Linking Technology Areas to Industrial Sectors

Final Report to the European Commission, DG Research

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1. Introduction

Technological innovations are one of the key factors in explaining economic competitiveness of advanced countries. Therefore it is important to monitor technological development of areas, countries and regions in a systematic way to support economic analysis and decision making. It is, however, impossible to describe the technological development by a single indicator encompassing all aspects and stages of innovation. Rather, it is necessary to establish a network of related indicators reflecting different aspects of innovation. At the same time to examine the relationship between technology and economic performance it is crucial to link technological indicators with those related to economic performance. At the international level, most economic indicators such as turnover, investment, employment, productivity, value added, R&D expenditure etc. are classified by industrial sectors, for instance, according to the NACE or ISIC schemes. In contrast, some of the most frequently used indicators for technology are based on patent statistics, classified according to the International Patent Classification (IPC).[1] However, the IPC is based on technological categories and cannot be directly translated into industrial sectors. One approach for solving this problem is to establish a reliable concordance between technology and industry classifications.

The report describes the development of such a concordance. In a first step, a set of industrial sectors, defined by NACE and ISIC codes, is selected as basis for the further analyses. In a second step, these sectors are also associated to technical classifications in terms of IPC codes. In a third step, the technical and industrial approaches are compared by investigating the patent activities by technology-based fields of more than 3000 firms classified by industrial sector. This computation leads to the elaboration of a transfer matrix or concordance between technology and industry classifications. In a fourth step, the adequacy and empirical power of the concordance is verified by comparing the country structures based on the concordance. In particular, this is done by comparing the patent activities – classified by industrial sectors – with the value-added and export structures.

The Fraunhofer Institute for Systems and Innovation Research (Fraunhofer ISI), Karlsruhe, Germany, the Observatoire des Sciences et des Techniques (OST), Paris, France, and the University of Sussex, Science and Policy Research Unit (SPRU), Brighton, United Kingdom, co-operated in carrying out the different tasks of the research project. Fraunhofer ISI was primarily responsible for the first and second working steps (definition of industrial and technical classification), OST for the third step (empirical elaboration of the concordance matrix), and SPRU for the fourth step (statistical verification). Fraunhofer ISI co-ordinated the different modules.

1 The relevance of national patent classifications such as the USPOC is decreasing, as in all cases, the national patents are additionally classified in terms of the IPC.

2. State of the art

There have been a number of attempts in the past to establish a link between technological and economic indicators. However these concordances have not found satisfactory solutions to the following four problems: (1) international comparability, (2) level of disaggregation (3) strong empirical basis, (4) easy applicability to specific problems. Furthermore, since some of these were established, industrial structures have changed, necessitating a change in the nomenclatures.

One of the earliest attempts at linking technology and industry classifications was by Kronz (1980), who classified the patent applications of four countries by NACE classes. This was based more on an intuitive approach, rather than on the basis of a systematic analysis leading to a well-defined concordance table.

Evenson / Puttnam (1988) use data from the Canadian Patent Office, where patent examiners simultaneously assigned IPC codes together with an industry of manufacture and sector of use to each of 300,000 patents granted between 1972 and 1995. On the basis of these data, they established a cross-tabulation between 8 IPC sections and 25 industries, called the Yale-Canada patent flow concordance. The two main problems with this approach, which limit its value in terms of practical applications are: (a) it is based on Canadian SIC, which needs to be translated to either ISIC Rev 3 or NACE; and (b) it is not very detailed in terms of IPC codes. An additional difficulty is that the relationship between sectors and technologies has distinctly changed during the period 1972 to 1995.

Verspagen et al. (1994) suggested a concordance scheme between four-digit level IPC subclasses and 22 (2 and 3 digit) industrial classes based on ISIC (rev. 2), the so-called MERIT Concordance. The linkage was established by an intellectual approach, and based on a similar concordance of Statistics Finland. In this approach, many of the 625 IPC subclasses are linked with different weights to different sectors, so that it is quite time-consuming to calculate statistics for specific sectors.

In the 1980s the US Patent and Trademark Office established a detailed concordance between subclasses of the USPC and 41 unique classes of the US Standard Industrial classification, and this is used to produce regular statistics of US patents by SIC sectors. This is simply done on the basis of examining the definition of each USPC class (and sometimes subclass) and assigning them to one or more of the 41 industrial classes. For our purposes this concordance has some of the problems already identified above. It is based on the USPC and not the IPC, limiting its applicability to EPO data. Further the industrial classification used is the US-SIC, which needs to be translated into ISIC for practical use.

Greif / Potkowik (1990) computed statistics of patents by industrial sectors based on an old German national statistical classification scheme (Wirtschaftszweige, WZ79) which is not compatible with the present NACE or ISIC codes. They assigned WZ codes to a sample of 280 applicants in 1983 at the German Patent Office and analysed their patent activities in terms of IPC codes. Again the validity for present purposes is quite limited.

The most recent attempt at defining a concordance between IPC and ISIC codes is by Johnson (2002). As with the earlier work of Evenson / Putnam (1988, see above), this is based on data from the Canadian Patent Office. For 625 IPC subclasses, Johnson defines probabilities of linkages to about 115 different sectors of manufacture and use. However, this interesting method has several limitations. Firstly the linkage between IPC codes and sectors is defined by examiners of the Canadian Intellectual Property Office, and is not based on the official industrial class of the company to whom the patent is assigned. This is likely to result in a technology bias. Secondly the Canadian Office stopped assigning sector codes to patents in the grant year 1995, equivalent to about 1991 in terms of first application (priority). Thus, the concordance is quite old, and there is a high probability that the relationship between technology and sectors has changed since then. Thirdly the sectors are defined in terms of Canadian SIC codes, and have to be translated into ISIC codes, implying certain inaccuracies due to translation. Fourthly the concordance is based on the determination of 70,000 probabilities of linkage between IPC and ISIC codes. Therefore it can only be handled with the support of a complex software package, consisting of three separate modules. Moreover as input, the user has to provide search results for all IPC subclasses which requires access to a comprehensive large-scale patent database. Notwithstanding these limitations, the Johnson concordance represents the most advanced suggestion for linking technologies to industrial sectors. However, its adequacy was never tested by a comparison to economic data.[2]

To sum up, there is still a need to design a concordance which provides a linkage between sector and technology classifications, and which can be handled in a straightforward way.

2 This is done with the concordance elaborated in this report in chapter 7.

3. Empirical basis for linking technologies and industries

3.1 Basic structures

Our approach starts with the selection of industrial sectors at the 2-digit level of NACE or ISIC with a finer breakdown of the quantitatively important sectors within chemicals, machinery, and electrical equipment, leading to 44 sectors of manufacture, documented in annex 1. This level of disaggregation is finer than most statistics on economic data, e.g. foreign trade, value added, or R&D expenditure, provided by OECD, Eurostat or other authorities. It was chosen to be able to show the main differences between the sub-sectors in chemicals, machinery, and electrical equipment industries. Thus a higher level of aggregation can be achieved by a simple combination (addition) of sub-sectors. Moreover it is possible to transfer the NACE-defined fields directly into ISIC-based sectors.

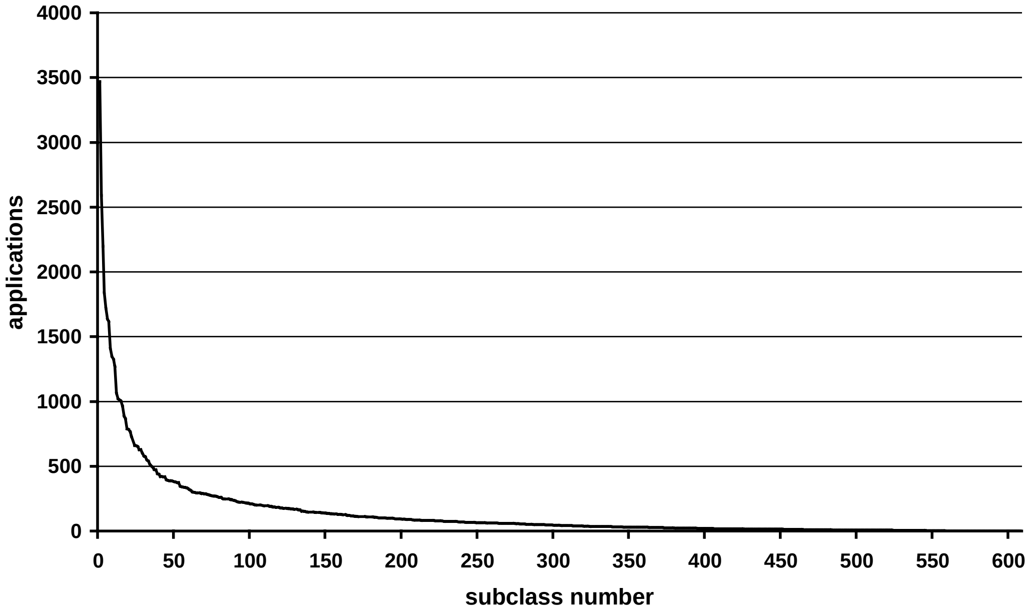
Industrial sectors are defined by the manufacturing characteristic of products, so that it is possible to associate them to technologies. On this basis, technical experts of Fraunhofer ISI associated each of the 625 subclasses of the IPC to one of the industrial categories mentioned above. In the following text, this first step is called "original, intellectual association" of technologies and sectors. Only subclasses that appear as primary classes were used, ignoring all index/cross reference codes. In the case of the subclasses F21M to F21Q (lighting), we included older codes that do not appear in the latest version (7th version) of the IPC. By this means, it will be possible to compute longer time series starting in about 1985.

The IPC subclasses were linked to one field only, even if multiple linkages to other fields were obvious, by applying the principle of main focus. In unclear cases, we made a statistical check of secondary IPC codes which generally led to a clear decision. In the few cases[3] where picture was unclear, we decided not to split the classes into different sectors, in order to keep the basic structures sufficiently clear.

The impact of the most "unclear" cases is generally low in terms of absolute numbers. The volume of patenting by IPC subclasses is quite uneven, as shown in figure 1. In the largest subclass, 3469 patent applications were registered in 1997, whereas in many subclasses no applications were filed at all. The top ten percent of subclasses (a segment of about 60 subclasses), account for 58 percent of all applications, and the top 30 percent for 85 percent (cf. figure 2) of the total. This implies that only the largest unambiguous cases would need to be considered in more detail. As an example, the subclass H03K (Pulse technique) is linked nearly in equal parts to telecommunications and computer technology and is sufficiently large to deserve special attention, with about 300 EPO applications in one year.

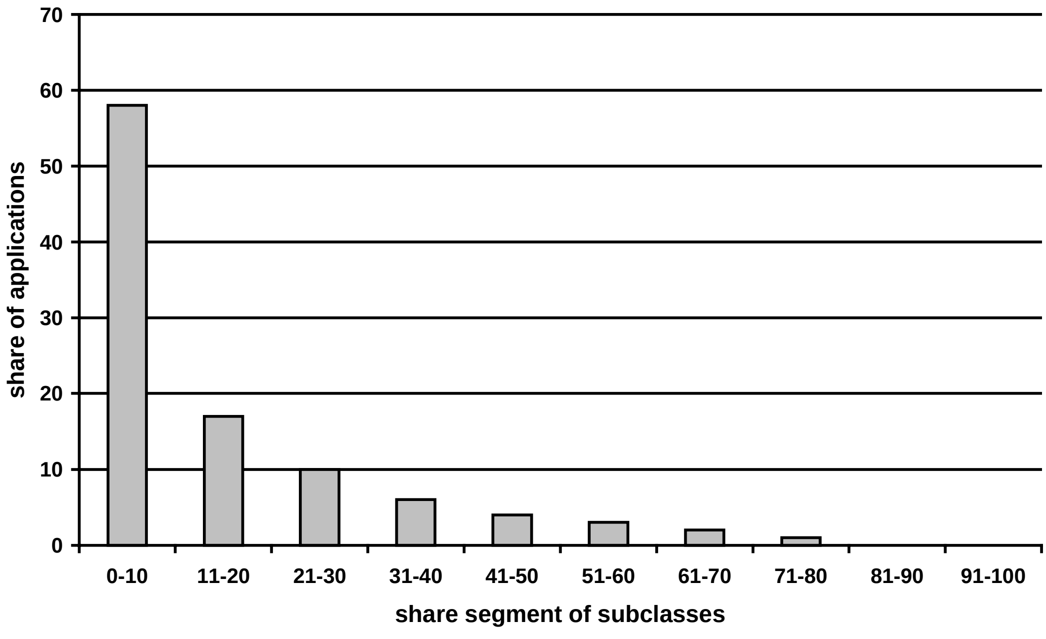
3 E. g. H03K, Pulse technique, or some subclasses of C07, Organic chemistry.

Figure 3-1: Distribution of the number of EPO applications by IPC subclasses in the priority year 1997



Source: EPAT; Computation by Fraunhofer ISI

Figure 3-2: Distribution of the number of EPO applications by segments of IPC subclasses (shares in percent, ordered by application volume) in the priority year 1997



Source: EPAT; Computation by Fraunhofer ISI

3.2 Approach of associating technologies and industries with regard to companies

For associating technologies and industries for single companies, an offline database of OST[4] containing all the data on European and PCT applications without double counting was employed. The information for each patent includes IPC codes, inventors, and applicants with geographical information. This was supplemented by data from Dun & Bradstreet (D&B)[5] which assisted in classifying each applicant by industry. In the D&B database, the industrial activities of firms are described using the US SIC classification, so that they had to be transferred to NACE codes for the purpose of the current project. Although there is no exact correspondence between SIC and NACE codes, it is possible to establish a good association between the classifications at a high level of aggregation (such as the 44 classes mentioned above). The concordance used in the project is documented in table 3-1. To sum up, the match of SIC and NACE (ISIC) is reliable at the present level of aggregation.

Table 3-1: Correspondences between the industrial classifications for the technology -industry correspondence

Field no	NACE	ISIC	SIC
1	15	15	20
2	16	16	21
3	17	17	22
4	18	18	23
5	19	19	31
6	20	20	24
7	21	21	26
8	22	22	27
9	23	23	29
10	24.1	241	281, 286, 2821, 2822
11	24.2	2421	287
12	24.3	2422	285
13	24.4	2423	283
14	24.5	2424	284
15	24.6	2429	289
16	24.7	243	2823, 2824
17	25	25	30

4 Oberservatoire des Sciences et des Techniques, Paris.

5 See http://www.dnb.com.

18	26	26	32
19	27	27	33
20	28	28	34
21	29.1	2911, 2912, 2913	351, 356 (not 3565, 3567, 3569), 3586, 3592, 3593, 3594, 3599
22	29.2	2914, 2915, 2919	3565, 3534, 3535, 3536, 3565, 3567, 3569, 3585, 3589
23	29.3	2921	352
24	29.4	2922	354
25	29.5	2923, 2924, 2925, 2926, 2929	3531-3533, 355, 3581, 3582
26	29.6	2927	348, 3795
27	29.7	293	363
28	30	30	357
29	31.1	311	3621, 3612
30	31.2, 31.3	312, 313	3613, 3625
31	31.4	314	3691, 3692
32	31.5	315	364
33	31.6	319	3694-5-9
34	32.1	321	367, 3629
35	32.2	322	366
36	32.3	323	365
37	33.1	3311	384, 385
38	33.2	3312	381, 3821, 3824-3826, 3829
39	33.3	3313	3822, 3823
40	33.4	332	386, 3827,
41	33.5	333	387
42	34	34	371
43	35	35-353	37372-379 (not 3827)
44	36	36	39, 25

In the project, the focus was on companies of the manufacturing sector, as patents are a intellectual property rights primarily used in the manufacturing sector; in the first approach, all companies outside manufacturing were excluded. However, Dun & Bradstreet classifies some companies – especially larger ones – as holdings and associate them to the service sector. These holdings were reclassified into manufacturing according to the activities of their major affiliations, at least in most cases where these information was available through national sources or the internet. This reclassification has a substantial impact on the outcome of the analysis, as most of the holdings represent very large manufacturing companies.

