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Explaining export success in the UK and German medical equipment industry

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Introduction

This paper aims to provide a clearer understanding of the relative trade performances and technological competitiveness of Germany and the UK, with a particular emphasis on the role of product quality, innovation, skills and low-wage country competition. We first provide a broad overview of the manufacturing sectors in the two countries followed by a more detailed analysis based on case studies at the firm-level. The data-based overview is at a fairly aggregate level - i.e., high, medium and low-technology production categories - and compares and contrasts the technological composition and performance of the manufacturing sectors in the two countries (focussing on indicators such as R&D expenditure, investment, export shares, import penetration and exposure to low-wage country competition). Preliminary interviews with companies manufacturing medical equipment suggested that this sector would provide interesting examples at the level of the firm of the importance of factors such as innovation, skills and low-wage competition in determining trade performance across a broad range of high, medium and low-tech products. Hence the case-study analysis uses the medical equipment sector as an illustration of the manufacturing sector as a whole in the two countries.

The present study has two principal objectives: to improve understanding of the underlying determinants of export performance of the UK and Germany; and to gain empirical insights into the relative importance of different sources of improvements in competitiveness in explaining differences in the trade performance of the two countries. By identifying the factors in the two countries which significantly contribute to export success, we hope to provide policymakers with strategies designed to improve trade performance in both countries. We believe that our combination of data analysis at the sectoral level and detailed case studies provides a useful description of the trade performance and overall competitiveness of the two countries and reveals new insights, with useful policy implications, into the factors and mechanisms at the firm-level which cause these aggregate outcomes.

[*] National Institute of Economic and Social Research (London), and Deutsches Institut fuer Wirtschaftsforschung (Berlin), respectively. We would like to thank colleagues at both NIESR and DIW for their useful comments, but any errors are the responsibility of the authors. We are also grateful to the Anglo-German Foundation for providing the financial support for the research described in this paper.

The paper is organised as follows. Chapter 1 provides a broad overview of the performance of the manufacturing sectors in Germany and the UK. The analysis begins by calculating the sectoral composition of manufacturing in the two countries (i.e., we calculate the proportions of manufacturing output, investment, trade and R&D that can be defined as high, medium and low-tech). We then calculate capital/output ratios, export and import propensities and R&D intensities for these three broad categories of production. This is followed by an analysis of the time profile of export performance and R&D expenditure in order to judge whether there has been any improvement over time in the relative export performance of the two countries and whether there is any relationship between R&D expenditure and trade performance. Finally, we evaluate the impact of increased international competition from low-wage countries and whether the impact of such competition has been different across the manufacturing sectors of the two countries. Chapter 2 analyses the export performance of the medical equipment sector in the two countries in order to provide a detailed illustration of the strengths and weaknesses of the German and UK manufacturing industries. The chapter begins with a brief description of the medical equipment sectors in the two countries and takes a detailed look at their export shares and investigates whether there are any differences in the quality of their manufactures, and whether there are differences in the degree to which the products of Germany and the UK are exposed to low-wage country competition, by examining unit values at the detailed product-level. This is followed by the results of our detailed case studies based on interviews with companies manufacturing surgical products and diagnostic, monitoring and therapy equipment. Finally, we summarise our findings and provide some policy recommendations.

An overview of German and UK manufacturing performance

1. Trade, technology and industrial performance

There is some evidence that UK export performance has improved relative to her major competitors since the early-1980s (see Anderton, 1991 and 1992). Econometric analyses suggest that improvements in innovation or product quality - proxied by R&D expenditure - explain much of the UK's recent export success. The hypothesised relationship between technological competitiveness - i.e., the use of new technology and innovation, etc - and trade performance is based on the new trade theories of Grossman and Helpman (1995) and Krugman (1983, 1989). In the Grossman and Helpman model, consumers choose between goods on the basis of both quality and price, and firms understand the importance of constant innovation as they realise that any single innovation will eventually become obsolete because of continual technical improvements by competitors. Innovation-enhancing activities, such as spending more on R&D, therefore enable firms to manufacture state-of-the-art products and thus improve product quality, and export sales, relative to competitors.[1] Furthermore, quality differences and product heterogeneity may also be important at the lower-tech end of the market. For example, Helpman and Krugman (1985) describe how the magnitude of the impact of increased price competition from low-wage countries (LWCs) varies according to the degree to which products of the LWCs and those of the industrialised countries are differentiated.

Therefore, before proceeding to the case studies, it is both informative and useful to gain a broad understanding of the trade and industrial performance of Germany and UK at the more aggregate level. Consequently, this section provides a broad overview of the trade performance and technological competitiveness of Germany and the UK over the past two decades. By separately examining high, medium and low-technology industries we hope to identify some of the sectoral strengths and weaknesses of the British and German manufacturing sectors, and to evaluate whether there has been any change in the relative performances of the two countries in recent years.

The contents of this chapter are as follows. Section 2 compares the technological structure of the manufacturing sectors in Germany and the UK (i.e., we calculate the proportions of output, trade and R&D expenditure accounted for by the high, medium and low-tech sectors). Section 3 compares the export and import propensities of the three sectors as well as capital/output ratios and R&D intensities

[1] Econometric results in Anderton (1999) show a strong positive relationship between R&D expenditure and the trade performance of the UK and Germany.

in the two countries. Section 4 compares the export performance of the two countries over time and investigates whether this is influenced by R&D expenditure, whereas section 5 examines the degree to which the manufacturing sectors of the two countries are prone to competition from low-wage countries. This is followed by a summary and interpretation of the results.

2. Technological structure of manufacturing output, investment, exports, imports and R&D expenditure in Germany and the UK

A first step towards understanding differences in the technological competitiveness of Germany and UK is to compare the sectoral composition of the manufacturing sectors in the two countries. Consequently, in this section we calculate the proportions of total output, trade and R&D expenditure, etc, that can be allocated to high, medium or low-tech sectors. For example, column (1) of Table 1 shows us how much of total manufacturing output is accounted for by low, medium and high-tech sectors in the two countries.[2] Averaging over a lengthy sample period, we find that output in the low-technology sectors accounts for about 55% of total UK manufacturing output, but only 48% of German production - suggesting that the UK has a relatively lower-tech manufacturing sector compared to Germany. However, this is only part of the story: although a larger proportion of Germany's production is devoted to the medium-tech sectors, both countries actually have similar output shares for the high-tech industries.

Table 1: Shares of high, medium and low-tech sectors in total manufacturing GDP, investment, exports, imports and R&D 1976-1992

Sector	(1) Output		(2) Investment		(3) Exports		(4) Imports		(5) R&D	
	GE	**UK**	**GE**	**UK**	**GE**	**UK**	**GE**	**UK**	**GE**	**UK**
L	0.48	0.55	0.42	0.48	0.29	0.30	0.46	0.40	0.08	0.09
M	0.38	0.31	0.39	0.34	0.53	0.45	0.34	0.39	0.48	0.27
H	0.14	0.15	0.18	0.18	0.18	0.25	0.20	0.22	0.45	0.65

Notes: **H**=high-tech sectors; **M**=medium tech sectors; **L**=low-tech sectors. Authors' calculations based on the OECD's STAN, trade and ANBERD databases.

[2] The sectors comprising the high, medium and low-tech industries are as follows: ***Low-tech*** - ISIC 31 (food, drink and tobacco), ISIC 32 (textiles, footwear and leather), ISIC 33 (wood, cork and furniture), ISIC 34 (paper and printing), ISIC 353+354 (petroleum refining), ISIC 36 (stone, clay and glass), ISIC 371 (ferrous metals), ISIC 381 (fabricated metal products), ISIC 3841 (shipbuilding); ***Medium-tech*** - ISIC 351+352-3522 (chemicals), ISIC 355+356 (rubber and plastic), ISIC 372 (non-ferrous metals), ISIC 382-3825 (non-electrical equipment), ISIC 3842+3844+3849 (other transport), ISIC 3843 (motor vehicles), ISIC 39 (other manufacturing); ***High-tech*** - ISIC 3522 (pharmaceuticals), ISIC 3825 (computers and office machinery), ISIC 383-3832 (electrical machinery), ISIC 3832 (communications and semi-conducters), ISIC 3845 (aerospace), ISIC 385 (instruments).

A similar story can be told for investment shares as investment in low-tech sectors accounts for a greater proportion of total UK investment relative to Germany (48% compared to 43%), but the proportion of investment in the high-tech sectors is again the same in both countries. In contrast, we see that high-tech exports account for a considerably larger proportion of UK total exports relative to Germany (i.e., 25% compared to 18%) - with Germany having a correspondingly larger proportion of exports accounted for by the medium-tech sector. In terms of import shares, the share of German imports of low-tech products is greater than that for the UK (approximately 46% compared to 40%), with the UK having correspondingly higher import shares for the high and medium tech sectors. Finally, Table 1 shows that there are quite extreme differences between Germany and the UK in terms of the sectoral composition of R&D expenditure which seems to explain the sectoral differences in export share between the two countries. Although the share of total R&D expenditure carried out in the low-tech sectors is the same in both countries (around 8%), the high-tech sectors account for about 65% of R&D expenditure in the UK compared to about 45% in Germany. Again, the medium-tech sectors are relatively more important in Germany and account for about 47% of total German R&D expenditure, compared to around 27% for the UK.

3. Investment, exports, imports and R&D as proportion of sectoral output

In this section we continue our analysis of the technological competitiveness of Germany and the UK by comparing investment/output ratios, R&D intensities and import and export propensities across our three sectors. Table 2 shows that over the whole sample period, each of the three German manufacturing sectors invested a higher proportion of gross manufacturing output relative to the UK. Although capital/output ratios are not all that different in medium-tech sectors in the two countries, German high-tech sectors exhibit a higher investment ratio relative to the UK.

Table 2: Investment, exports, imports and R&D as proportion of gross output 1976-1992

Sector	(1) Investment		(2) Exports		(3) Imports		(4) R&D	
	GE	**UK**	**GE**	**UK**	**GE**	**UK**	**GE**	**UK**
L	3.9	3.4	17.1	13.3	19.4	19.6	0.3	0.3
M	4.5	4.4	40.1	35.9	18.1	35.2	2.5	1.6
H	5.5	4.5	35.9	40.7	27.8	39.7	6.2	7.9
Total	4.3	3.9	28.1	24.3	20.1	27.5	2.0	1.8

Notes: **H**=high-tech sectors; **M**=medium tech sectors; **L**=low-tech sectors. Authors' calculations based on the OECD's STAN, trade and ANBERD databases.

Table 2 also shows that Germany exports a higher proportion of manufacturing gross output than the UK (i.e., a sample average manufacturing export propensity of around 28% compared to 24%), but this differential is mainly accounted for by a higher export propensity of German low and medium-tech products as UK high-tech categories export a higher proportion of their output relative to Germany. The figures show that the UK seems more prone to import penetration than Germany as the import propensity of UK manufacturing is around 27% compared to 20% for Germany. Although the import propensity for the low-tech sectors is roughly the same for both countries, UK import propensities for high and medium-tech industries are much higher at around 40% and 35% respectively, compared to 19% and 28% for Germany. Research and development expenditure as a proportion of total manufacturing gross output is about a quarter of a percentage point lower in the UK in comparison to Germany (i.e., 1.75% compared with 2%). However, one major difference that should be noted is that the R&D intensity in the UK high-tech sectors is much higher relative to Germany (i.e., almost 8% compared with 6%), whereas Germany's R&D intensity in the medium-tech industries is about one percentage point higher than the UK's (2.5% compared to 1.6%).

The above data point to several conclusions. First, the UK's relatively good export performance in the high-tech sectors seems to be directly related to the UK's higher R&D intensity in those sectors. However, this may not necessarily imply that increases in R&D expenditure cause an improvement in export performance, it may simply be the case that higher R&D expenditure requires substantial additional sales - which, in the case of a small country, can only be achieved by increasing exports - in order to recover the costs of the R&D expenditure. Second, in terms of capital expenditure, Germany has a higher capital/output ratio in the high-tech sectors relative to the UK. This may be consistent with frequent claims that, although the UK may be relatively good at creating innovations by carrying out R&D, UK firms are not as good as German firms at translating the R&D into profitable production (which requires a higher rate of capital investment). Third, Germany seems to have a superior manufacturing trade performance compared to the UK as it has a higher overall export propensity and lower import propensity, furthermore it shows a particularly strong trade performance in the medium-tech sectors. This seems to be consistent with claims that the UK has a sufficient number of high-tech 'top class' companies, but that the UK needs to improve its technological competitiveness in the medium-tech sector, particularly as this sector accounts for around a third of UK manufacturing production.

