ManVis, 2005d). It is interesting to compare this to the globalisation intentions of US manufacturers as reported by Deloitte (Deloitte, 2005). The lead destination in the short term for relocting from the United States is China. Europe (both Western and Eastern) is an intended destination for just over 10% of respondents for manufacturing. Reasons that prevent a total relocation of production from Europe can be summarised as follows. For manufacturing production where quality of the product as well as the quality of the supplier is of high importance, Europe remains competitive as certain levels of quality can not be achieved cost effectively overseas (KPMG, 2004). Furthermore, close user-producer relationships require a presence in the European market. The available pool of talent in Europe is still a factor in location decisions according to the KPMG survey. Lastly, the high labour productivity and high risks outside Europe also mean that there is a future for manufacturing production in Europe (KPMG, 2004). When considering total costs of relocation and outsourcing the picture becomes less bleak for Europe (and other industrialised nations) as firms face other costs in low labour cost countries due to business risks, weak institutions and weak infrastructure (ManVis, 2005c).

While R&D and other business services are increasingly outsourced, the question whether R&D will follow manufacturing production is hotly debated among experts. While a close user-producer interaction is increasingly important for innovative processes, this mechanism works both ways. European firms relocate R&D facilities to the emerging economies to build the necessary user relationships. However, ManVis experts see no 'automatism' of R&D following manufacturing production. One out of five ManVis experts do not believe that R&D will be performed close to manufacturing. While this does not imply that R&D will remain in its current locations, there does not seem to be a natural co-location pressure. What is clear though is that competition in R&D and R&D location will intensify in the coming years (ManVis, 2005c).

The implications of globalization for EU industry will vary. It could enhance the competitive position of established firms, through enabling them to exploit scale economies in larger markets and a broader supply chain. However, increasing variety in demand will create new market niches that offer opportunities to entrepreneurial firms. At the same time, increased competition from the emerging countries may threaten the survival of new and small firms with limited resources (Montalvo et al., 2007).

2.6. The emergence of regional and global production networks

The increasing ability to decompose and 'slice up' the value chain into a number of self-contained parts (activities/production processes as well as products) has, together with the search for cost reduction and new markets, led to the emergence of global production networks and – associated - an increase of trade in parts and components. The emergence of global production networks has also significantly stimulated the use of services, ranging from third-party logistics (3PL) services such as customs clearance and freight forwarding, quality assessment services through communication, transport, distribution and financial services, to R&D and

engineering (OECD, 2005a; UNCTAD, 2005).[8] The rise in IT-enabled services and more in particular business process outsourcing (BPO) of intra-business processes (ranging from support to development) signify the importance of ICTs in international value-chain decomposition (Erber and Sayed-Ahmed, 2005; OECD, 2006).

The complex, transnational character inherent in *global value networks* necessarily implies a growing importance of organization and coordination. Of particular interest is the role of leading firms that govern the chain and enforce the governing rules by which local producers - often micro-enterprises and SMEs - in the chain operate. The influence of chain coordinators, usually global leading firms, is huge and has major impacts on access to markets, acquisition of capabilities, distribution of gains and the possibilities for governments to intervene and support (Schmitz, 2006). MNCs are the classic example of chain governors and continue to play this role, particularly in so-called *producer-driven* value chains (OECD, 2005a). These producer-driven chains often manufacture complex goods such as semiconductor chips or automobiles, and in order to do so chain governors have significant control over both backward (raw materials, components) and forward linkages (distribution and retailing). *Buyer-driven* value chains on the other hand operate in competitive global and regional *production networks* typically situated in various locations around the world, the role of leading firm performed by a large manufacturer with a well-known brand name, a large marketing firm or a large retailer. Buyer-driven value chains are usually labour-intensive industries, ranging from apparel, footwear, toys and wood furniture.

2.7. Globalisation vis-à-vis further regionalisation and regionalism

China and India play an important and increasingly eminent role in internationalisation and globalization. At the same time, a trend of increasing intra-regional *Asian* trade and rising intra-Asian investment can be observed (regionalisation), along with a strong rise in Preferential Trade Agreements (PTAs) and other forms of intra-regional cooperation (regionalism). China and the other East and South-East Asian nations, including Japan, have developed a strong intra-regional trade and investment focus, while actively striving for further trade integration through the forming of PTAs at the same time (Evans et al., 2006). India is less pro-active in concluding bilateral trade agreements and lags behind China in opening up to global trade, although there are indications of an acceleration lately (The Economist, 2006a; ADB, 2006). Whether Asian regionalism is to the benefit of the world in the medium and longer term is not clear as yet. What the proliferation of PTAs in Asia means for unilateralism and the future of multilateral organizations, most importantly the WTO, neither. China and India, and throughout Asia, a strong preference for technological independence and an increasing ability to set technical rules and standards can be observed (Suttmeier, 2005; Schmitz, 2006; Kang and Segal, 2006).

[8] Manufacturing and services have become increasingly intertwined, and it is increasingly difficult to categorize firms as strictly manufacturers or service providers, especially where digital goods (e.g. software) are concerned.

Box 3: BRICs and Future Competitiveness

Globalisation and the coinciding intensifying international competition is the single most important driver shaping the future of manufacturing. While countries like Japan and South Korea have made the transition to compete on eye level with the West over time, similar expectations hold for at least China. The current discussion on future competitors focuses on the BRIC countries although large differences exist between these countries.

China being the world's manufacturing powerhouse is perceived as the biggest potential competitor of the BRICs. If current trends continue GoldmanSachs (2003) estimates that China will become the largest economy by 2050, although not the richest in terms of GDP per capita. Furthermore, China's large number of R&D employees, which is only second to the U.S., makes it not just an attractive low cost manufacturing location but increasingly competitive in high-technology and R&D (Amicus, 2006). While wage inflation is starting to affect highly skilled jobs in China, the large reservoir of unskilled labour means that wage inflation for low skilled manufacturing activities is less of an issue. Despite these advantages often the challenges China is likely to face determining its competitiveness receive less attention. For example even China has lost manufacturing jobs since the mid-1990s due to high productivity gains (ManVis, 2005c). Furthermore, energy and a lack of infrastructure are key constraints to future growth in China. The uneven growth within the country is hampering development as some areas such as Shanghai already lose their labour cost advantage, whereas other parts of the country lack the infrastructure to be attractive for manufacturing (ManVis, 2005). Due to the one child policy China is one of the most rapidly ageing societies posing similar challenges as in the West. Lastly, the industrial catching up process of China has come at a huge environmental cost, which seems unsustainable as the country is already suffering from heavy environmental pollution and shrinking water supplies (Amicus, 2006). Although, there are little doubts that China will see spectacular development making it a long-term competitor, the challenges on the way are significant and should not be underestimated.

Despite not experiencing the same growth rates as China, **India** is perceived as one of the most prospective economies for the coming decades. One reason is India's adoption of using special economic zones (SEZ) while having one of the best legal frameworks in Asia reducing investment risk. Although having well educated workers, labour costs in India are at the lower end of the emerging economies (KPMG, 2005). Also India's population is the only one expecting to grow up to 2050. However, problems with lacking infrastructure making transport expensive as well as unstable energy supplies could hamper future development (KPMG, 2005). Furthermore, India's federal structure leads to regional governments undermining each others efforts to attract foreign investment (KPMG, 2005). Overall, India is expected to play an important role in the second wave of outsourcing, where white collar work is outsourced and off-shored (Deloitte, 2006). Nevertheless, India's future development and impact on global manufacturing will depend on how it solves its challenges.

Although the economies of **Brazil and Russia** are expected to grow significantly, the future of manufacturing is much less rosy than in China or India. Brazil is perceived as far from being competitive on foreign markets and much less open to trade than China. Furthermore, its investment and saving rates are lower, whereas public and foreign debt is higher (Amicus, 2006). Also, to achieve the projected growth rates Brazil's performance would have to increase considerably (GoldmanSachs, 2003). Russia's growth is largely driven by recent increases in energy and commodity prices, whereas the economy is not diversified and at the mercy of cyclical movements of the world economy. Russia's biggest challenge is its weak institutions and expected decreasing population. Overall, although Russia and Brazil are expected to grow considerably, their role in the international division of labour in global manufacturing is uncertain judging their future challenges.

2.8. Financial globalisation and financialisation

Financial globalisation and integration. One of the most salient features of the current wave of globalisation is the surge in capital flows between industrial countries and, even more notably, between industrial and developing countries. Despite the fact that the pace of opening of capital markets has been slower than for trade, with many countries still maintaining restrictions on capital flows, the world has witnessed a huge increase in financial flows both in gross and in net terms (WorldBank, 2007). The facts leave little doubt about the importance of financial globalisation.[9] To illustrate its importance, we will provide two examples, one on global foreign exchange transactions, the other on the foreign direct investment (FDI), being less volatile than other capital flows. While in the early 1970s the ratio of foreign exchange trading to world trade was around 2:1, this had risen to 50:1 by the early 1990s and to 70:1 by the end of the 1990s, with the majority of foreign echange positions held for less than a week (Eatwell and Taylor, 2000). The daily volume of global foreign exchange transactions amounted to more than 1.9 trillion US$ each day in 2004, in contrast to 570 billion per day in 1989 (www.bis.org/press/p040928.htm; www.bis.org/publ/rpfx02t.pdf). FDI flows which accounted for US$22 billion only in 1990 have nowadays reached levels of some US$600 billion each year (after peaking at over US$1,300 in 2000 at the end of the dot-com boom) (WorldBank, 2007). Capital markets have become more integrated so that global and international industry-specific factors appear to have become more important and national factors less important in stock markets movements (Brooks and Catao, 2000). All but very short term interest rates are now determined in globally integrated markets (Perraton, 2003).

