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What are the recent macro-economic trends in the manufacturing sector and what do they tell us about the future?

Future of Manufacturing Project: Evidence Paper 14

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What are the recent macro-economic trends in the manufacturing sector and what do they tell us about the future?

By

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Cambridge Econometrics

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Contents

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Executive summary

Cambridge Econometrics (CE) was commissioned by the Government Office for Science to write this report as an input into the wider Foresight programme on the Future of Manufacturing, due to report in late 2013. This report investigates the recent macro-economic trends in the UK manufacturing sector and what they tell us about the future.

We present a review and analysis of official data (principally over the 1990s and 2000s, prior to the global financial crisis), to compare the performance and competitive position of UK manufacturing relative to other UK sectors and selected competitor countries (US, France, Germany and Japan). The analysis has identified a number of notable trends in how the UK's manufacturing base has been shaped by developments over recent decades and we summarise what this can tell us about the future of manufacturing.

Recent trends in UK manufacturing

Even after the sharp decline prompted by the recent global financial crisis, the level of UK manufacturing value added in 2012 was around 16% higher in inflation-adjusted terms than it was at the beginning of the 1970s[1].However, the number of manufacturing jobs has followed a downward course due to the radical restructuring of traditional manufacturing particularly during the early 1980s and ongoing improvements in productivity growth.

What is well known, however; is that manufacturing has been declining in its value *share* of UK value added in recent decades whilst the growth of domestic and tradable services has outstripped that of manufacturing. This has been the case in both the UK and many other developed countries. But amongst the selected competitor countries reviewed in this report[2], it was the UK that experienced the sharpest relative decline of manufacturing's share of economy-wide value added and employment, and this decline accelerated after 2000.

During the 1990s, the output and trade of emerging economies expanded rapidly and eroded the UK's share of global exports (and that of many other advanced economies). The expansion of emerging economies accelerated the trend for manufacturing, and for other economic activity, to become increasingly traded (in both directions, but with stronger growth in imports in the UK). Since the early 1990s, the UK has had a widening deficit in its trade of goods (and this performance has been worse than in many competitor economies), but a growing surplus in the trade of services.

Part of the explanation for the worsening performance of UK manufacturing was the deterioration of our cost competitiveness compared with that of our competitors, to which sterling's appreciation in the second half of the 1990s contributed. The general trend through the 1990s, until the global financial crisis, was of a deterioration of the unit labour cost (ULC) competitiveness of UK manufacturing, and this was accompanied by a widening deficit on manufacturing's balance of trade.

[1] In 2007, prior to the crisis, manufacturing output was 27% higher than it was in the early 1970s.
[2] These are the US, France, Germany and Japan.

There is some evidence that manufacturing sectors that are most cost-sensitive and subject to growing competition from emerging markets were amongst those that saw the more rapid deterioration of ULC competitiveness, and have consequently seen the weakest trade performance and output growth.

Technological change has been the driver of those manufacturing sectors that have seen the strongest output growth over the past three decades, and manufacturing has become increasingly specialised and knowledge based. However, the UK's record on R&D spending and indicators of innovation is less favourable than that in the selected competitor countries.

For analyses in this report, we use industry definitions to categorise manufacturing to three types: high-, medium- and low-technology. The premise is that there are certain advantages of high-technology manufacturing (e.g. global demand growth is strongest, high-cost countries could have a comparative advantage).

Compared to competitor countries, the UK has a relatively high concentration of manufacturing in high- and also low-technology sectors, but growth of UK high-technology manufacturing has been weaker than that of the selected competitors. Although, both Germany and Japan have a greater concentration of output and employment in medium-technology sectors, it is perhaps surprising that both countries have a sustained a relatively large and growing trade surplus in low-technology manufacturing.

But the official data used in this review can only take our analysis so far. To gain a better understanding of the transformation of manufacturing, we are also interested to distinguish (in a way that the industrial classification cannot) between the *stages* in the supply chain (e.g. design versus assembly) and also the *types* of product (e.g. customised versus off-the-shelf).

Although our analysis of input-output data is subject to the constraints of industrial classifications, it does offer insights into how manufacturing supply chains have been shaped by developments over recent decades.

As a consequence of technological change and specialisation in trade: traditional manufacturing products are becoming less important as domestically-produced inputs; and manufacturing linkages within the UK economy have become more fragmented (manufacturing is relying increasingly on trade – particularly for imports to *supply* inputs to production). Higher-tech manufacturing industries rely less on domestic outsourcing and are more tradable.

Outsourcing has been a key factor driving the difference between the long-term rates of growth of value added of manufacturing and services. The outsourcing of activities from manufacturing firms to specialist services subcontractors shows up in our analysis as a shift in value added from manufacturing to services, but the outsourced activities are essential to deliver the final demand for manufacturing.

Trends that will shape the future of UK manufacturing

We conclude that those key macro-economic drivers of change that have dominated recent decades are likely to remain those of most importance in the coming decades.

Shifts in global demand, driven by economic development and demographic change (the aging population and, in emerging economies, the growth of the 'middle classes' as per capita income grows), will continue to shape the geographical source and the characteristics of global demand.

Technological change will continue to be an important factor driving the fastest growing sectors in UK manufacturing. Those sectors likely to experience the fastest growth will be leaders of product and process innovation.

To support effective R&D, the UK will need to preserve and expand its ***knowledge-base***. For the past couple of decades the UK has underperformed many of its competitors with regards to R&D expenditure and indicators of innovation (such as patents), and this, along with the current period of fiscal constraint, will challenge the UK's ability to preserve and build its knowledge base.

The ***global nature of supply chains*** will persist in the coming decades and our positioning in those supply chains will shape the nature of UK manufacturing as it has done in the past. In the near term at least, the UK is likely to remain a relatively high cost producer in the global market and so the success of our manufacturing will depend strongly upon our quality competitiveness.

Those manufacturing activities that remain in the UK will be those, for which the UK has a ***comparative advantage***. These will include activities where the UK has some combination of: an established presence (in terms of skills, expertise and networks); access to markets; and assets in terms of quality competitiveness.

Knowledge-based business services have become more integrated with manufacturing activity and will continue to make a growing contribution to the success of UK manufacturing through the improvement of the quality and marketing of manufactured outputs.

As well as relying increasingly on services inputs, what are perceived as ***services occupations account for an increasing proportion of the UK's manufacturing workforce***. In the recruitment of technical professionals (e.g. engineers) with high-level STEM[3] skills, manufacturing will continue to compete with professional and financial services.

[3] Science, technology, engineering and mathematics.

1. Introduction

In August 2012 Cambridge Econometrics was commissioned by the Government office for Science to write this report as an input into the wider Foresight programme on the Future of Manufacturing, due to report in late 2013. This report investigates the recent macro-economic trends in the manufacturing sector and what they tell us about the future.

It is well known that manufacturing has been declining in its share of economic activity in recent decades, and that this is the case in both the UK and many other developed countries[4]. But there is more to the story than the shrinking share of manufacturing; the structure of UK manufacturing has been transformed as businesses have responded to macroeconomic, policy and other key drivers. Some drivers have persisted for decades (e.g. technological change, the changing composition of global markets), while the nature and influence of others have shifted and changed over time (e.g. policy measures, exchange rates, energy prices). The way in which the sector has been shaped in response to these drivers gives us insights into potential futures for UK manufacturing.

A stylised timeline is shown in

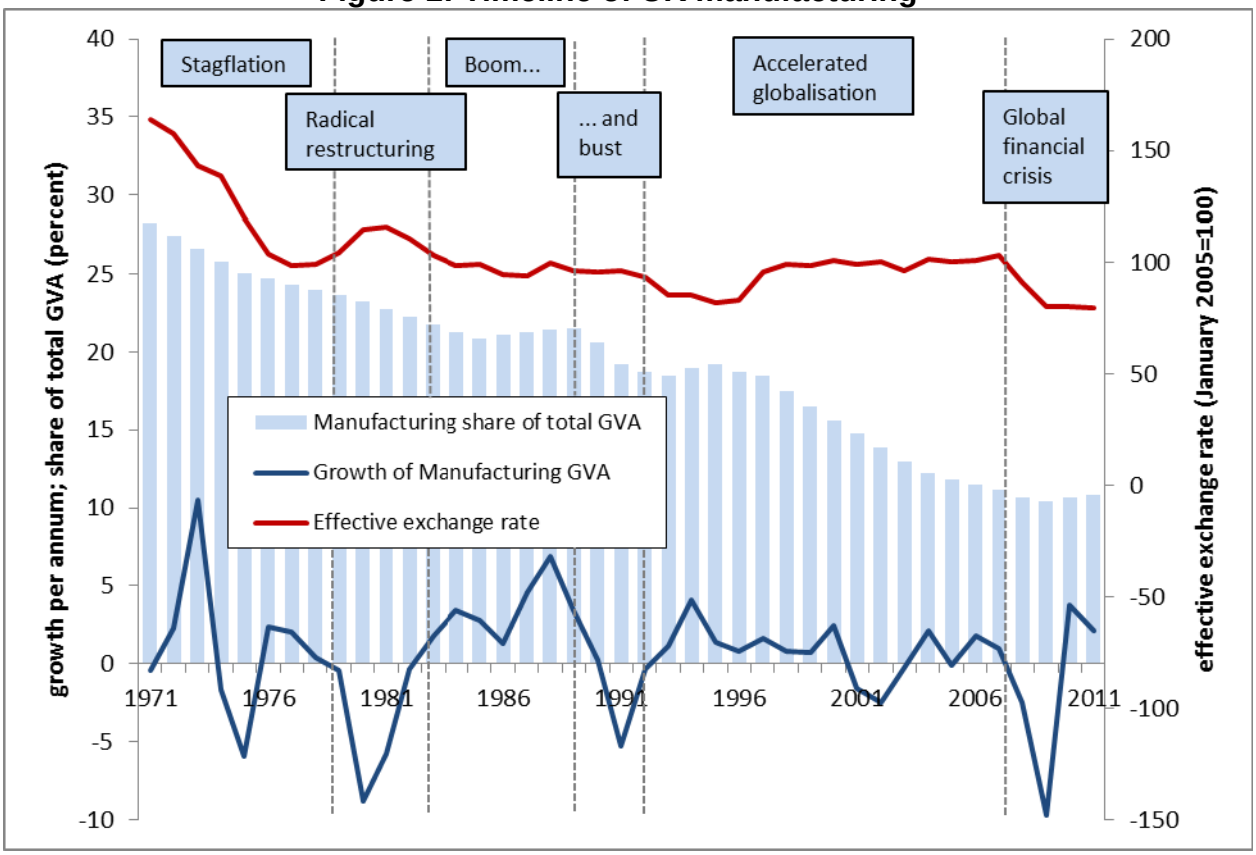
Figure 7 to frame the following narrative of key developments in UK manufacturing over the past three decades or so. The timeline clearly shows the decline in manufacturing's share of UK GVA from almost 30% at the beginning of the 1970s to around 10% in 2011.

It was during the recession of the early 1980s that UK manufacturing experienced a period of radical restructuring. Inflation had been exacerbated by a further hike in the oil price and rises in the rate of VAT, and monetary policy was tight - interest rates were at a record high and sterling was strong. Manufacturing output fell sharply, but productivity began to improve because the pace of job shedding was so rapid. The fall in production, and employment, was most severe typically in traditional sectors (textiles, clothing, metals, motor vehicles, shipbuilding) in which many activities were becoming increasingly 'commoditised' and/or subject to lower cost competition from overseas. The power of trade unions was eroded, partly because their membership was heavily concentrated in the traditional sectors where job losses were greatest, and partly because the Thatcher government was determined to confront them.

The mid to late-1980s brought a policy-induced boom in the UK, fostered by looser fiscal and monetary policy, and the deregulation of financial markets (which greatly boosted financial services activity). The UK enjoyed a period of relatively strong GDP growth, and house and other asset prices saw strong inflation. Manufacturing saw sustained output growth that kept pace with that of the economy as a whole such that the decline in its share of GVA was curbed. This resurgence of manufacturing growth was accompanied by further improvements in productivity to the extent that employment continued to fall, but less markedly than during the restructuring of the early 1980s.

[4] Germany and Austria, where the shares of manufacturing in whole-economy value added have been broadly constant for the past two decades, are the main counter-examples. At about 12½% in 2007, the UK's share was lower than in most other developed countries, apart from France and the USA where the shares were similar.

Figure 1: Timeline of UK manufacturing



Source: ONS and Cambridge Econometrics.

When the UK's boom turned to bust and global growth began to slow at the end of the 1980s, sentiment turned against sterling and, as a member of the European Exchange Rate Mechanism (ERM)[5], the Government was required to maintain high interest rates to keep sterling within the permitted trading range with the Deutschemark. This exacerbated the collapse of household spending and house prices, which had been the motor of growth during the 1980s, and hindered UK export growth. Consequently, manufacturing output and employment fell sharply once again during the early 1990s. But sterling fell sharply following the UK's exit from the ERM in 1992, and the improvement in competitiveness provided the impetus for a resurgence of export growth which supported renewed growth of manufacturing output.

It was during the 1990s that emerging economies began to make a sharply increased contribution to global trade in manufactures, and an expansion of global demand fuelled global commodity price inflation. The pressures on UK price competitiveness were further exacerbated by sterling's marked appreciation in 1997 which initially curbed the growth of manufacturing output. The burst of the dot-com bubble saw manufacturing output fall once more, before a period of modest growth in the mid-2000s. Manufacturing failed to keep pace with the growth in the rest of the economy, especially that of financial and other knowledge-based services. For these services, exports became an increasingly important component of demand: between 1992 and 2007 the surplus on the balance of trade in services grew from 1.5% of GDP to 3.7%, whereas the deficit on goods widened from 2.1% to 6.4%.