4. Time profile of export performance and R&D expenditure

In this section we take a look at changes in the export performance and R&D expenditure of Germany and the UK over time. Chart 1 below shows the total manufacturing exports of Germany and the UK expressed as a proportion of total manufacturing exports for the G7 countries.[3] The German share of G7 exports is approximately twice as large as that of the UK - which reflects the fact that Germany has a larger industrial sector than the UK and a higher export propensity.[4] We also see that the German share increased in the early 1980s and stabilised at this higher level throughout the rest of the 1980s and early 1990s, whereas the UK lost share at a rapid rate in the second half of the 1970s and early 1980s and then stabilised during the remainder of the period. Charts 2 and 3 show the exports of Germany and the UK expressed as a proportion of G7 exports for the high, medium and low-tech sectors (i.e., this measure proxies the two countries share of world exports). Again, the charts show that Germany has a higher export share in every sector relative to the UK. However, there are important sectoral differences between the two countries: first, the medium-tech sector accounts for the largest share, among the three technology categories, of G7 exports for Germany with the high-tech sectors accounting for the lowest export share; second, for the UK the shares of the sectors as a proportion of G7 exports are each very similar but - in complete contrast to Germany - it is the high-tech sector where the UK has the highest share. Finally, Chart 4 shows these same sectoral shares for Germany relative to the UK. For example, the chart shows that the German share of world medium-tech exports is around two and a half times as large as the UK share and about twice as large for the low-tech sector, whereas the differences in shares for the high-tech sector is much smaller (i.e., only about twenty five per cent higher for Germany) - reflecting the UK's relatively good export performance in this sector. All three sectors show a decline in UK export share relative to Germany in the early 1980s followed by a stabilisation in share during the rest of the period. The UK high-tech sectors also seem to have regained some of the earlier losses in share.

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[3] The G7 member countries are as follows: United Kingdom, Germany, France, Italy, United States, Canada and Japan.

[4] See Anderton and Mayhew (1994) who show that 'industry' accounted for around 28% of total employment in the UK in 1991, whereas the corresponding figure for Germany is over 10 points higher at around 39%.

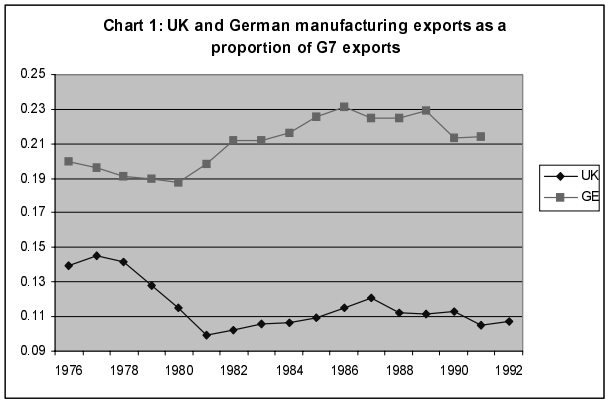
Chart 1: UK and German manufacturing exports as a proportion of G7 exports
0.25
0.23
0.21
0.19
0.17
0.15
0.13
0.11
0.09
1976 1978 1980 1982 1984 1986 1988 1990 1992
UK
GE

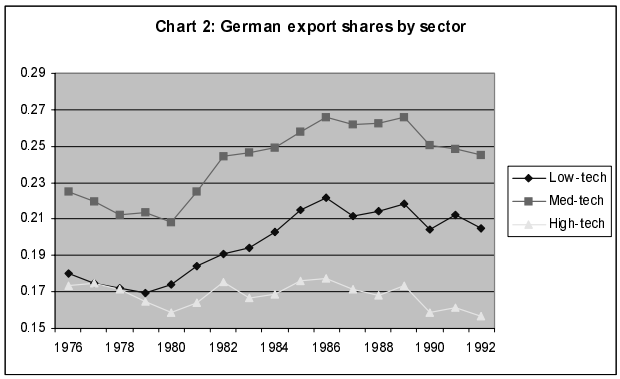
Chart 2: German export shares by sector
0.29
0.27
0.25
0.23
0.21
0.19
0.17
0.15
1976 1978 1980 1982 1984 1986 1988 1990 1992
Low-tech
Med-tech
High-tech

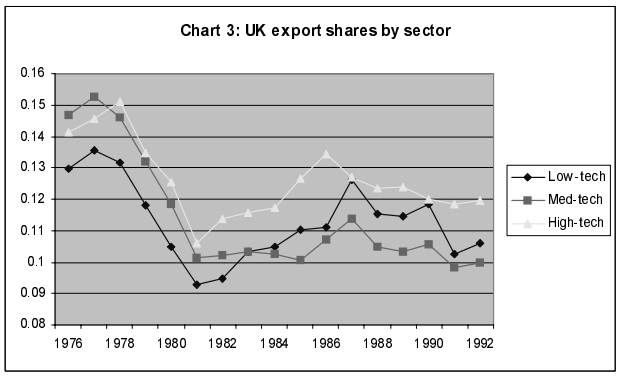
Chart 3: UK export shares by sector
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
1976 1978 1980 1982 1984 1986 1988 1990 1992
Low-tech
Med-tech
High-tech

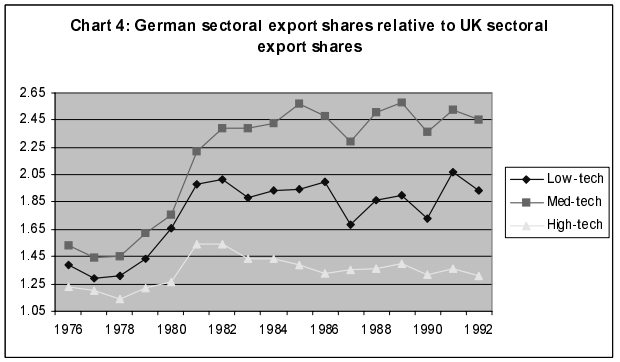
Chart 4: German sectoral export shares relative to UK sectoral export shares
2.65
2.45
2.25
2.05
1.85
1.65
1.45
1.25
1.05
1976 1978 1980 1982 1984 1986 1988 1990 1992
Low-tech
Med-tech
High-tech

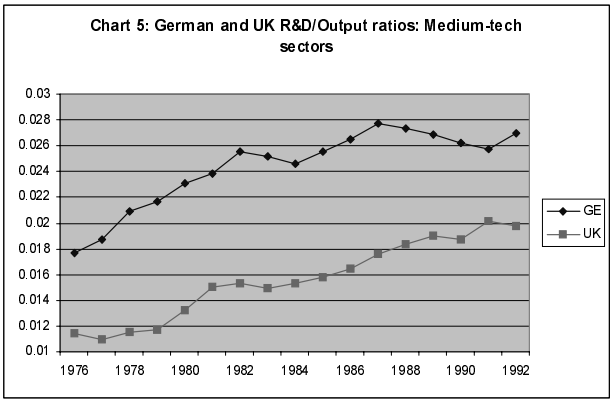
Chart 5: German and UK R&D/Output ratios: Medium-tech sectors
0.03
0.028
0.026
0.024
0.022
0.02
0.018
0.016
0.014
0.012
0.01
1976 1978 1980 1982 1984 1986 1988 1990 1992
GE
UK

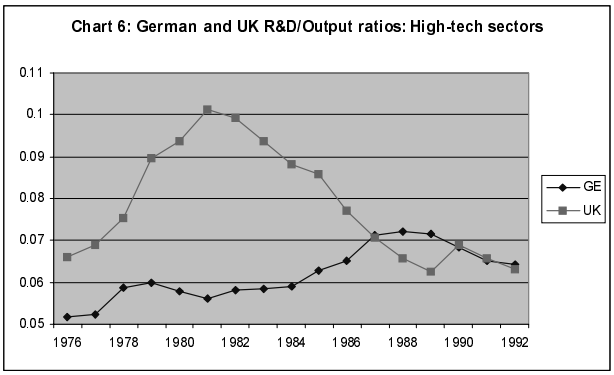
Chart 6: German and UK R&D/Output ratios: High-tech sectors
0.11
0.1
0.09
0.08
0.07
0.06
0.05
1976 1978 1980 1982 1984 1986 1988 1990 1992
GE
UK

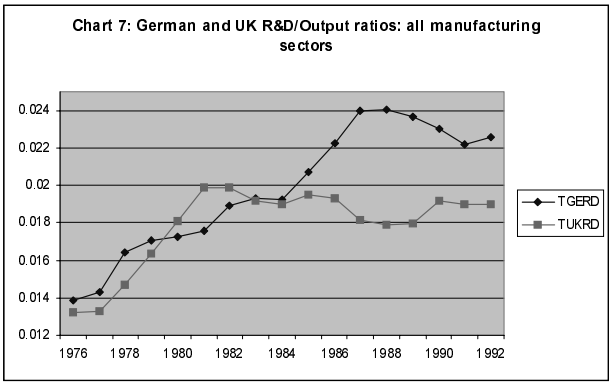
Chart 7: German and UK R&D/Output ratios: all manufacturing sectors
0.024
0.022
0.02
0.018
0.016
0.014
0.012
1976 1978 1980 1982 1984 1986 1988 1990 1992
TGERD
TUKRD

Charts 5 to 7 show R&D as a proportion of output for the two countries. One clear trend is that R&D ratios are rising over time. Chart 5 shows that Germany spends substantially more on R&D in the medium-tech sectors relative to the UK, but Chart 6 reveals that for most of the sample period the UK had a much higher R&D expenditure intensity compared to Germany for the high-tech sectors - which may in the long-run partly explain why the UK's export performance in the high-tech sectors is better than in the other two sectors. The final chart shows total manufacturing R&D ratios for the two countries. It seems that the UK's R&D ratio grew in line with Germany's until the mid-1980s after which the UK's R&D ratio stopped growing and stabilises at just under 2%, whereas Germany's ratio reaches a higher level of around two and a quarter per cent by the end of the sample period.

5. Exposure to competition from low-wage countries

In this section we try to gain a rough idea of the impact of increased international competition from low-wage countries on the manufacturing sectors of the UK and Germany and whether the impact of such competition has been different between the two countries. For example, if German products are on average, of higher quality than British products, as claimed by Jarvis and Prais (1996), it may be the case that German products are not so exposed to competition from the (supposedly) lower-quality products of the LWC's to the same degree as British manufacturers. An insight into how increased competition from LWCs may have had a differential impact on German and British manufacturers can be gained by looking at the impact of imports from LWCs on the domestic manufacturing sectors of the two countries. For example, if trade opens up between high and low-skill regions, the Stolper-Samuelson theorem predicts that the relative domestic price of low-skilled-intensive manufactures will decline in the high-skill regions (eg, Germany and the UK).[5] However, the magnitude of the above effect depends on the degree to which the traded goods are differentiated (see Helpman and Krugman, 1985). Hence, if UK products are fairly homogeneous relative to those of the LWCs, and German manufactures are much more differentiated due to quality differences, we should see a decline in the relative domestic price of those products within the UK, but not in Germany.

[5] See Sachs and Shatz (1996) for a more detailed description of the Stolper-Samuelson theorem.