While theoretical models have established a number of channels through which financial globalisation can promote economic growth, systematic examination of existing empirical evidence reveals that it is difficult to establish a strong causal relationship. In attracting capital inflows, much appears to depend on the absorptive capacity of countries, in addition to sound macroeconomic policies, well-functioning institutions and governance (Prasad et al., 2003; Kose et al., 2006). International financial integration should in principle help countries to reduce macroeconomic volatility. But also here the evidence is far from conclusive. The widespread (premature) capital account liberalisation amongst developing and transition economies in the 1990s has in some cases increased rather than reduced the vulnerability to crises, with cross-country linkages amplifying rather than dampening the effects of shocks and enabling its rapid transmission (ibidem; Perraton, 2003). Argentina, Turkey, Brazil and, most importantly, South-East Asia have experienced severe financial crises which have in turn led to destabilization, massive dislocations and a strong decline, at least temporarily, in living standards. Excessive capital inflows followed by rapid capital outflows, encouraged by financial liberalization, led to unsustainable debt positions in some cases, and speculative ‘sudden stops’ of lending that left governments and companies in highly vulnerable positions (Epstein, 2005).

[9] Although related concepts, a difference should be made between financial globalisation and financial integration. Financial globalisation is an aggregate concept that refers to rising global linkages through cross-border financial flows, whereas financial integration refers to an individual country’s linkages to international capital markets (Prasad et al., 2003).

The effects of financial globalisation are indeed tremendous. Amongst others it has rendered fixed exchange rate systems unsustainable; it also has deep implications for macroeconomic policy formulation. It is very likely that financial integration will further intensify in the future. Technological innovations and an even greater integration of markets are expected to impact strongly on the global financial system in the oncoming 25 years (WorldBank, 2007). However, far less certain are the form and shape that this integration is going to take. Economic and technological developments (notably ICTs) could lead to a further concentration of financial intermediation into a limited number of global banks and financial institutions. But a greater decentralization of financial intermediaries would be equally possible. Future changes can only partially be anticipated. With the continuing growth of emerging economies their role in the financial system is likely to grow in importance. Ageing will have a notable impact as well, with an expected decrease in savings due to declines in the labour force and a rise in elderly dependence ratios (ibidem) in most industrial and some developing countries. Another issue is the future role of the US dollar as a major currency of lending and reserves. Whether other currencies – the euro or perhaps the Chinese yuan – will play a major role in the future is not yet apparent (WorldBank, 2007).

Financialisation. Closely related to financial globalisation, but a distinct phenomenon is financialisation. Research on financialisation is relatively new, and no common agreement about its definition or its significance has yet been reached (Epstein, 2005; Krippner, 2005). Some use financialisation to mean the rise of 'shareholder value' as a mode of corporate governance. Others use it to refer to the growing dominance of capital market financial systems over bank-based financial systems, or – equally so – to the explosion of financial trading with a myriad of new financial instruments.[10] Again others use it to refer to the increasing political and economic power of a particular class (the "rentier" class). A useful encompassing definition by Krippner (2005) takes financialisation as 'the pattern of accumulation in which profit making occurs increasingly through financial channels rather than through trade and commodity production'.[11] Issues in the *ongoing* (!) academic debate on financialisation range from the question who controls the modern corporation, through what financialisation – and in particular the increasing influence of private equity - means in terms of social, governance and market stability challenges, to the question as to what extent financialisation impacts and affects the autonomy of the state.

Under influence of financial markets and shareholder pressures firms have been moved to increase their share prices, bringing firms to engage in various activities to satisfy shareholders and to deliver expected market returns. One of these activities comprises relocating and outsourcing to low cost suppliers / countries in order to cut wage costs and increase profits. Financial investors have increasingly used their power to influence corporate decision making. Analysis of the "rentier share" of national income would indicate that the gains of financialisation have accrued

[10] For example, Dore (2002) defines financialisation as "the increasing dominance of the finance industry in the sum total of economic activity, of financial controllers in the management of corporations, of financial assets among total assets, of marketised securities and particularly equities among financial assets, of the stock market as a market for corporate control in determining corporate strategies, and of fluctuations in the stock market as a determinant of business cycles."

[11] A much broader definition is by Epstein (2005) with financialisation referring to the increasing importance of financial markets, institutions and motives in the global economy. In this paper, we stick to the definition by Krippner to distinguish financialisation from the earlier discussed phenomena of financial globalisation and integration.

disproportionately to the financial sector in OECD countries (Epstein and Jayadev, 2005). The influence of financialisation on the performance of firms would be large, but not positive. For example, Crotty (2005) argues that financialisation has had a profound and largely negative impact on the operations of U.S. non-financial corporations. This is partly reflected in the increasing incomes extracted by financial markets from these corporations, which have more than doubled as a share of their cash flow between the 1960s and 1970s, and again between the 1980s and 1990s. Equally, by being predominantly managing and focusing on short-term financial returns, short-termism is likely to prevail over strategic thinking and longer-term objectives (Froud et al., 2000). In practice this could imply that firms cut strategic R&D spending in order to reach short-term financial goals and therewith potentially jeopardising their long-term competitiveness.

Both debates – the one on financial globalisation and the other on financialisation - have so far taken place in different intellectual communities and in relative isolation, the first one being dominated by international institutions (IMF, WorldBank, OECD) and academic economists, and the second one by academic sociologists and new political economists. Especially the second debate is, although having engendered a number of interesting questions and arguments, still largely unfolding. What is lacking so far is firm and robust *quantitative* evidence to the *qualitative* hypotheses and claims made. What's more: the potential impact of financialisation on the future of firms and society at large remains largely hidden.

3. TECHNOLOGICAL PROGRESS AND INNOVATION

3.1. Introduction

New technologies not only enable firms to reorganize and optimize business processes, but also enable the production of new and better quality goods and services. A key message signalled by a majority of futures studies is that the increasing pace of technological change and the need of staying competitive in a globalising and increasingly ICT-based world nowadays requires firms to focus even more on science, technology and innovation. Firms seem to be caught in a race in which rapid advances in science and technology exert an almost constant pressure to adapt and exploit new technological possibilities. Over the last decades the ICT revolution has had a profound impact across manufacturing industries. For the future the convergence of nano-tech, bio-tech, cognitive and neuroscience with ICTs is expected to cause similar disruptive changes, although no one exactly knows how and what these might look like (RAND, 2001; SRI, 2004b). For these key technologies the Aho report urges Europe to invest to prevent a technology gap to major competitors as has happened for ICT technologies (Aho et al., 2006) One of the envisaged changes in Europe is a transition from resource-based to knowledge-based manufacturing, with an increased ability to convert new advances in science and technology into innovative products and processes (Manufuture, 2006).

Technological progress is dealt with in different ways in the surveyed futures studies. Some studies attempt to outline the expected major technological developments over the coming decades (e.g. FutMan, 2003; IMTI, 2000; ManVis, 2005; ManuFuture, 20006; Nistep, 2005). Other studies instead make inferences about future productivity changes based on *assumed* technological progress, the latter largely or entirely remaining a black box (e.g. GoldmanSachs, 2003; PriceWaterhouseCoopers,

2005; WorldBank, 2007). Again other studies present a rudimentary outline of expected technological advances and combine these with trends in R&D expenditure and R&D capabilities to draw conclusions regarding the future technological competitiveness of countries or sectors (e.g. Amicus, 2006; CME, 2004; HM Treasury, 2004; U.S. DoC, 2004). These various perspectives all highlight different aspects for the future of European manufacturing.

Section 3.2 assesses the most important trends in R&D expenditure and R&D workers for Europe and its competitors. Secondly, key technological developments in '*enabling technologies', 'product, process and automation technologies'* are presented. Finally, crucial developments in skilled workers and organisational capabilities that enable the commercial exploitation of new knowledge are reported.

3.2. R&D and innovative capacity

Technological progress and innovative capacity are usually assessed on the basis of variables such as R&D expenditures, patents and patent applications, number of R&D workers. While these measures are *indicators* of technological and innovative capacity, it should be stressed that technological and innovative capacity is as much about *how* R&D money is spend and how results are *commercially exploited* as it is about how much R&D is spend or how many patents are granted. Intense international competition makes countries *perceive* their relative technological and innovative position to deteriorate. Consequently, the U.S. DoC report (2004) calls for higher R&D expenditure to secure American technological leadership in the future. Similarly, the Lisbon Agenda is asking European countries to increase R&D expenditure to 3% by 2010. Figures show that Japan spends most on R&D, somewhat above 3% of GDP, compared to the U.S. (around 2.5%) and Europe (NSF, 2006; ManuFuture, 2003).

Countries with high R&D expenditures such as Germany, Sweden and Denmark are perceived to have a viable long term future in manufacturing, whereas in countries with low R&D expenditure such as Spain and Portugal manufacturing is perceived to be problematic (KPMG, 2004). Implicit here is the belief that high R&D expenditure is associated with high-technology, highly innovative firms that can compete internationally by focusing on knowledge intensive activities. Contrarily low R&D expenditure is associated with low skilled manufacturing activities that are expected to be relocated to low cost countries over time (see also Box 4).

Box 4: A deepening technology gap within Europe?