In addition, some firms of the "real" service sector also apply for patents, first of all in research and technical services. Ordinarily, companies are assigned to one sector classification on the basis of their main activity. As some service companies also produce commodities and technological innovations as a “secondary” activity, we had to re-assign some companies with regard of their activities in the manufacturing sector, even though these companies are no “ordinary” manufacturing companies. The reason for this re-assignment is the simple but plausible assumption, that these companies do their patent activities only in the part of the firm, which can be assigned to the manufacturing sector, and thus can be treated as a company from the manufacturing sector for the specific purposes of the project. This assumption does not neglect the fact, that “pure” service companies may also apply for patents, for example like research institutions or software companies. As these institutions are not in the scope of our analysis and also are normally not included in the national and international statistics on the manufacturing sector – and the aim of this concordance is to establish a linkage between economic statistics and patent statistics – it seems to be better to exclude these institutions from our analysis. Some further reclassification of service companies and also the correction of mis-classifications in the D&B database have been done on the basis of national company databases and by internet queries.

Some companies had more than one sector classification in the D&B database. Also the assignment by SPRU, OST and Fraunhofer ISI lead in some cases to more than one sector code. In a second version of the matrix, this additional information on several companies was used to improve the association between sectors and technologies. For this purpose, the patents of these companies were split up and fractionally linked to several sectors in order to reduce the heterogeneity between sectors and technologies. The analysis showed that this approach did not reduce, but rather increase the heterogeneity. The reason for this effect is that the correct assignment of singular patents to a sector is not known, but only the overall of the companies’ activities in different sectors and technologies. For illustration, Table 3-2a shows the ideal relation matrix between technologies and sectors on the level of an individual company with all elements on the main diagonal. But as this ideal matrix cannot be realised, the “real” matrix in Table 3-2b is applied. Compared to the ideal case, many elements are not on the diagonal. The “bias” of technology-sector association is larger, the relevance of ideal relations decreases. Due to this result, only the main sector was used for the classification of each company. The referring outcome for the above mentioned example is illustrated in Table 3-1c.

A further approach of linking sectors and technologies on the micro level of companies is to assign patents to sectors only along the main diagonal as done in the example of Table 3-2a. But this would have two negative side effects. First, it leads to a kind of “self-fulfilling prophecy” as no variation in the assignment of technologies to sectors on the micro level and therefore also no variation on the macro level of the whole matrix would come in, even though in reality is does exist. Second, this approach does not solve the association of those technologies that do not directly match with one of the companies' sector codes. It does not seem to be appropriate to assign these ones to the main sector or distribute them among all sectors at equal shares. This reasoning leads the initial problem to exclusively use the main sector.

This situation is further complicated by the fact, that some sectors (parts of a company) are more patent-intensive whereas others are less patent intensive. Therefore the share of technologies in the patent-portfolio will not exactly match the referring share in the sector distribution of that company.

Tables 3-2: Illustrative example for the different associations of industrial sectors and technologies for an individual company

Table 3-2a: "Ideal" relation matrix

	Sector 1	Sector 2	Sector3	Total
Technology 1	50			50
Technology 2		30		30
Technology 3			20	20
Total	50	30	20	100

Table 3-2b: "Real" relation matrix

	Sector 1	Sector 2	Sector3	Total
Technology 1	25	15	10	50
Technology 2	15	9	6	30
Technology 3	10	6	4	20
Total	50	30	20	100

Table 3-2c: Employed association matrix

	Sector 1	Sector 2	Sector3	Total
Technology 1	50			50
Technology 2	30			30
Technology 3	20			20
Total	100	0	0	100

3.3 Sample characterisation

In its patent database, OST realised the match of technologies and industrial sectors only for institutional applicants with more than 5 patent applications in three years, called "large firms", which represents the lion's share of patent applications. For the period 1997 to 1999, the OST database contains more than 50,000 applicants. However only 3,955 applicants registered more than 5 patents in three years, and are thus considered as "large firms". These 3,955 applicants account for 169,282 patents, which are more than 65 percent of all patents applied for by institutions in the three years period.

According to D&B information, 2,555, applicants representing 122,512 applications have been assigned to the manufacturing sector. In a second step the primary sector codes from the service sector have been replaced by the "main" secondary sector codes for all those companies having more than one sector classification, as described in chapter 3.2. This lead to a total of 2,825 applicants with 137,907 applications. In a final revision of this database, further information from national sources and internet queries have been used to assess the remaining firms in terms of their industrial activities. This ended up in the **final database** containing **3,133 applicants accounting for 154,238 patents in the three years period**. The final data used for building the concordance matrix set represents 79.2 percent of the initial applicants or 91.1percent of the initial applications. From a statistical perspective this is a very good representation of the population.

Furthermore, the three partner institutes, Fraunhofer ISI, OST, and SPRU, generated a second data set of "small firms" (defined as those with less than 5 applications in 3 years), located in France, Germany and the United Kingdom. For these firms, the industrial sector codes were identified by national data sources and integrated into the OST database. The data set of small firms began with about 3,000 applicants, and it was possible to assign NACE codes in about 2,360 cases.

In the analysis of our concordance we put a focus on the five countries United States, Japan, Germany, France, and United Kingdom (Great Britain) and also defined a group of "other countries". The absolute and relative distribution of applicants as well as applications by country is shown in Tables 3-3a to 3-3b. Most applicants and also most applications come from the group of "others" followed –as expected– by the United States, Japan, Germany, France and finally Great Britain. The reason why the number of applicants and applications from Great Britain is only about half of the French ones is that applicant counts are used, and not inventor countries, to assign patents to nations. Many patents from British inventors are applied for by companies with US-American ownership and thus are classified under the heading of the United States. When looking at the inventors –as it is done in the reliability and validity checks below– the difference between France and Great

Britain is much smaller. Furthermore, firms with British ownership obviously apply less patents than firms of other countries are often do not meet the minimum requirement of five patents.

Besides statistical variance there is no obvious under- or overrepresentation of some countries in our database as the shares are distributed around the mean of 79.2 percent with the boundaries of 72.9 percent and 86.8 percent respectively. This indicates that neither in the D&B database nor in our further queries –or at least in the sum of both– there is a systematic bias in favour of any country. The somehow higher differences in patent numbers in our sample also show up expected pattern, as the patent shares of "others" and of Germany are above average reflecting their higher share of large enterprises applying for patents at the European Patent Office (Tables 3-4).

Tables 3-3: Number of companies with at least 5 patents in the period 1997 to 1999 included in the analysis with reference to the total number in the OST database

Table 3-3a: Absolute number

	US	DE	FR	GB	JP	other	Total
included	858	626	342	161	453	693	3133
not considered	278	137	103	60	69	175	822
total	1136	763	445	221	522	868	3955

Calculations on the basis of the OST sample by Fraunhofer ISI

Table 3-3b: Relative number

	US	DE	FR	GB	JP	other	Total
included	75.5	82.0	76.9	72.9	86.8	79.8	79.2
not considered	24.5	18.0	23.1	27.1	13.2	20.2	20.8
total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Calculations on the basis of the OST sample by Fraunhofer ISI

Tables 3-4: Number of patents of “large” firms used for the analysis included in the analysis with reference to the total number in the OST database

Table 3-4a: Absolute number of patents in and out of the analysis

	US	DE	FR	GB	JP	other	Total
included	46969	31141	10757	5449	36602	23320	154238
not considered	6996	1473	2416	805	680	2674	15044
total	53965	32614	13173	6254	37282	25994	169282

Calculations on the basis of the OST sample by Fraunhofer ISI

Table 3-4b: Relative number of patents in and out of the analysis

	US	DE	FR	GB	JP	other	Total
included	87.0	95.5	81.7	87.1	98.2	89.7	91.1
not considered	13.0	4.5	18.3	12.9	1.8	10.3	8.9
total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Calculations on the basis of the OST sample by Fraunhofer ISI

All in all, the samples used for the analysis are very large. Nevertheless, the number of firms is sometimes small, broken down by country and sector, as illustrated in Table 3-5. In particular, the figures are low for less technology-based sectors such as Tobacco, Textiles, Wearing, Wood products or Publishing. In some cases, there are even no firms in specific sectors at all, e.g. for Japan or UK in Wearing. But also in some R&D-intensive fields such as Telecommunications, the number of firms is low due to a distinct concentration of this industry. Therefore, the specific structures of some firms may have a relevant impact on the overall results.

The observation of sometimes small samples by industrial sector also applies to the number of patents, as documented in Table 3-6. Again, Wearing, Leather, Wood products or watches display low numbers, in contrast, Telecommunications is among the largest fields, although the referring number of firms is low.

To conclude, although the sample used in the project is considerable, it is necessary to check the statistical validity on the level of industrial sectors, in particular to specific countries. In Table 3-5, large countries were selected. In the case of smaller countries, these problems will be more distinct.

Table 3-5: Number of firms by industrial sector field in the sample of 1997 to 1999 for selected countries

No	Sector	Germany	France	UK	Japan	USA
1	Food	4	6	6	26	24
2	Tobacco	2	1	2	1	1
3	Textiles	2	2	2	3	9
4	Wearing	5	3	0	0	0
5	Leather	1	1	0	0	0
6	Wood products	4	0	0	2	1
7	Paper	7	6	2	9	18
8	Publishing	3	1	0	3	7
9	Petroleum	1	4	2	8	29
10	Basic chemicals	16	27	15	54	64
11	Pesticides	2	6	0	2	6
12	Paint	2	0	0	4	5
13	Pharmaceuticals	42	29	35	47	149
14	Soaps	8	5	0	5	8
15	Other chemicals	16	5	2	2	12
16	Man-made fibres	4	0	1	2	2
17	Plastic products	36	13	4	15	20
18	Mineral products	13	8	4	14	12
19	Basic metals	24	17	4	22	6
20	Metal products	57	21	4	10	18
21	Energy machinery	24	12	2	13	24
22	Non-specific machinery	31	7	1	14	16
23	Agricultural machinery	8	3	3	1	1
24	Machine-tools	14	6	2	8	8
25	Special machinery	88	8	8	24	26
26	Weapons	1	2	0	0	2
27	Domestic appliances	12	6	3	1	1
28	Computers	7	4	5	23	46
29	Electrical motors	7	7	3	4	3
30	Electrical distribution	8	4	1	9	11
31	Accumulators	3	2	0	1	4
32	Lightening	10	12	0	8	9
33	Other electrical	4	0	3	1	6
34	Electronic components	17	21	9	24	46
35	Telecommunications	8	14	7	11	48
36	Television	6	3	4	8	16
37	Medical equipment	21	14	2	6	79
38	Measuring instruments	13	13	3	5	35
39	Industrial control	2	1	3	3	14
40	Optics	13	2	1	15	6
41	Watches	1	0	0	3	0
42	Motor Vehicles	52	18	13	30	23
43	Other transport	20	19	5	3	29
44	Consumer goods	7	9	0	9	14
	Total	**626**	**342**	**161**	**453**	**858**

Table 3-6: Absolute number of patent applications by industrial sector field in the total sample for 1997 to 1999

field	field no	patents	field	field no	patents
food	01	3385	agro-machinery	23	563
tobacco	02	168	machine-tools	24	1068
textiles	03	535	special machinery	25	5792
wearing	04	81	weapons	26	173
leather	05	148	domestic appliances	27	1456
wood products	06	89	computers	28	19839
paper	07	1199	electric motors	29	371
publishing	08	428	electric distribution	30	2068
petroleum	09	2695	accumulators	31	206
basic chemicals	10	13296	lightening	32	1805
pesticides, agro-chemicals	11	392	other electrical equip-ment	33	726
paints varnishes	12	504	electronic components	34	7002
pharmaceuticals	13	16983	telecommunications	35	16935
soaps, detergents	14	4368	television	36	4205
other chemicals	15	3558	medical equipment	37	3637
man-made fibres	16	477	measuring instruments	38	1943
plastic products	17	2554	industrial control	39	1098
mineral products	18	2402	optics	40	2310
basic metals	19	3115	watches	41	448
metal products	20	2889	motor vehicles	42	12575
energy machinery	21	2362	other transport	43	4253
non-specific machinery	22	2851	consumer goods	44	1286

Source: Computations of OST and Fraunhofer ISI

3.4 Approach of associating technologies and industries with regard to field classifications

In a first working step, the initial association of technologies and industrial sectors was exclusively defined on the basis of qualitative expert assessment.[6] On this basis, a first association matrix was computed, using the firm sample described above. The results were not satisfying, visible in too small diagonal elements of the matrix

6 Technical experts of the Fraunhofer Society, in particular from Fraunhofer ISI, did this work.

and too large non-diagonal elements.[7] The major reason for this outcome are problems to link technologies and sectors in an unambiguous way. Therefore, this initial qualitative association needed a further refinement.

By the support of the OST database classifying firms as to technologies and industrial sectors, the original intellectual association of patent and industrial classifications was improved by information on both small and large firms; this second step is called "revised association". For this empirical verification, the industrial sectors applying patents in an specific IPC subclass were computed according to the frequency of applications. As first estimate, it can be assumed that the statistically most important sector in terms of patent numbers is the most suitable to be associated with the technical (IPC) subclass considered. In the case of small firms, the association of sectors and IPC codes proved to be closely linked to the technological content, whereas the technological orientation is blurred for large firms due to their broader spectrum of industrial activities. However, the number of patents in many IPC subclasses were too small for the sample of small firms, so that the results for larger firms were necessary to decide on an appropriate association. The final decision on the association of subclasses had to be taken intellectually, as the orientation of the concordance should be primarily technological. But in some technologies, patents are not primarily taken out by firms belonging to the industrial sector which could, in some sense, be regarded as being "responsible" for this technology. For instance, the enterprises in Basic chemicals[8] are often the most frequent applicants in IPC classes linked to Other chemicals[9] in terms of technology. In these cases, the decision was taken in favour of the technological content, if the "responsible" sector had still a substantial number of applications in the IPC subclass considered.