Table 3: Import share of low-wage countries

	UK			Germany		
	1980	**1993**	**80-93**	**1980**	**1993**	**80-93**
Textiles						
3211	27.0	41.6	14.6	25.8	21.7	-4.1
3212	48.2	60.9	12.6	44.4	35.5	-8.8
3213	24.2	51.0	26.8	27.7	29.0	1.4
3214	21.0	25.8	4.7	41.2	54.8	13.6
3215	23.7	22.3	-1.4	64.3	33.0	-31.3
3219	14.6	29.4	14.9	15.0	17.6	2.6
Clothing						
3220	58.1	70.6	12.5	47.6	56.5	9.0
Leather						
3231	39.3	37.3	2.0	24.5	27.5	3.1
3232	22.2	48.8	26.7	27.5	43.0	15.5
3233	71.6	77.2	5.6	56.3	72.9	16.6
Footwear						
3240	24.3	41.3	16.9	24.4	38.1	13.7
Wood products						
3311	49.4	56.5	7.0	50.9	28.9	-22.1
3312	52.6	81.4	28.8	59.2	77.9	18.6
3319	29.3	54.8	25.4	31.5	47.2	15.7
Furniture						
3320	20.4	32.6	12.2	24.8	32.5	7.7
Non-electrical machinery						
3821	20.7	40.9	20.2	25.4	26.5	1.1
3822	7.1	21.3	14.2	16.4	20.5	4.1
3823	18.2	30.8	12.6	35.6	15.9	-19.7
3824	14.4	29.0	14.6	25.3	12.0	-13.3
3825	9.3	36.8	27.5	8.7	39.6	30.8
3829	12.8	27.5	14.7	22.8	16.8	-6.0
Electrical machinery						
3831	12.6	34.8	22.2	30.4	23.6	-6.8
3832	21.9	41.5	19.6	22.7	33.0	10.3
3833	9.9	25.8	15.9	18.5	24.2	5.7
3839	11.7	27.9	16.2	24.6	32.2	7.6

Notes: First column of table shows sector and 4-digit ISIC code. First two columns for each country show the share of imports accounted for by LWCs for the years 1980 and 1993, whereas the third column shows the percentage point change in that share between 1980-1993. Data for Germany represent West Germany until 1990 and unified Germany from 1991 onwards. *Source*: Authors' own calculations based on OECD SITC trade data converted to ISIC.

Table 3 shows the share of imports from LWCs for Britain and Germany between 1980-1993 for a selection of 4-digit level industries (where the specific sectors are chosen to illustrate a variety of levels of technology, i.e., electrical and non-electrical machinery sectors represent high-skill-intensive and medium-skill-intensive industries respectively, and the remaining sectors proxy low-skill-inten-

sive industries).[6] The first two columns for each country show the share of imports accounted for by LWCs for the years 1980 and 1993, with the third column showing the change in share over those years. The medium and high-skill-intensive sectors tend to exhibit lower import shares for the LWCs - confirming our expectation that these sectors are less prone to import penetration from low-wage countries. One noticeable trend is that over the sample period the import share of LWCs increased in virtually all of the 25 sectors for the UK, whereas increases only occurred in two-thirds of the German sectors. Furthermore, by 1993 the share of imports coming from LWCs was higher in the UK relative to Germany in 21 out of the 25 sectors, providing some evidence that British industry is more susceptible to competition from LWCs than Germany. Furthermore, the table shows that an increase in import competition from LWCs is also apparent in the high-skill-intensive sectors, particularly for the UK.

Given the increased presence of low-wage countries as a source of imports, particularly for the UK in the 1980s, our next step is assess the impact of changing trade shares on the price of imports in the two countries.[7] We attempt a fairly crude analysis of what would have happened to import prices if the share of low-wage countries had remained constant by separating out from the sectoral import price index those changes due to movements in import shares and changes due to movements in actual prices.[8] We then show what would have happened to the aggregate price index by 1993 if trade shares had remained the same as in 1980. The basic assumption is that the price of imports, even for quite narrowly defined products, varies between high and low-wage country suppliers. Unfortunately, our analysis cannot provide unambiguous evidence of the role of low-wage countries in influencing the import prices of industrial countries as any change in import shares may also represent substantial changes in the type of product imported. However, the results are informative because the approach allows us to assess the extent to which increases in the price of imports of low-skill products have been constrained by a shift in demand towards cheaper sources of supply.

The import price columns in Table 4 show the extent to which the unit value index would have been higher or lower if the mix of supplying countries had remained unchanged at their 1980 shares (we show the figures at the 3-digit level so that we can compare import price changes with domestic rela-

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[6] The LWCs are the non-OECD countries and the OECD countries are defined as the members of the OECD up to and including 1993 (i.e., excluding later members such as the Czech Republic, Hungary, Poland, South Korea and Mexico).

[7] As data on the actual prices of imports are unavailable, in common with other studies, we use unit values (value per unit of volume) to proxy import prices.

[8] In other words, we calculate the difference between the unit value index and the Tornqvist index. A full description of this technique is described in Aw and Roberts (1986).

tive prices).[9] For example, the table reveals that for UK imports of textiles the import price would have been almost 14 per cent higher if the composition of import shares had not moved in favour of LWC suppliers.[10] In general, the impact on import prices is marginally greater in the low-skill-intensive sectors, but there does not seem any striking difference in the two countries in terms of the impact of LWCs on import prices.

Table 4: Counterfactual import price and actual relative domestic prices 1980-93

- percentage change -

Sector	Germany		United Kingdom	
	Counterfactual import price[a]	Actual dom. price[b]	Counterfactual import price[a]	Actual dom. price[b]
Textiles	-5.0	-17.6	13.8	37.8
Clothing	12.4	14.1	11.8	0
Leather	20.6	-15.6	-10.4	-7.1
Footwear	9.3	8.3	9.9	34.0
Wood, products	7.0	0	-5.2	-8.5
Furniture	13.8	28.6	43.5	32.5
Non-elect. mach.	10.6	3.0	5.4	5.0
Elect. machinery	-0.9	-16.8	5.8	-36.7

Notes: [a] Calculation of extent to which import price index would have been higher if share of LWCs in imports had remained at 1980 levels (i.e., the UK import price of textiles would have been 13.8 percentage points higher in 1993 if the share of UK imports of textiles from LWCs had not changed from its 1980 value). [b] Percentage change in the domestic sectoral price value of added output relative to the output price of total manufacturing (*Source*: OECD STAN database).

Finally, table 4 also shows the change in the price of value added for the sectors relative to the average price of value-added for manufacturing as a whole. According to the Stolper-Samuelson theorem, if domestic products are not sufficiently differentiated from those of LWCs then the downward pressure on the import prices caused by the increasing import share of LWCs should depress the relative domestic price of those sectors most affected. However, this relationship is only apparent in one or two sectors (eg, German leather products and British electrical machinery). In most cases, the downward pressure on import prices caused by an increasing share of imports from LWCs corresponds to an increase in the relative price of the domestic product - which is the opposite of what the Stolper-Samuelson theorem predicts. However, these relative domestic price movements may capture other responses to increased competition from LWCs. For example, if domestic firms manufacturing lower quality products in a particular sector are forced out of business by imports from LWCs (thereby

[9] Reliable domestic manufacturing prices are only available at the 3-digit level.
[10] However, some of the individual prices at the 4-digit level for, say, textiles would have been up to 25 per cent higher if the import share of low-wage countries had remained at their 1980 values.

leaving a greater proportion of domestic firms producing higher-quality products) - or if domestic firms simply upgrade the quality of their products to escape import competition from LWCs - the relative domestic price of these products may actually *rise* rather than fall.

Summary

1. Germany seems to outperform UK manufacturing according to several measures: first, Germany spends more on both investment and R&D as a proportion of manufacturing output relative to the UK; second, a relatively larger proportion of UK manufacturing production is concentrated in the low-tech sectors - suggesting that Germany has, on average, a higher-tech manufacturing sector than the UK; third, Germany's manufacturing sector exports a larger proportion of its output relative to the UK; fourth, Germany's share of the total manufacturing exports of the G7 countries is about twice as large as the UK's share. However, the UK's export performance did stop deteriorating relative to Germany in the 1980s.
2. The UK performs relatively well in the high-tech sectors. For example, the UK's R&D intensity in the high-tech sectors is substantially higher than in Germany. Furthermore, the UK's export propensity in the high-tech sectors exceeds that in the lower and medium-tech sectors. In the case of Germany the order is reversed. Although Germany's manufacturing sector has a higher overall export propensity and lower import propensity, it shows a particularly strong trade performance in the medium-tech rather than high-tech sectors (which is an advantage in the sense that production in the medium-tech sectors is twice the size of the high-tech sectors).
3. Germany has a higher capital/output ratio in the high-tech sectors relative to the UK. This may be consistent with frequent claims that, although the UK may be relatively good at creating innovations by carrying out R&D, Germany is better at translating the R&D into profitable production (which requires higher capital expenditure).
4. Another characteristic of the two countries which is apparent when looking at the time profile of both exports and R&D is that the UK is much more unstable in terms of export performance and R&D expenditure.
5. The UK's manufacturing sector seems to be more prone to competition from low-wage countries relative to Germany (if we use the LWCs share of total imports as our measure of competition).

Case studies of the export performance of medical equipment companies in Germany and the UK[11]

Introduction

For many years the medical equipment industry has been characterised by substantial world-wide growth, but ongoing cuts in public health expenditure have dampened this growth somewhat in recent years.[12] Under these circumstances, medical equipment producers have sought to increase their sales by means of increasing exports. Issues of international competitiveness have thus become ever more important in this sector. We therefore use this sector as an illustration of the manufacturing sector as a whole in the two countries in order to gain a detailed firm-level insight into the importance of factors such as product quality, innovation and skills in determining trade performance; and how these factors explain differences in the export performance of Germany and the UK. Since some segments of the medical equipment sector are now experiencing competition from low-wage countries as fierce as elsewhere in manufacturing, this sector provides the additional opportunity to investigate whether the responses to this growing challenge differ between the two countries. We begin by providing a brief summary of the medical equipment sectors in the two countries, we then analyse export shares for the UK and Germany at the detailed product-level and evaluate whether there is any evidence for differences in the 'quality' of their manufactures by comparing export unit values. Finally, we describe the results of our firm-level case studies.

The medical equipment industry

The European medical equipment-producing industry is extremely heterogeneous. It consists primarily of many small and medium-sized firms which concentrate on individual product lines or seek to

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[11] We are grateful above all to the variety of manufacturing companies we interviewed in the two countries. In keeping with our original arrangements, they shall remain unidentified throughout, yet we feel bound to acknowledge their valuable openness and co-operation - without which this project would not have been possible. Also worthy of thanks are the managers of trade associations and their deputies for the information and advice received, in particular: Ms. Meyer-Schuelke and Mr. Bursig (ZVEI), Mr. Meyer-Lueerssen (VDGH), Dr. Pohlen, Mr. Wenzel and Ms. Abraham (F+O), and Ms. Hochmeister (BVMed) in Germany; Mr. Gordon Aylward of the ABHI, Ms. Carol Kirkland of the Institute of Exporters in Britain. The trade associations of Freiburg i.B. and Villingen-Schwenningen proved particularly helpful. Thanks are also due to staff at both the UK Department for Trade and Industry and the Department of Health.

[12] Despite healthcare expenditure cutbacks in many countries over the past decade, the global medical equipment market grew by 7% in 1993 (compared to 1.2% for the world economy as a whole) to around 80 billion ECU in 1993, with the EU accounting for approximately 31% of the world market - just behind the largest purchaser, the USA with around 40% of world expenditure. Employment in the EU medical equipment sector grew by around 7% between 1990-94, compared to almost a 14% decline in EU manufacturing as a whole (*Source*: European Commission, 1998).

supply particular geographical regions, together with a small number of very large - often multi-national - firms with a wide product range. Europe-wide around 5,500 manufacturers of medical products employ some 240,000 employees. In 1993, R&D costs among European medical equipment producers amounted to roughly 5% of turnover.[13]

The heterogeneous structure of the European medical equipment industry is illustrated by the various types of product available - from the relatively uncontested markets for say, fixed endoscopic devices (where the two major German producers supply roughly 70 per cent of the world market[14]), to the market for small medical instrumentation and single use disposables, which used to be a stronghold of a variety of small firms Europe-wide, but is now increasingly subject to growing competition from the emerging industrialising economies, such as Pakistan, Malaysia and Indonesia. For example, Malaysia accounts for between 4-5% of EU imports in low-tech sectors such as needles, catheters, cannulae, etc, and transfusion apparatus (other notable countries active in these product areas are Brazil, Singapore, South Korea, etc). Pakistan accounts for around 1% of EU imports of 'instruments and appliances used in medical, surgical and veterinary sciences' (however, this is a category which includes higher-tech equipment as well as lower-tech products - such as simple scalpels - where Pakistan is a more important supplier).