The ManVis Delphi survey analyzed the opinions from more than 3,000 manufacturing experts from 22 countries and confirmed the view that a substantial technology gap exists between the EU-15 and the new EU-10, despite important technological advances through technology transfer since the 1990s. New Member states not only appear to suffer from a lack of R&D funding, but also from a lack of specialist infrastructure and qualified personnel. It is therefore possible that a transition from resource- to knowledge-based manufacturing will deepen the regional differences between countries within Europe in the coming decades (ManVis, 2005d).

Some studies highlight the large (absolute) number of R&D workers in China - only second to the U.S. – emphasizing a potential future threat of China becoming a high technology competitor rather than just a location for manufacturing production (Amicus, 2006). Others, however, point out that the relationship between R&D

workers and technological leadership is far more complex than mere numbers suggest. For example, during the Cold War Russia employed more R&D workers than the U.S., nevertheless failing to achieve technological leadership in the long-run (WorldBank, 2007).

The importance of strong institutions in relation to commercial exploitation of technological advances is stated as the main reason for the superior U.S. innovative performance (WorldBank, 2007). For emerging economies like China, which currently are a magnet for manufacturing production, key in closing the technological gap to industrialised economies in the future will be the development of efficient institutions (CEPII-CIREM, 2004).

3.3. Future key technologies

Future key technologies are expected to enable new products and processes and to pose disruptive qualities to markets (ManVis, 2005a; Manufuture, 2006). However, many of these new technologies are literally in the making with expected impacts coming to us only in the longer term.

Enabling technologies will play a crucial role in keeping a technological leadership role for Europe in the future. Key is their pervasive diffusing capacity, which potentially affects future competitiveness across sectors. The four key enabling technologies outlined by major foresight studies are Information and Communication Technologies (ICTs, most developed), micro-systems, advanced materials, and bio-technologies and nano-technologies (least developed) (FutMan, 2003; ManVis, 2005a; SRI, 2004). Technological advances also enable developing new products with better functionalities, creating new market opportunities and new customers. New process technologies will improve production processes increasing productivity, efficiency and the quality of products.

Most futures studies expect ICTs to play a decisive role in short-term *manufacturing operations* (CME, 2004; IMTI, 2000; ManVis, 2005; Nistep, 2005). ICTs allow for productivity increases through *automation* as well as through reorganizing *business processes*. In combination with technologies such as RFID, this will cause supply chains and value networks to dramatically transform. It will also enable the emergence of new business models. Although this will no doubt lead to productivity increases, high uncertainty precludes any firm quantitative predictions. Several studies outline the importance of ICTs in ‘virtual design’ which enables to reduce both production costs and development times (CME, 2004; IMTI, 2000; Manufuture, 2006; Nistep, 2005). Virtual manufacturing defined as the use of information technology and computer simulation to model real world manufacturing for the purpose of analyzing, evaluating and designing them, is increasingly used to engineer the real manufacturing environment (Offodile and Abdel-Mayek, 2002). In some instances, actual simulation can be carried on concurrently as the manufacturing facility is being built.

Furthermore, ICTs are important for the *customization* of products as they enable producers and customers to communicate in different and new ways, itself being a new and important ingredient for the creation of new business models (see section 4.3). ICTs also enable the delivery of product/services combinations, whose development is pursued by firms in order to generate new niches and a high(er) value added (ManuFuture, 2006a; Manufuture, 2003). However, in the long run, better

human-machine interfaces need to be developed to exploit further productivity increase from more flexible automation technologies based on ICT and complementary technologies in controls and sensors (ManVis, 2005d). Interestingly, futurists remain sceptical about long-term automation visions such as the manless factory (ManVis, 2005).

Micro-systems – particularly electromechanical micro-systems – such as actuators and integrated sensors and microprocessors are expected to be used across production systems in the mid-term to make machines more intelligent and efficient. This will allow using manufacturing machines more flexibly and hence will enable firms to tailor to individual customers' demand (ManVis, 2005). Other studies speak of *micro-machining*, meaning essentially the same as micro-systems (CME, 2004b). In the long run experts expect micro-systems to enable *plug-and-produce productions systems*, which allow combining different components to production systems according to the required task, thus allowing for even more flexible production in the future (ManVis, 2005a). However, this vision is still a long way off.

Advanced & smart materials are expected to enable the production of high performance products that fulfil the demands of customers better than current product technologies. While advanced materials focus on improving product and process performance, smart materials change material attributes such as colour or shape to external stimuli (CME, 2004b). Smart materials attempt to serve customer needs better. The challenge faced by manufacturing is to make the processing and manipulation of new materials feasible. Mastering this challenge would create opportunities for Europe to gain a further competitive edge (ManVis, 2005a).

Nano-technologies and bio-technologies allow the manipulation of inorganic and organic materials for manufacturing products and components. Firms are already exploiting scientific advances in this field using genetically modified products and nano-materials for some applications (CME, 2005b). However, over the coming decades huge advances are expected from developments in bio- and nano-technologies which will drastically change the way products in which are manufactured. In a long term - 20 to 50 year – vision, products may be manufactured from the molecular or 'bottom-up' level. However, scientific developments in this area are just starting and future developments are still highly uncertain (ManVis, 2005a; Manufuture, 2006b).

What is regarded as highly important for the future of European manufacturing is the development of complementary manufacturing technologies that will allow for the commercial exploitation of new technologies, and hence will create future opportunities as well as strengthen competitiveness. The development of these complementary technologies is a challenge for European manufacturing that needs to be addressed.

3.4. Non-technological innovation

Non-technological innovation, particularly organisational innovation, plays an important role in maintaining and improving competitiveness and growth, both as an enabler and facilitator of technological innovation and in its own right. The organisational changes manufacturing firms are expected to go through in the future are discussed in most of the surveyed studies, including the large European foresight

studies (FutMan, 2003; ManVis, 2005; Manufuture, 2006), U.S. (IMTI, 2000; SRI, 2004;) and Japanese reports (METI) as well as accounts by the large management consultancies (KPMG, BoozAllenHamilton, Deloitte). Organisational innovation is particularly important for knowledge development in companies (ISI, 2006). Examples of organisational innovations over the last decades include the widespread implementation of team work, Just-In-Time (JIT) production, Total-Quality-Management (TQM), Continuous Improvement Processes (CIP), Supply Chain Management (SCM), outsourcing/relocation and performance-based pay, to mention only a few. Over time numerous organisational innovations have been introduced, with varying relevance and impact on the various manufacturing sectors (ISI, 2006; ETEPS, 2006), although organisational innovation is a key source of competitive advantage. It allows firms to achieve cost savings through better management of business processes or better knowledge exploitation within organisations. However, the exact impact of organisational innovation on industrial performance is *very difficult to quantify*.

All studies agree that the future firm should network and collaborate to exploit knowledge that is *beyond its organizational boundaries* in order to remain competitive (CME, 2004; FutMan, 2003; ManVis, 2005; ManuFuture, 2006; SRI, 2004). The reason is that technologies become increasingly complex and interdisciplinary in nature. The increasing pace of technological change means that firms cannot build all competencies within the firm. Consequently, firms will have to learn how to exploit knowledge through collaborations with suppliers, customers, competitors, but also with research organisations and universities. This development of accessing external knowledge from networks and collaborations is broadly known as ***open innovation***. Open innovation will be a source of competitive advantage as it determines how cost effective firms manage to exploit knowledge commercially. An important observation is that companies prefer to limit these collaborations to pre-competitive research as they are afraid of losing competitive advantage (FutMan, 2003d). For firms the challenge is to find the right balance between 'openness' while defending competitive advantage.

Closely linked to open innovation is ***user-centred innovation***, a concept that refers to learning processes through close producer-user interaction. Learning is important to improve products and processes and hence is a major source of competitive advantage. If a firm knows what its customers want, it has already a competitive advantage over potential competitors that lack that knowledge. The special importance for Europe is that such close interaction can 'localise' production as it ties producers to users (ManuFuture, 2006). Whether such localisation actually occurs remains to be seen. Firm evidence here is (still) lacking. In order to seriously implement user-centred innovation, European firms are also required to build up R&D facilities in large overseas markets such as the U.S. and more importantly Asia to serve overseas users (KMPG, 2004).

3.5. Knowledge, skills & competencies

The transformation from a resource-based to a knowledge-based manufacturing paradigm leads experts to rate knowledge and skills as absolutely crucial to future growth and competitiveness. This is one of the key messages found across most futures studies (CME, 2004; FutMan, 2003; HM Treasury, 2004; KPMG, 2004; Manufuture, 2006; ManVis, 2005; Nistep, 2005). This transformation does not only require firms to develop and manage a *skilled and educated workforce* (see section

3.5.1), but also requires organizational competences in *knowledge* and *innovation management* (section 3.5.2).

3.5.1. Skilled workforce

One of the key challenges for manufacturing is warranting a continued supply of skilled labour. Future labour supplies are under threat, not only as a result of demographic change (ageing), but also as a result of underinvestment in education and training. These are not particular European problems, but also apply to the U.S. and Japan (FutMan, 2003d, IIPS, 2005, ManVis, 2005, ManuFuture, 2006, US DoC, 2004). The aforementioned studies specifically call for educating more *graduates* in areas relevant to manufacturing as well as *attracting* graduates to enter the manufacturing sector after graduation instead of seemingly more attractive sectors of the economy. More women need to be integrated into the labour market to prevent future skills shortages (FutMan, 2003; CEFIC, 2004).

Skilled workers in other parts of the world are assumed to increase, even though the skill premium (defined as the ratio of skilled wages relative to unskilled wages) is set to increase as well, and mostly so in countries with a high investment rate (WorldBank, 2007: 58). Currently, the share of skilled workers is 32 percent in developed countries and less than 10 percent in developing countries (ibidem).

