THE ORGANISATION OF R&D IN UK FIRMS AND ITS RELATIONSHIP TO THE MANUFACTURING BASE

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Abstract

In this paper, we consider the extent to which R&D outsourcing and centralisation of R&D within the firm varies depending on the products that the firm produces and how applied the R&D is to a particular product. We find that, in general, the most applied type of R&D is more likely to be co-located with production than R&D that is more basic research. On average, 46% of the most applied type of R&D is co-located with production compared to 42% of all R&D done in-house.

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1 Introduction

Which firms invest in research and development and how firms structure their R&D and productive activity are questions of considerable interest to policy makers and academics.

For example, the UK government has recently introduced R&D tax credits in order to encourage businesses to conduct more R&D in the UK. Understanding how firms structure R&D activities will help us to understand how effective this policy might be. Recent trends suggest that UK firms are conducting an increasing proportion of their R&D overseas.[1] Do firms co-locate R&D and production activity, so is it important to maintain a manufacturing base if we want to keep R&D in the UK,[2] or are R&D and production easily separable? Does this depend on the type of R&D being carried out? How much R&D is carried out by the firm using the R&D, and how much does it outsource?

In this paper, we use a new matched micro-level data set to describe the organisation of R&D and its relation to the British manufacturing base. To start with, we investigate the prevalence of R&D among UK manufacturing firms, and how this varies across firms by size and industry. We then look at how manufacturing firms organise their R&D, for instance whether they outsource their R&D to specialist R&D firms, whether they have centralised R&D facilities within the firm or whether they co-locate R&D with production. Finally, we consider whether there are any links between the way R&D is organised within the firm, the products the firm produces, the type of R&D it does and other firm characteristics such as size.

The decision whether to outsource R&D or retain in-house R&D facilities depends upon many of the same factors as any 'make-buy' decision, such as whether there are economies of scope between R&D and production and whether it does sufficient R&D to exploit economies of scale. An additional difficulty that arises if R&D is outsourced is how to design a contract between the customer (manufacturer) and R&D contractor when the outcome of the research is uncertain *ex ante*. This requires some kind of rule on how to share the intellectual property rights and the

[1] See Bloom and Griffith (2002) and Griffith and Harrison (2003).

[2] Around 80% of business R&D done in the UK relates to manufactured products.

revenues generated by a given innovation, which will reduce the marginal incentive of the customer to invest in R&D compared to a situation where it is the residual claimant on the profits from any innovation. [3] On the other hand, there may be offsetting benefits of outsourcing, such as the ability to exploit economies of scale if the contractor is able to spread some of its fixed costs across a number of customers.

Another benefit of doing R&D in-house from a private perspective is that intellectual property can only be imperfectly protected by patents. There is often a delay between an innovation and the point at which a new product or process can be patented, and patents may not cover all aspects of a new product or process. Keeping R&D in-house makes it less likely that such negative externalities arise, and thus increase the potential return to a given innovation for the firm. This is likely to be more important where a firm is already at the frontier in terms of efficiency, and its R&D is therefore more likely to push the frontier outwards. In such a situation, the lost profits that would result from the leakage of information would probably be greater than a situation where a firm is mainly doing R&D in order to allow it to imitate and implement the innovations of others. In this case, the R&D is more likely to benefit the firm doing it than any other firm and the potential losses due to information leakage from outsourcing R&D are likely to be lower.

Thus we would expect to see that, conditional on other firm- and product-specific factors, firms wishing to R&D that is more basic in nature and firms that are closer to the frontier in a given product group would do relatively more R&D in-house. Small firms that face financing constraints or high fixed costs of R&D would be more likely to outsource it, other things being equal.

When R&D is carried out in-house, firms have a choice about where they locate the R&D facilities within their organisational structure[4]. The two main alternatives are a centralised R&D facility that does research for one or more production facilities, or R&D facilities sited in or close to the manufacturing plants that will use the results of their research. The results of R&D will often benefit more than one product area, and could potentially lead to the development of

[3] See Aghion and Howitt (1998), Chapter 13.

[4] This is mainly relevant to large multi-product, multi-divisional firms.

entirely new products. Centralisation potentially enables these economies of scale and scope to be exploited by the firm more successfully than if R&D were delegated to individual production units. On the other hand, centralisation of R&D is likely to delay the adaptation of products to meet new requirements.

The more basic or fundamental the research, the greater the potential economies of scope and the less likely that it will be closely linked to the adaptation of existing products to new circumstances. This suggests that we would expect more applied research to be co-located with manufacturing, and more basic research to be centralised.