The UK medical equipment sector consists of around 1,600 firms - primarily small companies (three quarters of these firms had turnover of less than £1 million in 1995) - employing around 50,000-60,000 people.[15] Output amounted to about £2.7 billion in 1995 - equivalent to around one per cent of total UK manufacturing production. The largest medical equipment-producing sub-sectors in the UK are hospital equipment (eg, hospital beds, operating tables, sterilisers, hospital lighting, etc), 'single-use disposables' (eg, catheters, needles, syringes, dressings, etc) and in vitro (IV) diagnostic equipment (for testing blood and urine specimens). Around 50% of UK medical equipment companies engage in their own R&D, spending, on average, around 5% of turnover on R&D activities, but R&D spending varies widely according to which branch of medical equipment one looks at - eg, R&D expenditure accounted for 13% of sales in IV diagnostics in 1995, but only 2-5% in areas such as surgical instruments and single-use disposables.[16]

Approximately 60% of UK medical equipment production is exported and the sector was in trade surplus in 1995. Sub-sectors which include high-tech products - such as anaesthetic/respiratory, den-

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[13] *Source*: LEK (1997).
[14] European Commission, 1998, p. 16-14.
[15] *Source*: Keynote Report (1996).
[16] All UK R&D statistics relate to 1995 (*source*: Department of Health, 1997). For various reasons, the R&D

tal, electro-medical and IV diagnostic equipment - generally contain a high proportion of exporting firms, but so do many sub-sectors which make standardised low-cost products such as surgical instruments and single use disposables. The major UK export market is Western Europe (particularly Germany, France, Spain, Italy and Ireland) but other important (and growing) export markets also include South East Asia, the Middle East and the USA.

There are roughly 500 medical manufacturing companies in Germany (around 90 per cent in the former 'West'), ranging from small specialist manufacturers to large industrial conglomerates, providing employment for about 80-90,000 workers. Most are exclusively German-owned. Germany has a well developed medical manufacturing base - considered to be one of the country's most successful industries.[17] However, as a consequence of cost cutting in the German health care system, the market growth for electro-medical and other medical equipment has been sluggish in recent years. Some German manufacturers are still engaged in the provision of conventional output such as scalpels and blades, rigid endoscopes, and laboratory instruments used in GP offices while, at the same time, a much higher and rising proportion of total production is concentrated in the more sophisticated output of the new technology items such as computer tomography (CT) scanning, magnetic resonance imaging (MRI), and digital subtraction radiographic equipment.

Total output of the German medical equipment sector was roughly 25 billion DM in 1995/96.[18] Exports account for slightly over half of total output - with substantially higher export rates in certain product markets. Main export markets are the other member countries of the EU (accounting for around one third of total exports), with a further 20 % to other European destinations. The most important single export market is the United States, which alone accounts for around a quarter of all German medical equipment sold abroad. The other major single market is Japan.

R&D expenditure in the German medical equipment sector averages around 10 per cent of sales, ranging from around 5 per cent of turnover in the precision engineering branch of medical equipment production, to roughly 20 per cent in the field of IV diagnostics.[19]

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statistics may not be directly compatible across the countries mentioned.

[17] See Simpkins & Stevens, 1990.

[18] The figure has been composed from different sources which overlap substantially in their reporting.

[19] Verband der deutschen feinmechanischen und optischen Industrie eV, *Jahreszahlen 1996* (Cologne 1997). Stifterverband fuer die Deutsche Wissenschaft, *Forschung und Entwicklung in der Wirtschaft 1995 bis 1997; Bericht ueber die FuE-Erhebung 1995 und 1996*. Wissenschaftsstatistik GmbH im *Stifterverband fuer die Deutsche Wissenschaft*, Essen 1998.

German and UK exports of medical equipment

Columns 1 and 2 of Table 5 show German and UK exports as a proportion of EU exports for various segments of the medical equipment sector for the period 1988-1994 (with the top half of the table broadly representing higher-tech products, and the bottom half showing lower-tech products). A striking feature of the data is that Germany tends to account for a higher/lower proportion of EU exports in high-tech/low-tech product areas whereas the opposite is true for the UK (although a notable exception is UK exports of radiation equipment). For example, Germany accounts for 78% of EU exports of electrocardiographs and 56% of EU exports apparatus based on the use of x-rays - whereas the UK only accounts for 11% and 3% of EU exports in these respective high-tech product areas.[20] In contrast, the UK has higher than average export shares in low-tech products where low-wage countries are active exporters (eg, the UK accounts for 12% and 22% of EU exports of tubular metal needles and transfusion apparatus, whereas Germany has smaller than average export shares of 14% and 29% respectively).

Table 5: UK and German percentage shares of EU exports by medical product, 1988-1994

Product	German export share[1]	UK export share[1]	German unit value (UV)[2]	UK unit value (UV)[2]	German/ UK unit value ratio[3]	German/ LWC unit value ratio[4]	UK/LWC unit value ratio[4]
Electro-cardiographs	78.0	11.3	136.47	89.93	1.52	-	-
Electro-diagnostic equipment excluding electro-cardiographs	36.1	16.2	93.68	95.71	0.98	-	-
Apparatus based on use of X-rays	56.4	2.9	89.43	46.62	1.92	-	-
Apparatus based on use of Alpha, Beta or Gamma radiations	11.1	37.6	168.11	67.12	2.51	-	-
Instruments and apparatus used in medical, surgical procedures	30.6	18.2	106.98	45.62	2.34	-	-
Instruments and appliances used in medical, surgical procedures	28.4	23.1	102.69	29.74	3.46	-	-
Needles, catheters and cannulae	24.0	6.8	53.63	31.77	1.69	1.97	1.17
Tubular metal needles	14.1	12.1	33.23	16.25	2.05	2.96	1.45
Transfusion apparatus	28.8	21.8	24.15	9.55	2.52	2.03	0.80

Notes: Own calculations based on data from Eurostat's COMEXT database. [1] German and UK exports expressed as a percentage of EC total exports; [2] Unit values represent 1,000 Ecu's per metric ton; [3] German unit value divided by UK's unit value; [4] UK and German unit values divided by LWC's unit value (where LWC's are proxied by EC imports from Malaysia). Eurostat codes for the products in the table are as follows: 90181100, 90181900, 90221100, 90222100, 90189080, 90189090, 90183900, 90183210 and 90189050.

Columns 3 and 4 show the export unit values for Germany and the UK by type of medical product and column 5 derives the ratio of the German and UK unit values. The bottom three medical equipment

[20] An extreme example is endoscopes where Germany accounts for around 90% of EU exports in comparison to

categories in the table are usually thought of as very low-tech sectors - and represent product areas where LWCs account for a significant proportion of EU imports - and it is clear that these products tend to exhibit some of the lowest unit values. If we use the unit value as a proxy for product 'quality' we see that the unit value ratios suggest that virtually all of the German medical equipment products embody a higher level of 'quality' than UK products (only for electrodiagnostic equipment are the unit values similar for the two countries). Furthermore, the 'quality' differential between the UK and Germany is frequently higher in the low-tech sectors.[21] Columns 6 and 7 show the ratio of German and UK unit values relative to the unit values of a significant LWC exporter for the bottom three low-tech products (i.e., where LWC competition is most prevalent).[22] It is also clear that the UK unit value is closer to that of LWCs than it is to Germany - in fact, the UK unit value is actually lower than the LWC unit value for transfusion apparatus - providing some evidence that the 'quality' of these UK medical products is closer to that of LWC products than to German products.

The medical equipment sector as an illustration of manufacturing industry

In summary, it seems that the medical equipment sector will provide a useful illustration of the manufacturing sectors of the two countries as:

1. the medical equipment sector provides examples of high, medium and low-technology products where R&D spending (representing product quality and innovation) and competition with LWCs are significant for some products but not others;
2. the medical equipment sector reflects many of the aggregate characteristics highlighted in our preceding analysis, for example: (a) the relatively higher UK share of EU exports of low-tech products partly reflects the fact that a large proportion of UK output is accounted for by the low-tech sectors; (b) although the export unit values suggest that German medical equipment products embody a quality advantage, this disparity seems to be smaller for the higher-tech products; (c) the UK seems to be more exposed to competition from LWCs in comparison to Germany.

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about 2% for the UK.

[21] For example, if we take a simple average of the relative unit values in column 5 of the four UK products with the highest unit value and compare with the average of the four lowest unit value sectors for the UK, we find that the German quality differential is higher for the 'lower quality' products.

[22] Given that Malaysia is a major LWC exporter in these product areas we have used the unit value of Malaysian exports to the EC as a proxy for all LWCs.

The sample of establishments interviewed in the case studies

The medical equipment-producing sector covers a vast range of output at various levels of sophistication. So as to be able to report in detail on cross-country differences in production quality and strategy, our study focussed from the outset on two important sub-groups of medical equipment: surgical equipment and accessories (henceforth, collectively SEA), and diagnostic, monitoring and therapy equipment (henceforth DMT). Specific products within these groups represent the two 'sides' of the medical equipment industry, with sectors within the SEA group producing relatively low-technology products and the DMT group engaged principally in the manufacture of relatively high-technology medical products. These two product groups were therefore felt to capture the differences across high- and low-tech products in the roles played by features such as product quality, innovation, skills and low-wage country competition in explaining the export performance of the medical equipment industry in Britain and Germany.

Within these broader categories, visits were arranged to manufacturers in the two countries engaged specifically in the production of a narrowly-defined product range: in the SEA product area, for example, visits were arranged to producers in each country including in their product range the manufacture of cutting devices from the fairly basic type of production, such as scalpels and blades, to the more specialised range of instruments typically used in minimally invasive surgery (MIS) procedures. Within the more specialised field of DMT equipment, our visits were focussed on manufacturers of electro-medical products for cardio-, neuro- and vascular applications: X-ray, ultrasound, and radiotherapy products, computer tomography ('CT') scanners, magnetic resonance imaging (MRI) equipment and related products[23] (henceforth referred to as X-ray, CT and MRI products).

Since a major aim of this inquiry was to investigate the impact and importance of LWC competition in the export of medical equipment of varying levels of sophistication; in considering the role of LWC competition in relation to SEA manufacturers, we were interested to investigate whether LWC competition is as important in more sophisticated surgical instrument products as in the market for basic cutting devices; whether German and British firms are exposed to such competition to the same degree; and whether the response of firms to low-wage competition is the same in the two countries.

Within DMT equipment, we tried to choose areas where the performance of Britain compares favourably with Germany and vice-versa. It was hoped that the different sub-sectors of the diagnostic,

[23] Including laboratory diagnostics equipment.

monitoring and therapy equipment would provide particularly revealing insights into the role of R&D and innovation in the determination of product quality and export performance.

In selecting our sample of manufacturers to be visited, we aimed at a sample as representative as possible (within budgetary constraints) of the national mix of sizes. The most detailed official data on size distributions relate only to the medical equipment producing sector as a whole, and suggest the average German plant to be somewhat larger than its British counterpart - at around 163 employees, compared to 122 in Britain (see Table 6).[24] This feature is reflected in our sample of firms visited as shown in Table 6 below:[25]

Table 6

Distribution of plant sizes in medical equipment producing population and sample: UK, 1993; Germany, 1992

	POPULATION Percentage of employees		SAMPLE No. plants visited	
	UK	Germany	UK	Germany
1-20	12	1	3	1
21-100	33	40	1	3
101-200	20	16	5	4
201+	34	43	1	4
	100	100	10	12
Lower quartile	49	49		
Median	122	163		
Upper quartile	321	894		

Sources: for the UK: Central Statistics Office, PA1003 Size distribution of UK businesses 1993, Table 8 (local units); for Germany: Statistisches Bundesamt, Produzierendes Gewerbe Fachserie 4 Reihe 4.1.2 Betriebe, Beschaeftigte und Umsatz im Bergbau und im Verarbeitenden Gewerbe nach Beschaeftigtengroessenklassen 1992, Table 1.2.

Twenty-two companies were visited in total (12 in Germany, 10 in Britain). Of our sample total, approximately one third were engaged in the production of surgical equipment (the SEA sub-sector), two-thirds in the DMT sub-sector.[26] Information was collected on the basis of semi-structured interviews with managing directors, plant managers, export managers and production supervisors. In most of the visits, factory floor inspections were also carried out, which allowed us to observe directly the production methods in use and machinery in operation. Work taking place in technical support de-

[24] Mason (1997) shows that the average plant size in engineering generally is higher in Germany relative to Britain, with the median number of employees in German engineering firms roughly 50 per cent higher than in Britain, and the upper quartile of firms roughly two and a half times larger in terms of employment.

[25] Note that the population data may not necessarily conform with figures cited in previous sections due to differences in data sources and the exact definition of 'medical equipment'.

[26] The number of interviews was chosen in order to ensure that we covered a variety of firm sizes and levels of technology in the medical equipment industry.

partments was also observed during the visits. The respective trade associations proved invaluable in offering advice as to which branches of the medical equipment industry should be visited in the two countries.