To work in knowledge-based manufacturing employees increasingly need new *soft-skills*. These become more important as organizations are increasingly globally networked and flexible. Teamwork, networking, intercultural literacy, interdisciplinary thinking, high worker autonomy and mobility/flexibility are therefore crucial skills required in knowledge based businesses (FutMan, 2003d, FutMan, 2003e). Soft-skills are generally associated with university education. An OECD study revealed that one-fourth to one-third of workers do not possess the required soft-skills (FutMan, 2003e). Firms therefore need to develop their workforce to adapt to the new challenges. While life-long employment is expected to be a thing of the past, today's workers are required to engage in *life-long learning* (FutMan, 2003, UK Foresight, 2000). The pace of technological change makes this especially important for highly innovative rapidly changing sectors. New learning strategies and technologies are be adopted by companies in order to build and keep the necessary human capital competitive (FutMan, 2003d).

3.5.2. Knowledge and innovation management

Through the transition from resource-based to knowledge-based manufacturing, *knowledge management* becomes a source of competitive advantage. Experts judge the management of knowledge, learning and sharing within organizations as highly important for the future of manufacturing firms.

Box 5. Emergence of Foresight in Europe

While the desire to foresee the future is as old as mankind, in the 1940s serious attempts emerged in the U.S. to forecast future technological developments known as 'technological forecasting' (Jantsch, 1967). Disappointments with methods and results of these forecasts – particularly the failure to foresee the 'oil crisis' – meant that during the 70s and 80s interest was waning. The only nation consistently engaging in long-term forecasts were the Japanese, producing quinquennial large scale national Delphi surveys since 1971 (Cuhls, 2001). However, Europe experienced a renewed interest in forecasting in the early 1990's primarily to focus public resource allocation. Germany was the first to emulate the Japanese survey in 1991 soon followed by France (Grupp & Linstone, 1999). In these countries a mere focus on the Japanese Delphi-technique was however not considered useful (Cuhls, 2003). Consequently, countries such as the UK started exploring new methods using expert panels for the different UK industry sectors, informed by a national Delphi survey, scenarios, expert presentations and regional workshops to identify future science and technology areas, which could be exploited for wealth creation and improvements in quality of life (Georghiou, 1996). This formed the UK Technology Foresight Programme from 1996.

These developments marked a new approach commonly termed as 'technology foresight'. However, as these projects do not only focus on future technologies but as much on social and economic developments the term 'technology foresight' is misleading. Instead, it is nowadays plainly referred to as 'foresight' (Unido, 2005). Foresight is commonly described as "a systematic means of assessing those scientific and technological developments which could have strong impact on industrial competitiveness, wealth creation and quality of life" (Unido, 2005). It should not be confused with other approaches such as forecasting, future studies or strategic planning. In contrast to the previous forecasting attempts the emphasis has changed from predicting to creating the future through shared visions and plans to put these into practice. Furthermore, with the rise of the 'Systems of Innovation' concept, the importance of linking the various actors became a key aspect of national foresight exercises. Consequently, the emphasis changed to creating networks and shared visions among dispersed expert groups to create possible self-fulfilling prophecies linking social-demands with technological and economic developments.

While the early phase of foresight in Europe led to a number of large scale national programmes, the focus has changed to small scale, topic related exercises in the countries that conducted the first national programmes in the early 1990s. Examples are the 2nd and 3rd round of foresight exercises in the UK. However, the interest in national foresight exercises has spread to the New EU Member States and countries overseas, such as Romania and Hungary but also Thailand, India and China.

This spreading of foresight has led to a number of European exercises, also on the subject of manufacturing. In 2003 FutMan "The Future of Manufacturing in Europe 2015-2020 – The Challenge for Sustainability" was the first project focusing on manufacturing. It differed to the foresight exercises described above in the respect that it was research groups producing the reports based on expert surveys and desk research. However, it also included the construction of four scenarios. FutMan formed the basis for the large scale European foresight exercise ManVis – Manufacturing Visions 2020 – concluded in 2005. Backbone of the ManVis exercise was a large scale European Delphi survey involving more than 3000 manufacturing experts across Europe. The results of this survey were used to augment the scenarios developed in the FutMan project to create visions of European manufacturing in 2020. Furthermore, the FutMan and ManVis results also fed into the 'Strategic Research Agenda' of the European Manufacturing platform 'Manufuture' presented in 2006. All three projects represent important sources in this survey.

Three factors are crucial here: the acquisition of knowledge, the development of knowledge and the sharing of knowledge (ManVis, 2005d). Although much of this

relates to the skilled workforce mentioned earlier, from the firm perspective future competitiveness will depend on how well knowledge is managed within the organization. One particular challenge is the acquisition of external knowledge and expertise, now being broadly debated as open innovation and user-centred innovation (see section 3.4).

4. TRANSFORMING THE MANUFACTURING LANDSCAPE: NEW MANUFACTURING PARADIGMS AND FUTURE BUSINESS MODELS

4.1. Introduction

European manufacturing businesses will need to adapt and transform to new realities in which continuing globalization, international competition and innovation will play a pervasive role. Increasing international competition has already led firms in developed countries to move away from pure *cost competition* to higher *added value* activities and to relocate (parts of their) production to the new emerging economies with substantially lower wages labour costs. Manufacturing firms face more competition but also collaborate more and are increasingly part of global *value networks* (FutMan, 2003e; IMTI, 2000; ManVis, 2005; ManuFuture, 2006a; Meti, 2005; SRI, 2004a). Moving into *high value added* manufacturing segments and niches calls for *customization* and *high performance products*, with the latter increasingly including a *service* component. New requirements in terms of service, 'new' human capital and knowledge alter the manufacturing landscape as much as technological change.

Manufacturing firms will actively have to identify, promote and apply new business models, new methods and information tools, in order to sustain global competitiveness. If taken up well, this could allow existing industries to continue to operate from a base within Europe and allow new businesses to arise (ManuFuture, 2006b). Recent transformations in business models observed in industrialised countries are rather similar, as most firms are exposed to the same pressures of international competition and operate in similar environments with an increasing pace of technological change and innovation.

The search for new ways to adapt and transform to new realities also includes 'new' *grand visions* or *designs* at the higher, overarching 'supra-sector' level. New manufacturing paradigms have emerged, not only in Europe but also in Japan, on how manufacturing can transform and reinvent itself and sustainably face the future. The search for *grand visions* goes hand in hand with a desire to foresee the future – the latter being as old as mankind, but having gone through marked stages of renewal since the 1940s, as is illustrated in Box 5. This chapter starts with a concise discussion on new manufacturing paradigms (section 4.2), followed by a more extensive discussion on new trends and developments in manufacturing in relation to future business models (section 4.3).

4.2. New manufacturing paradigms

New *manufacturing paradigms* have been defined both in Europe (see our discussion of the '*Manufuture'* paradigm*)* and Japan (ditto, the '*Monodzukuri'* paradigm). While US studies refrain from coining a new manufacturing paradigm, the need of similar changes and similar cures for the future transformation of the manufacturing base as in Europe is certainly acknowledged (e.g. CME, 2004; SRI, 2004). This includes the

adoption of mass customization, more and better quality services, more networking and collaboration and embracing globalisation. Both '*Manufuture'* and '*Monodzukuri'* call for more fundamentally different ways of production in view of increasing scarcity of non-renewable energy and natural resources (water, minerals, metals) as well as climate change (global warming). Sustainability in the US seems to be less prominent an issue still. New impetuses and signals both from the global warming and climate change debate (Stern, 2006; IPCC, 2007 and 2007a; Al Gore's film *An Inconvenient Truth*), but also discussion and increasing concern about the effects of offshoring (e.g. Blinder, 2006) could quickly change the position and views in the US though.

4.2.1. The Manufuture paradigm

Manufuture is described as a powerful vision linking human and societal needs (demand) to both industrial and education systems (supply) (ManuFuture, 2004). This trend of linking future developments of manufacturing to societal needs can also be observed in Japan where foresight is similarly extensively used as in Europe. The change in paradigm is proclaimed as a transition from competing on 'cost' to competing on 'added value', which requires 'high performances', 'customization', 'new business models', 'new human capital' and a 'service dimension' in manufacturing (Manufuture, 2006a). Important to note is that this is a future vision and not yet reality, although the trends are visible.

While traditional manufacturing is based on land, labour, and capital, *'manufuture'* is founded on knowledge and capital. The transition hence depends on the successful adoption of new attitudes towards continuous acquisition, deployment, protection and funding of new knowledge as a source of competitive advantage (ManuFuture, 2004). *This requires a high degree of collaboration and networking with suppliers, customers, competitors and other sources of external knowledge* as firms will have to cooperate across whole manufacturing systems instead of competing individually as technologies become more complex. This also requires *complex organisational approaches* as dispersed organisations are collaborating in networks (ManuFuture, 2006)

4.2.2. The Monodzukuri paradigm

Monodzukuri seems similar to the *Manufuture* paradigm as the transformation is described as moving from 'manufacturing objects' to 'producing value' (JMA, 2003). However, the reasons for adopting this paradigm given by the Japanese Economic Ministry (METI) are the increasing environmental constraints, together with rapid ageing and decreasing population that force the paradigm of mass production to come to an end. Furthermore, it is stated that "the Monodzukuri spirit presents a path toward the attainment of sustainable economic development, one which enables growth that acknowledges environmental load, depletion of natural resources, and population issues." (Meti, 2005). The reason for adopting *Manufuture* however originates in wishes to remain competitive in the knowledge economy rather then switching to a sustainable production, even though sustainability is an element of the *Manufuture* paradigm. It is not clear how 'monodzukuri' is put into practice and how it is expected to affect Japanese manufacturing competitiveness in the future. This view could be influenced by the lack of material available in English.