Table 3-7 illustrates the approach for this additional empirical check. For instance, most patent applications in the subclass A01B belonged to (large) firms classified in the industrial field 23 (see column 1 in the Table in Annex 1). This is in agreement with the original purely intellectual association. The same applies to the IPC code A01C. In the case of the code A01G, most patents were assigned to firms belonging to the industrial field 23 with a nearly equivalent level for those in sector 9. In the initial intellectual association, this IPC code was linked to field 20 which appears to be less relevant according to Table 3-7. The technical code A01G refers Horticulture, cultivation of vegetables, watering, industrial field 20 contains Fabricated metal products. Thus in the intellectual association, the focus of patent applications was wrongly assumed to be on tools for horticulture. With the additional statistical information,. code A01G rather has to be associated to sector 23 (Agricultural ma-

7 See also the explanations of the association matrix in section 5.

8 NACE code 24.1.

9 NACE code 24.6.

chinery), or sector 9 (Petroleum products). All in all, a revised linkage of A01G to field 23 seems to be most appropriate, but this choice is of course ambiguous and a matter of subjective judgement.

The linkage of the 625 IPC subclasses to the 44 fields would differ from the initial purely intellectual association in about 60 percent of the cases, if the statistically most important sector of patenting had been taken as simple criterion, i.e., if the decision had been exclusively based on the statistical outcome. By considering the patent activities of small firms and the technological content in addition, the necessary changes of the initial intellectual association were less frequent. However the original association was still amended in about 30 percent of the cases. So the information on the firms patenting in each patent subclass resulted in a considerable refinement and improvement of the purely intellectual concordance. In contrast, a purely statistical definition of the association would have neglected the technical content of many IPC subclasses. The final association between sectoral fields and IPC sub-classes is documented in Annex 2. In the association table, all sectoral fields are linked to a set of IPC subclasses without any fractional association. In the case of the sectoral field 8 (Publishing), it was not possible to associate any IPC code, so that this field is not defined in terms of technology. On this basis, the patents of a specific sectoral field can be related to technological fields.

Table 3-7: Patent applications in IPC subclasses by industry-based fields for the sample of large firms (sample of 1997 to 1999)

IPC	Field	Number	Share
A01B	23	53	98.1
	42	1	1.9
A01C	23	62	84.9
	10	3	4.1
	16	3	4.1
	13	2	2.7
	11	1	1.4
	3	1	1.4
	7	1	1.4
A01G	23	10	19.2
	9	7	13.5
	1	6	11.5
	13	6	11.5
	42	5	9.6
	18	3	5.8
	19	3	5.8
	10	2	3.8
	11	2	3.8
	14	1	1.9
	15	1	1.9
	16	1	1.9
	20	1	1.9
	25	1	1.9
	27	1	1.9
	39	1	1.9
	7	1	1.9

Source: Computations of OST and Fraunhofer ISI

4. Generation of a concordance matrix

The association according to Annex 2 has a technological orientation and should be labelled "theoretical", as it still assumes a direct one-to-one association of technologies and industrial sectors. If the industrial sectors and the associated technology areas were in exact agreement, only the diagonal elements of a cross-tabulation in a matrix of 44 technological fields and 44 industrial fields would be filled. Table 4-1 illustrates the structure of such a matrix with seven fields. In the case of complete equivalence between technologies and industries, all applications should appear as diagonal elements D. However the results of the empirical analysis show that this is not the case, as there is a substantial number of patents in the non-diagonal fields. Several reasons may play a role:

- The linkage of an IPC code to a sector is "wrongly" assigned, i. e. the IPC code refers to a product range, not covered by the industrial sector
- The technology field cannot be linked to one sector in an unambiguous way, but it is linked to several sectors. However, the revised theoretical association links the field to the most relevant sector for this technology.
- The firms in a sector are active in several technologies, partly because they are large multi-product firms, and partly because the products they produce are multi-technology. Therefore, the concentration of applications on the diagonal of the matrix should be stronger in the case of smaller firms.

Table 4-1: Linkage structure between technological fields and industrial sectors presented in matrix form

		Technological field						
		1	**2**	**3**	**4**	**5**	**6**	**7**
Industrial fields	**1**	**D1**	N11	N12	N13	N14	N15	N16
	2	N21	**D2**	N22	N23	N24	N25	N26
	3	N31	N32	**D3**	N33	N34	N35	N36
	4	N41	N42	N43	**D4**	N44	N45	N46
	5	N51	N52	N53	N54	**D5**	N55	N56
	6	N61	N62	N63	N64	N65	**D6**	N66
	7	N71	N72	N73	N74	N75	N76	**D7**

The linkage of an IPC subclass to a "wrong" field was reduced to a minimum by the empirical checks described in section 3. The multiple association of an IPC code to different fields due to the multiple use of technologies or the multiple activities of companies show the technological interconnection of different fields, thus industrial sectors. This is the conceptual reason why the association of IPC codes to sectors was not purely made by a statistical choice of the most important industry in terms of patent applications. Furthermore the IPC codes were exclusively associated to one field, so that interconnections between different sectors become visible in the concordance matrix.

For generating the concordance matrix, the following decisions were made:

- Only large firms are considered. Due to the strong concentration of applications on these large actors (see section 4), this restriction seems to be justified. In country comparisons, the impact of small firms is less relevant.
- Only firms of the manufacturing sector are taken into account, as share of the service sector in all patent activities is about 3 percent (Blind et al. 2003).
- Only the principle industrial activity of a firm is taken into account, although many large firms have activities spread across different sectors, sometimes even in the service sectors. The reasons for this strategic choice are described in section 4 in more detail.
- Only the first IPC code is taken into account. Previous comparisons have shown that the distributions of patents according to the first classification only and those according to first and secondary classifications are quite similar (Schmoch et al. 1988). However, more distinct differences may appear in the case of pharmacy, as many patents relevant for this area have first codes in the chemical area and only a secondary code in Pharmaceuticals (A61K, A61P). This effect will be less important for the present context, as the major relevant chemical subclasses are already included in the definition of field 13 (Pharmaceuticals).

Table 4-2 shows the outcome of the analysis for the first seven fields, i.e., this is an extract of the full 44x44 matrix. In most cases, the diagonal elements receive the highest number of applications. However, this is not the case in technical field 3 (Textiles), where the industrial field / sector 7 (Paper) has a large number of applications.

The focus on diagonal elements, i. e., the level of correspondence between technical and industrial field definitions, can be visualised in two ways. Table 4-3 shows the distribution of applications within a technological field across industrial sectors. In field 1, the correspondence between technology and sector is high, whereas in the technical field 4 (Wearing), a considerable share of applications is taken out by the industrial fields / sectors 3 and 7 (Textiles and Paper). However, the comparison with Table 3-6, documenting the technological activities of the sectors, shows that this is largely due to the effect of low absolute application numbers of the Wearing sector. Any "irregularities" in the patent activities of some firms become more visible in small sectors, as they are not counterbalanced by the patents of the "normal" firms.

Table 4-2: Absolute application numbers for large firms (extraction for the first seven NACE sectors)

industrial sectors		technological fields						
		food 01	tobacco 02	textiles 03	wearing 04	leather 05	wood products 06	paper 07
food	**01**	758	0	16	0	0	0	5
tobacco	**02**	3	46	0	0	0	0	4
textiles	**03**	0	1	42	14	0	2	6
wearing	**04**	0	0	3	5	3	0	0
leather	**05**	0	0	7	1	26	0	0
wood products	**06**	0	0	1	0	0	13	1
paper	**07**	3	3	59	7	1	1	203

Source: Computation of OST

Table 4-3: Share of industrial sectors within technological fields with reference to the diagonal elements (vertical comparison in %) (extraction for the first seven NACE sectors)

industrial sectors		technological fields						
		food 01	tobacco 02	textiles 03	wearing 04	leather 05	wood prod-ucts 06	paper 07
food	**01**	100	0	38	0	0	0	2
tobacco	**02**	0	100	0	0	0	0	2
textiles	**03**	0	2	100	280	0	15	3
wearing	**04**	0	0	7	100	12	0	0
leather	**05**	0	0	17	20	100	0	0
wood products	**06**	0	0	2	0	0	100	0
paper	**07**	0	7	140	140	4	8	100

Source: Computation of OST and Fraunhofer ISI

Table 4-4: Share of technological fields within industrial sectors with reference to the diagonal elements (horizontal comparison in %), (extraction for the first seven NACE sectors)

industrial sectors		technological fields						
		food 01	tobacco 02	textiles 03	wearing 04	leather 05	wood prod-ucts 06	paper 07
food	**01**	100	0	2	0	0	0	1
tobacco	**02**	7	100	0	0	0	0	9
textiles	**03**	0	2	100	33	0	5	14
wearing	**04**	0	0	60	100	60	0	0
leather	**05**	0	0	27	4	100	0	0
wood products	**06**	0	0	8	0	0	100	8
paper	**07**	1	1	29	3	0	0	100

Source: Computation of OST and Fraunhofer ISI

Table 4-4 shows the contribution of different technological fields within each industrial sector. This perspective refers more closely to the way the database search has been generated. We started from the industrial sectors and looked for their applications in different technological fields. Thus, Table 4-4 indicates that firms belonging to sector 4 (Wearing) also have substantial activities in the technical fields 3 and 5 (Textiles, Leather). Furthermore, the representation in Table 4-4 is more suitable than the perspective offered in Table 4-3, because the different size of the industrial sectors has an important impact on the outcome with reference to technical fields. For instance, we have to take into account the fact that the pharmaceutical sector, in terms of turnover, employees etc., is much larger than the sector of Other chemicals (special chemistry) and therefore may dominate the absolute number of patents in the technical field of Other chemicals, due to technical interconnections of basic and special chemistry.

In the context of this report, it is not possible to discuss all details of the complete concordance matrix. Instead we concentrate on three sectors which are important both in terms of production as well as in terms of patent applications, namely Chemicals, Machinery, and Electrical equipment. To study the interconnections between the sub-sectors in each of these main-sectors, we disaggregated them down to 3-digit NACE codes (cf. annex 1).

Within the chemical industry, the patent activities of Basic chemicals and Pharmaceuticals are much larger than those of the other 4 sub-sectors (Pesticides, Paints, Soaps and detergents, Other chemicals). The analysis of the distribution of the patent applications of the subsectors by technological fields in Table 4-5 shows a close technological interconnection between Basic chemicals and Pharmaceuticals due to a mutual transfer of products, and a strong basis of pharmaceuticals in organic chemistry. The 4 smaller sub-sectors have strong linkages to these two large areas, to the extent that the number of patents in these fields are higher than those in their "core" fields. For instance, the Soaps and detergents sector has a high level of patents in Pharmaceuticals, as Cosmetics are a main group within the Pharmaceutical IPC subclass (A61K). The same applies to Other chemicals which comprise preparations for Dentistry and which is a main group of the Pharmaceutical IPC subclass. As the distinction between the chemical sub-sectors are not very clear-cut, there are good reasons to divide the Chemical industry into two fields only, namely Chemicals and Pharmaceuticals. Decisions on such changes may be taken by the users of the transfer matrices, as sub-sectors can be integrated without any problem.

Table 4-5: Share of technological fields within industrial sub-sectors with reference to the diagonal elements (horizontal comparison in %) for the Chemical industry

industrial sectors		technological fields					
		basic chemicals 10	pesticides 11	paints 12	pharmaceuticals 13	soaps, detergents 14	other chemicals 15
basic chemicals	**10**	100	5	5	27	2	4
pesticides	**11**	57	100	3	287	1	0
paints	**12**	116	5	100	14	20	15
pharmaceuticals	**13**	23	3	1	100	1	0
soaps, detergents	**14**	32	4	1	151	100	7
other chemicals	**15**	269	5	26	130	88	100

Source: Computation of OST and Fraunhofer ISI

In contrast to chemistry, the sub-sectors of the mechanical industry prove to be quite independent of each other (Table 4-6). This is surprising, because the sub-sector of Energy machinery comprises basic mechanical elements that can be used in all other sub-sectors of the mechanical industry. Within the mechanical sub-sectors, Agricultural machinery is the smallest one in terms of volume of patenting and Special machinery the largest one.

Table 4-6: Share of technological fields within industrial sub-sectors with reference to the diagonal elements (horizontal comparison in %) for the Machinery industry

industrial sectors		technological fields				
		energy machinery 21	non-specific machinery 22	agro machinery 23	machine tools 24	special machinery 25
energy machinery	**21**	100	33	1	16	21
non-specific machinery	**22**	40	100	0	10	23
agro machinery	**23**	7	2	100	0	3
machine tools	**24**	6	8	0	100	41
special machinery	**25**	8	12	0	9	100

Source: Computation of OST and Fraunhofer ISI

In the Electrical industry, the strong technical interconnection of its sub-sectors is clearly visible (Table 4-7). An example is the linkage between Computers and Electronic components, Telecommunications, and Television, reflecting the convergence between information technology and consumer electronics. In absolute numbers of patent applications, the sub-sectors of Computers, Electronic components, and Telecommunications distinctly dominate, so that it may be useful to put the other "traditional" sub-sectors together.

Table 4-7: Share of technological fields within industrial sub-sectors with reference to the diagonal elements (horizontal comparison in %) for the Electrical industry

industrial sectors		technological fields								
		computers 28	electric motors 29	electric distribution 30	accumulators 31	lightening 32	other eltc. equipmt. 33	eltc. components 34	telecommunications 35	television 36
computers	**28**	100	2	6	1	0	6	32	45	16
eltc. motors	**29**	32	100	43	8	0	66	16	22	1
eltc. distribution	**30**	31	11	100	15	2	22	52	36	17
accumulators	**31**	1	1	1	100	4	3	1	7	0
lightening	**32**	137	47	118	1	100	101	195	131	78
other eltc. equipmt.	**33**	345	43	65	0	0	100	620	185	75
eltc. components	**34**	102	5	45	2	1	9	100	76	16
telecommunications	**35**	32	1	3	4	1	3	13	100	16
television	**36**	128	1	2	4	0	6	20	71	100

Source: Computation of OST and Fraunhofer ISI

The possibility of analysing industrial structures is an interesting side effect of the concordance, but the major aim is, of course, the transformation of technology fields into industrial sectors. This task can be realised by a matrix that is largely equivalent to Table 4-3 where the contribution of the industrial sectors to the technological fields is considered. The elements of the transformation matrix do not refer to the diagonal elements, but to the sum of the columns. This approach is illustrated in Table 4-8 using the example of Special machinery. The results of the empirical analysis show that only 40 percent of the patent applications in this technical field come from the Special machinery industrial sector itself. Although the contributions of all the other sectors are quite small if considered individually, they sum up to almost 60 percent. This structure can be explained by the definition of Special machinery which involves the production of machines for specific sectors such as the Food, Textiles, Wearing, Paper etc. All these sectors use Special machines and contribute themselves to the technical improvement of these machines. Furthermore, the IPC codes in this area are not unambiguous. E.g., most of the patent applications in the IPC sub-classes on textiles (IPC section D) refer to machines for manufacturing textiles. But sometimes, they concern innovations on textiles themselves. Even on the level of IPC groups it is often not possible to separate machines and textiles in a clear-cut way. The distribution of patents of a certain technical field on different sectoral fields solves the problem of ambiguous technical associations of IPC codes at least on the aggregate level. As the association is determined on a strict empirical basis, even possible "incorrect" associations of IPC codes to sectoral fields according to Annex 2 would be compensated.