Surgical Equipment and Accessories

Altogether we interviewed seven companies (4 British, 3 German) involved in this branch of the medical equipment-producing industry. The plants visited ranged in size from 8 to 320 employees. We visited similarly sized establishments in both countries. A striking distinction between the countries became clear, with the majority of the British firms visited content to continue to produce the more standardised products (eg, simple blades and scalpels) which have changed little over the last decade or so; the product ranges of the German firms, meanwhile, seem constantly under review and are often substantially modified even within a 5-10 year period.[27]

The export propensity - i.e., the share of total sales exported - of the British firms ranged from 30-60 per cent, whereas the majority of the German firms reported much higher export propensities of more than 80 per cent.[28] Three quarters of the UK companies named German firms as their major export competitor. While only one of the British producers visited (specialising in the manufacture of basic surgical instruments) named Pakistan as their principal competitor in world markets, alarmingly perhaps, both Pakistan and India were frequently cited as major competitors for all the British firms in our sample. Within such markets, price competition is fierce: one line of surgical instruments exported by a British firm at a price of £25 are sold in the same export markets by Pakistani companies for around £1.[29]

For German firms, other German companies were viewed as the principal competition in export markets, with British surgical manufacturers generally perceived as operating at the lower-tech end of the market. For both countries, other advanced economies comprise the major export markets, although

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[27] Without substantial upgrading of the quality of their products over the past decade, and focussing more attention on the manufacture of highly specialised surgical tools for the expert user, most of the German firms believed they would not still be in business.

[28] A common criticism of British export performance is that British firms are often 'passive exporters' - i.e., they do not formulate a specific plan for maximising exports as they are primarily concerned with selling to the domestic market - whereas their German counterparts tend to target, and investigate in detail, specific markets for export and see themselves primarily as exporters. Hence this may provide part of the explanation for the differences in export propensities between the UK and German firms.

[29] A second British company told us that exporters from Pakistan in their field tend to sell similar products for about 10 per cent of the British price of such products. British firms claim that the products originating from many low-wage countries tend to be inferior in quality, suitable only on a disposable basis.

newly-industrialising countries and regions were also mentioned (particularly, India, Pakistan, the Middle East, South America and Malaysia).

Product quality and low-wage competition

The major product quality feature cited by producers in both countries was the reliability of their product - particularly the consistency and guaranteed durability of the cutting edge - a feature of considerable value to the surgical profession, where minimal variability in the performance of the instrument is essential - and the ability to provide customers with products at very short notice. One major difference between the two countries relates to how that reliability is achieved: British companies we visited were quick to describe their manual quality control procedures as the main means of ensuring product reliability.[30] Among German companies, by contrast, advanced technologies were seen as the main means of ensuring consistent output quality. Moreover, the German companies tended to employ 'just-in-time' production systems for the purpose of cost-saving, but did so very efficiently, thus maintaining their ability to respond to customers' increasingly short-notice order and delivery requirements; the British companies we visited met that challenge by holding ever greater stocks in order to satisfy unanticipated changes in customer demand - a difference which partly reflects the superior ability of German firms to quickly and reliably change between different batch runs.[31]

As competition increases, further efforts to maintain market share become necessary: one British firm recently applied a new coating to its surgical instruments which virtually doubles the hardness of the instrument and thereby extends the working life of the product by around 500 per cent (hence building upon the British quality advantage of 'durability' relative to low-wage country products). Another British firm we visited has effectively adopted the 'if-you-can't-beat-'em' strategy and begun to supplement domestic production with outsourcing - buying in low-wage country surgical instruments and re-selling them after a rigorous quality-control procedure, albeit with shorter periods of guarantee relative to domestic production.[32] Given the similarity of the low-wage-country products, few of the British companies expected to be able to compete in the long term simply by improving their existing product range; it was then surprising that so few seemed to have taken any very definite steps to move away from the traditional product portfolio.

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[30] One UK company, for instance, employs about 10 per cent of the workforce in quality control - so as to ensure that each product is inspected *twice by hand*!

[31] Previous studies such as Jarvis and Prais (1997) argue that the German's 'greater ability to change over quickly, without breakdowns and teething problems, depends in Germany on the greater proportion of vocationally qualified operatives and their highly qualified foremen (*Meister*)'.

[32] Around 70 per cent of this company's surgical instruments are manufactured entirely in-house, the rest are imported from low-wage countries and subsequently re-exported, with the country of origin stated clearly on the product.

In general, the German companies stated that they are not in direct competition with low-wage countries as the surgical products of these countries occupied a 'much lower quality segment of the market'. Similar comments were expressed about British competitors. The presence of low-wage country competition in this sector has made price competition 'very fierce' for British manufacturers. Although the German firms are also under pressure to reduce costs, they were less concerned about price competition since their strategy was based far more on achieving a consistent quality whilst moving into more sophisticated products.[33]

Two of the three German companies had already 'out-sourced' some of their more basic production to low-wage countries (eg, currently Malaysia, Indonesia, Pakistan and countries in Eastern Europe, with China, Thailand and Vietnam quoted as future locations for the outsourcing of production). Whereas the few British companies engaged in outsourcing we interviewed had tended to buy in finished products only to add some final touches such as for quality-control and -grading, the German approach to overseas manufacture was far more comprehensive such as acquiring or setting up new factories in LWCs. In so doing, the German companies interviewed had managed to economise on the costly German labour inputs involved in the labour intensive side of production, whilst maintaining German quality levels through the use of permanently-stationed German foremen and managers abroad. The German firms were of the opinion that the simpler types of (i.e., basic cutting) products are best manufactured by countries with an abundance of lower-wage labour, while the German-based production should be increasingly concentrated in more sophisticated, higher value-added, surgical products.[34]

[33] NHS cost containment measures in the UK are frequently said to be more stringent than the respective German measures. Therefore, the German strategy was less feasible for UK producers, where NHS finances have been partly responsible for much of the downward pressure on prices in recent years. One UK firm claimed that reduced spending by the NHS had caused a twenty per cent reduction in prices in recent years.

[34] German outsourcing seems to be a successful strategy as one UK firm told us that the combination of 'state-of-the-art machinery and cheap labour in Eastern Europe enable their main German competitor to undercut their prices by around ten to fifteen per cent'.

Innovation, technology and skills

Unsurprisingly, the low-tech product nature of most of the British companies we interviewed was associated with a minimal amount of innovation.[35] The German firms were certainly more innovative in terms of what they perceived themselves to be capable of manufacturing. For example, one German firm which currently manufactures a similar product range to some of the British firms we interviewed recently attempted to develop a range of surgical equipment suitable for use in MIS - whereas such a product development programme would be way beyond the ambitions and ability of virtually all of the British firms. Furthermore, product innovations at the German firms we visited were predominantly in-house.

All of the firms interviewed in both countries claimed that the aim of introducing new technology was two-fold: to increase the quality of their products *and* to decrease costs. However, the British firms interviewed tended to invest more in traditional forms of equipment and cited basic 'dust extraction' and 'welding' machinery as examples of recent major capital equipment investments. By contrast, the German factories we visited tended to invest in up-to-date CNC technology. The low profit rates generated by the majority of the British companies interviewed were cited as the major disincentive to investment in new technology or sophisticated machinery. One British factory visited relied predominantly on machinery between 20-40 years old (and originally purchased as second-hand) - involving technology incapable of the tolerances currently expected. For example, current methods for creating basic metal joints used archaic and crude machinery which resulted in an extremely rough finish requiring the joint to be finished off by hand. In addition, the organisation and layout of the factory seemed to us both inefficient and untidy. A further disincentive to greater investment was the noted skill deficiencies of the employed workforce: as one UK production manager told us, 'staff skill limitations and [the staff's] inability to cope with new machinery restricts the scope for investment in new technology'. Less than 10 per cent of the production staff employed in the UK plants visited held any vocational qualifications relevant to the manufacturing process (compared to 60 per cent in Germany) - a considerable hindrance both to further capital investment and product development. As one production manager put it, 'the range of products manufactured have to be developed *within the limits of staff skills'*.

Although one UK firm in our sample making a low-tech product also uses technologically unsophisticated equipment relative to German firms, its performance in terms of innovation and new technology was superior to the other British firms because of its ability to *customise machinery* which enables it

to extend the *range* of products manufactured and to develop new product designs in consultation with surgeons which, in turn, require the development of specialised machinery and tools. It was also clear that customisation of equipment and the ability to adapt machinery to perform new operations also results in greater efficiency and a higher quality of production.[36] As a consequence, this UK firm employs more skilled workers relative to the other UK firms as machinery customisation requires the skills of qualified design engineers and, in general, higher staff skills are necessary in order to maintain machinery in comparison to simply operating the equipment. The managing director at this firm usually operates from the factory-floor and knows the technical aspects of both the production techniques and the product itself. Hence the product quality and efficiency advantages of machinery customisation possibilities are quickly understood by the management and rapidly implemented. The machinery at this firm was also of a more recent vintage compared to the other British firms and ranged from five to ten years old and was a mixture of mechanical and CNC machinery. A major advantage of the CNC machinery is the much shorter *changeover times*.[37] Several characteristics of this relatively low-tech firm correspond more closely with the higher-tech UK manufacturer of MIS equipment. For example, both have recently invested in CNC machinery and the managing director partly compensates for the skill deficiencies of staff by possessing a considerable technical understanding of both the product and the CNC machinery.[38]

In stark contrast to the above, the German companies we interviewed tended to adopt a high rate of capital investment - hence machinery was usually of a much younger vintage relative to the British companies. The most obvious difference was the pervasive presence of high-tech CNC equipment at the German firms, the use of which had been firmly established for a number of years.[39] Furthermore, a significant proportion of the modern machinery on view on the factory floor in both countries was of German origin, whereas there was little evidence of any British machinery in use at the German firms. Customisation of machinery in Germany seemed to us to be far more routine than in Britain, as it was universally deemed necessary for carrying out specialised operations. A number of German production managers claimed further that the higher average quality of German manufacturing ensures that

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[35] In fact, the technical know-how for a recent innovation at one of these firms was kindly supplied by their German rival.

[36] For example: first, continual machinery customisation at this British firm has reduced the number of rejected units by around 60 per cent over the past five years; second, customisation has created machines which, in contrast to single-operation standard machinery, can perform several *simultaneous* cutting operations - whereas it is much more difficult to satisfy the requirements for quality standards if these operations are carried out separately.

[37] For example, stripping down a mechanical machine so that it can perform operations on a different product range can take up to a day, whereas the re-programming of a CNC machine for a similar changeover only takes a fraction of this time.

[38] The CNC machinery was imported from Germany and Austria.

[39] In most cases, CNC machinery had first been implemented at least ten years ago.

German firms can rapidly obtain components according to precise detailed specifications made to a guaranteed high quality-level - hence the high standards of the German engineering infrastructure is a major reason behind the general success of German manufacturing.

Except for 'closed systems', regular maintenance of the machinery by the firm's own staff was also a common feature among the German companies. Although not all of the German factories we visited were purpose-built, the layout of the factory floor in the German establishments was predominantly impressive in terms of its efficient organisation and cleanliness. In terms of skills, the workforce of the German firms was much better qualified than in the UK firms in the sense that a much higher proportion of the production workers are vocationally qualified. Our overall impression was that the German vocational training system provides small German companies with the ability to manufacture products of a more complex technical nature and a higher quality-level relative to firms of a similar size in the UK.

Policy

When asked about the difficulties faced when exporting, the responses of the British firms ranged from the current high level of sterling and its volatility (which causes difficulty in long-term investment planning) to severe import restrictions in key markets, fierce competition from low-wage countries, and concern over not being able to satisfy the high product quality standards demanded by customers. Although the problems caused to exporters by a high exchange rate were (at the time of our inquiry) primarily a British concern, of more concern to German firms were the amount of 'red tape' regarding the authorisation procedures required in entering new markets, and the ease with which foreign competitors - but not they - have access to 'soft' government loans.

When asked how government intervention might contribute to export success, a minority of British company representatives suggested some form of protection of their products against competition from low-wage countries. Although this simply reflects the desperate situation of some firms, others suggested practical measures to improve the 'fairness' of competition - such as ensuring that products truthfully state their country of origin.[40] British firms would also like government to put more emphasis on *technical support* in terms of expert advice on how to implement product and process innovations (eg, advice on what machinery to buy; how to work the machinery effectively and efficiently;

[40] Some firms claimed that a number of competitors buy low-wage country products and sell them on as their own.

how to improve the precision of output, etc).[41] Other suggestions from British firms were that full tax relief on stocks should be re-introduced and that more financial support from the DTI and other government bodies for participation in overseas trade fairs and exhibitions would be useful. German firms thought that the potential role of government in promoting export success was more limited, but several companies suggested that the commercial attaches in the embassies abroad could do more in terms of promoting German exports.