[5] The UK joined the European Monetary System's Exchange Rate Mechanism (ERM) in October 1990.

The global financial crisis that began in 2008 brought a sudden collapse of confidence and economic activity. In the UK (and in many other major industrialised countries), the policy measures implemented in the aftermath of the crisis caused a marked widening of the government deficit, and the UK's Coalition Government is now committed to a prolonged period of fiscal consolidation. Since March 2009, the Bank's Base rate has been held at a record low of ½% and further monetary easing has been provided in the form of the asset purchase programme. At the end of 2008, sterling weakened sharply (especially so against the dollar) and has since remained subdued; at the end of 2012 the (nominal) effective exchange rate remained 20% below its peak in 2007. The global crisis dealt a severe blow to manufacturing world-wide when investment and trade collapsed. In the UK, manufacturing output fell sharply and by the end of 2012 remained around 10% below its pre-crisis peak. During the recent downturn, manufacturing jobs have not been shed to the extent they were in previous recessions, suggesting that firms have sought to retain their skilled workers, and average earnings growth has been subdued. Since the crisis, the UK's trade of goods has remained in large deficit, but the surplus on services has continued to grow.

A number of notable characteristics of the UK's existing manufacturing base have been shaped by developments over recent decades:

- Manufacturing, and other economic activity, has become increasingly traded (in both directions) and this trend accelerated during the 1990s when the output and trade of emerging economies expanded rapidly. A good example is that of car production in the UK for which, in 2012: 83% of cars produced in the UK were exported; and 88% of new cars purchased were imported.
- The expansion of globalisation and intensification of price-competitiveness in markets for commoditised goods has been a catalyst for UK manufacturing to become increasingly specialised in higher value-added and knowledge-based manufacturing.
- Technological change has been the driver of those manufacturing sectors that have seen the strongest output growth over the past three decades. A notable example is pharmaceuticals, which continues to be subject to competition to retain its R&D base in the UK. Electronics activity has been transformed from manufacture and assembly to R&D and royalty fees (e.g. ARM), plus defence applications (e.g. BAE).
- As witnessed since the mid-1990s, the composition of world trade (in terms of trade shares of world areas) can shift fairly quickly and transform global patterns of production and sales. For example, by 2007 China accounted for 6% of the EU16's[6] manufacturing exports and 18% of its imports.
- Outsourcing has become more prevalent, both domestic and overseas, so that supply chains typically span international borders (e.g. imported inputs account for a growing proportion of inputs to production). Those activities that remain in the UK are those considered best done here and are those for which the UK has a comparative advantage.
- The UK has successfully attracted foreign direct investment (FDI) in its specialist manufacturing activities, especially those for which the UK has ready access to European markets (e.g. car production). But economic growth and development in other FDI locations that can readily serve the European market (e.g. eastern Europe) provides further competition for investment.

[6] Austria, Belgium, Czech Republic , Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Slovakia, Slovenia, Spain, Sweden, UK.

The report first analyses recent trends in the absolute and relative performance of manufacturing in the UK and competitor countries by looking at trends in output, employment, productivity, trade, R&D spending and innovation using data obtained from official data sources. The report then analyses Input-Output tables for the UK, Scotland and competitor countries to build up an understanding of supply-chain linkages and their relative importance, and to develop a more detailed picture on trends in outsourcing and offshoring between the mid-1990s and mid-2000s.

These narratives and themes are further illustrated by the review and analysis of official data presented in the following sections of this report. The report analyses recent trends in the absolute and relative performance of manufacturing in the UK and competitor countries by looking at trends in output, employment, productivity, trade, R&D spending, innovation and supply-chain linkages. Reflecting the themes that have emerged from the narrative of past trends and along with other drivers of future trends, the report concludes with a summary of the main findings and conclusions about possible future trends in manufacturing.

2. Recent trends at the broad sector level

Manufacturing value added grew in real terms over 1990-2007, but stronger value added and employment growth in services, especially financial & business services, meant manufacturing declined in relative terms

Manufacturing value added grew over 1990-2007, but growth almost ground to a halt over 2000-07, partly as a result of sterling's appreciation at the end of the 1990s and also as the global restructuring accelerated with the growth of exports from the BRICs. Strong labour productivity growth, spurred on by the need to remain competitive in the face of cost pressures, meant employment fell over the same period.

The tables show the extent to which manufacturing failed to keep up with the wider economy, which was driven by strong growth in services and in particular, financial & business services. Financial & business services benefited from strong growth in the number of companies locating their head offices in the UK, increasing international demand for the financial and legal services in which the UK specialises, and growth in outsourcing. This was reinforced by the strong inter-industry linkages that exist within financial & business services.

Broadly speaking, manufacturing's shares of whole-economy value added and employment halved over 1990-2007. In contrast, financial & business services' shares of value added and employment increased substantially over the period. Robust growth in Government & other services, especially after 2000 as government spending increased, mean this sector's footprint also increased.

Table 1: Trends in GVA

Trends in GVA

	Real GVA (£2005m)			Real GVA growth (% pa)			Share of GVA* (%)		
Sector	**1990**	**2000**	**2007**	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Agriculture etc	6,920	6,995	7,221	0.3	0.2	0.5	1.8	1.0	0.8
Mining etc	25,339	36,156	24,900	-0.1	4.4	-5.2	2.6	2.8	2.6
Manufacturing	138,782	150,631	151,371	0.5	0.7	0.1	22.5	17.4	12.4
Utilities	11,746	15,734	16,635	2.1	2.9	0.8	2.3	1.8	1.7
Construction	60,156	59,807	72,523	1.1	-0.2	2.8	6.7	5.3	6.4
Distribution	113,573	136,190	173,614	2.5	1.8	3.5	13.6	14.9	14.1
Transport and Comms	35,752	69,805	85,740	5.3	6.5	3.0	8.1	8.0	7.0
Fin. & bus. services	184,780	279,548	380,091	4.3	3.9	4.5	21.6	27.0	31.9
Govt & other services	198,854	237,623	269,007	1.8	1.8	1.8	20.9	21.8	23.1
Total Economy	775,903	992,489	1,181,102	2.5	2.4	2.5	100	100	100

Notes: * In current prices.

Source: OECD STAN and Cambridge Econometrics.

Table 2: Trends in employment

Trends in employment

	Employment (000s)			Growth in employment (% pa)			Share of UK total (%)		
Sector	**1990**	**2000**	**2007**	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Agriculture etc	317	275	253	-1.3	-0.8	-1.2	1.3	1.1	0.9
Mining etc	155	73	58	-5.6	-8.0	-3.2	0.6	0.3	0.2
Manufacturing	4,761	3,939	2,910	-2.9	-1.8	-4.2	19.3	15.2	10.7
Utilities	235	133	122	-3.8	-6.2	-1.2	1.0	0.5	0.5
Construction	1,260	1,170	1,300	0.2	-1.2	1.5	5.1	4.5	4.8
Distribution	5,449	6,097	6,401	1.0	1.1	0.7	22.1	23.5	23.5
Transport and Comms	1,458	1,537	1,587	0.5	0.2	0.5	5.9	5.9	5.8
Fin. & bus. services	3,838	4,875	5,778	2.4	2.3	2.5	15.6	18.8	21.2
Govt & other services	7,207	7,815	8,889	1.2	0.6	1.9	29.2	30.2	32.6
Total Economy	24,681	25,913	27,299	0.6	0.3	0.7	100	100	100

Source: OECD STAN and Cambridge Econometrics.

The sharp decline in employment helped to curb the deterioration in manufacturing's competitiveness

One positive consequence of these trends in output and employment was that the deterioration in the competitive position of UK manufacturers following sterling's appreciation in the second half of the 1990s was curbed in the 2000s.

Table 3 and

Table 4 show that as productivity of manufacturing (measured as output per employed person) picked up over 2000-07, growth in unit labour costs slowed sharply. Together with a broadly stable exchange rate, this was sufficient to bring to a halt the rise in manufacturing's real effective exchange rate[7].

Table 3 Trends in Labour Productivity

Trends in Labour Productivity

	£'000s per employee (real)			Real productivity growth (% pa)			As a % of UK average (UK=100)		
Sector	**1990**	**2000**	**2007**	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Agriculture etc	21.8	25.5	28.5	1.6	1.0	1.6	141	93	80
Mining etc	163.1	496.1	428.9	5.9	13.5	-2.1	418	1011	1215
Manufacturing	29.1	38.2	52.0	3.5	2.5	4.5	117	114	117
Utilities	50.0	118.3	136.3	6.1	9.7	2.0	239	356	379
Construction	47.7	51.1	55.8	0.9	1.1	1.3	130	117	135
Distribution	20.8	22.3	27.1	1.6	0.7	2.8	62	63	60

[7] The real effective exchange rate (REER) is a weighted average of bilateral comparisons of UK prices or costs and those of trading partners weighted by the importance of each partner to UK trade. Here we focus on unit labour costs as the competitiveness indicator. See Cambridge Econometrics (2011).

Transport and Comms	24.5	45.4	54.0	4.8	6.4	2.5	137	135	120
Fin. & bus. services	48.1	57.3	65.8	1.9	1.6	2.0	139	144	151
Govt & other services	27.6	30.4	30.3	0.5	1.2	-0.1	71	72	71
Total Economy	31.4	38.3	43.3	1.9	2.0	1.8	100	100	100

Source: OECD STAN and Cambridge Econometrics.

Table 4 Trends in Unit Labour Costs

Trends in Unit Labour Costs

	Index (2005 = 100)			Growth (% pa)		
Sector	**1990**	**2000**	**2007**	**1990-2007**	**1990-99**	**2000-07**
Agriculture etc	88.9	99.3	119.1	1.7	1.2	2.6
Mining and Quarrying	113.9	71.1	144.4	1.4	-6.1	10.7
Manufacturing	78.5	98.3	102.5	1.6	2.6	0.6
Utilities	128.7	98.7	109.7	-0.9	-2.0	1.5
Construction	58.8	84.8	116.4	4.1	2.9	4.6
Distribution	59.7	94.4	103.7	3.3	4.6	1.4
Transport and Comms	112.2	96	99.2	-0.7	-1.3	0.5
Fin. & bus. services	66.5	88.6	102.7	2.6	2.6	2.1
Govt & other services	52.6	78.8	106.3	4.2	4.1	4.4
Total Economy	67.7	88.6	104.2	2.6	2.7	2.3

Source: OECD STAN and Cambridge Econometrics.

2.1 Comparison with competitor countries

UK economic growth compared favourably to competitor countries, but UK manufacturing performed poorly compared to its competitors

Tables 5 and 6 show that manufacturing in the UK performed poorly when compared to the experience in the US, Japan, France and Germany.

The growth of value added in manufacturing over 1990-2007 was much stronger in all the competitor countries, especially the US. Furthermore, growth in Germany and Japan accelerated after 2000 when in the UK it slowed in the face of increasing global competition.

The growth of manufacturing value added in France, Germany and Japan did lag in whole-economy GVA growth, but not by as much as in the UK. Consequently, manufacturing's share of whole-economy value added did not fall as fast in France, Germany and Japan as it did in the UK.

In all countries, employment in manufacturing fell over 1990-2007 while whole-economy employment grew. But the strongest fall in employment in manufacturing was in the UK,

with an especially strong fall after 2000. Manufacturing's share of whole economy employment fell in all counties, but manufacturing in the UK experienced the sharpest decline.

This relative underperformance of UK manufacturing occurred at the same time as growth in the whole-economy matched or surpassed that in competitor countries underlining how important services became in driving growth in the UK over the period.

Table 5 Trends in GVA: competitor countries

Trends in GVA: competitor countries

	Real GVA growth (% pa):						Manuf. as % of whole economy*		
	Whole economy			Manufacturing					
Country	1990-2007	1990-99	2000-07	1990-2007	1990-99	2000-07	1990	2000	2007
UK	2.5	2.4	2.5	0.5	0.7	0.1	22.5	17.4	12.4
France	1.9	1.8	1.8	1.5	1.7	0.9	18.6	16.2	12.5
Germany	1.9	2.0	1.5	1.3	-0.1	2.4	28.1	23.0	23.8
Japan**	1.4	1.3	1.3	1.2	0.2	2.2	26.1	21.3	20.7
US	2.9	3.2	2.3	3.6	4.6	1.9	17.2	15.7	12.7

Notes: *In current prices. **For Japan, the time periods are 1990-2006, 1990-99, 2000-06.