Table 4-8: Distribution of the technical field of special machinery on different industrial sectors

field	field no	%
food	01	2
tobacco	02	0
textiles	03	1
wearing	04	0
leather	05	0
wood products	06	0
paper	07	3
publishing	08	0
petroleum	09	5
basic chemicals	10	6
pesticides, agro-chemicals	11	0
paints varnishes	12	1
pharmaceuticals	13	2
soaps, detergents	14	2
other chemicals	15	3
man-made fibres	16	1
plastic products	17	1
mineral products	18	1
basic metals	19	4
metal products	20	2
energy machinery	21	2
non-specific machinery	22	2

field	field no	%
agro-machinery	23	0
machine-tools	24	3
special machinery	25	40
weapons	26	0
domestic appliances	27	0
computers	28	8
electric motors	29	0
electric distribution	30	1
accumulators	31	0
lightening	32	0
other electrical equipment	33	0
electronic components	34	1
telecommunications	35	1
television	36	0
medical equipment	37	1
measuring instruments	38	1
industrial control	39	0
optics	40	1
watches	41	0
motor vehicles	42	2
other transport	43	2
consumer goods	44	0

Source: Computations of OST and Fraunhofer ISI

The analysis of Table 4-8 illustrates the orientation of the correspondence suggested in this report. It is linked neither to the sectors of manufacture nor to the sectors of use, but it looks at the sectors where new technological concepts are generated. This approach is based on the thesis that the patents from the different sectors of use (sector of concept creation), e. g., Textiles with reference to Special machinery, cannot be simply added to the activity of the sectors of manufacture. To a certain extent, the inventions of the sectors of use (e.g., Textiles) contribute to innovation in the sectors of manufacture (e.g., producer of textile machines), but they also improve the competitiveness in the sectors of use (e.g., Textiles), otherwise the patent applications of firms of the sectors of use would not be rational (e.g., patents on textile machines by firms of textile production). However, in the large majority of cases, the sector of concept creation is equivalent to the sector of manufacture.

Table 4-8 represents a column of the transfer/concordance matrix. The latter describes for the 44 technological fields in which way they have to be associated with industrial sectors and is documented in Annex 3.

5. Statistical verification of the concordance

This section addresses the following question:

Are there differences, if the concordance is applied to different countries and at different points in time?

As described above, we have constructed the concordance on the basis of a sample of firms from different countries in the late 1990s. Moreover the concordance was applied to the same sample of firms in the early 1990s. Thus we have a different concordance for each of the following

- All firms patenting from France (i.e. with applicant addresses in France)
- All firms patenting from Germany (i.e. with applicant addresses in Germany)
- All firms patenting from the UK (i.e. with applicant addresses in the UK)
- All firms patenting from Japan (i.e. with applicant addresses in Japan)
- All firms patenting from the US (i.e. with applicant addresses in the US)
- All firms combined in late 1990s
- All firms combined in early 1990s

In principle this allows us to examine whether differences across countries and over time matter for the application of the concordance presented in Annex 3. We address this issue at a very basic level by looking for simple correlations. In particular the following questions have been addressed:

What are the similarities in the distribution of a technology across industries across countries?

What are the similarities in the distribution of technologies within an industry across countries?

How do both these distributions differ over time?

Table 5-1 addresses the first of these. As an example, the first row of the table shows that the distribution of Food and beverages technologies across the 44 industrial sectors is significantly correlated across countries, with the highest correlation for UK and Japan. In general two-thirds out of all the possible correlations (283 from a total of 422) are statistically significant at the 5% level. In other words in aggregate there are considerable similarities in the distributions of technologies across industrial classes by country. The technologies where the distributions differ most greatly are:

- Leather articles
- Soaps, detergents, toilet preparations
- Weapons and ammunition
- Wearing apparel

Table 5-1: Similarities in the distribution of each technical field across industrial classes by country

Field	Field Name	UK vs US	UK vs JP	UK vs FR	UK vs DE	DE vs US	DE vs JP	DE vs FR	FR vs JP	FR vs US	US vs JP
1	Food, beverages	0.88*	0.99*	0.91*	0.73*	0.80*	0.74*	0.89*	0.91*	0.91*	0.93*
2	Tobacco products	0.99*	0.99*	0.89*	0.68*	0.67*	0.66*	0.65*	0.88*	0.93*	0.99*
3	Textiles	0.57*	0.45*	0.42*	0.68*	0.59*	0.50*	0.36*	0.35*	0.37*	0.54*
4	Wearing apparel	0.21	-0.07	0.67*	-0.05	-0.06	-0.06	0.15	-0.06	0.27	-0.07
5	Leather articles	.	.	.	.	-0.09	-0.05	-0.02	-0.03	-0.05	0.48*
6	Wood products	.	.	.	.	0.33*	-0.10	0.28	-0.06	0.33*	-0.10
7	Paper	0.49*	0.19	0.66*	0.58*	0.41*	0.48*	0.55*	0.60*	0.72*	0.60*
8	Publishing, printing	.	.	.	.	.	.	.	.	.	.
9	Petroleum products, nuclear fuel	0.97*	0.13	0.98*	0.09	-0.01	-0.06	0.12	0.13	0.95*	0.15
10	Basic chemical	0.88*	0.85*	0.82*	0.93*	0.81*	0.83*	0.81*	0.98*	0.94*	0.93*
11	Pesticides & agro-chemical prod.	0.75*	0.40*	0.12	0.72*	0.98*	0.87*	0.37*	0.16	0.21	0.88*
12	Paints, varnishes	0.62*	0.39*	0.72*	0.83*	0.65*	0.39*	0.80*	0.50*	0.80*	0.84*
13	Pharmaceuticals	0.98*	0.95*	0.63*	0.91*	0.95*	0.94*	0.71*	0.67*	0.72*	0.93*
14	Soaps & detergents	0.01	0.00	0.05	-0.02	0.14	0.10	0.11	0.18	0.03	0.98*
15	Other chemicals	0.33*	0.16	0.40*	0.09	0.54*	0.25	0.64*	0.18	0.58*	0.31*
16	Man-made fibres	0.21	0.19	0.06	0.19	0.81*	0.58*	0.37*	0.22	0.37*	0.59*
17	Rubber and plastics products	0.22	0.24	0.26	0.37*	0.57*	0.73*	0.64*	0.74*	0.79*	0.76*
18	Non-metallic mineral products	0.83*	0.88*	0.84*	0.76*	0.66*	0.68*	0.64*	0.86*	0.92*	0.81*
19	Basic metals	0.61*	0.65*	0.61*	0.31*	0.26	0.35*	0.28	0.92*	0.37*	0.34*
20	Fabricated metal products	0.42*	0.42*	0.19	0.49*	0.76*	0.92*	0.87*	0.92*	0.68*	0.71*
21	Energy machinery	0.76*	0.84*	0.95*	0.92*	0.80*	0.92*	0.95*	0.90*	0.78*	0.77*
22	Non-specific purpose machinery	0.57*	0.14	0.86*	0.35*	0.38*	0.68*	0.48*	0.41*	0.73*	0.46*
23	Agricultural & forestry mach.	0.91*	0.08	0.86*	0.89*	0.98*	-0.01	0.97*	-0.02	0.97*	0.02
24	Machine-tools	0.77*	0.22	0.77*	0.40*	0.67*	0.55*	0.59*	0.58*	0.73*	0.38*
25	Special purpose machinery	0.72*	0.73*	0.52*	0.80*	0.62*	0.90*	0.34*	0.55*	0.51*	0.54*
26	Weapons and ammunition	0.21	-0.09	0.06	0.59*	0.18	-0.02	0.12	-0.06	0.12	-0.07
27	Domestic appliances	0.50*	0.07	0.71*	0.73*	0.67*	0.04	0.95*	0.02	0.77*	0.29
28	Office machinery and computers	0.38*	0.31*	0.67*	0.19	0.89*	0.88*	0.20	0.37*	0.45*	0.97*
29	Electric motors, generators	0.34*	0.50*	0.14	0.38*	0.44*	0.67*	0.20	0.14	0.09	0.35*
30	Electric distribution, control,	0.15	0.53*	0.27	0.12	0.09	0.29	0.07	0.03	0.16	0.31*
31	Accumulators, battery	0.25	0.38*	0.25	0.05	0.41*	0.11	0.19	0.87*	0.85*	0.64*
32	Lighting equipment	-0.02	0.16	0.01	-0.06	0.61*	0.88*	0.96*	0.78*	0.60*	0.53*
33	Other electrical equipment	0.10	0.06	0.41*	0.01	0.21	0.89*	0.13	0.27	0.51*	0.31*
34	Electronic components	0.67*	0.25	0.87*	0.05	0.39*	0.93*	0.06	0.28	0.74*	0.56*
35	Signal transmission, telecomms	0.98*	0.50*	0.98*	0.05	0.20	0.81*	0.00	0.47*	0.97*	0.64*
36	TV & radio rec., aud-vis. electr.	0.63*	0.41*	0.68*	0.04	0.18	0.21	0.11	0.56*	0.85*	0.90*
37	Medical equipment	0.24	0.41*	0.19	0.61*	0.17	0.43*	0.05	0.75*	0.97*	0.79*
38	Measuring instruments	0.57*	0.44*	0.37*	0.41*	0.50*	0.70*	0.29	0.37*	0.66*	0.48*
39	Industrial process control equip.	0.25	0.21	0.42*	0.33*	0.17	0.25	0.12	0.31*	0.31*	0.19
40	Optical instruments	0.65*	0.29	0.66*	0.06	0.52*	0.91*	0.07	0.25	0.65*	0.65*
41	Watches, clocks	0.55*	-0.03	-0.03	-0.05	-0.09	0.93*	-0.07	-0.05	0.08	-0.06
42	Motor vehicles	0.94*	0.99*	0.94*	0.98*	0.93*	0.99*	0.94*	0.95*	0.91*	0.93*
43	Other transport equipment	0.97*	0.91*	0.96*	0.86*	0.85*	0.85*	0.86*	0.87*	0.99*	0.87*
44	Furniture, consumer goods	-0.03	-0.07	-0.04	0.04	0.83*	0.74*	0.81*	0.83*	0.99*	0.81*

* Correlation coefficient is significantly different from zero at the 5% level.
Source: Computations of SPRU

- Wood products
- Watches, clocks
- Electric distribution, control, wire, cable
- Petroleum products, nuclear fuel
- Other electrical equipment
- Industrial process control equipment

The closest matches between distributions across countries occur in the following technologies:

- Motor vehicles
- Pharmaceuticals
- Food, beverages
- Tobacco products
- Energy machinery

In all these areas more than half the possible correlations are greater than or equal to 0.9. In general only 15 percent of all possible correlations are greater than 0.9, suggesting that there are very few instances where the distributions of technologies are highly similar across countries.

Table 5-2 addresses the second question posed above, i.e., regarding the similarities in the contribution that each technology makes to an industrial product group across the different countries. The first point to note is that for a number of product groups there is a limited availability of firms from different countries: Wearing Apparel, Leather Articles, Wood products, Paints and varnishes, weapons and ammunitions, and Watches and Clocks (cf. section 3.3). In these sectors firms from only a few countries are included in our analysis.

Table 5-2 shows that in general there is a great deal of similarity in the contribution that technologies make to a particular industrial sector across countries. Thus 78 percent of all possible correlations are statistically significant (278 out of 356). The sectors with the greatest dissimilarities are:

- Other electrical equipment
- Weapons and ammunition
- Wearing apparel
- Leather articles
- Industrial process control equipment
- Agricultural and forestry machinery
- Watches, clocks
- Rubber and plastics products

Table 5-2: Similarities in the distribution of technical fields within each industrial class by country

Field	Field Name	UK vs US	UK vs JP	UK vs FR	UK vs DE	DE vs US	DE vs JP	DE vs FR	FR vs JP	FR vs US	US vs JP
1	Food, beverages	0.40*	0.62*	0.61*	0.68*	0.38*	0.85*	0.81*	0.82*	0.65*	0.23
2	Tobacco products	0.70*	0.35*	0.65*	0.87*	0.89*	0.38*	0.87*	0.37*	0.83*	0.70*
3	Textiles	0.43*	0.47*	0.17	0.61*	0.30*	0.33*	0.03	-0.07	0.38*	0.38*
4	Wearing apparel	.	.	.	.	.	.	-0.03	.	.	.
5	Leather articles	.	.	.	.	.	.	0.03	.	.	.
6	Wood products	.	.	.	.	0.48*	0.02	.	.	.	0.65*
7	Paper	0.61*	0.25	0.75*	0.78*	0.57*	0.62*	0.89*	0.75*	0.55*	0.32*
8	Publishing, printing	.	.	.	.	-0.04	0.73*	0.57*	0.78*	-0.03	-0.02
9	Petroleum products, nuclear fuel	0.91*	0.80*	0.87*	0.70*	0.60*	0.53*	0.55*	0.71*	0.94*	0.76*
10	Basic chemical	0.96*	0.94*	0.99*	0.94*	0.99*	0.99*	0.96*	0.97*	0.98*	0.99*
11	Pesticides & agro-chemical prod.	.	.	.	.	0.90*	0.88*	0.96*	0.75*	0.80*	0.88*
12	Paints, varnishes	.	.	.	.	0.60*	0.08	.	.	.	0.73*
13	Pharmaceuticals	0.99*	1.00*	1.00*	0.81*	0.75*	0.80*	0.77*	1.00*	1.00*	1.00*
14	Soaps & detergents	.	.	.	.	0.60*	0.93*	0.93*	0.86*	0.47*	0.66*
15	Other chemicals	0.20	0.30	-0.01	0.02	0.59*	0.46*	0.34*	0.56*	0.64*	0.82*
16	Man-made fibres	0.14	0.16	.	-0.07	0.72*	0.71*	.	.	.	0.95*
17	Rubber and plastics products	0.46*	0.45*	0.38*	0.31*	0.76*	0.80*	0.88*	0.92*	0.87*	0.99*
18	Non-metallic mineral products	0.93*	0.81*	0.80*	0.74*	0.63*	0.60*	0.88*	0.71*	0.75*	0.87*
19	Basic metals	0.64*	0.68*	0.58*	0.15	0.31*	0.40*	0.30	0.89*	0.96*	0.87*
20	Fabricated metal products	0.32*	0.14	0.34*	0.20	0.62*	0.47*	0.58*	0.41*	0.66*	0.64*
21	Energy machinery	0.66*	0.70*	0.80*	0.86*	0.76*	0.91*	0.69*	0.50*	0.75*	0.72*
22	Non-specific purpose machinery	-0.04	-0.07	0.12	-0.07	0.60*	0.40*	0.53*	0.61*	0.96*	0.69*
23	Agricultural & forestry mach.	0.95*	0.21	0.84*	0.82*	0.94*	0.25	1.00*	0.23	0.95*	0.22
24	Machine-tools	0.46*	0.53*	0.51*	0.50*	0.87*	0.96*	0.96*	0.89*	0.88*	0.77*
25	Special purpose machinery	0.23	0.63*	0.41*	0.54*	0.49*	0.96*	0.87*	0.82*	0.41*	0.47*
26	Weapons and ammunition	.	.	.	.	-0.06	.	0.18	.	-0.03	.
27	Domestic appliances	0.98*	0.34*	0.99*	0.94*	0.93*	0.35*	0.94*	0.35*	0.99*	0.41*
28	Office machinery and computers	0.91*	0.85*	0.89*	0.53*	0.55*	0.71*	0.42*	0.89*	0.98*	0.96*
29	Electric motors, generators	0.76*	0.17	0.33*	0.46*	0.79*	0.15	0.43*	0.06	0.45*	0.31*
30	Electric distribution, control,	0.05	0.01	0.07	0.05	0.83*	-0.02	0.70*	0.00	0.45*	0.21
31	Accumulators, battery	.	.	.	.	0.99*	0.98*	0.66*	0.64*	0.65*	0.99*
32	Lighting equipment	.	.	.	.	0.47*	0.72*	0.34*	0.22	0.36*	0.78*
33	Other electrical equipment	0.09	0.28	.	0.17	0.20	-0.10	.	.	.	0.01
34	Electronic components	0.72*	0.81*	0.84*	0.68*	0.76*	0.91*	0.73*	0.89*	0.88*	0.86*
35	Signal transmission, telecomms	0.98*	0.85*	0.97*	0.63*	0.67*	0.45*	0.69*	0.78*	0.99*	0.82*
36	TV & radio rec., aud-vis.	0.94*	0.77*	0.92*	0.85*	0.94*	0.68*	0.87*	0.93*	0.96*	0.80*
37	Medical equipment	1.00*	0.98*	1.00*	-0.05	-0.05	-0.04	-0.02	0.98*	0.99*	0.99*
38	Measuring instruments	0.70*	0.80*	0.59*	0.70*	0.76*	0.80*	0.69*	0.67*	0.81*	0.80*
39	Industrial process control equip.	0.43*	.	-0.12	-0.08	0.13	.	-0.08	.	-0.13	.
40	Optical instruments	0.06	0.17	-0.03	0.01	0.58*	0.56*	0.66*	0.53*	0.66*	0.91*
41	Watches, clocks	.	.	.	.	.	0.65*	.	.	.	.
42	Motor vehicles	0.99*	0.97*	0.99*	0.98*	0.99*	0.97*	0.97*	0.97*	0.98*	0.97*
43	Other transport equipment	0.57*	0.76*	0.88*	0.61*	0.51*	0.77*	0.66*	0.93*	0.59*	0.53*
44	Furniture, consumer goods	.	.	.	.	0.96*	0.66*	0.85*	0.67*	0.81*	0.65*