Few of the firms interviewed have any direct experience of direct public sector support. Of those who did, the impact was negligible. Indeed, in areas where government is involved - such as in the enforced implementation of the ISO 9001 quality standard - some German companies voiced concerns that the primary aim is being distorted by excessive formal requirements and paperwork in the checking procedure, mostly carried out by TUEV or DEKRA.

At the EU policy level, a prime concern centred around the reputation of the CE marking and the diverging requirements in different member countries to obtain this product quality stamp.[42] It was mostly British companies which brought this aspect to the fore, but German entrepreneurs also had objections in this respect.[43] A major problem according to our interviewees in both countries was the concern that the CE marking was insufficient to satisfy the quality requirements of the US FDA - hence EU firms wishing to export to the USA have to fulfil the extra requirements of the FDA regulations (viewed by some as a non-tariff trade barrier). Another objection concerns the treatment of EU imports from low-wage (and other) countries which do not have to satisfy the quality requirements of the CE marking. Some firms would like to see an EU Directive which requires that EU hospitals apply CE mark quality-levels in their procurement policy rather than allowing them to use low-cost imports which do not meet EU standards.

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[41] This is in contrast to current help whereby, for example, a government department pays half the fees of a management consultant to evaluate how the company can improve its performance. British firms with experience of this scheme felt that the consultant's recommendations usually concerned the advertising and marketing of the product, whereas firm-level suggestions as to how to improve both the quality of the product and manufacturing performance should come first.

[42] Since mid-June 1998, in the EU member countries all newly circulating medical products must have the CE mark. With this sign the producer clearly indicates that the stipulations of the EU Directive 93/42 EEC have been observed and the safety requirements for this particular product have been met. Depending on the risk category of each medical product (which corresponds to its intended use), the producer is free to declare conformity himself or to make use of the service of a notified body. This institution will check whether the measures taken by the producer are suitable to ensure the quality and safety of the product. To a considerable extent, the EU Directive leaves the decision to the producer whether he prefers individual examinations, batch examinations or the establishment of a system of quality management (DIN EN ISO 9001/2 or DIN EN 46001/2). He is free to make up his mind on the basis of cost considerations. However, in all the three procedural variants the proof of product safety must have a uniform high standard.

[43] The main difference in their concerns was that the former tended to blame all of the EU partners (the authorising bodies of the other countries allegedly not being as stringent as the UK MDA), while the latter focussed their concern on the Southern rim of the Community.

Other suggestions addressed to the government or the European Commission were concerned with providing help with the setting-up of a distribution network which would enable smaller exporters to gain a foothold in tough market places like the USA. This idea came from the British side. It is interesting to note that small and medium-sized firms in (Southern) Germany, rather than calling for government support, created their own, privately organised, marketing consortia (called 'Medicon' and 'Martin'), which help market and distribute part of their production - both domestically and abroad.

Diagnostic, Monitoring and Therapy Equipment

The diagnostic, monitoring and therapy (DMT) equipment-producing sub-sector includes a diverse range of manufactures - from products relating to cardio-, neuro- or vascular applications to more sophisticated 'imaging' equipment including X-ray and radiotherapy products, computer tomography (CT) scanners, magnetic resonance imaging (MRI) equipment and related products (henceforth referred to as 'X-ray, CT and MRI' equipment). Within the DMT sub-sector, we interviewed a total of 15 companies across the two countries (6 in Britain, 9 in Germany).

In general, the majority of the diagnostic and monitoring products we saw relied heavily on computer technology, whereby diagnostic tests and results were interpreted by sophisticated software designed specifically for the purpose. Similar in appearance to personal computers, the principal quality features of many of the products were essentially the degree of sophistication of the software design and the precision manufacturing techniques required for the development of the measurement systems.

A striking difference between X-ray, CT and MRI equipment manufacturers in the two countries is apparent from the very different structure of the industries. Very few of the British-based firms are also British-owned, particularly in the CT and MRI manufacturing segment. We also got the impression, from interviews with manufacturers in both countries, that British-owned companies tended to operate towards the lower end of the market - providing mainly the accessories rather than the high-tech equipment.[44] The German firms, by contrast, tended to operate primarily at the high-tech end of the market, including the 'cutting-edge' technologies of MRI equipment and CT scanners, etc.[45]

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[44] Accessories for this group consist of products such as lead-lined door sets, screens, lead glass and personnel protection equipment such as X-ray aprons and thyroid collars.

[45] According to one of our interviewees, the UK used to have more domestic manufacturers of X-ray equipment, but there has been a progressive demise of UK manufacturers of high-tech medical equipment, particularly X-ray based products, because the NHS dominates UK market demand and makes strenuous efforts to contain costs and therefore puts substantial downward pressure on prices – resulting in less sophisticated equipment being manufactured in UK (i.e., it is far easier to export high-tech equipment if there is an initial demand for it in the country of production). One interesting example of the impact of cuts in German health care spending is that the electro-

Export propensities of the British firms in our sample tended to be somewhat higher than those of the German firms we visited, and ranged from around 50-90 per cent of total output (compared to 35-85 per cent in Germany).[46] This perhaps surprising statistic reflects a combination of two factors: first, the larger domestic market in Germany for these types of products relative to the UK; second, given the high R&D expenditures necessarily required in the development of technologies for the more sophisticated products in this group, the smaller domestic market in the UK usually necessitates greater efforts towards export sales. Unsurprisingly, the major export markets are the same for both countries - primarily the USA along with other advanced industrialised countries - and it is not uncommon for UK and German exporters to find themselves in direct competition with one another on world markets, as well as with firms from the USA, Japan and other European countries. Eastern Europe and other emerging economies (such as China and Brazil), were also cited as customers - suggesting the possibility of a large potential market for the future, but not as potential rivals. Indeed, to date, there has been virtually no low-wage country competition in the DMT areas examined in our case studies.

Product quality and low-wage competition

The sophistication of the software programming plays a large part in determining the overall quality of the DMT equipment, particularly the ability of the software to allow the consultant or technician to store, access and analyse a multitude of information concerning patients easily and conveniently in a fast yet flexible and highly accurate fashion. Hence the 'quality edge' in this area is largely determined by the extent to which advantage is taken of the latest technological advances in Information Technology (IT). 'User-friendliness' - and the flexibility across a range of diagnostic procedures - of the software also contributes to its quality rating amongst customers - for example, one quality feature is the ease with which users can customise test-screen layouts and create their own specific tests.

In terms of the medical 'hardware' accompanying the software, the major features determining product quality were the durability, reliability, sensitivity and accuracy of the equipment. Most of the non-software R&D expenditure is focussed on improving the precision and sensitivity of the 'sensor' used in the diagnostic/monitoring procedure. The ability of, say, cardio-monitoring equipment to detect *minute* changes in a patient's condition, for example, is essential during the course of patient therapy

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medical industry has developed new technology (such as digital X-raying or tele-medicine), but has been reluctant to introduce it to the market because the current market price of such products is not sufficient to cover manufacturing costs. From this example, it seems that the general response of German medical equipment manufacturers to reduced health expenditure is to seek to rationalise of production and reduce capacity.

so that treatment can be altered in accordance with the patient's progress during disease remission. Quality features designed to aid the user also figure importantly in the quality perceptions of customers - eg, controls located on the 'sensor' allowing the doctor continual control over the diagnostic machine whilst carrying out the examination of the patient.[47] German quality features rely heavily on improvements in precision engineering. For example, for many liquid-based medical tests the accuracy of the results is highly dependent on being able to dispense minute sample measures. One German company which developed such dispensers argues that the manufacture of such products on a mass scale, and consistently attaining the required degree of accuracy for each dispenser, demands state-of-the-art precision production processes which can only be achieved via the latest computer controlled manufacturing systems and integrated automated quality control procedures.

Although our case studies gave us the impression that British DMT equipment manufacturers were at least as good as German companies in terms of providing 'quality' software for their equipment, the technological level of the German medical 'hardware' seemed superior relative to the British firms: many German companies remarked that British firms are technologically behind in terms of product development despite the fact that innovations arising from British R&D are of a similar standard to those of German origin. Once again, the major advantage of German firms is the technical excellence of their precision manufacturing which makes feasible the rapid translation of an R&D innovation into a commercially viable product, whereas the process of product development from the innovation stage to profitable commercial production is hampered in Britain by the technological backwardness of much of its manufacturing industry. All of the above points are particularly relevant for the CT and MRI equipment industry. Although the primary techniques required for MRI equipment and CT scanners were invented in Britain, UK firms did not succeed in manufacturing such sophisticated equipment on a large - or rather, commercially successful - scale.

Export sales of higher quality DMT equipment are not particularly sensitive to changes in price as the product competition mainly revolves around the ability of the machine to produce highly accurate data along with the necessary sophisticated software to interpret these data. Although the purchase price of these products may appear high, the innovations associated with such equipment frequently compen-

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[46] Putting too much emphasis on comparisons of export propensities may give misleading results as some of the firms had foreign, as well as domestic, production facilities. Hence, it was not always clear what a firm defines as 'exports'.

[47] British and German firms both gave further interesting examples of the quality features of their DMT manufactures. One British-based firm stressed the accuracy of its equipment which delivers a controlled dose of radiation exactly, directly and rapidly to the target site, thereby sparing nearby healthy tissue. A German firm had developed specialist biopsy needles for use with MRI intervention techniques which have a sophisticated metal content and surface treatment so that the MRI image of the target area does not disappear behind the image of the tool (as is the case with conventional needles).

sate for this by incorporating features which help reduce operational costs for hospitals (eg, by economising on specialist labour).[48]

Since direct labour costs are a relatively small proportion of total costs in the DMT field - with wage costs accounting for as little as 2-3 per cent of total production costs, particularly among larger manufacturers - there is less scope for competition from LWCs in DMT equipment manufacturing than in the lower-tech SEA branch of the medical equipment sector. However, where *higher* level skills are available at substantially reduced cost, or the more basic parts of production can be performed in LWCs, Western companies are exploiting the cost advantages of outsourcing. For example, one German company now carries out the development of its standard software in India and one British company pays for some of its basic medical research to be carried out in Eastern Europe (where researchers cost one tenth of the salary of researchers in Western Europe doing similar work).[49] The sheet metal work of one British diagnostic equipment manufacturer is presently carried out by local manufacturers, but the current high level of sterling is encouraging the firm to cut costs by outsourcing to the Far East. Some of the German therapy equipment manufacturers outsource the basic parts of production abroad, but the more complex manufacturing is still carried out in Germany.[50]

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[48] For example, the 'user-friendliness' of the software may allow complex tests to be carried out by a less-skilled person (relative to the past), or a bar-code identification system for test tubes combined with an automatically rotating sampling tray with positions for scores of test tubes, enables a far more rapid rate of testing to be achieved.

[49] Apart from the obvious cost advantages, a British firm argued that researchers in Central and Eastern European countries provide substantial scope for innovative ideas as scientific and medical research in these countries followed quite a different path in comparison to 'the West' and they are also more advanced in certain medical areas. In addition, Eastern Europe has a considerable supply of highly qualified scientific and technical personnel whereas there is a limited supply of such labour in Britain, but German companies are in a much better position to outsource to Eastern Europe because of their proximity and existing trade relations.

[50] Although some components manufactured by emerging economies could be used in X-ray equipment production, the quality and precision requirements for such components can not be satisfied if the product is intended to be sold in North America or Western Europe. However, one specific variant of 'outsourcing' mentioned by the companies is where high-tech products are sold in LWCs - supplemented by locally produced components - where lower quality standards are acceptable.

Technology, innovation and skills

Much of the progress made in the DMT-producing industry has its roots in the wider technological innovations now prevalent throughout the economy. This part of the medical equipment industry thus serves as an interesting case study of specialised applications of computer technology. The purchase of complete sub-assemblies is one of the most widely followed developments in the manufacture of British DMT equipment in recent years, particularly in cardio- and neuro- applications. Previously, British companies purchased components in order to design and construct their own computerised parts of the equipment, but nowadays whole sub-assemblies are purchased off-the-shelf and a large part of the manufacturing-side of the operation consists simply of assembling and testing the products. Another major technological change in this product area is the evolution of digital storage media (i.e., CD-ROMS, etc). In the past, the output of the equipment was printed directly onto paper and stored in this fashion, but the introduction of technology which enables these data signals to be stored digitally, combined with the enormous storage capacity of CD-ROMS, allows vast amounts of space consuming data to be stored efficiently in a way that can be conveniently accessed.[51] Hence, a major part of the value-added is in the design of the software which can efficiently manipulate the data.