Source: OECD STAN and Cambridge Econometrics

Table 6 Trends in Employment: competitor countries

Trends in Employment: competitor countries

	Employment growth (% pa):						Manuf. as % of whole economy*		
	Whole economy			Manufacturing					
Country	1990-2007	1990-99	2000-07	1990-2007	1990-99	2000-07	1990	2000	2007
UK	0.6	0.3	0.7	-2.9	-1.8	-4.2	19.3	15.2	10.7
France	1.0	0.8	0.8	-1.6	-1.7	-1.9	20.4	15.9	13.1
Germany	0.2	0.2	0.0	-2.0	-2.9	-1.1	29.7	22.1	20.5
Japan**	0.0	0.3	-0.3	-1.8	-1.8	-1.9	23.4	19.1	17.4
US	1.2	1.6	0.6	-1.3	-0.1	-3.0	15.7	13.3	10.3

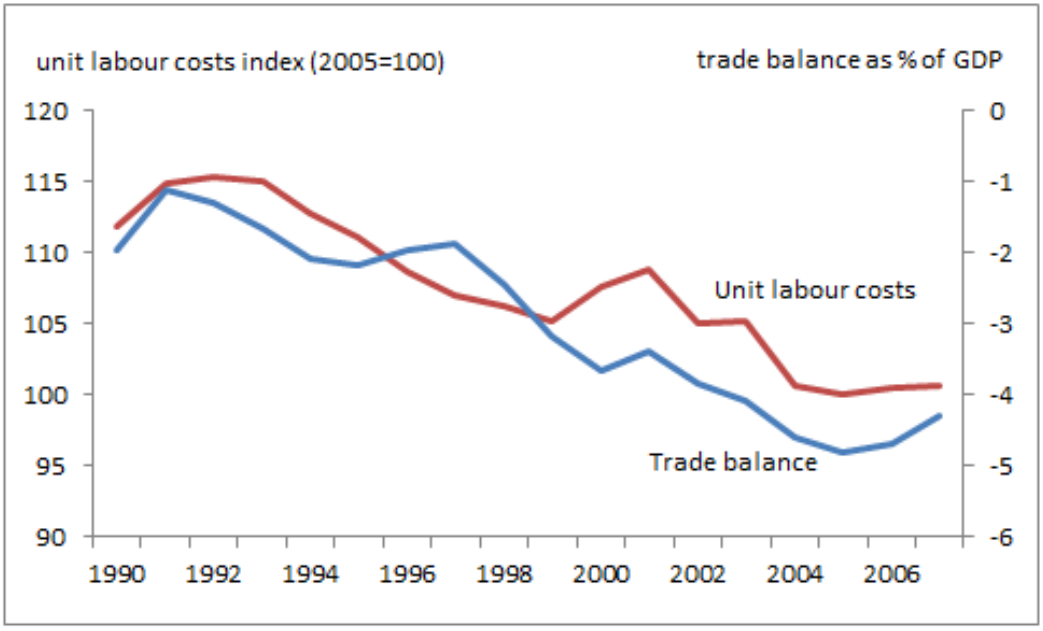
Notes: **For Japan, the time periods are 1990-2006, 1990-99, 2000-06.

Source: OECD STAN and Cambridge Econometrics.

Manufacturing in the UK experienced a deterioration in trade performance over 1990-2007 as a steady rise in unit labour costs eroded competitiveness

With regard to competitiveness and trade performance the charts below indicate that unit labour costs fell in the US, France and Japan over 1990-2007.

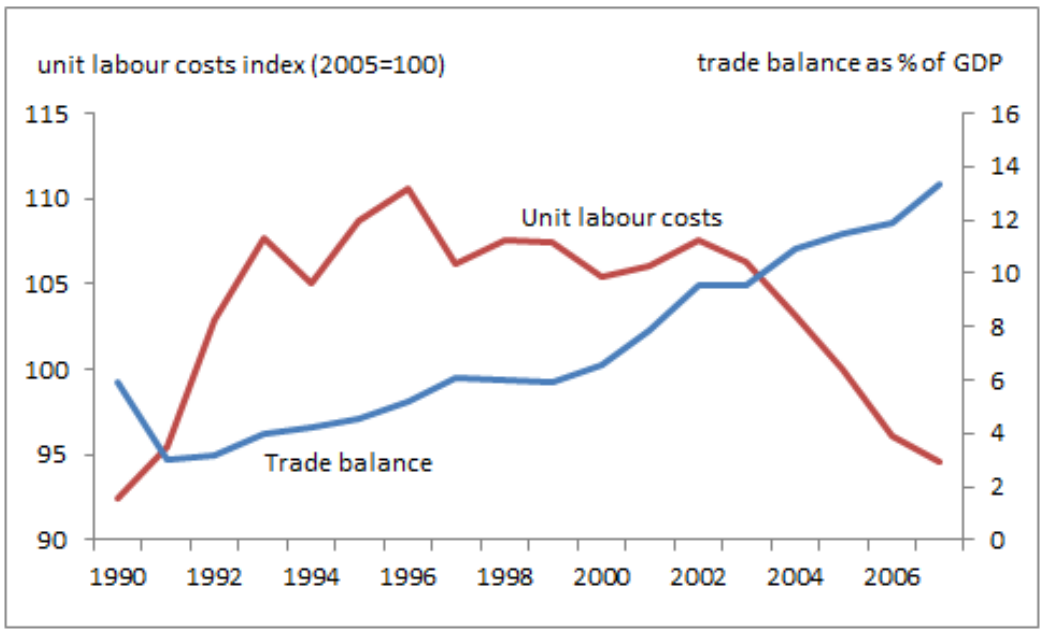
Figure 2: Trends in US manufacturing unit labour costs and trade balance



Source: OECD (STAN database, Bilateral Trade database, Trade in Services and National accounts) and Cambridge Econometrics.

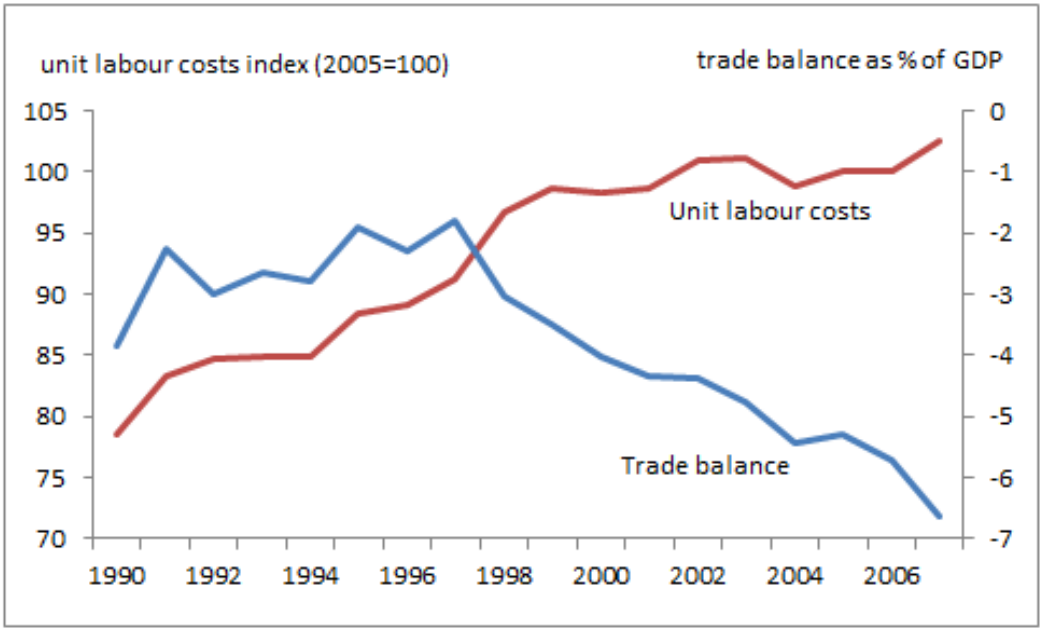
In Germany, unit labour costs increased sharply in the early-1990s following unification and remained broadly stable between the mid-1990s and early-2000s, before falling back to the levels seen before German unification. The UK was the only country where manufacturing unit labour costs rose over the period without falling back.

Figure 3: Trends in German manufacturing unit labour costs and trade balance



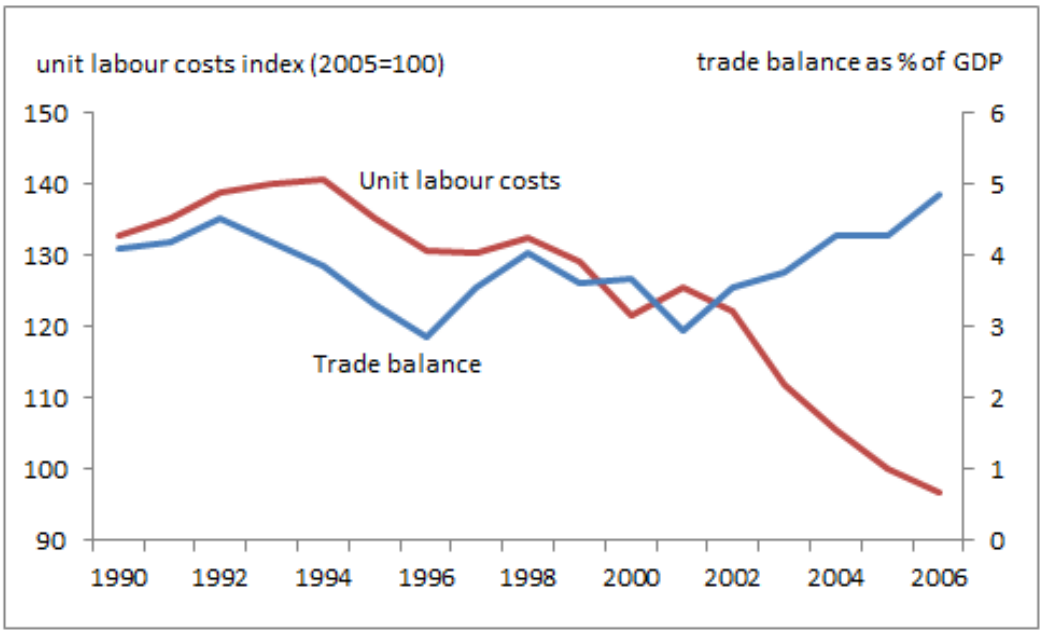
Source: OECD (STAN database, Bilateral Trade database, Trade in Services and National accounts) and Cambridge Econometrics.

Figure 4: Trends in UK manufacturing unit labour costs and trade balance



Source: OECD (STAN database, Bilateral Trade database, Trade in Services and National accounts) and Cambridge Econometrics.

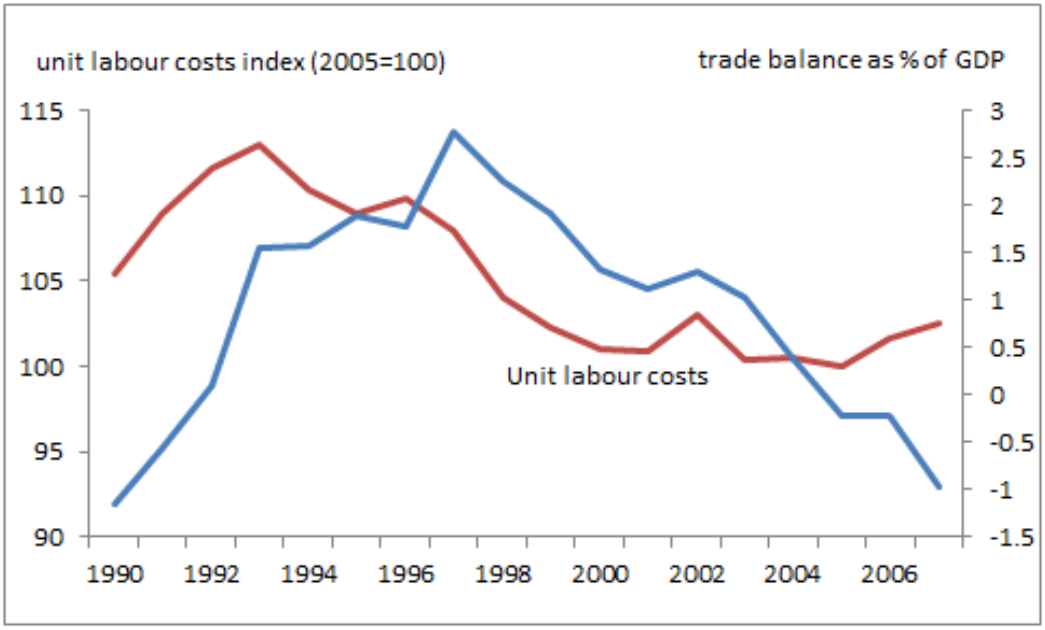
Figure 5: Trends in Japanese manufacturing unit labour costs and trade balance



Source: OECD (STAN database, Bilateral Trade database, Trade in Services and National accounts) and Cambridge Econometrics.

Unsurprisingly, manufacturing in Japan saw an improvement in its trade balance expressed as a ratio to GDP over the period, while UK manufacturing saw a deterioration because a greater share of UK manufacturing was focused on commoditised goods for which demand was driven by price rather than quality, and the steady rise in unit labour costs led to more production being relocated overseas as companies specialised to remain competitive in the face of increasing price competition.

Figure 6: Trends in French manufacturing unit labour costs and trade balance



Source: OECD (STAN database, Bilateral Trade database, Trade in Services and National accounts) and Cambridge Econometrics.

However, in France and the US, manufacturing's trade balance as a ratio to GDP deteriorated, despite the falls in unit labour costs. For manufacturing in Germany, the trade balance as a share of GDP increased steadily over the whole period.