2 R&D conducted by Business Enterprises located in Britain

We use a novel data set, which contains very disaggregate information on output, inputs and R&D expenditure in all production facilities in Britain from 1994 to 1998. In these data we observe the population of firms and establishments located in the UK that do R&D. An *establishment* can be thought of as a group of plants owned by the same firm and in the same line of business. A *firm* may own a number of establishments that operate in different lines of business.

Data on R&D expenditure is collected annually as part of the survey of Business Enterprise Research & Development (BERD). This breaks down R&D expenditure by establishments and by the product group it relates to, how it is funded, the type of R&D (basic, applied, etc.), as well as whether the R&D is carried out by the establishment itself or outsourced. Data on output and non-R&D inputs for establishments engaged in manufacturing is collected as part of the Annual Business Inquiry (previously Annual Census of Production) and stored in the Annual Respondents Database (ARD). The matched dataset therefore covers all manufacturing or R&D activity that takes place in Britain (including that done by foreign-owned firms), but does not cover manufacturing or R&D activity by British firms overseas or non-manufacturing activity in Britain.

2.1 R&D done by manufacturing firms in the UK

We begin by looking at the prevalence of R&D activity among UK manufacturing firms, and the number of firms and amounts of R&D accounted for by firms with and without UK manufacturing facilities. Table 1 shows that there are around 3,000 manufacturing firms doing R&D in the UK in the sample period. This represents about 2% of manufacturing firms and 50% of firms doing R&D in the UK. These firms own 4% of manufacturing establishments and 56% of R&D establishments respectively.

Table 1: Firms manufacturing and doing R&D in the UK, 1994 to 1998 average

	Number of firms	% of mfg firms	% of R&D doing firms	Number of mfg ests	% of mfg ests	Number of R&D ests	% of R&D ests
Firms manufacturing and doing R&D in the UK	2,967	1.9	50.8	7,100	4.2	3,786	56.0

Source: Authors' calculations from matched ARD-BERD micro data. See Annex A for full definition of industries/ product groups.

There is large variation in the proportion of firms doing R&D across different size bands. Table 2 shows that the overall proportion of manufacturing firms doing R&D is very low because almost none of the firms in the smallest two size bands, which make up the vast majority of the ARD population, do any R&D. In contrast, one quarter of firms with manufacturing capacity in the UK and with more than 250 employees also do R&D in the UK. There is a similar, though less extreme, variation with size in the proportion of R&D doing firms with UK manufacturing facilities. 8% of the smallest R&D doing firms are engaged in manufacturing, compared with 88% of the largest.

Table 2: Manufacturing firms doing R&D and R&D-doing firms with UK manufacturing facilities, by size band (1994-1998 average)

Number of employees	No of manufacturing firms	% of manufacturing firms doing R&D	No of R&D doing firms	% of R&D-doing firms with UK manufacturing establishments
1-9	64,731	0.2	1,508	8.2
10-49	64,229	0.7	1,209	34.5
50-99	14,500	2.1	554	55.6
100-249	9,811	5.0	720	68.5
250+	6,526	24.9	1,854	87.6
All	**159,798**	**1.8**	**5,845**	**50.8**

Note: Number of employees reflects the total number employed by the firm across both production and R&D establishments.

Source: Authors' calculations from matched ARD-BERD micro data. See Annex A for full definition of industries/ product groups.

Table 3 shows that on average 85% of R&D expenditure is done by manufacturing firms. R&D expenditure is skewed towards large firms, the firms in the largest size band doing more than

90% of the R&D. There is an upward trend in the proportion of R&D done by manufacturers as the size of the firm increases.

Table 3: Amount of R&D done by manufacturing and non-manufacturing firms, by size band (1994-1998 average)

Number of employees	Total intramural R&D (£m)	% of total R&D done by firms in size band	Intramural R&D done by manufacturing firms (£m)	% of R&D done by manufacturers within size band
1-9	27	0.3%	2	7.8%
10-49	101	1.1%	17	16.9%
50-99	105	1.1%	34	30.0%
100-249	403	4.2%	137	32.3%
250+	8,922	93.3%	7,930	89.0%
All	**9,560**	**100%**	**8,129**	**85%**

Source: Authors' calculations from matched ARD-BERD micro data. See Annex A for full definition of industries/ product groups.