German manufacturers of DMT equipment have undergone similar technological changes to those outlined above, but they have not decreased their in-house production of the computerised components to the same degree as UK firms. An additional, but related, difference between the two countries is that virtually all of the German firms we interviewed manufacture according to the 'modular system' whereby complete finished products are made of a given combination of 'modules'. This modular format allows for a higher degree of customisation of the product according to the specific needs of the customer, but also requires the capacity to manufacture specific components instead of purchasing more general 'off-the-shelf' components.[52] While several of the UK companies interviewed expressed a desire to return to manufacturing and assembling the hardware, difficulties in recruiting (and retaining) suitably trained operators and assembly workers in the UK were seen as major obstacles to doing so - despite the considerable benefits.

Another difference regarding the German manufacturers of DMT equipment - which again is partially dependent on the modular principle - was that the German firms are able to combine 'customer-orientation' with their traditional orientation towards production. Accordingly, rather than simply

[51] Vast amounts of data are generated. For example, one CD-ROM may be filled by cardio- or neuro-diagnostic data for just two or three patients.

being items of single equipment, the individual products of the German firms can be linked together to form an integrated system comprising diagnosis, testing, monitoring, analysis and documentation capabilities - but which allows the customer to choose the combination of individual machines which provide the most appropriate system for their specific needs.

The buying-in of sub-assemblies by the British firms has had a dramatic impact on the employment of less-skilled workers on the production-side. For example, at one British company - over a period of 20 years - the number of production workers as a proportion of total employees has fallen from 80 to 25 per cent. The reduction in staff has been the product of both the move to sub-assemblies, coupled with considerable efficiency improvements that have gone hand-in-hand with the changes in the nature of the product. Incoming goods and stock control systems have been combined and are now the responsibility of the production line workers. All of these changes have helped decrease the response times to customer orders. Similar efficiency gains have been made in other British companies - such that less than five years ago it took some 30-40 person-hours to manufacture and test each machine (including the manufacture of circuit boards and computer shells), compared to 6-8 hours (depending on the complexity of the machine) today - due mainly to the purchase of sub-assemblies. Similarly, lead times between customer orders and delivery have been cut dramatically - from 4-5 weeks ten years ago to 4-5 days today.

The technical superiority of German firms in the production of the DMT medical hardware was reflected on the factory floor in the two countries. Assembling and testing machinery dominated the factory floor of the British DMT firms whereas the dominant characteristic of the majority of the German firms was state-of-the-art CNC machinery employed along with Computer Aided Design (CAD) systems. This type of machinery substantially reduces the number of ‘discrepancies’ in production and is essential for achieving the required tolerances. In many cases the necessary technology for making the German medical hardware required that the firms manufacture their own specific high-tech tools which itself requires considerable expertise. Again, much of the CNC machinery was of a recent vintage in the German companies and of domestic origin. But the British firms did excel in other areas on the manufacturing side - for example, one technological advantage of one of the British companies is its expertise in Surface Mounted Electronic Manufacturing which allows the technical capacity of a machine to be increased while simultaneously reducing its size.

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[52] The modular principle applied by one German firm allows each product to have at least three to five standard variants which offer quite different features (which are in addition to the aforementioned customisation possibilities).

R&D expenditure is a vital component of innovation for all of the diagnostic and monitoring products we examined in this sector and, by making a substantial contribution to the creation of 'new products', ultimately generates most of the value-added for the companies in the sense that it is the key to maintaining or increasing export market share.[53] There was little difference between the firms in the two countries in terms of the amount spent on R&D - usually between 5-15 per cent of sales. Many of the British firms carried out at least some of their R&D in collaboration with universities or research institutes. However, some firms claimed that constraints regarding public expenditure on education had seriously damaged the capacity of British universities to carry out the basic research which has proved to be so valuable to the private sector in the past.

The ratio of technical support to production workers is similar in both countries in the DMT firms - with around 50 per cent of the technical support staff qualified to degree level or above. A range of skills are required in the development of DMT products - not least the full range of engineering skills of electronic engineers, systems engineers, and software engineers, etc; but software programming skills are now becoming increasingly important as the technological requirements move from the manufacturing operations to the software applications. The case was amply demonstrated by the R&D department of one British firm we visited: four years ago, around 40 per cent of the 20 researchers employed were involved in computer hardware development; since the buying-in of sub-assemblies, this proportion has now fallen to 10 per cent. The majority of non-production staff employed in the British firms are, in consequence, educated to degree level or above (in one firm all staff had at least a BSc first degree), with software skills in greatest demand for those concerned with structure design. British companies complain that IT staff are in very short supply and these companies have to compete with the salaries of the City of London, where IT staff would earn up to twice as much as is typically paid for such positions in manufacturing.[54]

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[53] Various innovations were cited by the German manufacturers of DMT equipment. For example: one firm created a machine which simulates the impact of radiation therapy on the human body therefore obviating the need for dosage tests to be carried out on humans; another firm manufacturing MRI equipment has designed *compact* super-conducting magnets, without compromising on image quality, which enable the MRI machine to be smaller in size thereby taking up less hospital space. A British firm in this product area cited its development of digital X-ray equipment as a major innovation as this technique requires a much lower dose of X-rays (resulting in less potential damage to the patient).

[54] The industry is far from alone in its concerns at the apparent IT skills shortage: As Simon Sperryn, Chief Executive of the London Chamber of Commerce and Industry recently acknowledged, 'The skill shortages in computing throughout industry are especially worrying. We simply do not have enough experienced people to take up the type of jobs on offer …One in five IT professionals is expected to change jobs this year. In the Thames Valley, computer network managers are staying in post for only three months on average. One company has had 10 network managers in the last 14 months...the millennium 'time bomb' has made the situation more acute.' See report on London Chamber of Commerce and Industry Quarterly Survey, quoted in *Financial Times* (13/8/97).

Although skill levels on the production side were high in the British firms, the emphasis on advances in skills seemed relatively stronger in the German establishments we visited, with approximately two-thirds and three-quarters of production staff vocationally qualified in Britain and Germany, respectively. The German firms viewed it as a necessity that staff continually develop and improve their skills via further training. Higher skilled staff are particularly important to German firms as they are capable of coming up with their own ideas for product development and they facilitate the introduction of new technology (i.e., they welcome new technology rather than oppose change and are quick to solve the 'teething' problems often encountered during its introduction). In the case of CNC machinery, skilled workers are important for regularly maintaining the machinery, and their expert knowledge helps them to tell the machinery supplier exactly what is wrong with the machine when external repair skills are required, hence significantly reducing machine 'downtime'. The important role of higher-skilled staff in the useful exchange of information between staff and customers was highlighted by German DMT equipment firms. For example, skilled staff first ascertain the exact specifications of the precision required by consulting with the expert users on the customer-side and then the firm's physicists and engineers work out how they can manufacture a new product which delivers this level of precision. Against this background, the relatively high costs of highly-skilled staff are justified.

Policy

Six of the 15 companies in our bilateral sample said that the high level of the exchange rate was the greatest obstacle to export success. Five of these firms were British and most of these felt that joining EMU would be a great advantage if it provided stability for sterling. Other obstacles cited were the severe restrictions regarding US imports (caused by FDA regulations), the difficulties in finding good distributors, uncertainties concerning the future health care policies/expenditure in a number of countries and the bureaucratic admission requirements when entering foreign markets.[55] Common across the two countries are the problems of having a market large enough to justify the high R&D outlays necessary in conjunction with the permanent race to devise 'cutting edge' technology.

When asked how government policy might help to improve export performance, the majority of firms in both countries suggested implementing policies which improve professional skills and the educational system in general. The firms did not feel that young people were well enough equipped with the

[55] However, this does not only apply to foreign markets. One of the German firms mentioned an antiquated stipulation of the local trade association requiring drawing boards to be installed in the building before trainees are allowed in the company - even though this company is a high-tech establishment where drafting and designing takes place by means of CAD.

appropriate skills required by industry, particularly with regard to IT. In fact, many companies suggested that educational institutions should establish stronger links with industry so that the skills needed by business are more clearly understood. There is a definite demand for more and better graduates in science, engineering and software programming skills, particularly in the areas of computer networking operations and structure design. Although companies in both countries complained about deficiencies in school and university graduates, these shortages seemed to be less severe for the German firms.

Previous British-German comparisons of the acquisition of 'technological know-how' indicate that German firms have superior R&D links with external science bodies such as universities and independent research institutes (eg, Fraunhofer and Max-Planck Institutes).[56] However, in the medical equipment industry the UK firms seem to have good links with universities (many of the UK firms we visited were situated in towns with large universities which may reflect historic 'knowledge-ties' between medical equipment producers and universities).[57] Indeed, some German companies expressed envy at the knowledge-exchange between universities and business in the UK and USA medical equipment sectors. It should be added, however, that neither in the UK or Germany do the links between universities and equipment producers concern efforts to improve the translation of innovations into commercial production. Rather they appear to primarily consist of research activities.

Both German and British firms thought that government help would be useful in establishing contacts abroad (for example, mediation via the embassies or financial contributions towards participation in trade fairs). In particular, 'supplementary platforms' could be offered to SMEs.[58] This was a particular concern to several German firms who felt that the bulk of public support goes to large companies.

In a similar fashion to the surgical equipment manufacturers, serious concerns were raised regarding the reputation of the CE marking. If it is to be successful, the CE quality stamp must be a reliable indicator of uniform quality standards across all European partner countries. Many of the firms interviewed claimed that the EU quality regulations are not applied consistently, or even enforced, by all EU members. As a consequence, the CE marking is not recognised by some major foreign markets,

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[56] For example, Mason (1994a,b) describes how 'knowledge transfer' between the science base and industry in Germany is facilitated by the network of research institutes operated by the Fraunhofer and Max-Planck Societies who create or implement a wide range of product and process innovations for industrial clients.

[57] For example, a survey by the ABHI found that half of the firms in this sector carry out R&D via a subcontractor and universities are used by over 60% of all companies subcontracting R&D (see Dept. of Health, 1997)

[58] One suggestion addressed to the European Union was to establish a European radiology fair, thus benefiting smaller firms which would no longer have to attend several fairs around the globe. The European Commission

particularly the USA where the CE marking is deemed not to meet FDA quality standards. Hence European exporters to the USA are burdened with having to satisfy the separate requirements of both the CE marking and the FDA regulations. The companies we interviewed suggest that the CE marking be improved so that it guarantees comparable standards across all EU countries and simultaneously ensures that the CE stamp is recognised as satisfying quality standards across the world. Mutual recognition by the FDA and the EU of their respective quality standards would not only reduce the costs of EU producers of accessing the US market, but would also provide them with a large single European market.

Finally, self-help measures by partners in German industry seem to be more successful compared to the UK. In a similar fashion to the co-operative approach of some companies in the surgical equipment industry who collaborate when attempting to enter new markets, there are German export groups working together on large projects and organising finance on a group basis. Examples are the German Health Care Export Group which is active globally, but focuses on the Middle and Far East; and the German Group of Medical Technology co-ordinating sales efforts of member companies with respect to X-ray, artificial respiration and monitoring equipment (particularly vis-à-vis Eastern Europe).

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could also help by providing information to SMEs on partners interested in co-operation across national boundaries - perhaps in the form of a newsletter containing details of firms looking for suitable partners.

Summary

In general, the firm-level case studies in the medical equipment sector support the conclusions arising from the aggregate data-based analysis of the manufacturing sectors in the two countries. For example, Germany spends more than the UK on product quality enhancing activities such as R&D and investment in the lower and medium-tech areas of production (which seems to partly explain why Germany is less susceptible to competition from LWCs). In contrast, the German advantage in manufacturing performance seems narrower in some of the higher-tech areas of production where R&D expenditure, investment and workforce skills are similar in the two countries. Finally, both our macro and micro findings suggest that macroeconomic volatility and increasing competition from LWCs are causing serious problems for UK industry.