3. Recent trends in manufacturing key sectors

In this analysis manufacturing has been broken down into three key sub-sectors, as follows:

Manufacturing sector	SIC(2003) definition
High-technology manufacturing	24.4 Manufacture of pharmaceuticals, medicinal chemicals and botanical products
	30 Manufacture of office machinery and computers
	32 Manufacture of radio, television and communication equipment and apparatus
	33 Manufacture of medical, precision and optical instruments, watches and clocks
	35.3 Manufacture of aircraft and spacecraft
Medium-technology manufacturing	23 Manufacture of coke, refined petroleum products and nuclear fuel
	24.1 Manufacture of basic chemicals
	24.2 Manufacture of pesticides and other agro-chemical products
	24.3 Manufacture of paints, varnishes and similar coatings, printing ink and mastics
	24.5 Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations
	24.6 Manufacture of other chemical products
	24.7 Manufacture of man-made fibres
	25 Manufacture of rubber and plastic products
	26 Manufacture of other non-metallic mineral products
	27 Manufacture of basic metals
	28 Manufacture of fabricated metal products, except machinery and equipment
	29 Manufacture of machinery and equipment n.e.c.
	31 Manufacture of electrical machinery and apparatus n.e.c.
	34 Manufacture of motor vehicles, trailers and semi-trailers
	35.1 Building and repairing of ships and boats
	35.2 Manufacture of railway and tramway locomotives and rolling stock
	35.4 Manufacture of motorcycles and bicycles
	35.5 Manufacture of other transport equipment n.e.c.
Low-technology manufacturing	15 Manufacture of food products and beverages
	16 Manufacture of tobacco products
	17 Manufacture of textiles
	18 Manufacture of wearing apparel; dressing; dyeing of fur
	19 Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
	20 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
	21 Manufacture of pulp, paper and paper products
	22 Publishing, printing and reproduction of recorded media
	36 Manufacture of furniture; manufacturing n.e.c.
	37 Recycling

The distinction between the three types of manufacturing implies that high-technology sectors are ‘better’. One argument for this is that the high-technology sectors are generally those in which global demand growth is strongest, spurred on by the development of new products and, sometimes, rapid cost reductions. They therefore offer the prospect of the fastest output growth. A second argument is that the high-technology sectors are sometimes regarded as those in which high-cost countries could have a comparative advantage, on the grounds that they may be more knowledge-intensive and less commoditised. But to understand comparative advantage we need to distinguish more or less knowledge-intensive *stages* in the supply chain for a product. The *design* of electronics components and the devices that depend on them is a knowledge-intensive process; once production has been standardised, the *manufacture* of those components and their *assembly* into devices are not knowledge-intensive (although these processes may depend on the use of sophisticated capital equipment). The *development* of a new chemistry-based pharmaceutical drug is knowledge-intensive; the *manufacture* of the drug is generally not. But in cases where the manufacture of the product is not readily standardised for mass production, the manufacturing stage may remain knowledge-intensive, as in the case of large aircraft and their engines or the production of some biotechnology therapies. We also need to distinguish, in a way that the industrial classification cannot, between different kinds of products within a given product type.

Output growth in high-technology manufacturing in the UK did not match that in other competitor countries

In all the countries shown in

Table 7, over 1990-2007 the fastest-growing group of manufacturing sectors was in high technology (HTM) and the slowest was in low technology (LTM). But the growth in HTM in the UK was typically around half that in the other countries. In Germany, Japan and the US, GVA growth in HTM accelerated strongly in the more recent period, 2000-07, whereas in the UK GVA in HTM fell.

Employment in high-technology manufacturing fell in all countries, but the fall was strongest in the UK because output growth slowed sharply while productivity growth remained robust

Across all countries, labour productivity growth was strongest in HTM over 1990-2007 (and weakest in LTM). Consequently, despite strong output growth in HTM, employment in HTM fell in all countries over the period. The fall in employment was strongest in the UK, which had the slowest growing HTM sector among all the countries.

Furthermore, in the UK, the decline in employment in HTM accelerated sharply after 2000 as productivity growth remained robust and output underwent a sharp reversal, from growth of 4% pa in the 1990s to -½% pa after 2000, as output in IT equipment and electronics fell sharply and failed to recover as more production was offshored.

Table 7: Trends in GVA; manufacturing sectors

Trends in GVA: manufacturing sectors

	Real GVA growth (% pa)			Share of manufacturing (%)		
UK	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Manufacturing	0.5	0.7	0.1			
High-technology manufacturing	2.6	4.1	-0.5	14.9	17.1	17.2
Medium-technology manufacturing	0.4	0.3	0.7	49.6	45.9	46.1
Low-technology manufacturing	-0.1	0.2	-0.4	35.5	37.0	36.7
	Real GVA growth (% pa)			**Share of manufacturing (%)**		
France	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Manufacturing	1.5	1.7	0.9			
High-technology manufacturing	4.2	4.4	3.3	11.4	15.0	14.0
Medium-technology manufacturing	1.0	1.3	0.4	54.0	54.3	55.2
Low-technology manufacturing	0.0	0.2	-0.3	34.6	30.7	30.8
	Real GVA growth (% pa)			**Share of manufacturing (%)**		
Germany	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Manufacturing	1.3	-0.1	2.4			
High-technology manufacturing	5.4	0.9	9.5	10.7	11.1	12.8
Medium-technology manufacturing	-0.2	-3.0	2.3	65.1	65.0	67.9
Low-technology manufacturing	-1.3	-1.5	-1.6	24.2	23.9	19.3
	Real GVA growth (% pa)			**Share of manufacturing (%)**		
Japan	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Manufacturing	1.2	0.2	2.2			
High-technology manufacturing	6.0	4.2	7.9	16.1	17.9	16.5
Medium-technology manufacturing	0.5	-0.7	1.6	56.8	54.6	60.1
Low-technology manufacturing	-1.7	-1.8	-1.7	27.1	27.5	23.4
	Real GVA growth (% pa)			**Share of manufacturing (%)**		
US	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Manufacturing	3.6	4.6	1.9			
High-technology manufacturing	7.2	5.3	7.8	17.5	18.1	19.0
Medium-technology manufacturing	3.0	4.5	0.6	47.4	46.4	48.1
Low-technology manufacturing	2.8	4.6	0.9	35.1	35.4	32.8

Source: OECD STAN and Cambridge Econometrics.

Table 8: Trends in employment; manufacturing sectors

Trends in employment: manufacturing sectors

	Employment growth (% pa)			Share of manufacturing (%)		
UK	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Manufacturing	-2.9	-1.8	-4.2			
High-technology manufacturing	-2.9	-1.9	-4.6	12.2	12.4	12.1
Medium-technology manufacturing	-2.9	-1.9	-4.1	49.2	48.6	48.9
Low-technology manufacturing	-2.8	-1.6	-4.2	38.6	39.0	39.0

	Employment growth (% pa)			Share of manufacturing (%)		
France	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Manufacturing	-1.6	-1.7	-1.9			
High-technology manufacturing	-1.3	-1.7	-1.5	9.9	10.2	10.5
Medium-technology manufacturing	-1.5	-1.7	-1.7	52.7	53.2	54.1
Low-technology manufacturing	-1.9	-1.7	-2.4	37.4	36.6	35.4

	Employment growth (% pa)			Share of manufacturing (%)		
Germany	**1991-2007**	**1991-99**	**2000-07**	**1991**	**2000**	**2007**
Manufacturing	-2	-2.9	-1.1			
High-technology manufacturing	-2.3	-5.1	0.1	10.5	9.4	10.2
Medium-technology manufacturing	-2.0	-3.2	-0.9	60.1	61.2	62.2
Low-technology manufacturing	-2.6	-3.4	-2.0	29.4	29.4	27.7

	Employment growth (% pa)			Share of manufacturing (%)		
Japan	**1990-2006**	**1990-99**	**2000-06**	**1990**	**2000**	**2006**
Manufacturing	-1.8	-1.8	-1.9			
High-technology manufacturing	-2.0	-1.3	-2.7	13.6	13.9	13.2
Medium-technology manufacturing	-1.3	-1.6	-0.9	51.2	52.2	55.3
Low-technology manufacturing	-2.4	-2.1	-2.9	35.2	33.8	31.5

	Employment growth (% pa)			Share of manufacturing (%)		
US	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Manufacturing	-1.3	-0.1	-3			
High-technology manufacturing	-2.5	-1.2	-4.7	16.6	15.0	13.3
Medium-technology manufacturing	-1.3	0.5	-4.1	45.9	49.2	45.4
Low-technology manufacturing	-0.7	-0.6	-1.1	37.5	35.8	41.3

Source: OECD STAN and Cambridge Econometrics.

UK manufacturing became more oriented towards high-technology manufacturing and low-technology manufacturing

The share of UK manufacturing that belonged to high-technology manufacturing increased from 15% in 1990 to 17¼% in 2007. The UK was also the only country where the LTM's share of manufacturing increased over the period.

Within HTM, there has been a shift away from IT equipment and electronics, which experienced strong growth up to 2000 but never recovered from the dot-com bubble as producers shifted the less knowledge-intensive manufacturing stages overseas in order to remain competitive, and a shift towards pharmaceuticals and medical and precision instruments as ageing populations in developed countries increase demand for healthcare equipment and drugs, and, to a lesser extent, aerospace, which benefited from rapid growth in air travel during this period.

Within LTM there was a shift away from: textiles and clothing, which never fully recovered from the recessions in the early 1980s and 1990s and could not compete with lower-cost imports of mass produced goods; tobacco, as stronger demand in developing countries encouraged producers to focus on these markets; and paper, as falling demand and squeezed margins led to the closure of paper mills in the UK (e.g. by SCA Hygiene, Sappi, Curtis Fine). These declines were offset by growth in the food and drink, printing and publishing and furniture industries. Alongside the falling share of agriculture in the whole economy, these trends indicate a general pattern of a move away from primary production towards production further down the supply chain, which in most cases is higher value added because outputs are less standardised and competition is more quality-driven.

Table 9 shows the varied trade patterns across countries and key sectors. In the UK, Japan and the US the contribution of HTM to net trade declined between 1990 and 2007. All ran a trade surplus in 1999, albeit small in the case of the UK, but by 2007 the US and the UK were running substantial deficits, while Japan's surplus had shrunk. In contrast, after running a deficit in 1990 HTM in France and Germany ran a surplus in 2007.

Table 9: Trends in net trade; key manufacturing sectors

Trends in net trade: key manufacturing sectors			
	Net trade (millions of $)		
UK	**1990**	**2000**	**2007**
High-technology manufacturing	56	-4,906	-24,593
Low-technology manufacturing	-26,087	-34,285	-78,699
Medium-technology manufacturing	-9,104	-13,563	-62,006
France			
High-technology manufacturing	-3,616	6,511	5,223
Low-technology manufacturing	-7,589	-4,493	-17,860
Medium-technology manufacturing	-1,526	13,669	-10,151
Germany			
High-technology manufacturing	-7,017	-3,804	25,991
Low-technology manufacturing	-30,740	-18,093	2,752
Medium-technology manufacturing	86,881	134,082	369,339

Japan			
High-technology manufacturing	61,044	64,559	38,100
Low-technology manufacturing	-44,393	-74,885	-89,412
Medium-technology manufacturing	110,204	188,090	270,452
US			
High-technology manufacturing	13,057	-35,182	-82,265
Low-technology manufacturing	-59,202	-149,427	-226,686
Medium-technology manufacturing	-68,691	-174,682	-281,678

Source: OECD (STAN, Bilateral Trade database, Trade in Services and National accounts), UN COMTRADE and Cambridge Econometrics.

Across all counties the trade deficits of the IT equipment and electronics industries widened but the offset from a surplus in the medical, precision and optical instruments industry did not materialise in the UK

Across all countries the contributions of the electronics (radio, television and communication equipment) and IT equipment (office machinery) industries declined as deficits deteriorated sharply or surpluses shrank. At the same time, the contribution of the medical, precision and optical instruments industry to net trade increased because in the US, Japan and Germany the industry generated a growing trade surplus over 1990-2007. In France it ran a small deficit that shrank a little. In the UK, however, the industry's trade balance deteriorated, from a small surplus in 1990 to a small deficit in 2007.

Over the period, MTM in the UK, France and the US ran deficits that increased four- to seven-fold. In the UK, all MTM industries experienced deteriorations in their balances. In all three countries, fabricated metal products suffered one of the sharpest deteriorations, especially after China became a member of the WTO in 2001, as producers in the UK, France and the US struggled to compete with lower-cost producers in developing countries. Among other MTM industries, Electrical Machinery and Machinery in the UK and the US also suffered badly. In France, Electrical machinery ran an increasing surplus over 1990-2007. In the UK and US, the trade balance for Motor Vehicles, which accounts for 40-50% of the MTM deficit in each, deteriorated over the period as increasing specialisation led to more production being outsourced and offshored. In Germany and Japan, MTM ran a surplus over the whole period and by 2007 the surpluses were 2½-4 times larger.

The experience of mass producers of low-technology products struggling to compete on price was not unique to the UK

In all the countries except Germany, LTM ran deficits that rose two- to four-fold over the whole period. In Germany, LTM managed to turn a large deficit in 1990 into a small surplus by 2007.

In the UK, the furniture, clothing (wearing apparel) and food and drink industries experienced the largest deteriorations in their trade balances, as rising input costs and intense price competition from overseas producers made it difficult for UK mass-producers to compete on price. The trade balances of leather and textiles did not fare much better.

These patterns can be seen in the other countries as well. In France and the US, the furniture industry suffered the sharpest deterioration in its trade balance, with clothing and textiles not far behind, and in both cases the wood industry also experienced a sharp widening of its deficit. In Japan, the sharpest deteriorations in trade balances came in textiles and leather, closely followed by clothing and furniture.

The comparative success of German LTM is down to improvements across all LTM industries but, in particular, the wood, paper and food and drink industries, which turned deficits into surpluses between 1990 and 2007; the textiles, clothing and leather industries, where the deficits did not deteriorate over the period as they had in the other countries; and the tobacco and printing and publishing industries, whose surpluses grew over the period.

4. Trends in productivity

4.1 Labour productivity

In all five countries manufacturing labour productivity grew much faster than the productivity of the whole economy over 1990-2007 (see

Table 10 and Table 11). Over this period, only US manufacturing experienced stronger productivity growth than the UK.

The acceleration of UK manufacturing productivity after 2000 was due almost exclusively to falling employment as GVA stagnated

In the 1990s, manufacturing productivity growth in the UK was slower than that of the other countries, except for Japan. But the UK recovered some ground after 2000, when only the US had stronger productivity growth; productivity growth slowed in France and Germany after 2000. However, the acceleration in the UK after 2000 was due almost exclusively to falling employment as GVA stagnated, consistent with restructuring in response to pressure from global competition. In contrast, the acceleration seen in Germany and Japan after 2000 was driven by faster GVA growth as the decline in employment did not accelerate as it did in the UK (in Germany the decline slowed).