Table 4 shows that the observed population of establishments and firms doing R&D has increased over the 1994 to 1998 period. This may partly reflect a genuine increase in the size of the population of R&D-doing firms. However, other information suggests that it mainly reflects the fact that ONS has detected more firms that do R&D as time has gone on. For instance, there is a big increase in the observed BERD population in 1996. And 69% of the R&D establishments first observed in the BERD population in that year are in the R&D services industry, compared to around 5% in other years. This suggests that new R&D establishments were identified from other information sources in that year.

Table 4: Number of establishments, firms and intramural R&D in BERD, by year

Year	No. of establishments	No. of firms	Total intramural R&D (£m)	% of R&D doing firms with UK manufacturing capacity	% R&D expenditure relating to manufacturing product groups
1994	3,813	2,861	9,204	72	76
1995	4,846	4,049	9,116	66	78
1996	7,763	6,867	9,297	41	78
1997	8,170	7,312	9,556	42	80
1998	9,197	8,138	10,133	52	80

Source: Authors' calculations from matched BERD-ARD micro data.

The last two columns of Table 4 show the variation over time in the proportion of R&D doing firms in BERD that match with the ARD at the firm level, and the proportion of R&D

expenditure that relates to manufacturing product groups respectively. The proportion of R&D doing firms that also manufacture in the UK appears to decline over the period until picking up again in 1998. The proportion of R&D related to manufacturing product groups increases over the same period. This appears to suggest that the extent of outsourcing of R&D to non-manufacturing firms increased significantly up to 1997 until declining again. However, this is far more likely to be due to the fact that a disproportionate amount of the firms entering the BERD population in 1996 were non-manufacturing firms.

2.2 Extent of outsourcing of R&D

How much R&D is done within manufacturing firms and how much is outsourced? The extent to which firms outsource their R&D can be gauged directly by looking at the amount of R&D they purchase from other firms.[5] It should also bear a strong relationship to the amount of R&D done by non-manufacturing firms, the majority of which is typically done by firms supplying R&D services to manufacturers. The relationship will not be exact because of the possibility that R&D can be outsourced to overseas R&D establishments and that domestic R&D establishments can do R&D that is used by overseas manufacturers.

Intramural R&D (that carried out by the firm itself) and extramural R&D (that paid for by the firm but carried out on its behalf by someone else) are shown separately in Table 5. The first column of Table 5 shows the number of R&D establishments that are classified in each industry (as opposed to doing R&D that relates to that product group in each industry). By far the largest number of establishments are in the R&D services industry, with several other industries also having large numbers of R&D establishments. The second column shows the total amount of intramural R&D carried out by establishments in that industry. It shows that around 60% of R&D expenditure is undertaken by manufacturing establishments. Considering that 85% of UK business R&D is done by firms that also have UK manufacturing facilities (see Table 3), this implies that another 25% of R&D expenditure is done by non-manufacturing establishments owned by manufacturing firms. The third column reports extramural R&D and the fourth simply

[5] As the BERD data is collected at the establishment level, some intra-group sales of R&D between R&D establishments may be included in extramural R&D expenditure. Extramural R&D summed across all establishments in the firm therefore represents an upper bound to the quantity of R&D that is outsourced.

shows the second column over the sum of the second and third. Overall around 90 per cent of R&D conducted by manufacturing *establishments* is intramural, although this varies from a low of 77 per cent in motor vehicles to a high of 96 per cent in Iron & Steel and Aerospace. Services establishments outsource a greater proportion of R&D expenditure than manufacturing establishments. So relatively little R&D is outsourced, and the use of outsourcing does not vary very much across product groups.

Table 5: R&D expenditure by *industry* of R&D doer, 1994 to 1998

Industry	No. R&D establishments	Intramural R&D (£m)		Extramural R&D (£m)	Intramural R&D as % of total R&D
Food & tobacco	225	120		9	93
Textiles, clothing, etc	158	23		.	94
Wood, paper, publishing	140	42		.	95
Oil/ nuclear	14	.		.	88
Chemicals	276	605		132	82
Pharmaceuticals	62	655		88	88
Rubber & plastic	215	71		.	94
Non-metallic minerals	108	34		.	95
Iron & steel	34	.		.	96
Non-ferrous metals	39	9		.	92
Metal products	278	52		.	94
Machinery	583	562		29	95
Computers	91	312		16	95
Electrical machinery	246	234		15	94
TV/ radio	180	550		50	92
Precision instruments	416	654		49	93
Motor vehicles	145	600		181	77
Trains	34	25		.	.
Ships	25	16		.	93
Aerospace	56	837		31	96
Other manufacturing	163	29		.	95
Manufacturing	3,488	5,559	(59%)	633	90
R&D services	1,527	2,087		463	82
Other non-manufacturing	1,744	1,815		291	86

Note: . indicates that the value is less than £5m or cannot be reported because it is disclosive.
Source: Authors' calculations from BERD micro data. See Annex A for full definition of industries/ product groups.