* Correlation coefficient is significantly different from zero at the 5% level.

Source: Computations of SPRU

- Wood products
- Paints, varnishes
- Electric distribution, control, wire, cable
- Publishing, printing
- Man-made fibres

In the following sectors similarities across countries in the contribution made by different technologies are the greatest (i.e. where more than half the correlation co-efficients are greater than or equal to 0.9):

- Basic chemical
- Motor vehicles
- Medical equipment
- Domestic appliances
- Pharmaceuticals
- Office machinery and computers
- TV & radio receivers, audiovisual electronics
- Across all sectors 23% of all correlations are greater than or equal to 0.9.

Another question in relation to the evaluation of the concordance is the extent to which both the above distributions differ over time. Thus in Table 5-3, we compare the global matrices for the late 1990s to those for the early 1990s. One caveat needs to be borne in mind when assessing the results. Here we have simply taken the companies as they are in the latter period and examined their performance in the early 1990s. In other words this analysis is not based on company identification for the early 1990s.

The main point to note from this analysis is that the global distributions across technologies or across industries are very similar over time. There are only 3 sectors/technologies where this is not the case:

- Wearing apparel
- Other electrical equipment
- Industrial process control equipment.

Table 5-3: Similarities in the distributions by technical field and by industry over time

Field	Field Name	By Technical Field	By Industry
1	Food, beverages	0.97*	0.74*
2	Tobacco products	0.98*	0.67*
3	Textiles	0.45*	0.47*
4	Wearing apparel	0.51*	0.07
5	Leather articles	0.72*	0.47*
6	Wood products	0.72*	0.87*
7	Paper	0.84*	0.76*
8	Publishing, printing	0.00	0.68*
9	Petroleum products, nuclear fuel	0.94*	0.90*
10	Basic chemical	0.93*	0.98*
11	Pesticides & agro-chemical prod.	0.81*	0.43*
12	Paints, varnishes	0.91*	0.90*
13	Pharmaceuticals	1.00*	0.98*
14	Soaps & detergents	0.41*	0.92*
15	Other chemicals	0.70*	0.83*
16	Man-made fibres	0.43*	0.30
17	Rubber and plastics products	0.93*	0.92*
18	Non-metallic mineral products	0.91*	0.87*
19	Basic metals	0.94*	0.88*
20	Fabricated metal products	0.94*	0.88*
21	Energy machinery	0.53*	0.82*
22	Non-specific purpose machinery	0.77*	0.89*
23	Agricultural & forestry mach.	0.98*	1.00*
24	Machine-tools	0.78*	0.94*
25	Special purpose machinery	0.96*	0.97*
26	Weapons and ammunition	0.48*	0.73*
27	Domestic appliances	0.72*	0.97*
28	Office machinery and computers	0.83*	0.91*
29	Electric motors, generators	0.34*	0.83*
30	Electric distribution, control, wire, cable	0.53*	0.79*
31	Accumulators, battery	0.34*	0.98*
32	Lighting equipment	0.88*	0.46*
33	Other electrical equipment	0.20	0.35*
34	Electronic components	0.33*	0.90*
35	Signal transmission, telecomms	0.93*	0.96*
36	TV & radio receivers, audiovisual electro-	0.88*	0.74*
37	Medical equipment	0.97*	1.00*
38	Measuring instruments	0.54*	0.91*
39	Industrial process control equip.	0.24	0.81*
40	Optical instruments	0.59*	0.73*
41	Watches, clocks	0.58*	0.66*
42	Motor vehicles	0.98*	0.97*
43	Other transport equipment	0.96*	0.86*
44	Furniture, consumer goods	0.98*	0.96*

* Correlation coefficient is significantly different from zero at the 5% level.

The final question that is pertinent to the evaluation of the concordances is the extent to which there are similarities across countries in the importance of the "core" sector in each area of technology, i.e. the diagonal elements of the matrices (see the discussion above in Section 4). Table 5-4 addresses this question. It shows for example in the first row that in technologies related to Food and beverages the importance of firms whose principle industrial activity is also in this area is very high in the UK but low in Germany. A major point to note from this table is that the importance of the “core” sector varies greatly across countries in all sectors.

There are many sectors in which the contribution of the “core” is less than 20 percent globally:

- Other electrical equipment
- Electric motors, generators
- Wearing apparel
- Industrial process control equipment
- Pesticides & agro-chemical products
- Textiles
- Paints, varnishes
- Measuring instruments
- Accumulators, batteries
- Weapons and ammunition
- Electric distribution, control, wire, cable
- Energy machinery
- Optical instruments
- Non-specific purpose machinery
- Leather articles
- Electronic components
- Machine-tools

Table 5-4: Importance of the 'core' sector in each technical field (in percent)

Field	Field name	US	JP	UK	FR	DE	Global
1	Food, beverages	45.2	67.2	86.0	60.6	30.3	66.8
2	Tobacco products	81.8	80.0	100.0	66.7	40.0	71.9
3	Textiles	10.8	4.8	33.3	5.9	9.1	8.9
4	Wearing apparel				10.0	66.7	7.6
5	Leather articles				3.1	40.0	19.5
6	Wood products	12.5				39.1	22.0
7	Paper	24.9	24.0	2.2	35.4	7.0	20.3
8	Publishing, printing						
9	Petroleum products, nuclear fuel	75.4	11.9	64.7	56.8		58.9
10	Basic chemical	43.7	44.1	44.1	71.3	44.2	43.3
11	Pesticides & agro-chemical prod.	2.3	0.9		76.9	11.8	8.1
12	Paints, varnishes	13.1	16.1				9.4
13	Pharmaceuticals	75.1	50.7	85.3	40.2	55.5	65.8
14	Soaps & detergents	82.6	70.0			7.3	47.6
15	Other chemicals	18.7	4.6		25.7	26.4	21.8
16	Man-made fibres	5.9	33.3			4.8	21.0
17	Rubber and plastics products	22.8	40.4	4.8	25.5	18.8	24.4
18	Non-metallic mineral products	32.2	28.9	28.7	48.9	16.6	27.0
19	Basic metals	8.5	51.8	24.4	52.1	14.6	34.0
20	Fabricated metal products	16.0	33.9	5.3	45.4	33.2	29.8
21	Energy machinery	7.5	16.5	3.6	13.4	17.2	14.3
22	Non-specific purpose machinery	22.2	15.2		9.5	8.5	17.9
23	Agricultural & forestry mach.	64.9	1.1	57.9	68.3	84.9	62.8
24	Machine-tools	10.4	13.5	10.6	20.0	12.7	19.9
25	Special purpose machinery	16.4	30.7	27.0	8.9	64.8	40.0
26	Weapons and ammunition				59.3	1.2	12.6
27	Domestic appliances	18.5	1.8	39.1	60.5	50.6	35.1
28	Office machinery and computers	58.8	54.8	8.1	9.3	43.8	46.5
29	Electric motors, generators	11.6	0.7	25.0	10.5	6.2	6.4
30	Electric distribution, control, wire, cable	10.1	1.3	12.8	45.5	6.3	12.6
31	Accumulators, battery	26.6	1.7		21.9	22.4	12.5
32	Lighting equipment	21.5	32.6		75.7	68.3	41.4
33	Other electrical equipment	2.5				0.1	1.8
34	Electronic components	27.3	13.8	33.3	54.1	6.2	19.7
35	Signal transmission, telecommunications	62.6	24.1	73.6	64.9	1.8	52.4
36	TV & radio receivers, audiovisual electronics	29.4	21.9	21.8	48.8	9.7	22.8
37	Medical equipment	58.8	21.7	7.0	64.6		49.2
38	Measuring instruments	12.5	5.1	4.0	30.3	6.4	9.8
39	Industrial process control equipment	27.1				0.5	7.8
40	Optical instruments	8.8	26.9		9.9	26.3	17.8
41	Watches, clocks		60.2		0.0	42.1	61.2
42	Motor vehicles	40.3	71.2	86.8	53.1	64.3	60.2
43	Other transport equipment	64.5	44.5	72.3	84.0	43.1	52.6
44	Furniture, consumer goods	55.6	42.9		81.8	35.7	55.1

6. Relationship between technology and economic performance

6.1 Aim

One of the main reasons for constructing the concordance between technology classes and product classifications is that this enables us to evaluate the relationship between technological performance and economic performance. The aim of this section is to illustrate how this could be done on the basis of the patent data resulting form the application of the concordance described above. In particular we use the data on patenting by country of invention and value-added and export data from the OECD STAN database to address the following questions:

- *To what extent is higher economic performance of a country (measured as shares of value-added or exports) within a sector associated with higher technological performance (measured as shares of patenting)?*

- *To what extent is sectoral specialisation in trade and value-added within a country associated with sectoral specialisation in technology?*

6.2 Data and Methodology

6.2.1 Industries

The data on economic performance is derived from the OECD STAN database which contains information on a number of variables by industry. In principle all data are available for the manufacturing industries listed in Table 6-1 over the period 1970 to 2000. However in practice the database contains many missing values for many of the countries and many of the sectors. The main problem for our purposes is that export and value-added are not available for many of the 44 sectors for which we have patent data. The result is that the analysis below is based on 21 sectors indicated in the last column of Table 6-1. Thus a number of sectors for which patent data exist have had to be aggregated. In particular this applies to the subsectors of the following industries: Chemical industry (where we have 7 sectors for patents and only 2 for the economic variables), Non-electrical machinery (7 versus 1), Electrical machinery (5 versus 1), Radio & TV, etc. (3 versus 1), Instruments (5 versus 1).

6.2.2 Countries

The following 13 Countries included in the analyses:

Austria, Belgium, Denmark, Germany, Finland, France, Italy, Netherlands, Spain, Sweden, UK, US, and Japan. Amongst the current EU member states Greece, Luxembourg and Portugal are excluded, due to unavailability of data. The main reason for this is the lack of sufficient volume of patenting in the various industries for meaningful analysis for these countries.

6.2.3 Time Period

As to the time period, we have used the data for the years 1989 to 2000. We divide the data into three sub-periods in the 1990s: 1989-92, 1993-96 and 1997-2000.

6.2.4 Indicators Used

The analysis below is based on two indicators for each of the 3 variables (Patents, Value-added and Exports):

Share: Value for a country in an industry divided by the total for that industry.
Specialisation index: *Share* of a country in an industry divided by its *overall share*. When constructed on the basis of patents, this is sometimes referred to in the literature as the 'revealed technology advantage index (RTA)' (Soete/Wyatt 1983).

The first is a measure of *absolute* measure of performance and the second is a *relative* measure of performance.

6.2.5 Statistical measures used

The analysis below is based on *simple correlations* between the patent indicators and the two performance indicators. The main reason for this is that the construction of a 'full-blown' econometric model of the relationship between technology and economic performance is beyond the scope of this project. Rather our aim here is to illustrate the first use of the patent data by industry constructed on the basis of the new concordance.

Table 6-1: Industries from the STAN database used in the analysis.