Table 10: Trends in Labour Productivity; competitor countries

Trends in Labour Productivity: competitor countries

	Productivity growth (% pa):						Manuf. as % of whole economy*		
	Whole economy			Manufacturing					
Country	1990-2007	1990-99	2000-07	1990-2007	1990-99	2000-07	1990	2000	2007
UK	1.9	2.0	1.8	3.5	2.5	4.5	117	114	117
France	1.0	1.0	1.0	3.2	3.4	2.9	91	102	95
Germany	1.7	1.8	1.5	3.4	3.0	3.5	95	104	116
Japan	1.4	1.0	1.6	3.1	2.0	4.1	112	111	119
US	1.7	1.6	1.7	4.9	4.8	5.1	110	118	123

Notes: **For Japan, the time periods are 1990-2006, 1990-99, 2000-06.

Source: OECD STAN and Cambridge Econometrics.

There appears a correlation between higher technology and higher productivity growth. In the UK, labour productivity in MTM grew in line with that for the manufacturing sector as a whole over 1990-2007, while LTM experienced slower growth and HTM much faster growth.

Germany, Japan and the US all saw much stronger labour productivity growth in high-technology manufacturing than the UK, where it was driven by falling employment

In the other countries, labour productivity in LTM and MTM grew below the average for manufacturing as a whole over 1990-2007, while productivity in HTM grew above the average. But while the acceleration in productivity growth in HTM in the UK was driven by falling employment, in Germany and Japan it was driven by stronger GVA growth. In the US, stronger productivity growth in HTM after 2000 was driven by both.

Table 11: Trends in labour productivity; manufacturing sectors

Trends in labour productivity: manufacturing sectors

	Productivity growth (% pa)			As % of manufacturing		
UK	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Manufacturing	3.5	2.5	4.5			
High-technology manufacturing	5.7	6.1	4.3	122.1	137.5	142.4
Medium-technology manufacturing	3.4	2.3	5.0	100.9	94.6	94.2
Low-technology manufacturing	2.8	1.8	4.0	91.9	94.8	94.1

	Productivity growth (% pa)			As % of manufacturing		
France	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Manufacturing	3.2	3.4	2.9			
High-technology manufacturing	5.5	6.2	4.8	114.5	147.1	133.0
Medium-technology manufacturing	2.5	3.0	2.1	102.5	102.1	102.1
Low-technology manufacturing	2.0	2.0	2.1	92.6	83.8	87.0

	Productivity growth (% pa)			As % of manufacturing		
Germany	**1991-2007**	**1991-99**	**2000-07**	**1991**	**2000**	**2007**
Manufacturing	3.4	3	3.5			
High-technology manufacturing	9.0	8.2	9.5	102.5	118.6	126.1
Medium-technology manufacturing	2.9	2.1	3.3	108.3	106.3	109.2
Low-technology manufacturing	2.4	3.9	0.5	82.1	81.1	69.7

	Productivity growth (% pa)			As % of manufacturing		
Japan	**1990-2006**	**1990-99**	**2000-06**	**1990**	**2000**	**2006**
Manufacturing	3.1	2	4.1			
High-technology manufacturing	8.1	5.6	10.9	118.1	128.6	125.3
Medium-technology manufacturing	1.8	0.9	2.5	111.0	104.5	108.7
Low-technology manufacturing	0.7	0.3	1.3	77.0	81.2	74.2

	Productivity growth (% pa)			As % of manufacturing		
US	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Manufacturing	4.9	4.8	5.1			
High-technology manufacturing	9.9	6.5	13.1	105.8	120.7	143.1
Medium-technology manufacturing	4.3	3.9	4.9	103.2	94.4	105.9
Low-technology manufacturing	3.5	5.2	2.0	93.5	99.0	79.6

Source: OECD STAN and Cambridge Econometrics.
In 1990, labour productivity in HTM in the UK was around 22% above the average for manufacturing as a whole, the highest among all the countries. By 2007 it was 42% above the manufacturing average, just behind labour productivity in HTM in the US, where the labour productivity gap (between HTM and manufacturing as a whole) had caught up to UK levels. Labour productivity in HTM in France, Germany and Japan also increased over the period and by 2007 (2006 in Japan) was 25-33% above the average for manufacturing as a whole in that country.

In the UK, the growth in labour productivity in HTM over the period was underpinned by especially strong growth in the IT equipment and electronics industries, where employment fell dramatically over 1990-2007 (and especially after 2000 when the dot-com bubble burst) as increasingly the lower value added stages of manufacturing were relocated overseas as the products became increasingly commoditised.

In LTM, productivity was below the average for total manufacturing in all countries in 1990 and remained so in 2007. In all countries except the UK productivity in LTM fell further behind that for total manufacturing. The lowest productivity in LTM was in Germany. In the UK, the textiles, clothing and paper industries experienced the strongest growth in productivity, driven by strong falls in employment as rising input costs in the face of strong competition from lower cost imports, and weak demand due to technological change, made it difficult for producers to remain viable.

4.2 Total factor productivity

Total factor productivity (TFP) can be interpreted as a measure of an economy's technological dynamism. Technological change is a key component of TFP, and so we might expect those countries that invest most in R&D to achieve greater TFP growth (note that for some time, the UK has under-performed many key competitors on headline measures of innovation, such as R&D expenditure and patenting[8]). However, the story is not so simple; TFP also captures the conditions required for the effective application of technology (e.g. human resource development).

In all countries the growth of total factor productivity (TFP) in manufacturing outpaced that for the whole economy over 1990-2007, with broadly similar rates of growth in the UK, Germany and France, as shown in Table 13. Compared to the UK, the US enjoyed stronger growth of manufacturing TFP (and saw relatively strong growth of manufacturing R&D expenditure); while in Japan the growth of manufacturing TFP growth was weaker. In all the countries, except France, manufacturing TFP growth accelerated after 2000; the acceleration was particularly strong in the UK.

[8] See below for 'Trends in R&D spending' and 'Trends in innovation'.

Table 12: Total Factor Productivity

Total Factor Productivity	Growth (% pa)		
UK	**1990-2007**	**1990-99**	**2000-07**
Manufacturing	1.9	0.7	3.4
Whole economy	0.7	0.9	0.5
France			
Manufacturing	2.0	2.3	1.3
Whole economy	0.6	0.5	0.5
Germany			
Manufacturing	1.9	1.1	2.4
Whole economy	0.7	0.5	0.7
Japan			
Manufacturing	0.6	0.2	0.7
Whole economy	0.0	-0.2	0.3
US			
Manufacturing	2.9	2.3	3.7
Whole economy	0.5	0.2	0.8

Source: OECD STAN and Cambridge Econometrics.

4.3 Unit labour costs in manufacturing

The competitiveness of HTM industries in the UK was undermined by strong wage growth.

Table 14 shows that whole-economy unit labour costs in France, Germany, the US and the UK, grew over 1990-2007, with the strongest growth in the UK. Within manufacturing, unit labour costs fell over the period in Japan, the US and France, while in Germany they were flat. Only in the UK did unit labour costs rise over the period, although growth did slow sharply after 2000. As a result UK manufacturing became less competitive over 1990-2007.

It was not possible to present unit labour cost data for the same key manufacturing sectors (high-, medium- and low-technology) but we can look at trends at the industry level. In the table below we present the growth rates for unit labour costs in three high-technology manufacturing industries: Office Machinery, Communications equipment and Medical & precision instruments, and two industries that are part high technology and part medium technology: Chemicals (which includes Pharmaceuticals) and Other Transport Equipment (which includes Aircraft and Spacecraft).

Table 13 Trends in Unit Labour Costs: competitor countries

Trends in Unit Labour Costs: competitor countries

	Growth in unit labour costs (% pa):					
	Whole economy			Manufacturing		
Country	1990-2007	1990-99	2000-07	1990-2007	1990-99	2000-07
UK	2.6	2.7	2.3	1.6	2.6	0.6
France	1.4	1.0	2.0	-0.2	-0.3	0.2
Germany	0.7	1.6	-0.3	0.1	1.7	-1.5
Japan	-0.9	0.2	-2.3	-2.0	-0.3	-3.7
US	2.1	2.0	2.0	-0.6	-0.7	-1.0

Notes: Growth rates are based on common currency (US dollar) measures.
**For Japan, the time periods are 1990-2006, 1990-99, 2000-06.

Source: OECD STAN and Cambridge Econometrics.

In all countries, unit labour costs fell in the electronics (radio, television and communication equipment) and IT equipment (office machinery) industries over 1990-2007; but in the UK they declined at a much slower pace. What is even more striking is that unit labour costs in the IT equipment and electronics industries in the UK increased after 2000, whereas in all the other countries they continued to fall at similar or faster rates. A key explanation for this is that GVA in the IT equipment and electronics industries in the UK fell sharply after 2000 and never recovered, as UK companies increasingly focused on design and R&D activities rather than production; in each of the other countries GVA recovered quickly and continued growing at much the same rate. Meanwhile, unit labour costs in the medical and precision instruments industry fell in Japan, France and the US over the period. In the UK and Germany they increased, but the growth was faster in the UK. Like most of the other countries, the UK saw unit labour costs in the medical and precision instruments industry rise in the 1990s and then fall in the period after 2000. The pace of decline after 2000 was in line with the declines in France and Germany, but well behind the rapid declines in Japan and the US, where productivity growth outpaced the growth in average wages. In the UK, wage growth outpaced productivity growth over the period.

Table 14: Trends in unit labour costs; High technology manufacturing

Trends in unit labour costs: High technology manufacturing

	Growth in unit labour costs (% pa)		
	1990-2007	1990-99	2000-07
UK			
Total manufacturing	1.6	2.6	0.6
Chemicals and chemical products	0.0	0.2	0.0
Office machinery and computers	-2.8	-9.5	7.9
Radio, TV and comms equipment	-2.0	-2.9	1.0
Medical and precision instruments	1.4	3.4	-1.3
Other transport equipment	1.4	0.7	1.8
France			

Total manufacturing	-0.2	-0.3	0.2
Chemicals and chemical products	-1.5	-1.2	-1.2
Office machinery and computers	-23.6	-16.5	-33.3
Radio, TV and comms equipment	-11.0	-11.9	-9.1
Medical and precision instruments	-0.4	0.9	-1.0
Other transport equipment	3.2	0.5	2.6
Germany			
Total manufacturing	0.1	1.7	-1.5
Chemicals and chemical products	-2.2	-1.4	-3.3
Office machinery and computers	-21.0	-20.4	-19.7
Radio, TV and comms equipment	-8.1	0.2	-15.6
Medical and precision instruments	0.4	2.7	-0.9
Other transport equipment	-1.1	-1.3	-2.6
Japan			
Total manufacturing	-2	-0.3	-3.7
Chemicals and chemical products	-1.3	-2.3	-1.0
Office machinery and computers	-7.8	-3.6	-14.2
Radio, TV and comms equipment	-9.4	-6.0	-12.1
Medical and precision instruments	-1.6	1.1	-5.0
Other transport equipment	-1.2	-1.8	1.2
US			
Total manufacturing	-0.6	-0.7	-1
Chemicals and chemical products	1.1	2.2	-1.1
Office machinery and computers	-15.4	-11.2	-19.8
Radio, TV and comms equipment	-12.8	-12.3	-12.1
Medical and precision instruments	-12.4	-8.5	-15.4
Other transport equipment	3.1	3.7	2.3
Notes: Growth rates are based on common currency (US dollar) measures.			

Source: OECD STAN and Cambridge Econometrics.

While the growth in unit labour costs in Other transport equipment in France and the US can be attributed in part to a fall in GVA between 1990 and 2007, in the UK, where value added in Other transport equipment grew, the loss of competitiveness (as a result of the rising unit labour costs) arises from wage growth outpacing productivity growth.

In the UK, unit labour costs in Chemicals were flat over 1990-2007, while in Germany, Japan and France they fell. In Germany the decline accelerated after 2000. The difference between the trends in the UK and Germany arise as a result of stronger output growth in Germany and productivity growth outpacing wage growth, whereas in the UK they grew at much the same rate.

5. Trends in R&D spending

UK R&D spending ranks below the OECD average, and increasingly comes from foreign-owned firms and is concentrated in a few key product groups.

In recent years, the UK has under-performed the OECD-average on headline measures of innovation, such as R&D expenditure and patenting. ONS[9] data show that in 2011:

- Business enterprise R&D expenditure amounted to around 1.1% of GDP. This ranks the UK 19th amongst the 34 OECD members, below the US (2.5%, 4th), Japan (2.0%, 8th), Germany (1.9%, 9th) and France (1.4%, 13th).
- For the first time, the proportion of R&D expenditure in the UK accounted for by foreign-owned firms rose to 50% (compared with 31% in 2000).
- The 'top-five' product groups accounted for more than 60% (compared with 53% in 2000) of R&D expenditure in the UK. These groups include technology-driven activities in manufacturing and services, namely: pharmaceuticals; computer and software services; motor vehicles; aerospace; and telecommunications.

The case of the motor vehicles industry in the UK illustrates these statistics. The industry is technology-driven, and characterised by high exports and significant foreign direct investment (for example, at Nissan's plant at Sunderland).

R&D spending was weaker in the UK than in the other competitor countries

Table 15 compares the UK's manufacturing R&D expenditure, disaggregated by high-, medium- and low-technology sectors (HTM, MTM and LTM), with that in the selected competitor countries.

- In all the countries, manufacturing accounts for a large proportion (70-90%) of all R&D expenditure. In the UK and the US, which are economies in which manufacturing accounts for a smaller share of total GVA, there is a smaller proportion of R&D expenditure in manufacturing.
- In all the countries, manufacturing's share of R&D expenditure shrank because R&D spending across the whole economy grew at a faster rate than did manufacturing R&D spending.
- But in the UK, R&D spending in manufacturing *and* across the economy as a whole was slower than in the other countries.
- In the UK and the US, HTM accounted for the largest share of manufacturing R&D and it was in HTM that the growth in R&D expenditure was the fastest.
- It is notable that in Germany there is a large proportion of R&D expenditure in MTM, and this is consistent with Germany's relatively large proportion of value added and employment in MTM.