Table 6 shows R&D classified by the *product group* that the R&D relates to, rather than the industry of the establishment undertaking the R&D. Close to 80% of R&D relates to manufacturing product groups. Around 87 per cent of R&D carried out with respect to manufacturing products is intramural, ranging from 81 per cent in Pharmaceuticals to 97 per cent in Wood and Non-ferrous metals. So the extent of outsourcing is very similar whichever way we look it.

This table (compared to Table 5) also shows that in some industries (e.g. pharmaceuticals) a much higher proportion of R&D is done in respect of that industry (almost £2 billion per year on average over 1994-1998) than is done by *establishments* themselves classified in the industry (around £655 million per year). Most of the additional R&D related to manufacturing product groups is done by R&D services establishments that are either owned by pharmaceuticals firms or do R&D for them on contract. This leads us on to a more detailed investigation of how R&D is organised within firms across the different product groups.

Table 6: R&D expenditure by *product group*, 1994 to 1998

Product group	Intramural R&D (£m)		Extramural R&D (£m)	Intramural R&D as % of total R&D
Food & tobacco	205		13	94
Textiles, clothing, etc	28		.	95
Wood, paper, publishing	46		.	97
Oil/ nuclear	211		.	.
Chemicals	685		54	93
Pharmaceuticals	1,969		473	81
Rubber & plastic	65		.	93
Non-metallic minerals	53		.	92
Iron & steel	45		.	96
Non-ferrous metals	17		.	97
Metal products	88		6	94
Machinery	613		33	95
Computers	134		10	93
Electrical machinery	479		55	90
TV/ radio	663		48	93
Precision instruments	312		.	.
Motor vehicles	838		185	82
Trains	39		.	90
Ships	22		.	.
Aerospace	898		149	86
Other manuf	22		.	93
Manufacturing	7432	(78%)	1149	87
R&D services	400		16	96
Other non-manufacturing	1631		224	88

Note: . indicates that the value is less than £5m or cannot be reported because it is disclosive.
Source: Authors' calculations from BERD micro data. See Annex A for full definition of industries/ product groups.

2.3 Organisation of R&D within the firm

In Table 7 we look at how much R&D is done by manufacturing and non-manufacturing firms in different product groups and, for those firms with some UK manufacturing capacity, how R&D

Table 7: R&D expenditure done by manufacturing firms/establishments, 1994 to 1998

Product group	(A) Total intramural R&D (£m)	Firms (B) Intramural R&D matched to manuf. firm (£m)	Firms (C) Proportion of R&D done in manuf. firms (B)/(A)	Establishments (D) Intramural R&D matched to manuf. estab. (£m)	Establishments (E) Proportion of intramural R&D done in manuf.. estabs. (D)/(A)
Food & tobacco	205	183	0.90	79	0.39
Textiles, clothing, etc	28	22	0.79	19	0.68
Wood, paper, publishing	46	37	0.80	30	0.65
Oil/ nuclear	211	156	0.74		
Chemicals	685	623	0.91	258	0.38
Pharmaceuticals	1969	1691	0.86	335	0.17
Rubber & plastic	65	62	0.95	50	0.77
Non-metallic minerals	53	49	0.91	24	0.44
Iron & steel	45	.	.	5	0.11
Non-ferrous metals	17	.	.	5	0.29
Metal products	88	67	0.77	30	0.34
Machinery	613	501	0.82	361	0.59
Computers	134	.	.	73	0.54
Electrical machinery	479	442	0.92	85	0.18
TV/ radio	663	581	0.88	235	0.35
Precision instruments	312	272	0.87	206	0.66
Motor vehicles	838	665	0.79	568	0.68
Trains	39	.	.	7	0.18
Ships	22	.	.	14	0.64
Aerospace	898	857	0.95	613	0.68
Other manufacturing	22	19	0.90	18	0.86
Total manufacturing	**7432**	**6423**	**0.86**	**3114**	**0.42**

Note: . indicates that the value is less than £5m or cannot be reported because it is disclosive.

Source: Authors' calculations from matched ARD-BERD micro data. See Annex A for full definition of industries/ product groups.