4.3. New business models: importance and possible ingredients

Whereas *manufacturing paradigms* can be compared with grand future visions at the supra-sector level, *business models* represent the set of (multidimensional) opportunities and choices that individual firms - the micro-level - make vis-à-vis the future. These range from value propositions to customers, financial models, value networks to functional architecture[12]. Business models are crucial for future competitiveness as they determine revenue generation by integrating the production system, workforce and organisational competencies (Manufuture, 2006b). Recent changes in business models reflect four major trends identified across futures studies (e.g. FutMan, 2003; KPMG, 2004; ManVis, 2005; Manufuture, 2006; SRI, 2004). Firstly, large businesses become *less vertically integrated* as they *increasingly manage global networks*. Secondly, a *transition from products to services* is observed, with manufacturing firms increasingly providing add-on services to their traditional products as well as relocating and sourcing production. Thirdly, firms increasingly diffuse intellectual property (IP) beyond company and even country boundaries, as *firms innovate more openly*. Lastly, small businesses have to *compete in manufacturing networks* and collaborate openly to address market challenges.

That business models and manufacturing paradigms will play an important role in the future of manufacturing is beyond doubt. *Future business models* will need to reflect 'new ways of working' based on rapid formation of open networks in both traditional and emerging sectors, which according to experts will improve capabilities and increase productivity translating into competitive advantage. At the same time, future business models will need to take account of other factors, issues and trends. From the futures studies at least six of such determining factors and trends can be distilled, which in creative combination, in isolation or in concentration on only a few, may form the basis for successful business models. These will be discussed in the following sub-sections.

4.3.1. Managing global networks, firms becoming 'orchestrators'

In the past big manufacturing firms controlled large parts of the supply chain. However, today many of the most successful manufacturers rely on outside suppliers for major portions of their supply system. This trend is acknowledged across all studies surveyed, without exception. An extreme example is Dell that sources all components from outside vendors. The core competence here changes from producing to managing the production, which requires well managed global networks (SRI, 2004). This trend also offers new opportunities for smaller manufacturers that are capable of participating in these global networks of large manufacturers.

[12] A business model can be defined as "a description of the value a company offers to one or several segments of customers and of the architecture of the firm and its network of partners for creating, marketing, and delivering this value and relationship capital, to generate profitable and sustainable revenue streams" (Osterwalder et al., 2005). Business model analysis is widely applied in the context of strategic, financial and operational decisions by private firms.

Box 6: Successful Business Models of Large Firms

While technologies and competencies are crucial to the firm its business model determines success or failure. Current trends on outsourcing, collaborating, networking and the provision of services are clear, although differences between sectors exist. On the other hand new developments in business models such as 'Second Life' or 'Long Tail' presently receive much media attention while it is yet unclear if and how these impact manufacturing.

In manufacturing **Dell** represents a role model of a business model innovator that has become a manufacturing '*orchestrator'*. Although a manufacturer, Dell assembles and markets products using system designs and architectures developed in-house but *sources* most product technologies and components from a *global network of suppliers*. Furthermore, Dell sells directly to end consumers specified to order mainly over the internet. Production only starts with product payment. Large parts of its business focuses on the provision of *services*, which range from maintenance contracts, technology consulting, technical support, training of system administrators as well as financial services. (SRI, 2004a) Similarly, Nike has adopted a business model based on 'orchestrating' production, sourcing all production from suppliers globally while focusing on R&D, marketing and sales. Dell's business model today is already widely emulated indicating its potential beyond electronics and textiles. Nevertheless, many firms still have to make the transition of stringently exploiting opportunities from ICT technologies to reorganize their supply chain and adapt their business model.

Another example is **Siemens** which is becoming a 'solutions provider' by combining the delivery of products and services for such wide ranging products as power plants to telephone networks. Similarly, **GE** generates most of its sales growth from the provision of *services* rather than products allowing it to outperform its competitors (SRI, 2004a; 2004d). These examples emphasize the general trend across manufacturing sectors of traditional firms adapting their business models to become service providers.

While the orchestrating of global value chains is a prevalent aspect of changing business models for large firms, outsourcing seems to be limited to *non-critical* products / technologies. Pharmaceutical companies like **GSK** represent a special case as they exploit global scales in production through sourcing, but keep the majority of production of strategic drugs and active ingredients in-house. In fact GSK chooses to produce its active ingredients in only five countries, namely Australia, Ireland, Singapore, the U.K. and the U.S. Consequently, its supply chain has two components: primary sites produce active ingredients which are then mixed and packaged into final products at secondary sites. (SRI, 2004d). Furthermore, the pharmaceutical sector provides fewer opportunities to provide services. This emphasizes the varying degrees of outsourcing, collaboration and networking between sectors. The key determinant is competitive advantage, which in industries such as pharmaceuticals could be jeopardized by collaborating or outsourcing critical products / processes.

Some firms have understood to adapt their business models exploiting new technological developments and a changing institutional framework. However, the examples also show that there is no 'one size fits all' business model. Instead, even within sectors different business models can co-evolve. Structural differences between sectors, such as high R&D expenditure and negligible variable production costs in the pharmaceutical sector, lead to limited sourcing and R&D collaboration. Furthermore, the demand for add-on services provision also varies between sectors. Nevertheless, the successful business models will be emulated by competitors erasing competitive advantage over time. One thing seems certain. Business models adapt to the prevailing business environment. Future changes in the environment will hence directly trigger changes in business models. The big question remains what trends will emerge beyond what can be observed today.

4.3.2. (Mass) Customization

All studies point at an increasing future demand for customized products, yet with short delivery times. Firms therefore adjust their organisational structure to provide mass customized goods. Mass customization requires close user-producer interaction and allows charging higher prices than for commoditized products. This also implies that firms produce according to demand-pull production systems to take into account customer specifications. Demand-pull production reduces working capital, increases flexibility, satisfies customer demand and tightens user-producer linkages. These advantages are all sources of competitive advantage, and also offer the opportunity to attach add-on services to the product. According to industry experts surveyed in FutMan, the demand for this type of production is, however, still lower than expected (FutMan, 2003d: 51).

4.3.3. Services and servation

Across the studies surveyed the services and servation trend receives most attention, with manufacturers adding services to their core manufacturing activities in a search for further differentiation and increased performance. Services and servation implies a whole new business model which no longer emphasises the maximisation of output and unit sales, but instead revenue generation via long-term customer relationships (FutMan, 2003e). However, customers are still very price sensitive and cost competition remains crucial (CME, 2006). A recent US study even identified the services and servation trend as the main driver for the growth of sales in manufacturing (SRI, 2004a) and hence a key source of growth for the manufacturing sector overall. It is expected to continue as services allow manufacturers to diversify, create new revenue opportunities and gain competitive advantage. Furthermore, the close user-producer interactions necessary for the provision of services provide customer feedback into the design and manufacturing process, which is important for innovative competitiveness (see section 3.4). Services and servation require high skilled labour, however. In an era in which ageing and increasing labour and skill shortages are expected, the provision of labour will pose a major challenge to manufacturing firms (see section 3.5).

While manufacturing firms increasingly offer services to their customers, they also outsource many business functions to external service providers. This has important implications for the labour market, as the number of people directly employed by manufacturing firms is decreasing. In statistical terms, however, this is largely a problem of sector classification rather than of job losses. An expected decrease in employment in manufacturing therefore is not *per se* an undesirable development. The question is where the outsourced business functions are located, and whether the job losses in the manufacturing sector can be compensated by new jobs in the services sector.

4.3.4. Co-opetition and collaboration

Especially for small and medium sized enterprises, operating in manufacturing networks and collaborating openly to grab new market opportunities and face new challenges is of crucial importance. This particularly applies to the acquisition of external knowledge from suppliers, customers, competitors and universities (see section 3.4: ‘open innovation’). However, apart from collaborating, firms need strong competition to their advantage (ManuFuture, 2004). The fruitful combination of

collaboration and competition has been termed *co-opetition*. Experts participating in ManVis remain sceptical about the economic viability of external cooperation as it is cost intensive (ManVis, 2005a). Furthermore, firms fear losing competitive advantage through collaborating with competitors (FutMan, 2003d). Nevertheless, the need and current trend towards collaborating and networking in value chains and knowledge networks is given high importance across studies (inter alia: FutMan, ManVis, ManuFuture, SRI, KPMG, Deloitte).

4.3.5. Virtual factory

The business concept of the virtual factory is based on purely electronic linkages between the firm and its suppliers and customers. It is only dealt with in FutMan (2003d) and is a possible long term vision rather than a current trend. The virtual factory should enable a flexible and inexpensive production regardless of geographic location. Ideally, suppliers and customers can be sourced globally. However, this business model has been experimented with by global firms operating in global industries. Nevertheless, even these large firms so far struggle implementing the concept (FutMan, 2003d: 61). A reason could be that the virtual factory is a contradicting trend to the closer linkages between producers and their suppliers / customers that can be observed across industries. Furthermore, technology does not yet replace personal contacts important to the management of networks.