[9] Business Enterprise Research and Development, 2011, ONS, 20 November 2012.

Table 15 Trends in total business R&D

Trends in total business R&D

	Real growth in total R&D (% pa)			Share of whole economy R&D (%)		
UK	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Whole economy	0.9	0.3	1.7			
Manufacturing	0.6	0.6	0.6	78.0	80.2	74.1
High-technology manufacturing	1.6	1.4	1.2	41.9	48.3	46.7
Medium-technology manufacturing	-0.7	-0.5	-0.5	32.8	28.8	24.7
Low-technology manufacturing	0.0	-0.3	-0.2	3.2	3.1	2.7
France	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Whole economy	1.5	1.5	1.5			
Manufacturing	0.9	0.6	1.2	92.4	85.0	83.6
High-technology manufacturing	0.2	-0.1	0.8	53.0	44.6	42.4
Medium-technology manufacturing	1.6	1.3	1.8	36.6	36.4	37.1
Low-technology manufacturing	3.8	4.6	1.3	2.7	4.0	4.0
Germany	**1991-2006**	**1991-99**	**2001-06**	**1991**	**2001**	**2006**
Whole economy	1.7	1.2	1.6			
Manufacturing	1.2	0.5	1.5	96.0	90.4	90.0
High-technology manufacturing	-0.3	-0.5	-0.8	34.9	29.3	25.9
Medium-technology manufacturing	2.0	1.0	2.7	59.2	58.9	62.1
Low-technology manufacturing	1.8	2.7	-0.5	2.0	2.2	2.0
Japan	**1991-2005**	**1991-99**	**2000-05**	**1991**	**2000**	**2005**
Whole economy	2.5	1.1	4.7			
Manufacturing	2.1	0.4	4.2	94.4	90.4	88.3
High-technology manufacturing	3.1	1.8	4.3	33.7	36.7	36.2
Medium-technology manufacturing	1.4	-0.6	4.2	55.4	48.6	47.6
Low-technology manufacturing	1.4	1.5	2.4	5.3	5.1	4.6
US	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Whole economy	2.9	3.9	1.0			
Manufacturing	2.1	1.0	3.3	82.8	62.2	69.6
High-technology manufacturing	5.1	-3.1	5.2	35.1	37.7	47.8
Medium-technology manufacturing	-2.0	3.2	-0.6	47.8	23.1	19.7
Low-technology manufacturing	6.9	-2.7	7.8	1.2	1.4	2.2

Note: The data for Germany and Japan cover slightly different, but broadly comparable, time periods. Source: OECD STAN, NSF and Cambridge Econometrics.

6. Trends in innovation

The UK is characterised as an 'innovation follower' in the European Commission's Innovation Union Scoreboard

In the European Commission's Innovation Union Scoreboard 2011, the UK is characterised as an 'innovation follower': its overall score is better than the EU average but it falls short of 'innovation leaders', such as Sweden, Denmark, Germany and Finland. Those dimensions of innovation in which the UK is assessed to have relative strengths include: human resources, openness, excellent & attractive research systems and finance & support. The relative weaknesses include: firm investments, innovators and intellectual assets (including patents - see below for further analysis of patents data). Many of the foundations for successful innovation are in place (e.g. international centres of excellence in scientific research) yet the UK seems to underperform when it comes to innovation in terms of: taking new products and services to market; and introducing product and process innovations. In contrast, the strengths of Germany (an 'innovation leader') are in innovators and intellectual assets (see below).

Although in the Innovation Union Scoreboard, the UK scores well on human resources, this is primarily because the indicator used simply captures the relatively large proportion of the UK population that is qualified to degree level. Other evidence suggests that manufacturing struggles to attract workers with the required skills. Evidence from the UK Commission's Employers Skill Survey suggests that where manufacturing employers have a vacancy it is likely to be more difficult to fill because of a shortage of applicants with the required skills, qualifications, or experience than is the case for employers generally. In Germany, the apprenticeship scheme is regarded as being central to the relative competitiveness of the manufacturing sector but in the UK apprenticeships are yet to be perceived by potential learners in the same way. In the recruitment of technical professionals (e.g. engineers) with high-level STEM[10] skills, manufacturing competes with professional and financial services.

Patenting activity in manufacturing in the UK compares less favourably to that in other countries

One of the dimensions of innovation is intellectual assets, and here we unpick the trends in patenting activity in more detail.
Table 16 compares the UK's patenting activity, disaggregated by high-, medium- and low-technology sectors (HTM, MTM and LTM), with that in the selected competitor countries. Patenting activity in manufacturing in the UK compares less favourably to that in other countries, and this picture is played out consistently across high-, medium- and low-technology manufacturing:

The number of UK patent applications is marginally lower than in France, but substantially lower than in the US, Germany and Japan. Patent applications in Germany, Japan and the US were typically four to five times higher than in the UK.

[10] Science, technology, engineering and mathematics.

Table 16 Trends in innovation (patenting activity)

Trends in innovation (patenting activity)

	Number of patents			Growth (% pa)			As a % of manufacturing		
UK	**1990**	**2000**	**2007**	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Manufacturing	3508.36	5851.66	5153.7	2.3	5.4	-1.8			
High-technology manufacturing	1535.14	3046.75	2525.96	3.0	7.1	-2.6	43.8	52.1	49.0
Medium-tech. manufacturing	1737.83	2419.49	2278.99	1.6	3.7	-0.9	49.5	41.3	44.2
Low-technology manufacturing	235.4	385.42	348.75	2.3	5.0	-1.4	6.7	6.6	6.8

	Number of patents			Growth (% pa)			As a % of manufacturing		
France	**1990**	**2000**	**2007**	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Manufacturing	4855.17	7060.27	8215.5	3.1	4.1	2.2			
High-technology manufacturing	1974.59	3255.64	3724.36	3.8	5.5	1.9	40.7	46.1	45.3
Medium-tech. manufacturing	2573.95	3363.35	4026.21	2.7	3.0	2.6	53.0	47.6	49.0
Low-technology manufacturing	306.62	441.28	464.93	2.5	4.0	0.7	6.3	6.3	5.7

	Number of patents			Growth (% pa)			As a % of manufacturing		
Germany	**1990**	**2000**	**2007**	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Manufacturing	11322.84	21671.62	23377.5	4.4	6.9	1.1			
High-technology manufacturing	4051.98	8738.48	9105.98	4.9	8.0	0.6	35.8	40.3	39.0
Medium-tech. manufacturing	6591.47	11778.37	12947.35	4.1	6.2	1.4	58.2	54.3	55.4
Low-technology manufacturing	679.39	1154.77	1324.17	4.0	5.8	2.0	6.0	5.3	5.7

	Number of patents			Growth (% pa)			As a % of manufacturing		
Japan	**1990**	**2000**	**2007**	**1990-2007**	**1990-99**	**2000-07**	**1990**	**2000**	**2007**
Manufacturing	12838.03	21360.45	20586.3	3.0	4.2	-0.6			
High-technology manufacturing	6922.6	11412.51	10757.04	2.8	4.1	-1.0	53.9	53.4	52.3
Medium-tech. manufacturing	5349.15	9017.09	8928.18	3.3	4.4	-0.2	41.7	42.2	43.4
Low-technology manufacturing	566.28	930.85	901.08	2.9	4.3	-0.5	4.4	4.4	4.4

US	Number of patents			Growth (% pa)			As a % of manufacturing		
	1990	2000	2007	1990-2007	1990-99	2000-07	1990	2000	2007
Manufacturing	17109.83	30808.68	28857.48	3.1	6.4	-0.9			
High-technology manufacturing	8432.42	17293.96	16017.01	3.8	7.9	-1.1	49.3	56.1	55.5
Medium-tech. manufacturing	7671.94	11814.16	11176.61	2.2	4.7	-0.8	44.8	38.3	38.7
Low-technology manufacturing	1005.47	1700.56	1663.87	3.0	5.5	-0.3	5.9	5.5	5.8

Source: Eurostat and Cambridge Econometrics.

The growth in patent applications over 1990-2007 was weaker in the UK than in all the other countries. The only exception was in HTM in Japan, which grew at a slightly weaker rate than in the UK, but even so, HTM in Japan was making four times as many patent applications as its UK counterpart.

In the UK, the US and Japan, patent applications in all three technology sectors fell after 2000. In France and Germany they continued to grow, but at a slower pace.

The distribution of patent applications across the three key technology sectors is broadly similar in all countries. In all countries less than 10% of all patent applications are attributable to LTM. Typically 40-50% of patent applications came from MTM.

7. Trends in outsourcing and off-shoring

In this and the next section on supply-chain linkages, an analysis of input-output tables is undertaken to inform an assessment of trends in outsourcing, off-shoring and supply chains. The analysis unpicks the trends in different sectors, both in manufacturing and services. Note that the data used are nominal, that is, they include the effect of prices changes.[11]

Trends in outsourcing and off-shoring can help to explain the evolution and growth of manufacturing over time. Industrial restructuring is not new, it has shaped the UK and other economies over many decades; but the gathering pace of globalisation in the past 20 years has contributed significantly to changes in industrial structure. Our analysis shows that in the UK:

- Manufacturing as a whole has a higher than economy-average dependence on outsourcing.
- Outsourcing, by manufacturing and other sectors of the economy, has become more prevalent, both domestic and overseas.
- Suppliers from overseas (i.e. off-shoring) account for a growing proportion of outsourced inputs to manufacturing, whereas this has not been balanced by an increase in the share of UK manufacturing output that is exported.
- Outsourcing has been a key factor driving the difference between the long-term rates of growth in value added of manufacturing and services: there has been a clear shift towards greater use of service inputs in production (e.g. the outsourcing of the ICT function from within a manufacturing firm to the computing services industry).
- Higher-tech manufacturing industries: rely less on domestic outsourcing (they have a lower than average ratio of domestic intermediate purchases to gross output) and more on foreign outsourcing (imported inputs account for a larger proportion of intermediate purchases of goods and services); and are more tradable (exports account for a larger proportion of output).

Our analysis by industry sector identifies general shifts of value added between different industry sectors (e.g. the clear shift towards greater use of service inputs in production). It also gives some insights into the extent to which the activity of an industry sector has been outsourced overseas, but it does not fully identify which particular *activities* have been outsourced (e.g. design, assembly). The reasons to outsource and off-shore are many and varied, for example to: cut costs; access specialist knowledge and skills; counter currency exchange risks (e.g. in aeronautics in which contracts are priced mainly is US dollars). In addition, the strategic priorities vary with the characteristics of the business, for example, manufacturers of higher value, innovative products in an earlier stage of development might demonstrate a preference for full control over the value chain (and intellectual property) – which can be achieved by less outsourcing - but once products move to more mature stages, manufacturers are more willing to outsource and make use of multiple global suppliers. The outcome of successful overseas outsourcing

[11] The UK analyses make use of the 1995 and 2005 Input-Output Analytical Tables (IOATs). The analysis for Scotland uses the 1998 and 2005 IOATs. Trend absolute changes (annual averages, 1995-2005) in input-output coefficients for Germany, France, the US and Japan were calculated using data from the World Input Output Database (WIOD).

should be that those manufacturing activities that remain in the UK are those for which the UK has a comparative advantage.

In the UK, manufacturing as a whole has a higher than average dependence on outsourcing...

The gross output of each industry comprises three broad components:

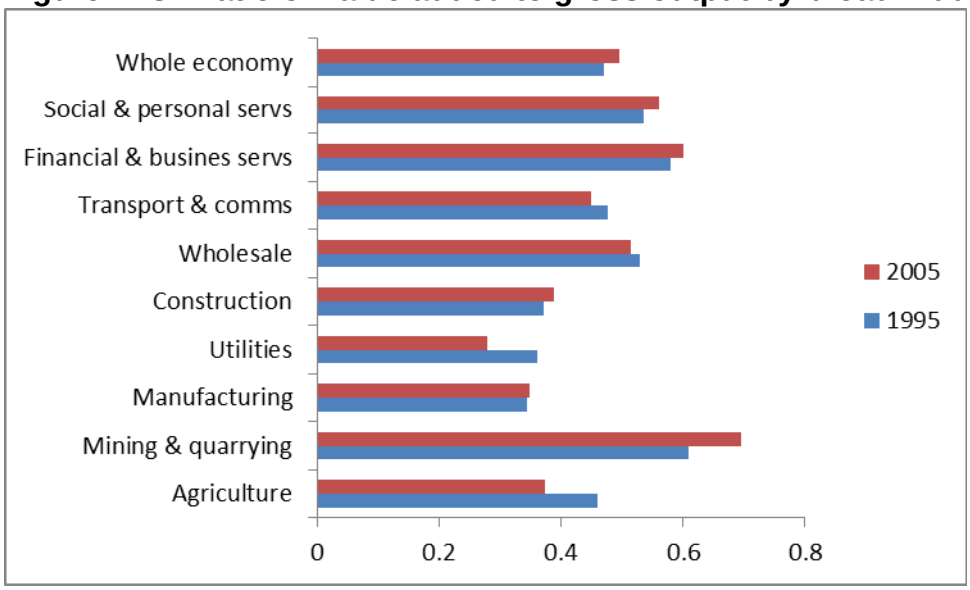
- intermediate purchases of goods & services, which are required as inputs to production;
- net taxes on products;
- gross value added (GVA), which comprises principally wages & salaries and profits.

The relationships between these components give some indication of trends in outsourcing. In

Figure 7 the ratio of GVA to gross output is plotted for broad industry sectors. Broadly speaking, the higher this ratio, the less dependent the sector is on outsourcing – that is, a larger proportion of the value of the sector's product is accounted for by the value added by the sector's own activities (rather than by intermediate purchases, from other sectors, of inputs to production).