The relative export performance of our sample of UK and German firms producing surgical equipment corresponds, by and large, to the higher technological standards in German manufacturing relative to the UK. Another reason behind the significantly lower UK export propensity in this sector is that UK firms are often 'passive' exporters who concentrate mainly on the domestic market, whereas German firms and other major competitors tend to formulate explicit export targets. In the provision of Diagnostic, Monitoring and Therapy (DMT) equipment for the world market, there are many UK manufacturers who can compete with the 'best', but their German counterparts are generally stronger in providing medical equipment requiring cutting-edge technologies due to superiority in precision manufacturing.

Without doubt, the lower level of staff skills in UK surgical equipment firms prevent successful business expansion. The generally higher proportion of vocationally trained personnel in German establishments is an asset which has a major influence on competitiveness. Higher-skilled staff may come up with their own ideas for product development and facilitate the introduction of new technology or the customisation of both machinery and or product - hence enabling firms to manufacture high quality and technically complex products. Skilled staff are also more likely to identify the problems of malfunctioning machinery and can carry out in-house maintenance of, for example, sophisticated CNC machinery - thus keeping the machine 'downtime' to a minimum. The importance of skills is not limited to the factory floor - successful firms in our sample tended to have management who have a good understanding of the technical details of both the manufacturing process and the product.

German firms were far more impressive in terms of the level of technology on the shopfloor, particularly with regard to the age and sophistication of the machinery. In contrast, large-scale investment in sophisticated machinery is virtually impossible for the majority of the UK surgical equipment companies given the low profit margins of the majority of the firms and, more importantly, staff skill limitations. Indeed, it would be misguided to suggest that increased capital expenditure by UK firms on

sophisticated equipment would improve export performance as the efficient use of such advanced machinery requires a skilled labour force which is not readily available in the UK.

The amount spent on R&D relative to sales in both countries in the DMT sector is similar and innovation arising from UK R&D is of a high standard but, compared to their German counterparts, UK firms often fail to translate the resulting innovations into commercial production due to the technical backwardness of UK manufacturing. Contrary to previous observations, most of the German firms in the sample tend to generate essential technological know-how in-house. Nevertheless, they would prefer, like their UK counterparts, to see the research links between industry and universities improved.

Although a positive relationship between R&D expenditure and export performance is frequently observed, this does not simply mean that an increase in R&D causes an increase in export propensity. In many cases, firms have to increase their total sales in order to reach a market large enough to cover the cost of their R&D investments.

UK companies making surgical equipment have comparatively high labour costs because they maintain product quality by engaging a large proportion of the workforce in quality control (i.e. manual inspection of the products). The relatively large amount of stocks held by UK surgical equipment firms also pushes up costs, whereas German firms rely much more on just-in-time delivery methods due to their advantage in their ability to rapidly switch to different batch runs. These are important disadvantages for UK firms as they tend to compete in terms of price to a greater extent than their German counterparts, perhaps reflecting the ‘standardised’ nature of many UK products. Although the downward pressure on prices, caused by severe cuts in public budgets in the field of health expenditure, is felt in both countries the impact seems to be greater in the UK.

The manufacture of DMT products provides a good illustration of how the desire to cut costs by British firms reduces flexibility on the production side (i.e., the buying-in of complete sub-assemblies, rather than in-house manufacture, creates a more standardised product). German firms prefer to produce more in-house. In doing so they frequently use the ‘modular’ system whereby finished products are made up of building blocks which facilitates production according to the specific needs of the customer.

Competition from low-wage country surgical equipment manufacturers is felt much more severely in the UK because German producers have continually climbed up the 'quality ladder', thereby occupying a higher quality segment of the export market and escaping competition from the range of products offered by emerging economies.

Outsourcing is a common feature both in Britain and in Germany. German companies seem to be more successful in this respect, at least with their partners in Central and Eastern Europe, which may

be due to geographical proximity and traditional business ties. With regard to DMT equipment, basic parts of production are sometimes carried out in low-wage countries, but the more complex parts of the production process are performed at home. Although the outsourcing of production to low-wage countries is often blamed by economic theorists for the apparent decline in demand for less-skilled workers, it should be noted that outsourcing to high-wage countries - such as the importing of whole computer sub-assemblies - can substantially reduce the employment and wage prospects for the less-skilled. Outsourcing to LWCs does not necessarily jeopardise the total number of jobs at home as a gradual expansion of the range of products manufactured overseas can safeguard existing jobs and increase the numbers engaged in advertising, marketing and distribution.

Small and medium sized enterprises sometimes face severe problems with respect to marketing and distributing their products in export markets. In this context, calls for more public support are being voiced (e.g., mediation via the commercial officers in the embassies). This applies to firms in both countries. However, for both SMEs as well as bigger establishments, self-help measures - such as creating sectoral marketing and distribution organisations - seem to be more successful in German industry.

A major problem cited by exporters which could be remedied by policymakers concerns the CE quality mark of the European Union. Currently, contrary to its main purpose, the CE mark does *not* guarantee comparable quality standards across European Union member states - hence the quality level indicated by the CE mark is in doubt and the stamp is therefore not recognised as a sufficient quality standard by institutions such as the US FDA.

The accompanying box below summarises our findings as to the relative importance of key factors in terms of their importance for export performance. According to the firms we interviewed, the skills of the workforce are the major determinant of export performance closely followed by R&D and innovation respectively (with obvious strong links between these factors which reinforce each other). Capital equipment or new technology were deemed to be the next most important factor with competition vis-à-vis low-wage countries the least important factor (although this was sometimes the most important factor for British companies making low-tech products). Given the cuts in public health budgets world-wide and the increasingly fierce export competition, maintaining market shares on international markets also requires constant efforts in marketing and distribution as well as in the establishment of an after-sales service network. This applies in particular to the capital-intensive DMT sub-sector where these factors are an essential ingredient to long-term success in export performance.

The Relative Importance of the Major Factors Determining Export Success

We asked our sample of firms to rank the following four factors in terms of their importance for export performance (with a rank of 1 being the most important and 4 the least important):

- Capital equipment/machinery.
- R&D.
- Competition from low-wage countries.
- Workforce skills.

Twenty firms responded to this question in full with another firm judging low-wage country competition to be the *only* important factor. The table below shows the various permutations of rankings given by the firms interviewed. Some firms gave an equal ranking to some factors (for example, the first row of rankings shows that two UK firms manufacturing DMT equipment ranked skills and R&D as equally the most important factor). The top half of the table shows the two most important factors according to the firms - i.e., workforce skills and R&D - whereas the bottom half shows the rankings for the less important factors (i.e., capital equipment/machinery and competition from low-wage countries). The figures reveal that *all* of the fully responding firms put skills as the first or second most important factor, with around eighty five per cent naming R&D as first or second (note that around forty per cent of the firms ranked R&D first whereas approximately fifty five percent put skills as the most important factor). Some companies described workforce skills as the 'driver' of export performance as they believe that skills determine which product range/quality segment the firm can potentially occupy. Capital equipment/machinery was ranked third in around seventy per cent of the interviews.

Although sixteen responding firms thought competition from low-wage countries was the least important factor, fifty per cent of the British surgical equipment manufacturers deemed it to be the most important. Some lower-tech firms described competition from low-wage countries as an export 'blocker' (i.e., if low-wage countries occupy a product branch/market then firms from more industrialised nations are effectively blocked from entering that market as they can not compete in terms of product price).

Company Rankings of Major Factors Determining Export Performance

Rank Permutation		Number of Surgical Equipment firms		Number of DMT Equipment Firms		Total Number of Firms
Skills	R&D	Britain	Germany	Britain	Germany	
1	1	-	-	2	-	2
1	2	2	1	1	4	8
1	4	1	-	-	-	1
2	1	-	1	1	5	7
2	3	-	-	1	-	1
2	4	-	1	-	-	1
N/A	N/A	1	-	1	-	2
Rank Permutation		Number of Surgical Equipment Firms		Number of DMT Equipment Firms		Total Number of Firms
Mach.	LWC	Britain	Germany	Britain	Germany	
4	4		-	2	-	2
3	4	1	2	3	6	12
2	4	1	-	-	-	1
1	4	-	-	-	1	1
4	3	-	-	-	2	2
3	1	1	1	-	-	2
N/A	1	1	-	-	-	1
N/A	N/A	-	-	1	-	1
Total		4	3	6	9	22

Notes: **LWC** denotes Low-wage country competition. **Mach.** denotes capital equipment/machinery. **N/A** denotes that the firm did not respond to the question.

Recommendations

During the course of the interviews we identified the following areas where intervention by policy makers might help to improve export performance:

- Export performance is primarily determined by the skills of the workforce and is therefore dependent on the quality of the national educational system. State educational policy, above all for education in schools and vocational training, must be oriented towards a long-term perspective - particularly with regard to ensuring that there is an adequate supply of young people equipped with the skills required by industry. Establishing stronger links between educational institutions and industry is one way of making sure that the skill needs of business are properly understood.

- Given the presence of low-wage countries in labour intensive segments of manufacturing, and the increasing mobility of capital and international division of labour, it seems that high-wage countries such as the UK and Germany can only maintain their competitive position and increase income per capita by specialising in human capital-intensive products (where competition is based on factors such as product innovations and quality rather than price). Comparing the two countries under consideration in our medical equipment analysis, German firms manufacturing low and medium-tech products have made considerably more headway in this respect than their UK counterparts. Hence there is an understandable request on the part of UK manufacturers to obtain support in their efforts to climb up the 'quality-ladder'.

- A case in point could be R&D which is of crucial importance in improving competitiveness, particulary product quality. Some government support in this area could be justified in order to help small and medium-sized exporters retain or expand market share. More effort should be focussed on increasing the success rate of firms in terms of translating innovations arising from R&D expenditure into profitable commercial production.

- Hence the emphasis of practical government assistance for small and medium-sized firms (and in contrast to the current British situation where most help received consists of advice on advertising and marketing) should therefore shift towards providing expert advice on how to actually implement product and process innovation. Such advice should carefully consider whether the current skill levels of the workforce are compatible with the suggested innovations, or provide precise details of the additional skills required.

- Serious concerns were raised by both British and German firms regarding the reputation of the CE quality mark. Consequently, steps should be taken to ensure more harmonisation between national tests and certification procedures across EU member states (without burdening businesses with even more 'red tape' as the current requirements regarding CE mark formalities and paperwork are thought to be excessive). In some member countries, the prime prerequisite would be the

enforcement of existing legislation and rules. The ultimate target should be to ensure that the CE mark is a reliable indicator of uniform quality standards across all partner countries.

- Financial support from government bodies for participation in overseas trade fairs and exhibitions would help to increase exports. There is also scope for further help using existing resources - such as increased assistance from embassy staff in forging links with new trading partners. This applies to both British and German exporters.
- Our analysis encountered clear limitations as to data availability with respect to the medical equipment sector. Therefore, for establishing a better basis for surveying the medical equipment industry, a comprehensive statistical data base should be created by joint action of government, trade associations and industry.

Glossary of abbreviations

ABHI	Association of British Health-Care Industries
ASEAN	Association of Southeast Asian Nations
BfAI	Bundesstelle für Aussenhandels-Information
BVMed	Bundesfachverband Medizinprodukteindustrie
CAD	Computer Aided Design
CD-ROM	Compact Disc, Read Only Memory
CE	Conformité Européenne
CNC	Computer Numerically Controlled (Machinery)
CT	Computer Tomography
DEKRA	Deutscher Kraftfahrzeug-Ueberwachungsverein
DIN	Deutsche Industrie-Norm
DMT	Diagnostic, Monitoring and Therapy
DTI	Department of Trade and Industry
EEC	European Economic Community
EFTA	European Free Trade Association
EMU	European Monetary Union
EU	European Union
FDA	Food and Drugs Administration
FuE	Forschung und Entwicklung
F+O	Verband der Deutschen Feinmechanischen und Optischen Industrie
ISO	International Standards Organisation
IT	Information Technology
LCCI	London Chamber of Commerce and Industry
MDA	Medical Device Association
MIS	Minimally Invasive Surgery
MRI	Magnetic Resonance Imaging
NACE	Nomenclature générale des activités économiques dans les Communautés Européennes
NHS	National Health Service
OECD	Organisation for Economic Co-operation and Development
PC	Personal Computer
R&D	Research and Development
SEA	Surgical Equipment and Accessories
SME	Small and Medium-Sized Enterprises
TUEV	Technischer Ueberwachungs-Verein
UK	United Kingdom
US(A)	United States (of America)
VDGH	Verband der Diagnostika-Industrie
ZVEI	Zentralverband Elektrotechnik und Elektroindustrie

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