4.3.6. Sustainability

Manufuture points out the unique opportunity to base business models on a wide variety of European cultures, ethical traditions and aesthetics beyond seemingly dominating Anglo-Saxon perspectives. Some consumer groups increasingly demand environmentally friendly and sustainable products (see section 5.4: ‘changes in social values’). Sustainability can be used as a marketing tool especially in sectors where consumer power is large. Such business models focus on waste reduction, energy efficiency as well as attempting to close production loops, where waste outputs from one process are used as inputs for other process (FutMan, 2003a: 24). Emphasis is also put on regional or local production networks to reduce environmental impacts from transportation (FutMan, 2003e: 20-25). However, it is less clear to what extent large groups of consumers are willing to pay for more sustainable products and services (FutMan, 2003d). While this move towards business models based on sustainable production is proclaimed in European and Japanese studies, this holds to a lesser extent for American studies.

5. SOCIETY AT LARGE: DEMOGRAPHICS, EDUCATION AND SOCIAL PREFERENCES

Future societal developments and consumer behaviour will to a large extent determine the beacons for industries and firms and are key in any analysis on the future of manufacturing. Population growth associated with rising consumption levels, increasing incomes, but also changing consumption patterns driven by several factors will all affect future demand in manufactured products. At the same time, the supply of labour and their skill levels will impact the structure, organization and performance of industries located in Europe.

Key drivers are future developments in economic growth, income and wealth, demographic changes and the impact of an *ageing society*, developments in *education and skill* levels as well as *changes in social values* of European consumers

impacting future consumption patterns. A*geing society* in industrialised economies and, related, overall expected *skill shortages* are two major factors that are found across almost all studies (inter alia: CME, 2004; CEFIC, 2004; FutMan, 2003; ManVis, 2005; Manufuture, 2006; WorldBank, 2007; US DoC, 2004; SRI, 2004). However, other important factors such as *changes in social values* determining future consumption patterns are discussed in more detail by only a few studies (Futman, 2003e, 2003a; Montalvo *et al.*, 2006). For an update on developments in economic growth, income and wealth (inter alia GoldmanSachs, 2003; PricewaterhouseCoopers, 2006; Poncet, 2006; WorldBank, 2007), the reader is referred to section 2.2.

5.1. Demographics and ageing

Between 2005 and 2030 the world population is expected to grow from 6.5 billion to 8 billion persons. According to WorldBank (2007) calculations, roughly 12 percent of the world population will be living in high-income countries, down significantly from 18 percent in 1980 and 14.5 percent in 2005. The population growth rate, however, will gradually slow to 1 percent in 2015 and 0.7 percent toward 2030. High-income countries will observe population declines – Japan after 2010 and the EU soon thereafter. Under current projections Japan will fall from 128 million in 2005 to 117 million in 2030. The EU15 population will fall likewise from 412 to 402 million persons (WorldBank, 2007: 38). In the EU accession countries, population declines will average about 0.2 to 0.3 percent annually up to 2030. The US population, with much higher fertility rates than in other high-income countries, is expected to grow with 45 million to 345 million in 2030. Elsewhere, population growth patterns are more highly varied, with declining populations in Central Asia and Russia, but steep increases in India (up by 320 million), Sub-Saharan Africa (up by 320 million), and less so but still significantly, China (up by 170 million).

The ‘greying’ of society in the Western world as a result of huge declines in fertility on the one hand and longer life expectancy on the other is regarded as an important driver for future change (FutMan, Montalvo *et al.*, Manufuture, WorldBank, HM Treasury, ManVis, US DoC). While ageing is not limited to the developed economies, the developed economies are expected to age faster than the rest (HM Treasury, 2004). The ageing of society has three major implications for the future of manufacturing.

Firstly, manufacturing will have to *adapt to the demands of an ageing society*. More health care products, pharmaceuticals, medical equipment but also medical services will be demanded. Furthermore, future products need to be designed in more user-friendly ways for older and disabled people (FutMan, 2003e). This change offers a chance for Europe to become a lead market for such products as ageing is a global trend. Changing consumer behaviour as a result of ageing may also imply less demand for food and education, and more demand for leisure and health services (WorldBank, 2007; Montalvo *et al.*, 2006). Whether or not rising healthcare costs will negatively affect manufacturing competitiveness seems largely an organizational-institutional matter. In the US rising healthcare costs are indeed perceived to affect manufacturers’ competitiveness (US DoC, 2004).

Secondly, as a result of ageing the *labour force* is declining as the baby boomer generation retires, particularly in Europe and Japan (FutMan, 2003e; HM Treasury, 2004; Montalvo *et al.*, 2006; WorldBank, 2007). In Europe this decline is expected

shortly after 2010. If aggregate growth of 2-3 percent on an annual basis is to be sustained over the next decades, this will necessarily imply that both capital accumulation and productivity will have to accelerate in order to compensate for the effect of a declining labour force and the resulting negative employment growth (Poncet, 2006; WorldBank, 2007). At the same time, important skill shortages across industries can be expected, as the combined effect of a declining labour force and an increasing need for skills in tomorrow's knowledge-based economy (see section 3) What is clear, however, is that manufacturing sectors need to make workplaces more attractive for potential high-skilled employees. This especially refers to a sizeable part of the female workforce, an underexploited labour reservoir, as well as the young (Cefic, 2004; EMCC, 2005; FutMan, 2003e; ManVis, 2005). The argument of making the workplace attractive equally holds for adapting the workplace to the needs and wishes of the elderly. Another point of discussion in relation to the expected labour and skills shortages is the need for temporary foreign workers, especially in the high-skilled segment (FutMan, 2003e).

Thirdly, an ageing society not only faces a reduced share of workers, but also an increased share of dependents consuming out of existing assets. *Dis-savings* tend to lower the rate of overall savings in developed economies, including Europe. Yet, evidence for this effect is mixed since other factors may affect savings and investment patterns as well. Lower labour supply could lessen investment needs in sectors where labour and capital are close complements. Yet more intense labour-saving technology investments may counteract this effect in sectors where the capital and labour are substitutes (WorldBank, 2007). The exact implications for industry and competitiveness are, however, less clear (FutMan, 2003e).

5.2. Education & skills

Experts across studies identified a skilled and educated workforce as a key to future competitiveness as they are the source of innovative products and processes. As life-long employment is a thing of the past people will have to engage in *life-long learning* to keep their skill levels up-to-date (see also section 3.5). Important here is that new demands on higher skill levels can potentially lead to a skills gap between societal groups. Furthermore, over the last decades the income gap between skilled and unskilled jobs has widened (WorldBank, 2007). Potentially, unskilled groups of society will find it difficult to be employed as low skilled jobs will relocate outside Europe over time. Together with the income gap to high skilled jobs this can lead to *social exclusion* of potentially large societal groups (FutMan, 2003e). Implications of such development are not explored in the studies although this might develop into an important political factor in the future.

5.3. Social values and preferences

Social values and preferences determine how consumers react to new technologies, but also products and firms and hence are determinants of future developments. Two key trends are changing lifestyles of European consumers (section 5.3.1) as well as the importance of environmental concerns (section 5.3.2).

5.3.1. Changing lifestyles

The future generation in Europe will be strongly dominated by changing family structures, as trends towards more single households, patchwork families and multi

generation families are observed (FutMan, 2003e). Three consumption pattern trends were identified. The individualization in society as well as higher incomes put a premium on time-saving and convenient products, which leads to c*onvenience consumption* (SCP, 2001). Secondly, consumers increasingly want more than just a product and demand to be entertained in a variety of ways. This trend is referred to as e*xperience consumption* (SCP, 2001). Thirdly consumption is increasingly used to reflect self-identity of individuals and groups. Labels, brands and marketing are therefore increasingly important to cater consumer demands leading to i*ncreasing market segmentation*. European firms will have to adapt to these changing consumption patterns over time.

5.3.2. Health, ethics, safety and the environment

In Western Europe the environment is of high importance to people also reflected in public debates on ethics, health and safety as well as strict environmental regulations. Environmental concerns of consumers are important to the future of manufacturing in two respects. Firstly, recent debates on genetically modified food and stem cell research have shown that the public does not want to adopt new technologies that are perceived as risky or unethical. This might lead to Europe losing technological edge in these areas if countries outside Europe develop and exploit such technologies (Manufuture, 2003). Secondly, consumers are expected to increasingly consume more environmentally friendly products reflected in trends towards organic food, fair trade etc.. However, these predictions have been made in the past and experts doubt that large shares of consumers are willing to pay extra for green products (FutMan, 2003d). Instead, legislation is perceived as the main driver for more environmentally friendly or sustainable production and consumption (also see 'environmental aspects').

6. ENVIRONMENTAL AND NATURAL RESOURCE CONCERNS

Our environment not only provides the raw materials and natural resources that form the very basis of manufacturing, but it also determines the physical context in which manufacturing production takes place. In the following we will discuss three key drivers that will shape the future of manufacturing. The drivers that have been discussed across a number of influential studies are: (i) the availability of natural resources focusing on the supply of energy and energy efficiency, (ii) the impact of climate change, and (iii) the impact of environmental regulation. The key studies dealing with environmental aspects most comprehensively are Futman (2003), ManVis (2005), Montalvo et al. (2006) and WorldBank (2007). These are complemented by studies such as Stern Review (2006) and IPCC Summary (2007) focusing on climate change, analyses on the availability of mineral resources (BMWi, 2007) and projections on energy resources (IAE, 2005).

Climate change is a major issue on current global and national policy agendas. In particular the Stern Review and the Intergovernmental Panel on Climate Change (IPCC) have outlined the potential impacts of global warming for humanity. Both address the necessary actions for governments and industries. Waste and pollution as by-products of 'normal' manufacturing processes also have potentially serious negative impacts on the environment and humanity. In a response to counteract the negative impact of waste and pollution new laws and regulations are being

introduced (e.g. REACH), with the envisaged effect of creating structural adjustment and hence changes in the future composition of European manufacturing.