The amount of R&D done by non-manufacturing firms implied by Table 7 is similar to the amount of extramural R&D outsourced by manufacturing firms (see Table 6) in most product groups, except pharmaceuticals and aerospace where extramural R&D is noticeably higher. This may be because more R&D is outsourced to overseas laboratories in these product groups.

One of the reasons why the proportion of R&D that is centralised within the firm may vary quite a lot between product groups may be that R&D fulfils a different purpose in some product areas than others. R&D is not homogeneous, but encompasses a spectrum of activities. At one end is basic or fundamental research that does not have a specific commercial use in mind. This

accounts for around 5% of business expenditure on R&D[6]. At the other end is experimental development, where the results from earlier (basic and applied) research are applied to the introduction of new, or improvement of existing, products and processes. This accounts for around 62% of business expenditure on R&D. The remaining third of business R&D (classified as applied R&D) lies somewhere in between these two extremes.

[6] The BERD survey only contains the breakdown of current expenditure between basic and applied R&D and experimental development. However, since current expenditure accounts for 85% of total intramural R&D expenditure, any differences in the capital-intensity of R&D across different types are unlikely to change the relative proportions significantly.

Table 8 shows how the proportion of basic, applied and experimental R&D varies across product groups. No more than 14% of business expenditure on R&D is classed as basic in any product group. Motor vehicles and electrical machinery have relatively less basic research done on them than other product groups. There is much more variation in the proportion of applied and experimental R&D, which together account for 95% of the total, across product groups.

Table 8: Type of R&D expenditure by product group, 1994 to 1998

Product group	(A) Total current expenditure on intramural R&D (£m)	(B) Proportion spent on basic R&D (£m)	(C) Proportion spent on applied R&D (£m)	(D) Proportion spent on experim develop (£m)
Food & tobacco	177	0.06	0.54	0.41
Textiles, clothing, etc	26	.	0.44	0.52
Wood, paper, publishing	44	0.14	0.32	0.54
Oil/ nuclear	.	.	0.73	0.22
Chemicals	614	0.06	0.55	0.39
Pharmaceuticals	1547	0.06	0.37	0.58
Rubber & plastic	58	0.10	0.50	0.40
Non-metallic minerals	49	.	0.58	0.37
Iron & steel	.	.	0.98	.
Non-ferrous metals	.	.	0.96	.
Metal products	81	.	0.42	0.58
Machinery	589	.	0.41	0.49
Computers	120	.	0.23	0.65
Electrical machinery	449	0.01	0.15	0.83
TV/ radio	607	.	0.29	0.71
Precision instruments	294	0.04	0.33	0.64
Motor vehicles	724	0.01	0.13	0.86
Trains	.	.	0.39	.
Ships	.	.	0.90	.
Aerospace	863	0.05	0.15	0.80
Other manuf	18	.	0.45	0.51
Total manufacturing	**6,557**	**0.05**	**0.33**	**0.62**

Note: . indicates that the value is less than £5m or cannot be reported because it is disclosive.

Source: Authors' calculations from ARD and BERD micro data. See Annex A for full definition of industries/ product groups.

Table 9 looks at experimental development (ie that R&D that is closest to market) in more detail. We can see that products vary both in the proportion of R&D that falls into this category and in the proportion of experimental development that takes place in production establishments. Over 80% of R&D expenditure is classified as experimental development in electrical machinery, motor vehicles and aerospace, compared to less than 10% in metal production and shipbuilding. A higher proportion of experimental development takes place in production establishments than other types of R&D - 46% compared to 42% for all intramural R&D. This is consistent with the theoretical argument that firms will tend to site the most applied R&D related to a given product closer to where production of that products takes place. However, there are some products

where experimental development is more likely to be centralised than other types of R&D, for instance pharmaceuticals, electrical machinery and TV/ radio equipment. For these products, experimental development constitutes 60 to 80 per cent of R&D but only 15 to 30 percent of it is co-located with production. This may reflect the fact that the synergies between R&D and production are less significant in, say, pharmaceuticals, than, say, motor vehicles. This, in turn, could perhaps be because R&D is more closely related to product than process innovation the relative cost of siting the most applied kind of R&D with production is higher for these products, perhaps because the economies of scale or scope from centralisation are more significant for these kinds of products than for less standardised products such as aeroplanes.