INDUSTRY	ISIC	Used
TOTAL MANUFACTURING	**15-37**	
FOOD PRODUCTS, BEVERAGES AND TOBACCO	15-16	
….FOOD PRODUCTS AND BEVERAGES	15	1
….TOBACCO PRODUCTS	16	2
TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR	17-19	
….TEXTILES AND TEXTILE PRODUCTS	17-18	
……..TEXTILES	17	3
……..WEARING APPAREL, DRESSING AND DYING OF FUR	18	4
….LEATHER, LEATHER PRODUCTS AND FOOTWEAR	19	5
WOOD AND PRODUCTS OF WOOD AND CORK	20	6
PULP, PAPER, PAPER PRODUCTS, PRINTING AND PUBLISHING	21-22	
….PULP, PAPER AND PAPER PRODUCTS	21	7
….PRINTING AND PUBLISHING	22	
CHEMICAL, RUBBER, PLASTICS AND FUEL PRODUCTS	23-25	
….COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL	23	8
….CHEMICALS AND CHEMICAL PRODUCTS	24	
……..CHEMICALS EXCLUDING PHARMACEUTICALS	24ex2423	9
……..PHARMACEUTICALS	2423	10
….RUBBER AND PLASTICS PRODUCTS	25	11
OTHER NON-METALLIC MINERAL PRODUCTS	26	12
BASIC METALS, METAL PRODUCTS, MACHINERY & EQUIPMENT	27-35	
BASIC METALS AND FABRICATED METAL PRODUCTS	27-28	
….BASIC METALS	27	13
……..IRON AND STEEL	271+2731	
……..NON-FERROUS METALS	272+2732	
….FABRICATED METAL PRODUCTS, except machinery and equipment	28	14
MACHINERY AND EQUIPMENT	29-33	
….MACHINERY AND EQUIPMENT, N.E.C.	29	15
….ELECTRICAL AND OPTICAL EQUIPMENT	30-33	
……..OFFICE, ACCOUNTING AND COMPUTING MACHINERY	30	16
……..ELECTRICAL MACHINERY AND APPARATUS, NEC	31	17
……..RADIO, TELEVISION AND COMMUNICATION EQUIPMENT	32	18
……..MEDICAL, PRECISION AND OPTICAL INSTRUMENTS	33	19
TRANSPORT EQUIPMENT	34-35	
….MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS	34	20
….OTHER TRANSPORT EQUIPMENT	35	21
……..BUILDING AND REPAIRING OF SHIPS AND BOATS	351	
……..AIRCRAFT AND SPACECRAFT	353	
……..RAILROAD EQUIPMENT & TRANSPORT EQUIPMENT N.E.C.	352+359	
MANUFACTURING NEC; RECYCLING	36-37	
….MANUFACTURING NEC	36	
….RECYCLING	37	

6.3 Main Results

6.3.1 Within sector analysis

The aim of this analysis is to examine the extent to which country shares of value-added within a sector are related to country shares of patenting. Table 6-2 gives an example of the variables used for two industries, with contrasting performance. In the case of Wood and Wood products, the US accounts for nearly half of all the value-added of the 13 countries in 1997-2000, but only accounts for 15% of patenting. On the other hand Germany has more than one-third of all EPO patents in this industry but only accounts for 10% of value-added. In contrast the relationship between the two variables is much closer in the Computing and Office Machinery industry. Here the US has both the highest share of patenting and the highest share of value-added. Moreover Japan also has a high proportion in both cases. Germany has the highest level of patenting among EU countries but the UK has a higher share of value-added.

Table 6-2: Shares of Value Added and Patenting in Two Industries

Wood and Wood Products

	Value-added Shares				Patent Shares		
Country	89-92	93-96	97-00		89-92	93-96	97-00
Austria	2.2	2.2	2.2		4.8	2.6	3.2
Belgium	0.9	0.8	0.8		1.0	1.3	1.6
Denmark	0.7	0.7	0.8		1.8	1.3	1.8
Finland	1.6	1.5	1.6		1.8	3.6	3.0
France	5.6	4.8	4.6		12.8	9.6	7.8
Germany	10.3	11.6	10.1		34.7	39.4	33.2
Italy	7.0	7.0	7.0		4.3	4.3	6.2
Japan	15.0	16.2	12.2		5.3	7.9	9.4
Netherlands	0.9	0.9	1.0		6.5	4.3	3.0
Spain	2.7	2.7	3.0		1.3	2.4	2.5
Sweden	3.3	2.1	2.3		7.3	7.7	7.4
UK	4.3	3.2	4.2		9.8	6.9	5.5
US	44.7	45.3	49.1		8.8	8.6	15.1
Total	**100.0**	**100.0**	**100.0**		**100.0**	**100.0**	**100.0**

Computing and Office Machinery

	Value-added Shares				Patent Shares		
Country	89-92	93-96	97-00		89-92	93-96	97-00
Austria	0.0	0.0	0.2		0.2	0.4	0.4
Belgium	0.0	0.1	0.1		0.4	0.7	0.7
Denmark	0.2	0.2	0.2		0.1	0.2	0.3
Finland	0.2	0.2	0.1		0.2	0.5	0.6
France	5.7	4.5	3.4		5.1	5.1	5.0
Germany	10.4	6.6	5.6		8.6	8.1	9.5
Italy	1.4	1.1	0.9		1.3	1.5	1.2
Japan	32.5	38.1	32.9		40.0	33.4	29.0
Netherlands	0.6	0.6	0.8		3.0	2.5	3.5
Spain	1.0	1.3	1.0		0.2	0.2	0.4
Sweden	0.8	0.4	0.4		0.5	0.9	1.4
UK	5.8	6.4	6.7		5.1	4.7	5.4
US	41.4	40.4	47.8		35.4	41.9	42.6
Total	**100.0**	**100.0**	**100.0**		**100.0**	**100.0**	**100.0**

Table 6-3 contains the results of our examination of the relationship between the shares of value-added and shares of patenting in 21 industries. In order to minimise the influence of very low level of patenting we have excluded all countries with less than 10 patents in each ‘cell’ (i.e. time period and industry combination). This means that for some sectors the results are based on very few observations and these have been highlighted in the table (in italics). In general the more ‘high-tech’ the sector the closer the relationship between patenting and output: with the highest correlations for the electronics-related sectors: *Office, and computing machinery, Radio, television and communication and Medical, precision & optical instruments*, and *Chemicals* and *Pharmaceuticals*, and the lowest for many of the traditional industries, e.g. *Wearing Apparel and Wood*.

Table 6-3: Relationship between Patent Shares and Shares of Value added within each sector; correlation of shares

		1989-92	1993-96	1997-00	1989-2000
Sector	**Sector name**	**Correlation Coefficient**			
15	Food products and beverages	0,93*	0,82*	0,88*	0,86*
16	Tobacco products	*0,97**	*0,91**	*0,89**	0,91*
17	Textiles	*0,94**	*0,86**	*0,84**	0,84*
18	Wearing apparel	*0,79**	*0,60**	*0,71**	0,67*
19	Leather, leather products & footwear	*0,81**	*0,61**	*0,55**	0,60*
20	Wood and products of wood and cork	*0,91**	*0,71**	*0,77**	0,71*
21	Pulp, paper and paper products	0,82*	0,61*	0,67*	0,65*
23	Coke, refined petroleum products	0,90*	0,63*	0,66*	0,69*
2423	Pharmaceuticals	0,96*	0,91*	0,95*	0,93*
24ex2423	Chemicals exc. Pharmaceuticals	1,00*	0,96*	0,97*	0,96*
25	Rubber and plastics products	0,95*	0,95*	0,90*	0,91*
26	Other non-metallic mineral products	0,90*	0,80*	0,89*	0,85*
27	Basic metals	0,89*	0,76*	0,80*	0,77*
28	Fabricated metal products	0,96*	0,84*	0,83*	0,82*
29	Machinery and equipment, n.e.c.	0,93*	0,88*	0,91*	0,87*
30	Office, and computing machinery	0,99*	0,96*	0,96*	0,97*
31	Electrical machinery and apparatus	0,96*	0,87*	0,90*	0,91*
32	Radio, television and communication	0,98*	0,92*	0,93*	0,93*
33	Medical, precision & optical instruments	0,98*	1,00*	0,99*	0,99*
34	Motor vehicles	0,90*	0,84*	0,84*	0,83*
35	Other transport equipment	0,88*	0,84*	0,82*	0,80*

* Correlation coefficient is significantly different from zero at the 5% level.

Grey cells indicate too few observations.

Another relationship examined in this report is that between technology and trade performance, where the latter is proxied by exports. Table 6-4 illustrates the underlying data (export and patent shares) used in the correlation analysis. For the Wood industry there are a number of big differences in country performance in exports compared to country performance in patents. As expected Scandinavian (Finland and Sweden) countries, together with Germany are the leading EU countries in terms of trade performance, with very similar levels of export shares. However when it comes to patent shares, the leading country by far is Germany, with nearly one-third of all patents in 1997-2000. On the other hand the share of Finland is very small. Again the performance of the US is very different in the two variables, with a very high level of exports but a much lower level of patenting.

Table 6-4: Shares of Exports and Patenting in Two Industries

Wood and Wood Products

	Export Shares				Patent Shares		
Country	89-92	93-96	97-00		89-92	93-96	97-00
Austria	9.9	8.3	8.9		4.8	2.6	3.2
Belgium	6.6	6.0	6.4		1.0	1.3	1.6
Denmark	3.1	3.5	3.0		1.8	1.3	1.8
Finland	8.2	10.8	10.1		1.8	3.6	3.0
France	7.5	7.3	7.5		12.8	9.6	7.8
Germany	11.8	9.9	12.7		34.7	39.4	33.2
Italy	3.8	5.4	5.6		4.3	4.3	6.2
Japan	0.6	0.5	0.3		5.3	7.9	9.4
Netherlands	3.7	3.4	2.5		6.5	4.3	3.0
Spain	2.0	2.5	3.3		1.3	2.4	2.5
Sweden	13.1	14.0	12.7		7.3	7.7	7.4
UK	1.3	1.5	2.0		9.8	6.9	5.5
US	23.6	22.4	20.2		8.8	8.6	15.1
Total	**100.0**	**100.0**	**100.0**		**100.0**	**100.0**	**100.0**

Computing and Office Machinery

	Export Shares				Patent Shares		
Country	89-92	93-96	97-00		89-92	93-96	97-00
Austria	0.6	0.4	0.5		0.2	0.4	0.4
Belgium	1.5	1.7	2.1		0.4	0.7	0.7
Denmark	0.6	0.7	0.6		0.1	0.2	0.3
Finland	0.3	0.7	0.5		0.2	0.5	0.6
France	6.8	6.2	6.2		5.1	5.1	5.0
Germany	10.5	8.4	8.8		8.6	8.1	9.5
Italy	3.6	3.8	2.1		1.3	1.5	1.2
Japan	28.1	28.0	21.2		40.0	33.4	29.0
Netherlands	7.6	9.2	13.0		3.0	2.5	3.5
Spain	1.0	1.0	1.0		0.2	0.2	0.4
Sweden	1.5	0.7	0.5		0.5	0.9	1.4
UK	11.0	12.5	13.0		5.1	4.7	5.4
US	26.9	26.6	30.2		35.4	41.9	42.6
Total	**100.0**	**100.0**	**100.0**		**100.0**	**100.0**	**100.0**

In contrast the relationship between technology and trade is much closer in Computing and Office Machinery. US and Japan are the leaders in terms of both variables. The two main anomalies are the UK and the Netherlands, with a high share of exports (amongst the highest in the EU) but a much lower share of patenting. Germany on the other hand has a very similar level of performance in both technology and trade.

Table 6-5 examines the relationship between exports and patenting more systematically for 21 sectors. The first point to note is that in contrast to the results in Table 6-3 for Value added and patenting, there are fewer significant correlations. This indicates that the relationship between trade and technology performance is weaker than that between technology and output performance.

Table 6-5: Relationship between Patent Shares and Export Shares within each sector, correlation of shares

		1989-92	**1993-96**	**1997-00**	**1989-2000**
Sector	Sector name	**Correlation Coefficient**			
15	Food products and beverages	0,42	0,52	0,58 *	0,53
16	Tobacco products	*0,87* *	*0,81* *	*0,77* *	0,82 *
17	Textiles	*0,33*	*0,46*	*0,56* *	0,52
18	Wearing apparel	*0,15*	*0,38*	*0,52*	0,50
19	Leather, leather products & footwear	*0,38*	*0,27*	*0,23*	0,28
20	Wood and products of wood and cork	*0,52*	*0,48*	*0,61* *	0,55
21	Pulp, paper and paper products	0,50	0,70 *	0,72 *	0,69 *
23	Coke, refined petroleum products	0,42	0,51	0,47	0,47
2423	Pharmaceuticals	0,64 *	0,57 *	0,61 *	0,61 *
24ex2423	Chemicals exc. Pharmaceuticals	0,85 *	0,87 *	0,90 *	0,89 *
25	Rubber and plastics products	0,76 *	0,87 *	0,92 *	0,89 *
26	Other non-metallic mineral products	0,46	0,50	0,60 *	0,58 *
27	Basic metals	0,75 *	0,85 *	0,89 *	0,86 *
28	Fabricated metal products	0,82 *	0,90 *	0,95 *	0,93 *
29	Machinery and equipment, n.e.c.	0,94 *	0,91 *	0,94 *	0,94 *
30	Office, and computing machinery	0,98 *	0,92 *	0,91 *	0,94 *
31	Electrical machinery and apparatus	0,95 *	0,92 *	0,97 *	0,96 *
32	Radio, television and communication	0,90 *	0,86 *	0,96 *	0,93 *
33	Medical, precision & optical instruments	0,96 *	0,91 *	0,96 *	0,95 *
34	Motor vehicles	0,81 *	0,85 *	0,92 *	0,89 *
35	Other transport equipment	0,95 *	0,92 *	0,90 *	0,91 *

* Correlation coefficient is significantly different from zero at the 5% level.

Grey cells indicate too few observations.

There is a strong positive association between patenting and exports in the electronics related sectors, in machinery and transport equipment. On the other hand in the traditional goods sector this association is weak. The main anomaly is the Pharmaceuticals sector where patenting performance coincides with export performance on a lower, but still significant level.

6.3.2 Analysis of specialisation

Thus far we have examined country performance within sectors, now we turn to an analysis of country patterns of specialisation. In particular we want to examine the extent to which specialisation in technology is related to specialisation in trade or output. This analysis is based on the Specialisation Index which is defined as the share of a country in a sector (world-wide) divided by the share of that country in all sectors. Thus a value of above unity indicates that this is a sector of relative specialisation (or advantage) for a country.