6.1. Availability of resources

The availability of natural resources is usually discussed along two distinctive lines: energy and *other* natural resources. The reason is that energy makes up a considerable part of production costs *across* sectors. As a result some studies focus on energy and do not deal with other natural resources. This holds for example for US DoC (2004). Experts appear to have contradicting opinions regarding the future availability of 'other resources'. While some experts only expect 'other natural resources' to become scarce in 50 years time (FutMan, 2003d), others see scarcity already now as an important driver for manufacturing (Montalvo *et al.*, 2006).

Important to note here is the recently published study by the German Ministry for Economic Affairs (BMWi, 2007) that sees no critical shortages of long term supplies of mineral resources for industry and expects shortages for specific minerals to be eased through technological change creating substitutes and new reserves. The SRI (2004c) study is the only surveyed study that makes quantitative long-term predictions of future prices. These long-term price predictions are questioned by BMWi (2007) as it found that mineral prices in the past followed a 'random-walk' making the last price the best forecast available.

6.1.1. Energy and energy efficiency

Past trends make it very clear that energy consumption is broadly rising in line with GDP growth (Montalvo *et al.*, 2006). As studies expect global growth to continue over the long-term, global energy demands are also expected to rise (HM Treasury, 2004). However, this rise in energy demand can have an adverse effect on energy prices, possibly slowing down growth rates as high energy prices continue. Furthermore, globalization thrives on cheap transport costs, which could increase in case of higher future energy costs impacting global trade. A 2004 US background report (SRI, 2004c) estimated that oil prices will remain relatively stable in the medium term and growing gradually over the long term. Long term forecasts – extending 5-15 years – see the price of oil in the range of $20 – $30/bbl (SRI, 2004c). However, oil prices are subject to severe short term fluctuations as could be observed over the last years. The WorldBank (2007) therefore estimates oil prices at around $53/bbl for the coming two years but does not give a long term forecast. The question remains whether oil prices will return to their long-term average or remain at high levels. Surprisingly, recent high oil prices do not seem to affect global economic growth as adversely as experts might expect.

As energy prices rise energy efficiency becomes an increasingly important topic. However, FutMan (2003d) argues that energy efficiency is only an important topic in *product markets* for example in automotive and lighting sectors. Energy efficiency is less important for mechanical manufacturing processes, as energy cost are only one cost factor and need to be balanced against cost savings. This is, however, not true for process manufacturing such as the chemicals industry where energy is a considerable cost factor in production (FutMan, 2003d). Here energy efficiency measures are taken up by industry without specific legislation for cost reasons. Furthermore, recent increases in energy costs make it increasingly attractive to save energy, changing the underlying assumptions of the FutMan assessment for

mechanical manufacturing processes. The subject of energy efficiency nevertheless seems to be of varying importance across manufacturing sectors, receiving attention wherever representing a considerable cost factor. This fits the observation of experts stating that increasingly alternative sources of energy are used across manufacturing industries (FutMan, 2003d). The FutMan study based on expert interviews also states that Japan is the only country seriously focusing on energy saving in manufacturing.

6.1.2. Other resources

As indicated above the scarcity of other resources than fuels is controversially debated among experts. While experts participating in the FutMan study indicated that the availability of other natural resources are not relevant to the future of manufacturing over the coming 50 years (FutMan, 2003d), others perceive this as far more problematic. While this discussion has been going on for several decades starting with the 'limits to growth' debate, it remains unconcluded (Montalvo *et al.*, 2006). A recently published study by the German Ministry for Economic Affairs BMWi (2007) analysing past trends of mineral resources gives strong evidence that there are no critical future absolute shortages to be expected, contradicting any experts proclaiming scarce resources. The study expects technological change stimulating substitutes and new reserves to prevent any absolute shortages. From 1995 to 2002 world commodity prices have declined structurally to around 75% of 1995 levels and were expected to do so in the future (SRI, 2004c). However, commodity prices have increased considerably since then due to increasing global demand, particularly from China. According to the WorldBank (2007), mineral prices have increased by around 200% from their low in 2001 until 2006. Again, similar to the predictions of long-term oil prices a couple of years ago this only highlights how difficult quantitative predictions are. Consequently, the BMWi (2007) study does not make any price forecasts as past data shows that mineral prices follow a 'random-walk' making the last price the best forecast available.

6.1.3. Recycling

In terms of resource availability BMWi (2007) points at the increasing importance of recycling levels as more and more materials – especially metals – are recycled, making predictions about future supply levels even more complex. This increasing importance of recycling is also confirmed by the results of the Japanese Delphi (2005) that outlines the future importance of recycle oriented manufacturing technology in the manufacturing sector (Nistep, 2005). According to FutMan (2003d), recycling of other materials is largely driven regulation creating a trend to more environmentally friendly production. However, as products comprise multi-materials, recycling becomes increasingly difficult and needs to be considered in product development (FutMan, 2003d).

6.2. Global warming and climate change

The Stern Review, consecutive IPCC reports and other studies have led to a wide consensus that climate change will be one of the main drivers affecting the future of the globe over the coming centuries. However, the consensus that temperatures are rising caused by greenhouse gas emissions has only been agreed on recently. As a result we get better and better predictions of what future temperatures and levels of precipitation might look like for different emission scenarios (IPCC, 2007). We also know that climate change will affect European regions as ecosystems adapt to the

changing climate. For example, worsening conditions (high temperatures and drought) are expected in Southern Europe, while in Northern Europe first mixed effects will occur, followed by negative impacts (more frequent winter floods, endangered ecosystems and increasing ground instability). Central and Eastern Europe are faced with decreasing summer precipitation, and higher health risks due to heat waves (IPCC, 2007a). Furthermore, more extreme weather events and rising sea levels will have wider economic and social impacts as agricultural and human settlement patterns will have to adapt (HM Treasury, 2004). Climate change will pose challenges to many economic sectors and to magnify regional differences in Europe's natural resources and assets (IPCC, 2007a). However, the studies cannot tell us *how* exactly climate change will affect European manufacturing sectors.

Much depends also on clear policy responses as well as individual actors (business and consumers) following the latest climate change reports. Policy-makers and others are urged to take steps to reduce green house emissions in an attempt to stabilize climate change (Stern, 2006; IPCC, 2007). The key message of the Stern Review for example is to introduce a global carbon-price that reflects the real cost of fossil energy to reduce global consumption of fossil energy, while making substitutes more attractive (Stern, 2006: 324). Such policy actions will have implications for all sectors of the economy but particularly for energy-intensive sectors, as energy cost will be rising. However, so far no global concerted binding actions have been implemented that could cause major structural changes.

6.2.1. Impact of climate change on manufacturing

Even if the proposed policy actions raised in the Stern Review or IPCC reports (part of which is still forthcoming) are not implemented, manufacturing will be impacted by climate change in one way or the other. Either directly through environmental changes or through legislation passed to stabilize global warming. The Stern Review estimates future costs caused by climate change if no actions are taken at 5%-20% of GDP annually over the next century or two (Stern, 2006). This estimate is considerably higher than other studies that come to estimates of around 3% GDP annually (The Economist, 2006). This compares to an estimated mitigation cost of 1% GDP annually by 2050 for policy measures expected to stabilize global warming (Stern, 2006). The WorldBank (2007) emphasizes the risks from climate change but nevertheless does not expect *global* economic growth rates to depress below the rates of the lower scenario. At the same time, it acknowledges that if the worst climate change scenarios materialise, the development prospects of whole regions and or countries can be undermined through the potential effects on agriculture, water supplies and ecosystems. Again, also this report does not refer to specific regions making it impossible to draw particular conclusions for Europe.

6.3. Environmental rules and regulations

Environmental legislation is the third key driver often as a response to environmental pollution and risk perceptions of consumers. Legislation influences industry structures as companies have to adapt the regulatory changes. Firms generally have two options: they can either adapt to regulatory changes or relocate to areas where legislation is less strict.

Adapting to regulatory changes, particularly the measures proposed by the Stern Review, will come at a cost (Stern, 2006). This mitigating cost is estimated to be

around 1% of GDP by 2050 if actions are taken now. However, experts also point out that the proposed changes create new business opportunities in markets for low-carbon, high-efficiency goods and services (ibid). The impact on competitiveness does also depend whether carbon reduction policies are implemented simultaneously around the globe, preventing relocation of the worst affected sectors (Stern, 2006:253). However, it is argued that only very few of the most affected sectors have internationally mobile plants and processes limiting expected impacts (ibid).

Important environmental legislations discussed in the studies surveyed are the European Chemicals legislative REACH and the CO2 trading scheme (CEFIC, 2004; FutMan, 2003; IEA, 2005; ManVis, 2005). While the current impact of CO2 emission trading is perceived as modest on the most energy intensive industries, it is expected to increase energy prices in the long-run (IEA, 2005). The implications of REACH are less clear as it forces firms to test new chemicals, hence increasing business costs for firms located in Europe resulting in a competitive disadvantage against foreign competition (CEFIC 2004; FutMan, 2003). Nevertheless, it also provides European chemical firms new incentives and opportunities to develop innovative products based on less hazardous substitutes that ensure competitiveness tomorrow (EMCC, 2005; FutMan, 2003h).