Figure 7 shows that this ratio is lower than average for manufacturing as a whole and that it hardly changed between 1995 and 2005 – this indicates that the extent of outsourcing in manufacturing is higher than the economy average, but that it did not change greatly between 1995 and 2005.

Figure 7: UK ratio of value added to gross output by broad industry sector



Source: ONS Input-Output Analytical Tables 1995 and 2005.

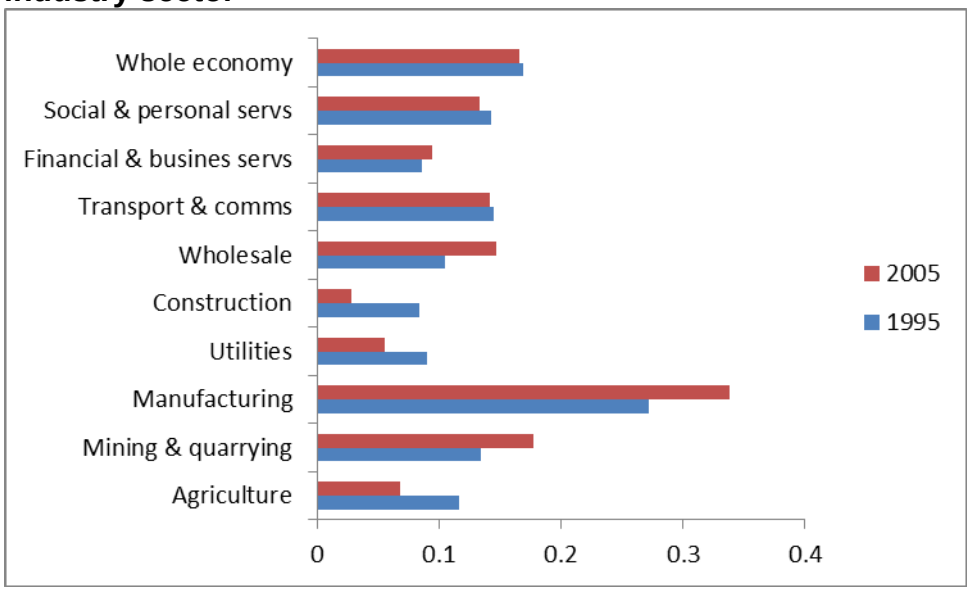
…especially from suppliers outside of the UK

Of the goods and services purchased as inputs to manufacturing, a large and growing proportion was imported, as shown in Figure 8. In 2005, the proportion of intermediate

purchases that were imported by manufacturing exceeded 33%. Of course, manufacturing is a highly traded sector;

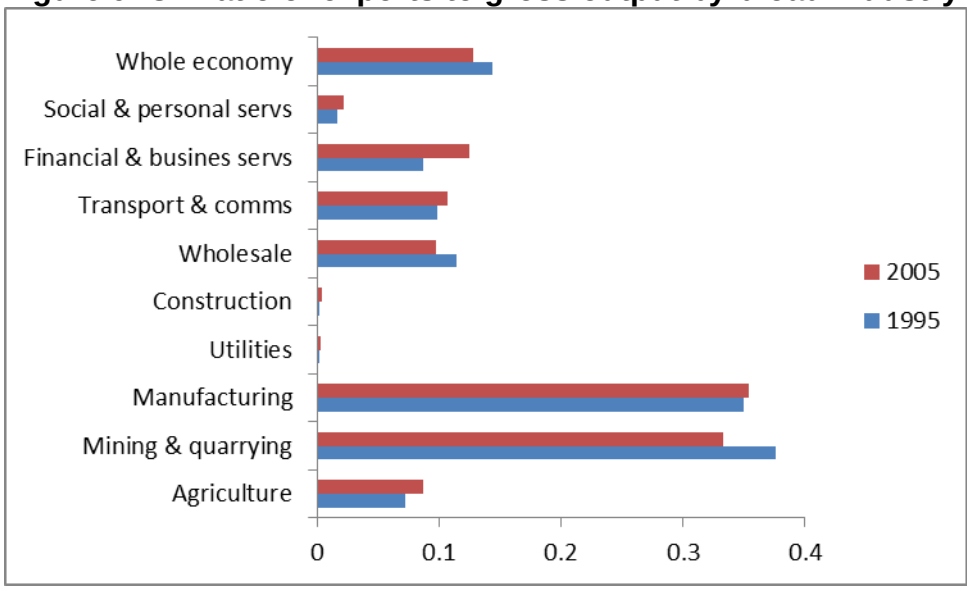
Figure 9 shows broad sector ratios of export demand to output - these are by far the highest for manufacturing and for mining. Note, however, that between 1995 and 2005 manufacturing sourced an increasing proportion of inputs from outside of the UK while at the same time manufacturing's proportion of output exported remained unchanged. For the service sectors, the proportion of intermediate purchases imported did not exceed 20%. The data illustrate the growing importance of UK financial & business services as an international provider; financial & business services imported only around 9% of inputs but increased its proportion of output exported from 9% to 12%.

Figure 8: UK ratio of imported to all purchases of goods & services by broad industry sector



Source: ONS Input-Output Analytical Tables 1995 and 2005.

Figure 9: UK ratio of exports to gross output by broad industry sector



Source: ONS Input-Output Analytical Tables 1995 and 2005.

Scotland depends more than the UK on imported inputs because it is a smaller, open economy

For most broad sectors, including manufacturing, the ratio of GVA to gross output in Scotland is similar to the UK average. However, because Scotland is a smaller economy than the UK the proportion of manufacturing's intermediate purchases that are imported (including from the rest of the UK) is larger; 52% in Scotland in 2005 compared with 33% in the UK. If the data were available, the same would be true for any English region.

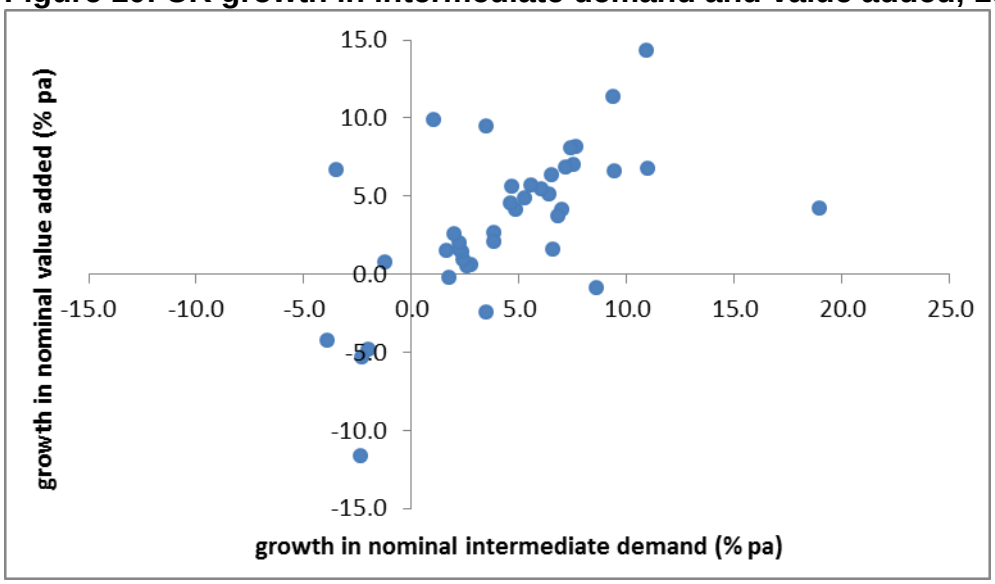
A key driver of growth in the UK, and in Scotland, was outsourcing

A key factor driving the difference between the long-term rates of growth in value added of manufacturing and services has been a shift towards greater use of service inputs in production. The scatter chart in

Figure 10 shows (for the 41 industry sectors of our analysis, of which 17 are manufacturing) a strong correlation between: growth in intermediate demand (i.e. sales as inputs to production by all UK industries) for a given industry's product (whether in manufacturing or services); and, the growth in an industry's value added. For example, when a company or government department outsources its ICT function, value added is immediately transferred to the computing services industry. Of the 18 industries for which the (nominal) growth in demand for their product (as an input to production) grew by a rate faster than 5% pa 1995-2005, only four were manufacturing industries (manufactured fuels, manufacturing not elsewhere classified, pharmaceuticals and other transport equipment). Those industry sectors that saw the most rapid growth of intermediate demand *and* value added include those that have benefitted from outsourcing, for example, computing and other supporting business services.

The analysis of data for Scotland also shows a clear shift towards greater use of service inputs in production – in Scotland computing and other supporting business services saw the most rapid growth of intermediate demand *and* value added during 1998-2005.

Figure 10: UK growth in intermediate demand and value added, 1995-2005



Source: ONS Input-Output Analytical Tables 1995 and 2005.

Higher-tech manufacturing depends less on domestic outsourcing

In the UK, and in Scotland, higher-tech manufacturing:

- relies less on domestic outsourcing - it has a lower than average ratio of domestic intermediate purchases to gross output; and
- is more tradable - exports account for a larger proportion of output, and imported inputs (off-shoring) account for a larger proportion of intermediate purchases of goods and services.

In the UK, we saw that suppliers from overseas (i.e. off-shoring) accounted for a growing proportion of outsourced inputs to manufacturing as a whole, whereas this was not balanced by an increase in the share of UK manufacturing output that was exported. We observe a similar trend in UK *high-tech* manufacturing, and indeed the share of high-tech exports in output shrank during 1995-2005. So, there is no evidence that the UK was successfully specialising in adding value to and exporting high-tech products, which is the kind of specialisation one might expect to see (if production of high-tech products can be interpreted as 'knowledge-intensive'). However, it may be the case that our analysis by *industry sector* is not sufficiently identifying those manufacturing *activities* and *types* of products that are high-tech.

8. Supply-chain linkages

In this section we further analyse the input-output tables to investigate supply-chain linkages in more detail. We focus our analysis on the *domestic* use matrix which shows the purchases of products (goods and services) and primary inputs used in each industry's production process; that is, it describes the supply-chain linkages *within a given economy*.

Our analysis shows that:

- As a consequence of technological change and specialisation in trade: traditional manufacturing products are becoming less important as domestically-produced inputs; and manufacturing linkages within the UK economy have become more fragmented (manufacturing is relying increasingly on trade – particularly for imports to *supply* inputs to production).
- As a consequence of domestic outsourcing, those products that are becoming increasingly more important as inputs are principally (non-transport) services, and it is to other services that they are becoming more important (it is business-to-business purchases amongst services industries that have seen the greatest expansion).
- These broad trends have also been observed in Scotland.
- The patterns of change in Germany and the US were more similar to the UK than were those in Japan and France. In Japan and France, the disparities between manufacturing and services appear less distinct than in the UK.

'Old economy' products are becoming less important as inputs

In the UK over 1995-2005, the use of some domestically-produced goods as intermediate inputs to production grew relatively slowly or fell. These were typically 'old economy' products, several manufacturing, and their reduction in importance can be interpreted either as 'pure technological change' or the consequence of specialisation in trade (we no longer specialise in the industries that use these products as inputs). These products include (on the 41-industry classification): agriculture; coal; textiles, clothing & leather; basic metals; and wood & paper.

Services, some of which have benefitted from domestic outsourcing, are becoming more important as inputs

The products whose use as intermediate inputs grew most were certain (mainly non-transport) services. These products include: computing services; other business services; construction; and professional services. They were by no means all 'new economy' products. The trend changes in the importance of products as inputs to production were similar in Scotland to those in the UK. Note that in Scotland, the largest falls (1998-2005) of intermediate demand (from Scottish industries) were for electronics, reflecting the collapse of electronics production in Scotland during this time, and also pharmaceuticals products.

'Supporting' services industries are more dependent on intermediate demand than are manufacturing industries

Using the UK 1995 and 2005 IOATs[12] we use the same method as Harris[13] to calculate metrics to measure the relative (to the whole economy average) forward (a measure of 'dependence' on intermediate demand) and backward linkages ('dominance' over suppliers) of industries. The results are sensitive to the level of disaggregation used, as was noted by Harris. The broad sector results for 2005 (see Figure 11) show that: those broad sectors with the strongest forward linkages were financial & business services and manufacturing; and those with the strongest backward linkages were utilities (electricity, gas & water), construction and agriculture.

Figure 11: Relative forward and backward linkages by broad industry sector in the UK in 2005

Sector	Forward	Backward
Agriculture etc	0.64	1.12
Mining and quarrying	0.86	0.79
Manufacturing	1.37	0.98
Utilities	0.87	1.23
Construction	0.94	1.19
Distribution	0.83	0.94
Transport and Comms	1.01	1.00
Fin. & bus. Services	1.71	0.88
Govt & other services	0.77	0.89
Whole economy	1.00	1.00

Source: ONS Input-Output Analytical Tables 1995 and 2005.

The results are affected by scale as shown when the linkages are calculated by the 41-industry classification: only one manufacturing sector (food, drink & tobacco) features in the top-ten forward linkages and only two (food, drink & tobacco and non-metallic mineral products) feature in the top-ten backward linkages. It is 'supporting' services, such as land transport, distribution, professional and other business services, that have the strongest forward linkages because they are more dependent on intermediate demand than is manufacturing; manufacturing is more dependent on final demand, including exports. Those of the 41 industries that have the largest backward linkages, that is, they drive demand in the economy, are primary industries, construction and less traded manufacturing industries (food, drink & tobacco and non-metallic mineral products).

The results for Scotland show similar patterns to those in the UK of relative forward and backward linkages. In Scotland the only manufacturing sector amongst the top-ten forward linkages was chemicals, whilst those manufacturing industries amongst the top-ten backward linkages were food, drink & tobacco (as in the UK) and also wood & paper and chemicals.