Table 6-6: Specialisation Index for Value-Added and for Patenting

Finland		***Value-Added***				***Patents***		
Sector	Sector name	1989-92	1993-96	1997-2000		1989-92	1993-96	1997-2000
15	Food products and beverages	1.16	0.98	0.71		1.98	1.31	1.24
16	Tobacco products	0.70	0.37	0.13		0.00	0.00	0.34
17	Textiles	0.54	0.49	0.50		0.90	0.71	0.55
18	Wearing apparel	0.86	0.57	0.45		2.37	0.57	0.14
19	Leather, leather products & footwear	0.90	0.72	0.66		0.58	0.51	1.08
20	Wood and products of wood and cork	2.66	2.45	2.22		2.29	3.14	2.28
21	Pulp, paper and paper products	2.95	3.45	3.44		2.84	2.99	3.83
23	Coke, refined petroleum products	0.74	0.52	0.40		0.58	0.52	0.37
2423	Pharmaceuticals	0.54	0.40	0.31		0.56	0.39	0.32
24ex2423	Chemicals exc. Pharmaceuticals	0.77	0.79	0.76		0.54	0.62	0.51
25	Rubber and plastics products	1.00	0.93	0.95		1.37	0.80	0.70
26	Other non-metallic mineral products	1.23	0.77	0.83		2.22	1.54	1.04
27	Basic metals	0.91	1.19	0.98		0.85	0.85	0.83
28	Fabricated metal products	0.88	0.73	0.82		1.10	0.99	0.55
29	Machinery and equipment, n.e.c.	1.21	1.26	1.16		1.80	1.43	1.40
30	Office, and computing machinery	0.41	0.36	0.13		0.28	0.43	0.43
31	Electrical machinery and apparatus	0.79	0.79	0.80		0.73	0.62	0.68
32	Radio, television and communication	0.57	1.08	2.23		0.87	1.97	2.49
33	Medical, precision & optical instruments	0.54	0.71	0.78		0.89	0.84	0.64
34	Motor vehicles	0.27	0.16	0.15		0.79	0.61	0.29
35	Other transport equipment	1.05	1.20	0.80		1.50	1.48	0.78

USA		Value-Added			Patents		
Sector	Sector name	1989-92	1993-96	1997-2000	1989-92	1993-96	1997-2000
15	Food products and beverages	0.93	0.88	0.88	1.15	1.13	1.04
16	Tobacco products	1.76	1.59	1.56	1.81	1.03	1.02
17	Textiles	1.01	1.05	0.99	1.06	1.05	1.01
18	Wearing apparel	0.85	0.82	0.80	1.28	1.21	1.06
19	Leather, leather products & footwear	0.64	0.61	0.51	0.80	0.64	0.80
20	Wood and products of wood and cork	1.43	1.42	1.34	0.29	0.24	0.42
21	Pulp, paper and paper products	0.92	0.85	0.83	0.95	0.91	0.91
23	Coke, refined petroleum products	1.10	0.86	0.80	1.73	1.37	1.43
2423	Pharmaceuticals	1.10	1.16	1.19	1.36	1.35	1.40
24ex2423	Chemicals exc. Pharmaceuticals	1.14	1.15	1.14	1.12	1.01	1.01
25	Rubber and plastics products	1.10	1.15	1.13	0.82	0.79	0.78
26	Other non-metallic mineral products	0.65	0.65	0.75	0.92	0.90	0.88
27	Basic metals	0.76	0.81	0.83	0.75	0.73	0.66
28	Fabricated metal products	0.93	0.94	0.98	0.64	0.57	0.61
29	Machinery and equipment, n.e.c.	0.86	0.89	0.87	0.74	0.74	0.73
30	Office, and computing machinery	1.32	1.27	1.30	1.16	1.17	1.18
31	Electrical machinery and apparatus	0.78	0.71	0.65	0.92	0.84	0.75
32	Radio, television and communication	1.14	1.23	1.24	0.97	1.06	1.05
33	Medical, precision & optical instruments	1.54	1.46	1.38	1.23	1.28	1.29
34	Motor vehicles	0.72	0.97	0.96	0.58	0.64	0.56
35	Other transport equipment	1.88	1.67	1.49	0.88	0.81	0.85

Table 6-6 illustrates the specialisation patterns in value-added and in patenting for two countries, Finland and the US. The former has a very high degree of specialisation in a few sectors both in terms of output and in terms of patenting: Wood Products, Pulp and Paper and Radio and Telecommunication equipment. The sectors with very low values of the specialisation index in both value-added and patenting are Pharmaceuticals, Office and computing machinery, and Motor vehicles. The pattern for the US is very different, with many more sectors of relative specialisation: 9 out of 21 in terms of value-added in 1997-2000 and 10 in terms of patenting. However the two variables show different patterns. Thus for example in Petroleum products the US has a high degree of specialisation in terms of patenting but not in terms of value-added. The reverse is the case for Other Transport equipment. In some of the ‘high-tech’ sectors (e.g. Computing and Pharmaceuticals, Medical and other Instruments), the US has a high value of specialisation for both the variables.

Table 6-7: Relationship between specialisation in value-added and patenting, correlation of specialisation indices

	1989-92		1993-96		1997-00		1989-2000	
Austria	0,48	*	0,41		0,70	*	0,56	*
Belgium	0,00		0,00		0,52	*	0,18	
Germany			0,43		0,54	*	0,49	*
Denmark	0,63	*	0,58	*	0,59	*	0,65	*
Spain	0,61	*	0,30		0,60	*	0,54	*
Finland	0,21		0,20		0,16		0,22	
France	0,51	*	0,47	*	0,62	*	0,57	*
Italy	0,86	*	0,86	*	0,85	*	0,86	*
Japan	0,51	*	0,51	*	0,43		0,48	*
Netherlands	-0,21		-0,01		0,02		-0,08	
Sweden	0,70	*	0,55	*	0,58	*	0,66	*
UK	0,43		0,46	*	0,23		0,38	
USA	0,39		0,22		0,31		0,31	

* Correlation coefficient is significantly different from zero at the 5% level.

Table 6-7 reports the results of our systematic analysis of patterns of specialisation across 13 countries over the period 1989 to 2000. As could be predicted from the above examples, there is a very low and insignificant correlation between output specialisation and technology specialisation in the USA. At the same time the relationship between these two variables is positive and significant for Finland. The other countries with a positive relationship throughout the period are Denmark, Finland, Sweden, Italy and Germany. On the other hand for the Netherlands, UK and Spain there is no relationship. In general 29 out of the possible 52 correlation coefficients are statistically significant.

In Table 6-8 we begin the analysis of country specialisation in technology and in trade. It illustrates the two variables for Finland and the US. The pattern of export specialisation for Finland is very similar to that based on value-added shown above: high degree of specialisation in Wood, Pulp and Paper and Radio and Telecommunications equipment. These are also areas in which Finland is highly specialised in terms of patenting. Again the US results are very similar to those reported above in terms of value-added: very contrasting patterns of specialisation in technology compared to exports.

Table 6-9 confirms the results for these two countries on the basis of correlations. Again, as with value-added, the same countries have a strong relationship between technology and trade: Denmark, Finland, Sweden, Italy, and to a lesser extent Germany and Japan. The countries with no association between the two variables are

Spain, UK, and France. In general 25 out of a possible 52 correlations are significant.

Table 6-8: Relative specialisation index for exports and for patenting

Finland		**Exports**				**Patents**		
Sector	Sector name	1989-92	1993-96	1997-2000		1989-92	1993-96	1997-2000
15	Food products and beverages	0.31	0.39	0.37		1.98	1.31	1.24
16	Tobacco products	0.14	0.16	0.12		0.00	0.00	0.34
17	Textiles	0.31	0.31	0.31		0.90	0.71	0.55
18	Wearing apparel	1.01	0.53	0.41		2.37	0.57	0.14
19	Leather, leather products & footwear	0.47	0.33	0.24		0.58	0.51	1.08
20	Wood and products of wood and cork	7.59	7.89	7.06		2.29	3.14	2.28
21	Pulp, paper and paper products	10.89	9.48	8.85		2.84	2.99	3.83
23	Coke, refined petroleum products	0.96	1.31	1.45		0.58	0.52	0.37
2423	Pharmaceuticals	0.48	0.32	0.26		0.56	0.39	0.32
24ex2423	Chemicals exc. Pharmaceuticals	0.52	0.50	0.51		0.54	0.62	0.51
25	Rubber and plastics products	0.71	0.66	0.61		1.37	0.80	0.70
26	Other non-metallic mineral products	0.64	0.69	0.71		2.22	1.54	1.04
27	Basic metals	1.55	1.59	1.54		0.85	0.85	0.83
28	Fabricated metal products	0.88	0.97	0.84		1.10	0.99	0.55
29	Machinery and equipment, n.e.c.	0.88	0.84	0.85		1.80	1.43	1.40
30	Office, and computing machinery	0.32	0.52	0.36		0.28	0.43	0.43
31	Electrical machinery and apparatus	0.78	1.11	1.08		0.73	0.62	0.68
32	Radio, television and communication	0.69	1.16	1.97		0.87	1.97	2.49
33	Medical, precision & optical instruments	0.54	0.54	0.56		0.89	0.84	0.64
34	Motor vehicles	0.29	0.23	0.24		0.79	0.61	0.29
35	Other transport equipment	0.63	0.72	0.49		1.50	1.48	0.78

USA		Exports				Patents		
Sector	Sector name	1989-92	1993-96	1997-2000		1989-92	1993-96	1997-2000
15	Food products and beverages	0.85	0.86	0.79		1.15	1.13	1.04
16	Tobacco products	2.71	2.53	1.75		1.81	1.03	1.02
17	Textiles	0.43	0.52	0.61		1.06	1.05	1.01
18	Wearing apparel	0.46	0.65	0.67		1.28	1.21	1.06
19	Leather, leather products & footwear	0.41	0.34	0.34		0.80	0.64	0.80
20	Wood and products of wood and cork	1.37	1.20	0.94		0.29	0.24	0.42
21	Pulp, paper and paper products	0.93	0.95	0.85		0.95	0.91	0.91
23	Coke, refined petroleum products	0.98	0.88	0.75		1.73	1.37	1.43
2423	Pharmaceuticals	0.86	0.76	0.72		1.36	1.35	1.40
24ex2423	Chemicals exc. Pharmaceuticals	1.12	1.08	1.02		1.12	1.01	1.01
25	Rubber and plastics products	0.78	0.88	0.95		0.82	0.79	0.78
26	Other non-metallic mineral products	0.52	0.53	0.58		0.92	0.90	0.88
27	Basic metals	0.63	0.72	0.67		0.75	0.73	0.66
28	Fabricated metal products	0.67	0.80	0.86		0.64	0.57	0.61
29	Machinery and equipment, n.e.c.	0.96	0.98	0.97		0.74	0.74	0.73
30	Office, and computing machinery	1.56	1.43	1.41		1.16	1.17	1.18
31	Electrical machinery and apparatus	0.97	0.99	1.00		0.92	0.84	0.75
32	Radio, television and communication	1.15	1.22	1.37		0.97	1.06	1.05
33	Medical, precision & optical instruments	1.44	1.44	1.46		1.23	1.28	1.29
34	Motor vehicles	0.72	0.81	0.73		0.58	0.64	0.56
35	Other transport equipment	2.17	1.76	1.71		0.88	0.81	0.85

Table 6-9: Relationship between specialisation in Exports and Patenting, correlation of specialisation indices

	1989-92	1993-96	1997-00	1989-2000
Austria	0,53 *	0,43 *	0,43 *	0,61 *
Belgium	0,57 *	0,59 *	0,58 *	0,69 *
Germany		0,35	0,35	0,49 *
Denmark	0,77 *	0,81 *	0,80 *	0,85 *
Spain	0,44	0,02	0,02	0,29
Finland	0,03	0,25	0,25	0,24
France	0,36	0,26	0,25	0,33
Italy	0,89 *	0,84 *	0,83 *	0,87 *
Japan	0,82 *	0,81 *	0,81 *	0,82 *
Netherlands	0,08	0,24	0,23	0,17
Sweden	0,55 *	0,64 *	0,64 *	0,62 *
UK	0,19	-0,04	-0,03	0,23
USA	0,41	0,21	0,20	0,30

* Correlation coefficient is significantly different from zero at the 5% level.

Table 6-10: Relationship between relative specialisation in patents and value added within each sector

		1989-92		1993-96		1997-00		1989-2000	
Sector	Sector name	Correlation Coefficient							
15	Food products and beverages	0,76	*	0,80	*	0,55		0,7	*
16	Tobacco products	-0,15		-0,27		-0,12		-0,17	
17	Textiles	0,65	*	0,27		0,40		0,67	*
18	Wearing apparel	0,38		0,46		0,40		0,23	
19	Leather, leather products & footwear	0,62	*	0,76	*	0,84	*	0,76	*
20	Wood and products of wood and cork	0,44		0,69	*	0,73	*	0,58	*
21	Pulp, paper and paper products	0,02		0,41		0,09		-0,02	
23	Coke, refined petroleum products	0,31		0,30		0,15		0,2	
2423	Pharmaceuticals	0,67	*	0,29		0,57	*	0,74	*
24ex2423	Chemicals exc. Pharmaceuticals	0,74	*	0,57	*	0,64	*	0,78	*
25	Rubber and plastics products	0,41		0,71	*	0,44		0,5	
26	Other non-metallic mineral products	0,49		0,37		0,65	*	0,54	
27	Basic metals	0,82	*	0,51		0,47		0,77	*
28	Fabricated metal products	0,28		0,76	*	0,42		0,45	
29	Machinery and equipment, n.e.c.	0,12		0,39		0,34		0,26	
30	Office, and computing machinery	0,66	*	0,79	*	0,72	*	0,71	*
31	Electrical machinery and apparatus	-0,09		0,59	*	0,42		0,26	
32	Radio, television and communication	0,80	*	0,72	*	0,33		0,5	
33	Medical, precision & optical instruments	0,50		0,41		0,78	*	0,81	*
34	Motor vehicles	0,26		0,03		0,35		0,34	
35	Other transport equipment	-0,24		-0,18		-0,14		-0,19	

* correlation coefficient is significantly different from zero at the 5 % level

** correlation coefficient is significantly different from zero at the 1 % level

Table 6-11: Relationship between relative specialisation in patents and export within each sector

		1989-92		1993-96		1997-00		1989-2000	
Sector	Sector name	Correlation Coefficient							
15	Food products and beverages	0,87	*	0,80	*	0,71	*	0,81	*
16	Tobacco products	0,01		-0,27		-0,06		-0,13	
17	Textiles	0,70	*	0,27		0,47		0,59	*
18	Wearing apparel	0,73	*	0,46		0,56	*	0,69	*
19	Leather, leather products & foot-wear	0,67	*	0,76	*	0,79	*	0,78	*
20	Wood and products of wood and cork	0,71	*	0,69	*	0,71	*	0,7	*
21	Pulp, paper and paper products	0,33		0,41		0,33		0,32	
23	Coke, refined petroleum products	0,31		0,30		0,21		0,26	
2423	Pharmaceuticals	0,38		0,29		0,44		0,51	
24ex2423	Chemicals exc. Pharmaceuticals	0,41		0,57	*	0,60	*	0,6	*
25	Rubber and plastics products	0,69	*	0,71	*	0,62	*	0,72	*
26	Other non-metallic mineral prod-ucts	0,42		0,37		0,45		0,34	
27	Basic metals	0,71	*	0,51		0,62	*	0,52	
28	Fabricated metal products	0,64	*	0,76	*	0,73	*	0,77	*
29	Machinery and equipment, n.e.c.	0,22		0,39		0,37		0,38	
30	Office, and computing machinery	0,90	*	0,79	*	0,77	*	0,8	*
31	Electrical machinery and apparatus	0,46		0,59	*	0,51		0,36	
32	Radio, television and communica-tion	0,72	*	0,72	*	0,62	*	0,64	*
33	Medical, precision & optical in-struments	0,55		0,41		0,51		0,55	
34	Motor vehicles	0,03		0,03		0,29		0,04	
35	Other transport equipment	-0,21		-0,18		-0,06		-0,12	

* correlation coefficient is significantly different from zero at the 5 % level

** correlation coefficient is significantly different from zero at the 1 % level

A further analysis refers to the relationship between specialisation in patents and value added within each sector equivalent to the computation of table 6-3 for shares. The level of correlation is lower than in the case of shares which may be due to the different content of the indexes (cf. Table 6-10). Shares reflect absolute structures, and the probability that large countries in terms of value added are also large in terms of patents is higher than in the case of the relative specialisation indices. So the more positive correlations in terms of shares might reflect size effects, whereas the specialisation indices reflect country structures. But with regard to the total period of 1989 to 2000, 9 of the 21 sectors still show up significant correlations in terms of specialisation. In some cases, the correlation is not significant due to insufficient availability of value added data and linked to that too small samples. However, in other cases such as Machinery, the sector structures in the countries considerably differ. To conclude, the concordance leads to positive correlations for many countries and sectors, but not for all of them.