While experts see relocation of especially global sectors impacted by legislation as a possible consequence (ManVis, 2005d: 108; FutMan, 2002), legislation might also lead to innovative technologies / substances that can give European manufacturing a competitive lead. 80% of ManVis experts believe that relocation as a result of environmental legislation is an important issue for companies. However, 31% do not think that European companies will relocate their entire production abroad as a result, while 43% believe that this will happen before 2020 (ManVis, 2005d). No unanimous view appears to exist on the consequences of relocation caused by environmental legislation. It therefore remains unclear and case-specific of how environmental legislation will affect future industry structures.

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Annex 1: Manufacturing Visions Japan

Japan is one of the countries with the longest tradition in using foresight for economic development, attempting to align future developments with societal needs. Nevertheless, only very few Japanese studies are available in English language – parts of the Japanese Delphi survey (Nistep, 2005) and the Nakagawa report (Meti, 2004) – making an assessment of Japans future manufacturing sector reliant on Western studies including such assessments. After the successful 1980s Japan struggled over the last decade. The *trends and challenges Japan is facing are similar to Europe* but more sever. Japan is struggling with economic growth as it is exposed to the same intense international competition as Europe while its population is ageing even more rapidly (). Additionally, Japan's workers work fewer hours than in the past reducing the labour supply even further (IIPS, 2006). However, with 3% Japan is still leading R&D expenditure as a percentage of GDP (NSF, 2006) giving it the opportunity to compensate lower labour supply through higher levels of automation.

The two important developments in Japanese policy in regards to the future of manufacturing are the 'Nakagawa Report' and a new manufacturing paradigm called 'Monodzukuri'. The Nakagawa report draws out the Japanese strategy to revitalize its industry. Key future industry areas have been identified based on three criteria; leading edge industries that are globally competitive, industries focusing on new market needs as well as industrial clusters for regional revitalization (Meti, 2004). The identified industry areas based on these criteria are 'fuel cells', 'digital consumer electronics', 'robots', 'digital content', 'healthcare products and services', 'environmental technology products and services' as well as 'business support services' (Meti, 2004). While this strategy is not limited to the manufacturing sector it nevertheless gives an impression of future Japanese strategic industry sectors.

Monodzukuri is a manufacturing paradigm developed as a response to cost competition and the proclaimed end of 'mass production' (Meti, 2005). The literature available is unclear what exactly this paradigm entails apart from moving towards value-added production. It is presented as integrating skill, technology and science to achieve industrial innovation on a sustainable basis (Meti, 2005). However, particulalry the JMA (2003) report conveys little more information than using Monodzukuri as a brand in global markets (for more details on 'Monodzukuri' see 'new business models' section).

Despite developing these strategic visions these convey little information that help clearly envisioning a future state of manufacturing. Overall, Japan faces the same challenges as all advanced economies triggering the same move towards knowledge intensive, high value-added sectors and production that are anticipated in Europe.

Annex 2: Future Developments in the Automotive Industry – Personal Cars

Due to its size and its advanced manufacturing methods is the automotive industry of crucial importance to the future of European manufacturing. New emerging competitors such as China and India might not pose serious competition yet, but this is likely to change over time. However, competitive pressures in the past from Japanese production methods such as lean production / toyotism were successfully weathered by embracing these changes giving hope to repeat past successes. Currently, changes in the supply and distribution chain are the most important drivers of change, as value chains become global with an increasing specialization of suppliers taking place (FutMan, 2003g). The trends towards outsourcing put increasing importance on cooperation between firms and suppliers, leading to regional supply clusters. Recent developments in the emergence of supplier-buyer networks have been a key competitive advantage for the European automotive sector compared to U.S. and Japanese competitors (ibid). ManVis experts go as far as expecting first tier suppliers to transform into system integrators, producing and delivering complete cars beyond the year 2015. Additionally, today's car manufacturers are expected to transform into transport services providers beyond 2015 instead of selling vehicles (ManVis, 2005d). However, 10% of ManVis respondents also believe that this vision will never materialize (ibid).

In the *long-term* the increasing 'electrification' of vehicles and developments in alternative propulsion systems pose potentially radical transformations to the industry (FutMan, 2003g). Such radical transformation is also dependent on regulatory changes such as the agreed reduction of 130g/CO2 emissions by 2012, road pricing schemes, as well as other potential carbon regulations increasing fossil energy prices. Visions of 'intelligent networked vehicles' emphasise the importance of electronics to the future vehicle (ibid). Compared to the U.S. and Japan, European competitiveness in electronics could weaken the strong position in automotives. On the other hand this development could give European industry the chance to catch-up in the field of electronics (ibid). Secondly, over the last decade the automotive industry has worked seriously on alternative propulsion concepts such as the fuel cell. While currently the combustion engine represents one of the core competencies in car making, alternative propulsion concepts such as the fuel cell where U.S. competence is stronger than in Europe, pose future challenges (ibid). However, the increasing importance of electronics and sustainable propulsion concepts gives Europe – as well as Japan and the U.S. – the chance to keep the emerging Asian competitors from China and India, which catch-up fast in traditional automotive technologies, abreast by building a technological lead.

Annex 3: Future Developments in the Chemicals Industry

As a highly regulated industry chemicals sector future in Europe depends largely on the regulatory environment. This was a key message from the FutMan (2003g) case report on basic chemicals presenting two different visions of the sector by 2020. One vision correlates with the views of industry experts who envision an incrementally innovating industry, whereas independent experts such as university professors, researchers and consultants have a more radical vision based on strict regulatory changes. The *vision* of an *incrementally innovating* chemicals industry distinguished between low value and high value added production. Low value added production will have migrated to the Middle East and Asia for cost reasons, while headquarters and R&D centres are expected to remain in Europe. Furthermore, products will be optimized to improve technical performance and reduce environmental impact, while customisation is used for product differentiation. High value added production is expected to remain in Europe as resource inputs only represent a small proportion of total production cost, while required technical personnel is highly qualified in Europe. Product innovation is key for high value added production to provide high performance products to industry, while the provision of services is crucial for customising products building close customer relationships. A second more *radical vision* is based on the assumption of strict environmental, health and safety regulations from the European Commission and national governments demanded by society. This would lead to 'green chemistry' where traditional raw materials have largely been substituted by biomaterials. This vision is inspired by strict environmental regulations in the Nordic countries forcing firms to innovate to adapt to the stricter regulations supporting long term competitiveness in international markets. This move towards a sustainable chemicals industry is furthermore driven by changing consumption patterns of consumers, who continuously pressure firms and governments to reduce environmental impact. (FutMan, 2003g)

Reconciling the two opposing visions, the green chemistry vision seems rather unlikely as such strict regulatory changes are difficult to pass when relocating is an option potentially jeopardising large number of jobs. However, also taking into account the speciality chemicals sector the vision of the first scenario seems more likely. In line with other studies the relocation of low value added production to Asia and the Middle East is widely accepted (Cefic, DTI, EMCC). This process is driven by cost advantages of overseas producers benefiting from scale advantages of larger plants, lower energy prices and laxer regulation (ibid). Furthermore, in addition to low-value added production even the basic chemicals sector is expected to relocate to Asia, particularly China, as downstream user industries in electronics, textiles, leather and plastics have relocated there (CEFIC, DTI, EMCC). However, this does not mean that the overseas production plants are not managed or owned by European firms. The future of the chemicals sector *located* in Europe is broadly envisioned as focusing on research intensive and high value added specialty chemicals exploiting technological advances in genomics and nanotechnology. Potential challenges arise from possible shortages of skilled labour. Nevertheless, a viable future for the chemicals sector is envisioned although transformation processes will lead to the relocation of low value added activities and basic chemicals.

Annex 4: Future Developments in the Food& Beverage Sector

The European Food & Beverage sector plays a special role in manufacturing as it is one of the largest industrial sectors, transforming 70% of agricultural raw materials produced in the EU and is characterised by a lower than average productivity (EMCC, 2004; 2006b). Consumer demand is particularly important as products focus on end-consumer. Furthermore, the sector is very broad comprising activities from sourcing, processing, preservation and packaging, including micro enterprises employing 1-9 people to large multi-nationals with thousands of employees.

While international competition in the food sector is currently restricted by trade regulation, it is nevertheless loosing up. As a result the European food industry is increasingly exposed to low cost overseas competition benefiting from low transport costs. Currently, the industry reacts by consolidating, outsourcing and relocating where adequate (EMCC, 2006b). The important question is how trade liberalization will progress after the failure of the Doha trade talks. In case multilateral trade agreements are signed, cheap agricultural imports intensifying competition are more likely than a future characterised by bi-lateral trade agreements.

Developments in ICT technologies impacted greatly on the supply chain increasing productivity. As cost for these technologies are falling, smaller firms increasingly benefit, too. However, ICT technologies represent high capital costs while enabling the management of larger and larger organisations, leading to consolidation within the sector particularly the retailing end (EMCC, 2006b). Further advances in ICT, RFID and robot technologies are likely to further increase productivity and economies of scale. Other technologies with particular relevance to the sector are genetically modified (GM) crops and developments in bio-chemistry enabling new flavours / products.

Changing consumption patterns influenced by social values and demographic change particularly impact the food & beverage sector exposed to large groups of end-consumers. Food safety scandals such as BSE, foot and mouth as well as risk from genetically engineered food lead in parts to increasing demand for organic and fair trade products. However, experts doubt that people are willing to pay more for green products (FutMan, 2003), making visions of a sustainable food sector unlikely. On the other hand changes in lifestyle lead to more consumption of processed convenience food. Obesity and other health related diseases are likely to lead to policy actions regulating food production.