[12] Input-Output Analytical Tables.
[13] See Harris (1987).

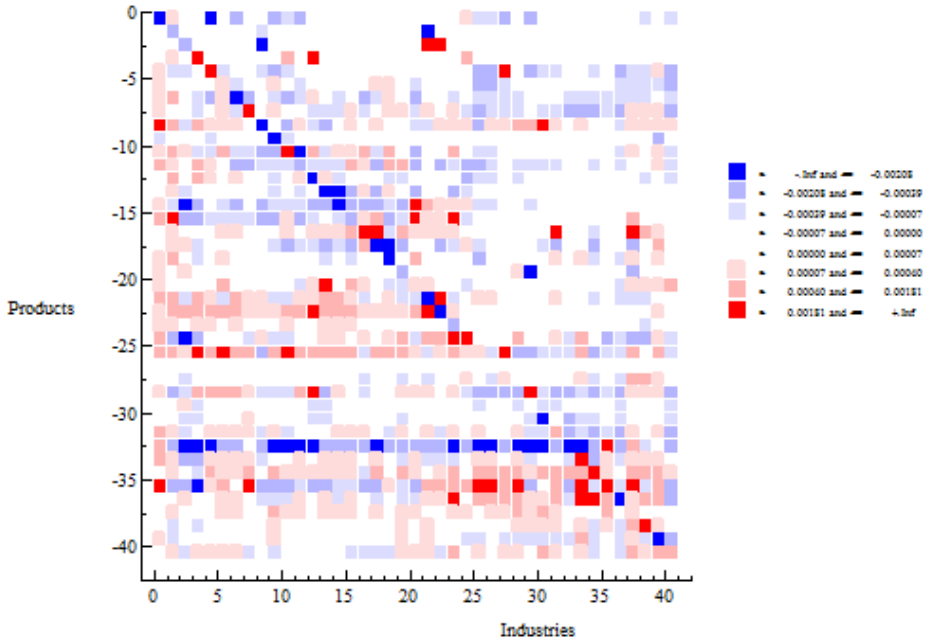
It is business-to-business purchases amongst services industries that have seen the greatest expansion

We can also look at input-output coefficients[14] to see which particular products are becoming increasingly important as inputs to which particular industries**.**

Figure 12 shows (for the 41 industry sectors of our analysis) the trend absolute annual changes 1995-2005 in UK input-output coefficients. Industries 1-4 are 'primary' (agriculture and extraction) ; industries 5-21 are manufacturing sectors ; industries 22-25 are construction and utilities; and industries 26-41 are services. Each blue block represents a negative value and each red block represents a positive value; the more intense the colour, the more rapid the change. The key points are:

- most of the declining values (blue) are in manufacturing, and most of the increasing values are in services
- there are many decreasing values in the row for banking & finance (the 33rd industry), indicating a diminishing importance of banking & finance products as an input to production for many industries
- the largest increases are in professional services (36th), computing services (35th), and other business services (37th), particularly in sales to other services industries
- the trend for sub-contracting within industries[15]:
    - amongst manufacturing was positive for food, drink & tobacco (5th), printing & publishing (8th) and most notably electronics (17th) and chemicals (11th)
    - amongst services was most positive for education (39th), insurance (34th), computing services (35th) and professional services (36th)

Figure 12: UK annual absolute changes in input-output coefficients, 1995-2005



Source: ONS Input-Output Analytical Tables 1995 and 2005.

[14] Input-output coefficients are calculated by dividing each column (industry) of the use table by the industry's gross output; the coefficients show what proportion of output is accounted for by intermediate purchases of different products (rows).

[15] See the leading diagonal of the matrix which represents purchases by an industry of its own products.

In Scotland, the patterns of change (1998-2005) are similar to those observed for the UK, those products that are becoming increasingly more important as inputs are principally non-transport services, and it is other services that are the customers for these purchases.

The patterns of change in purchases in Germany and the US were more similar to the UK than were those in Japan and France

The patterns of change (1995-2005) for Germany and the US have similarities to those in the UK. Most of the declining values of the input-output coefficients are in manufacturing, and most of the increasing values are in services. Sales of services to other services are becoming more important. In Germany, there are many decreasing values in the row for financial intermediation and very few increasing values in the rows for manufacturing industries, the exception being manufactured fuels (which likely reflects the increase in the oil price during this period). In the US, some of the largest positive values were for sales of financial and supporting business services to themselves and to public services.

For France and Japan, the disparities between manufacturing and services appear less distinct than in the UK. In France: there are more positive values in the top-left quadrant indicating a growing importance of sales of manufacturing products to manufacturing industries; and amongst services there were many decreasing values in the row for public administration (likely reflecting the fall of government spending during this period). In Japan: there are positive values in parts of the rows for manufactured fuels, chemicals and some engineering industries; and amongst services there were many increasing values in the row for other business services.

9. Conclusions

In this report we have presented a review and analysis of official data so to provide a narrative of recent macro-economic trends in the manufacturing sector. The analysis has identified a number of notable trends in how the UK's manufacturing base has been shaped by developments over recent decades. In this concluding section we summarise these trends, assess the extent to which they are likely to persist into the future, and highlight what the likely key challenges and opportunities are for the future of UK manufacturing.

Recent trends in UK manufacturing

Even after the sharp decline prompted by the recent global financial crisis, the level of UK manufacturing value added in 2012 was around 16% higher in inflation-adjusted terms than it was at the beginning of the 1970s[16]. However, the number of manufacturing jobs has followed a downward course due to the radical restructuring of traditional manufacturing particularly during the early 1980s and ongoing improvements in productivity growth.

What is well known, however; is that manufacturing has been declining in its value *share* of UK value added in recent decades whilst the growth of domestic and tradable services has outstripped that of manufacturing. This has been the case in both the UK and many other developed countries. But amongst the selected competitor countries reviewed in this report[17], it was the UK that experienced the sharpest relative decline of manufacturing's share of economy-wide value added and employment, and this decline accelerated after 2000.

During the 1990s, the output and trade of emerging economies expanded rapidly and eroded the UK's share of global exports (and that of many other advanced economies). The expansion of emerging economies accelerated the trend for manufacturing, and for other economic activity, to become increasingly traded (in both directions, but with stronger growth in imports in the UK). Since the early 1990s, the UK has had a widening deficit in its trade of goods (and this performance has been worse than in many competitor economies), but a growing surplus in the trade of services.

Part of the explanation for the worsening performance of UK manufacturing was the deterioration of our cost competitiveness compared with that of our competitors, to which sterling's appreciation in the second half of the 1990s contributed. The general trend through the 1990s, until the global financial crisis, was of a deterioration of the unit labour cost (ULC) competitiveness of UK manufacturing, and this was accompanied by a widening deficit on manufacturing's balance of trade.

There is some evidence that manufacturing sectors that are most cost-sensitive and subject to growing competition from emerging markets were amongst those that saw the more rapid deterioration of ULC competitiveness, and have consequently seen the weakest trade performance and output growth.

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[16] In 2007, prior to the crisis, manufacturing output was 27% higher than it was in the early 1970s.
[17] These are the US, France, Germany and Japan.

Technological change has been the driver of those manufacturing sectors that have seen the strongest output growth over the past three decades, and manufacturing has become increasingly specialised and knowledge based. However, the UK's record on R&D spending and indicators of innovation is less favourable than that in the selected competitor countries.

For analyses in this report, we use industry definitions to categorise manufacturing to three types: high-, medium- and low-technology. The premise is that there are certain advantages of high-technology manufacturing (e.g. global demand growth is strongest, high-cost countries could have a comparative advantage).

Compared to competitor countries, the UK has a relatively high concentration of manufacturing in high- and also low-technology sectors, but growth of UK high-technology manufacturing has been weaker than that of the selected competitors. Although, both Germany and Japan have a greater concentration of output and employment in medium-technology sectors, it is perhaps surprising that both countries have a sustained a relatively large and growing trade surplus in low-technology manufacturing.

But the official data used in this review can only take our analysis so far. To gain a better understanding of the transformation of manufacturing, we are also interested to distinguish (in a way that the industrial classification cannot) the *stages* in the supply chain (e.g. design versus assembly) and also the *types* of product (e.g. customised versus off-the-shelf).

Although our analysis of input-output data is subject to the constraints of industrial classifications, it does offer insights into how manufacturing supply chains have been shaped by developments over recent decades. As a consequence of technological change and specialisation in trade: traditional manufacturing products are becoming less important as domestically-produced inputs; and manufacturing linkages within the UK economy have become more fragmented (manufacturing is relying increasingly on trade – particularly for imports to *supply* inputs to production). Higher-tech manufacturing industries rely less on domestic outsourcing and are more tradable. Outsourcing has been a key factor driving the difference between the long-term rates of growth of value added of manufacturing and services: there has been a clear shift towards greater use of service inputs in production (e.g. the outsourcing of the ICT function from within a manufacturing firm to the computing services industry).

Trends that will shape the future of UK manufacturing

Shifts in global demand, driven by economic development and demographic change, will continue to shape the geographical source and the characteristics of global demand. The global share of demand from industrialised economies will shrink further and the importance of the BRICs and other emerging economies as markets will continue to grow. Demand for particular products and services will change in response to the aging population and, in emerging economies, the growth of the 'middle classes' (as per capita income grows).

Technological change will continue to be an important factor driving the fastest growing sectors in UK manufacturing. Those sectors likely to experience the fastest growth will be leaders of product and process innovation. In many of the emerging technologies already in the pipe-line (e.g. nanotechnology, digital and advanced materials, industrial

biotechnology, and low carbon technologies) the UK has the opportunity to build on its existing expertise and knowledge-base.

Recent trends in UK manufacturing suggest that our future successes will best be achieved by specialising in the R&D and design stage of the supply chain. Fragmentation of the supply chain appears to occur once products move to more mature stages when price-based competition becomes more important and once intellectual property is less of a concern. For example, in electronics the UK has not generally been able to retain price-sensitive activities (the *manufacture* of components and *assembly* into devices) but is a global leader in design (e.g. ARM, pharmaceuticals research). However, for some technologies successful design work is intimately related to the continued presence of the manufacturing process (e.g. Rolls-Royce).

To support effective R&D, the UK will need to preserve and expand its ***knowledge-base***. A success story of UK manufacturing has been that of the pharmaceuticals industry which has been fostered by biomedical research. As in other industries, such as electronics, the UK is less attractive as a location for the price-sensitive *manufacture* of pharmaceuticals, but it has mostly been able to retain R&D activities, by building on its existing knowledge-base and nurturing links between universities, entrepreneurs and industry.

However, for the past couple of decades the UK has underperformed in comparison to many of its competitors with regards to R&D expenditure and indicators of innovation (such as patents), and this, along with the current period of fiscal constraint, will challenge the UK's ability to preserve and build its knowledge base.

The ***global nature of supply chains*** will persist in the coming decades and our positioning in those supply chains will shape the nature of UK manufacturing as it has done in the past. In the near term at least, the UK is likely to remain a relatively high cost producer in the global market and so the success of our manufacturing will depend strongly upon our quality competitiveness. The expansion of globalisation and intensification of price-competitiveness in markets for commoditised goods has been a catalyst for UK manufacturing to specialise more in higher value-added and knowledge-based manufacturing and it has been typical that more price-sensitive activities such as mass-production have moved to lower cost locations. Indeed, for some manufacturers their strategy has depended on combining design work in the UK with manufacture in the Far East (e.g. Dyson).

Those manufacturing activities that remain in the UK will be those, for which the UK has a ***comparative advantage***. These will include activities where the UK has some combination of: an established presence (in terms of skills, expertise and networks); access to markets; and assets in terms of quality competitiveness. In some cases the growth of the UK domestic market can serve as an opportunity for UK-based firms to develop the expertise and scale required to compete effectively in the global market: the market for products and services to support a low carbon economy is a good example to illustrate the strengths to which UK manufacturing can play. A supportive policy environment has enabled the UK to develop expertise in off-shore wind engineering, building on its expertise in offshore oil. An example working in the opposite direction is the potential threat to UK-based pharmaceutical research coming from the importance of the US market (and hence the attraction of a US location for R&D).

Knowledge-based business services have become more integrated with manufacturing activity and will continue to make a growing contribution to the success of UK manufacturing through the improvement of the quality and marketing of manufactured outputs. Our analysis of supply chain linkages shows that those products that are becoming increasingly more important as inputs to manufacturing (and to other economic sectors) are principally non-financial business services (including knowledge-based services such as computing services, research and development, professional and consultancy services). In our input-output analysis, this outsourcing of activities from manufacturing firms to specialist services subcontractors shows up as a shift in value added from manufacturing to services, but the outsourced activities are essential to deliver the final demand for manufacturing.

As well as relying increasingly on services inputs, what are perceived as ***services occupations*** (e.g. managers, technical professionals, sales and customers services) now ***account for an increasing proportion of the UK's manufacturing workforce***. This reflects a number of drivers such as, the growing specialisation and knowledge-intensity of manufacturing, the increasing provision of support services to buyers of manufacturing products and the changing skills of the UK population. In the recruitment of technical professionals (e.g. engineers) with high-level STEM[18] skills, manufacturing will continue to compete with professional and financial services, though it is yet to be seen what will be the longer-term impact of the global financial crisis on the attractiveness of working in the City.

Closing remarks

To conclude, those key macro-economic drivers of change that have dominated recent decades are likely to remain those of most importance in the coming decades. Our review and analysis of official data has highlighted the manner in which the UK's manufacturing base has been shaped by these drivers and we have summarised what this can tell us about the future of manufacturing. Care needs to be taken when drawing a distinction between manufacturing and services as entirely different types of economic activity. Each is integral to the other in a global, knowledge-based economy.

[18] Science, technology, engineering and mathematics.

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