Table 9: Experimental R&D expenditure, 1994 to 1998

Product group	(A) Total current expenditure on intramural R&D (£m)	(B) Amount spent on experim develop (£m)	(C) Proportion spent on experim develop (B)/(A)	(D) Amount spent on experim develop in mfg estabs (£m)	(E) Proportion spent on experim develop in mfg estabs. (D)/(B)
Food & tobacco	177	72	0.41	40	0.56
Textiles, clothing, etc	26	13	0.52	9	0.72
Wood, paper, publishing	44	23	0.54	18	0.76
Oil/ nuclear	.	.	0.22	.	0.44
Chemicals	614	238	0.39	90	0.39
Pharmaceuticals	1547	893	0.58	136	0.15
Rubber & plastic	58	23	0.40	16	0.75
Non-metallic minerals	49	18	0.37	7	0.44
Iron & steel	.	.	0.02	.	0.25
Non-ferrous metals	.	.	0.04	.	0.67
Metal products	81	47	0.58	11	0.22
Machinery	589	288	0.49	196	0.66
Computers	120	78	0.65	46	0.60
Electrical machinery	449	374	0.83	59	0.16
TV/ radio	607	425	0.71	133	0.31
Precision instruments	294	186	0.64	134	0.71
Motor vehicles	724	620	0.86	451	0.73
Trains	.	.	0.61	.	0.19
Ships	.	.	0.09	.	0.62
Aerospace	863	688	0.80	501	0.73
Other manuf	18	9	0.51	8	0.86
Total manufacturing	**6,557**	**4,064**	**0.62**	**1,878**	**0.46**

Note: . indicates that the value is less than £5m or cannot be reported because it is disclosive.

Source: Authors' calculations from ARD and BERD micro data. See Annex A for full definition of industries/ product groups.

3 Conclusions

Theory suggests that R&D that is more basic in nature is more likely to be done in a central R&D facility than be co-located with production. We find that this is supported by the evidence for the UK to a reasonable extent. Around 10% of R&D is outsourced. Of the remaining 90%, 42% is co-located with production within firms that have UK manufacturing facilities. This proportion rises to 46% for the most applied form of R&D, experimental development.

As well as type of R&D actors that might also affect location of R&D within the firm include a firm's proximity to technical frontier and the products it produces. 'Frontier' firms may be less likely to contract out their R&D for fear of the results of the research leaking out to competitors. R&D may perform different functions in different product areas, reflecting a different mix between product and process innovation, for example. Other firm characteristics may also be important factors – eg size and product range. The larger the firm and the broader the range of products it produces, the more likely it is to reap economies of scale or scope from keeping its R&D in-house.

Future work will investigate the relative importance of the type of R&D, the product group to which it relates and other firm characteristics (eg size, extent of vertical integration, product mix) in explaining how R&D is organised, and in particular whether it is outsourced or not or where it is done within the firm.

Annex A: Definitions of industries and product groups

Product group	Name used in tables	Description	Industry code (sic92)
C	Food & tobacco	Food, beverages, tobacco	15, 16
D	Textiles, clothing, etc.	Textiles, clothes, leather, footwear	17, 18, 19
E	Wood, paper, publishing	Wood and wood products, pulp, paper, publishing, printing, recorded media	20, 21, 22
F	Oil/ nuclear	Refined petroleum products, nuclear fuel,	23
G	Chemicals	Chemicals, chemical products and man-made fibres	24 (excluding 24.4)
H	Pharmaceuticals	Pharmaceuticals, medical chemicals and botanical products	24.4
I	Rubber and plastics	Rubber and plastics	25
J	Non-metallic minerals	Other non-metallic mineral products,	26
K	Iron & steel	Basic iron & steel and ferro-alloys	27.1, 27.2, 27.3, 27.51, 27.52
L	Non-ferrous metals	Basic precious and non-ferrous metals	27.4, 27.53, 27.54
M	Metal products	Fabricated metal products	28
N	Machinery	Machinery and equipment (n.e.s.)	29
O	Computers	Office machinery, computers	30
P	Electrical machinery	Electrical machinery	31
Q	TV/ radio	Radio, TV and communications equipment	32
R	Precision instruments	Medical and precision instruments,	33
S	Motor vehicles	Motor vehicles, motor parts and engines	34
T	Trains	Railway locomotives and rolling stock, motorcycles and bicycles, other transport n.e.s.	35.2, 35.4, 35.5
U	Ships	Ships and boats	35.1
V	Aerospace	Aircraft and spacecraft	35.3
W, X	Other manufacturing	Furniture, jewellery, musical instruments, sports goods, games and toys and other manufacturing (n.e.s.), recycling	36, 37

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