If a similar analysis is performed for the relationship between patents and exports, equivalent to table 6-5 for shares, we get lower correlations than for values added, similar to the situation for shares, and many non significant correlations (cf. Table 6-11). Only 10 out of 21 sectors display significant correlations. So in the case of exports, it is necessary to carefully look at the countries and sectors analysed.

7. Assessment of the validation tests

The statistical verifications documented in chapter 5 show a high level of similarity of the distribution of technical fields across and within industries by country. The major differences generally refer to fields with low technology intensity, e.g. Leather articles or Wood products, or fields with less precise linkage to specific technologies such as Industrial process control equipment where in terms of technology the distinction from Measuring instruments is difficult. But all in all, the high similarity level supports the validity of the transfer matrix.

The comparison of the matrices over time shows a high stability of the distributions so that a frequent revision of the concordance matrix due to structural changes of the technical activities of sectors is not necessary.

However, the comparison of the relevance of the ‘core’ sector in the technology fields (diagonal elements of the country-specific concordance matrix) by country often varies considerably. Therefore it is not clear whether the general concordance matrix representing a world average of the technology-industry relationship can be appropriately applied to all countries, in particular to smaller ones.

An important step to analyse the usefulness of the concordance is the comparison of patents with economic data, in particular value-added and exports. The referring investigation, documented in chapter 6, was restricted by the limited availability of economic data. Because of this, the 44 sectors of the concordance matrix had to be aggregated to 21 sectors. Furthermore, data for some countries and sectors were not available at all. In the case of some less technology-intensive sectors the number of patents per country were quite low which has a restricting effect on the affected correlation coefficients.

Despite these restrictions, some conclusions can be drawn from the validation tests. The correlation between the **shares** of patents and the shares of value added and exports is generally very high and significant. The linkages are stronger in technology-intensive fields, and generally, but not always lower in less technology-intensive fields. A major exception is the pharmaceuticals sector with a lower, but still significant correlation between patent and export shares. The correlations between patent and value added shares are higher than those between patent and export shares. However, the good correlation of shares might largely reflect size effects, as in the present situation, the technology-intensive sectors are also the stronger sectors in economic terms, at least in industrialised countries. But the very high correlations, generally above $R = 0.9$, also reflect a close linkage between the economic position and the patent activity within countries, independently of the international structures.

The correlation between the **specialisation** in patents and that in value added and exports is often positive and significant, but less distinctly than with regard to shares. Specialisation indices are normalised by international averages, and the size effects of sectors and/or countries are eliminated. As to specialisation, only about half of the countries analysed display positive correlations between patent and economic data. This outcome obviously reflects the different sector-specific propensities to patent for different countries. On the level of sectors, the correlation is positive and significant; but for many cases, also some technology-intensive sectors, no correlation can be found. Again this may be due to different country-specific propensities to patent.

Similar to shares, the correlation of specialisation indices between patents and value added is weaker for pharmaceuticals than for other technology-intensive sectors, for patents and exports it is lost completely. This might reflect other relevant factors than technology such as the admission of drugs to national markets, the economic relevance of generic drugs but also the less clear technological and economic distinction of pharmaceuticals from basic chemicals and other chemicals (= special chemicals).

All in all, the less positive correlations of the specialisation indices cannot be taken as an indication that the concordance matrix does not work. Rather, it may reflect specific structures of countries and sectors. In any case, it is not possible to assume a positive correlation between patent performance on the one hand and value added and export performance on the other hand for all countries and sectors. Rather it is necessary to determine those countries and sectors displaying a high correlation between technical and economic performance.

The structures of the concordance matrix, in particular the often moderate level of the diagonal elements show the high level of technology mix within industrial sectors. Therefore, it can be expected that the correlation between relative measures of patents and exports is higher on the product than on the sector level. The weaker correlation on the sector level, shown in section 6.3.2, and the better correlation on the product-level (Grupp et a. 1996) is consistent with this assumption.

Some results of the validation tests suggest that the concordance matrix may be further improved. The unequal distribution of the diagonal elements by country (Table 6-4), the sometimes weak or non-existing correlation of patents and economic data for some technology-intensive sectors (e.g., pharmaceuticals) indicate that the concordance may be improved at least for some sectors.

Furthermore, – to test these assumptions – the calculations in section 6 were also done on a technological basis without transforming patent data into sectors. So it was assumed that the 44 technology fields are directly equivalent to the 44 industrial sectors. For about half of the countries and sectors analysed, the correlation values improved; for the rest, they were less positive. This outcome shows that the quality of the technology-based definition of sectors, suggested in section 4 is quite high and that the impact of the technology mix within sectors is less important with regard to the correlation of technologies to economic performance. However, there still seems to be a potential to improve the technical definition of fields and their transformation into sectors.

The experience of this study shows that a change of the company set for the empirical analysis, described in section 3.3, is the most promising approach for achieving a relevant improvement. In this study, we aimed at including as many companies as possible in order to cover as many patents as possible. However, the multiple sector classification of large companies and the impossibility to link the patents of these firms to specific sectors, obviously implies a less precise definition of technology fields referring to specific sectors. The data show that the number of patents per applicant is highly skewed, and the most active applicants in terms of patents are those classified in a high number of sectors. It is promising to leave out the upper ten percent of the applicants, although the number of patents included in the sample will be reduced substantially. But then, the association between technologies and industrial sectors will become more precise. This already became visible in this study in the context of the small applicants from France, the United Kingdom and Germany; but for some sectors the patent samples became too small for valid statistically based associations of technologies and sectors. With the inclusion of medium and large firms (and the exclusion of very large firms), the association will be more clear-cut and the samples per sector will remain sufficiently large. It can be assumed that the outcome of such an approach will also be valid for the analysis of very large firms, as in many countries, the economic data are collected on the basis of operating sites and not total companies (head quarters) so that the sectors have a closer link to technologies than the technology mix of large firms suggest.

As to the statistical verification of the concordance, it might be better to focus the analysis on technology-intensive sectors, as the patent samples per sector will be sufficiently large and a correlation between patents and economic performance is more likely. In particular, a better correlation on the country level can be expected.

Finally, it may be useful to compare the outcome of the concordance suggested in this report to that of the Johnson concordance. To compare the validity of the results for specific countries and sectors it will be useful to compare the outcome of the Johnson concordance to economic data as well.

8. Summary

The analyses of the project have provided a concordance between technical fields and industrial sectors, first, by defining 44 matched technical and industrial fields, second, by linking codes of the patent classification to industrial sectors, third, by analysing the patents by technology for a large international sample of companies classified by industrial sectors, and fourth, by computing a transfer matrix between technologies and industrial sectors based on the empirical analysis of the company sample.

The correspondence has a sound empirical basis, as it does not entirely rely on expert assessment in a technological perspective, but on the patent activities of industrial sectors, determined by a very large sample of enterprises. Moreover, the application of the concordance to specific examples requires a limited amount of work. Database searches have to be performed for only 44 technological fields, defined by a set of IPC subclasses, whereof the results can be transformed into industrial sectors using a 44x44 concordance matrix. Therefore the searches do not require in-house databases, but can be realised by online databases as well. The transformation does not need special software developments and can be done by standard calculation programs.[10]

The suggested concordance can be used for international comparisons, as it refers to international classifications, namely NACE and ISIC for industrial sectors and IPC for patents. With 44 sector fields, the concordance has a reasonable level of disaggregation. A further differentiation would not be useful, as the economic data for international comparisons are not available in a finer breakdown, and the technical interconnections between the sub-sectors would become too strong. Higher aggregation levels can be achieved by a mere combination of sub-sectors.

A specific advantage of the correspondence is the possibility of analysing industrial structures, for instance, by making comparisons across countries, looking for changes over time, or examining differences between large and small enterprises. For such purposes, the technical definitions are kept invariant, whereas different data sets are used for the empirical construction of structural matrices.

The empirical analyses show that a simple, straightforward definition of industrial sectors by technologies would not be appropriate. The two main reasons are that there is often a strong technological interconnection between different sectors, and secondly that large firms produce a broad spectrum of technologies. This result is primarily reflected in the sometimes low importance of the diagonal elements in the concordance matrix, frequently below 20 per cent. This means that in many cases,

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[10] Search instructions for the 44 IPC-based fields and an Excel-sheet for the computations will be available for download on the web-pages of Fraunhofer-ISI (http://www.isi.fhg.de/ti/Projektbeschreibungen/us-development_Concordance_e.htm).

other sectors contribute more to patents of a specific field than the related "core" sector itself.

The comparison of distribution of the technical fields and industrial classes for different countries, based on country-specific transfer matrices, show a good correlation in many cases. However, there is a relevant number of technical fields with considerable differences. These cases primarily refer to fields with low absolute numbers of patents and firms and to less technology-intensive fields.

These differences between sectors and countries may be, to a certain extent, due to inaccuracies of the association of technological and industrial fields or of the problem to directly link the technological activities of a firm to secondary industrial classifications. Major reasons are, however, the structural differences between the technological activities of industrial sectors in the different countries. The country comparisons in this report exclusively refer to large countries. The structural differences will become even larger, if smaller countries are considered, where the technological activities of a specific sector are often dominated by a few firms. Therefore, the comparison of countries has to be handled with care, at least with regard to specific sectors. The concordance matrix developed in this project represents an international average structure.

The structural changes in time prove to be less relevant, at least with regard to the international structures in the nineties, so that the concordance can be used for analysing longer time series. A frequent revision does not seem to be necessary, though controlling the relationship from time to time is appropriate.

If patents, transferred by the concordance matrix, and economic data, in particular value added and export, are compared, the correlation is quite good on the basis of shares reflecting absolute measures of performance. However, in some sectors, in particular less technology-intensive sectors, the correlation is not significant. If the specialisation in patens and in economic data are compared, the similarities are even lower. This applies to the comparison of sectors as well as countries. In consequence, the correlation can only be found for specific sectors and countries. The major reason for this outcome are the different sector structures of different countries and the technological heterogeneity of sectors. E.g., the sector machinery comprises high-tech as well as low-tech sub-sectors in most countries, with different R&D and patent intensities and differences in the relevance of technology for export performance. Thus, the outcome of the project confirms the assumption of Grupp et al. (1996: 272) that "industries do not represent homogenous technologies". Therefore the correlation of patents and exports by a product-based approach is generally higher than by the sector-based approach of this report.

Despite the various restrictions described above, the outcome of this report is highly valuable. Due to the very large firm sample, it has been possible to analyse the distribution of technologies on sectors and differences between countries for the first time in a detailed way. Furthermore, it is possible to apply the concordance for the analysis of economic structures on many sectors and countries. However, further research is needed on the specific reasons of good and less positive similarities for achieving clear rules for an appropriate application of the concordance. In addition, the outcome of the suggested correspondence has to be compared to that of other concordances in order to improve its utility. In any case, the concordance provides a powerful tool for analysing the relationship between sectors and technologies and between technological and economic performance.

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Annex 1

Definition of 44 sectoral fields by NACE codes

Field no	NACE	Description
1	15	Food, beverages
2	16	Tobacco products
3	17	Textiles
4	18	Wearing apparel
5	19	Leather articles
6	20	Wood products
7	21	Paper
8	22	Publishing, printing
9	23	Petroleum products, nuclear fuel
10	24.1	Basic chemical
11	24.2	Pesticides, agro-chemical products
12	24.3	Paints, varnishes
13	24.4	Pharmaceuticals
14	24.5	Soaps, detergents, toilet preparations
15	24.6	Other chemicals
16	24.7	Man-made fibres
17	25	Rubber and plastics products
18	26	Non-metallic mineral products
19	27	Basic metals
20	28	Fabricated metal products
21	29.1	Energy machinery
22	29.2	Non-specific purpose machinery
23	29.3	Agricultural and forestry machinery
24	29.4	Machine-tools
25	29.5	Special purpose machinery
26	29.6	Weapons and ammunition
27	29.7	Domestic appliances
28	30	Office machinery and computers
29	31.1	Electric motors, generators, transformers
30	31.2, 31.3	Electric distribution, control, wire, cable
31	31.4	Accumulators, battery
32	31.5	Lightening equipment
33	31.6	Other electrical equipment
34	32.1	Electronic components
35	32.2	Signal transmission, telecommunications
36	32.3	Television and radio receivers, audiovisual electronics
37	33.1	Medical equipment
38	33.2	Measuring instruments
39	33.3	Industrial process control equipment
40	33.4	Optical instruments
41	33.5	Watches, clocks
42	34	Motor vehicles
43	35	Other transport equipment
44	36	Furniture, consumer goods

Annex 2

Association of sectoral fields according to Annex 1 to sub-classes of the International Patent Classification (IPC)

Field	IPC	Field	IPC	Field	IPC	Field	IPC	Field	IPC	Field	IPC
1	A01H	10	B09B	15	C06B	19	H01B	21	F16C	24	B23C
1	A21D	10	B09C	15	C06C	20	A01L	21	F16D	24	B23D
1	A23B	10	B29B	15	C06D	20	A44B	21	F16F	24	B23G
1	A23C	10	C01B	15	C08H	20	A47H	21	F16H	24	B23H
1	A23D	10	C01C	15	C09G	20	A47K	21	F16K	24	B23K
1	A23F	10	C01D	15	C09H	20	B21K	21	F16M	24	B23P
1	A23G	10	C01F	15	C09J	20	B21L	21	F23R	24	B23Q
1	A23J	10	C01G	15	C10M	20	B22F	22	A62C	24	B24B
1	A23K	10	C02F	15	C11B	20	B25B	22	B01D	24	B24C
1	A23L	10	C05B	15	C11C	20	B25C	22	B04C	24	B25D
1	A23P	10	C05C	15	C14C	20	B25F	22	B05B	24	B25J
1	C12C	10	C05D	15	C23F	20	B25G	22	B61B	24	B26F
1	C12F	10	C05F	15	C23G	20	B25H	22	B65G	24	B27B
1	C12G	10	C05G	15	D01C	20	B26B	22	B66B	24	B27C
1	C12H	10	C07B	15	F42B	20	B27G	22	B66C	24	B27F
1	C12J	10	C07C	15	F42D	20	B44C	22	B66D	24	B27J
1	C13F	10	C07F	15	G03C	20	B65F	22	B66F	24	B28D
1	C13J	10	C07G	16	D01F	20	B82B	22	C10F	24	B30B
1	C13K	10	C08B	17	A45C	20	C23D	22	C12L	24	E21C
2	A24B	10	C08C	17	B29C	20	C25D	22	F16G	25	A21C
2	A24D	10	C08F	17	B29D	20	E01D	22	F22D	25	A22B
2	A24F	10	C08G	17	B60C	20	E01F	22	F23B	25	A22C
3	D04D	10	C08J	17	B65D	20	E02C	22	F23C	25	A23N
3	D04G	10	C08K	17	B67D	20	E03B	22	F23D	25	A24C
3	D04H	10	C08L	17	E02B	20	E03C	22	F23G	25	A41H
3	D06C	10	C09B	17	F16L	20	E03D	22	F23H	25	A42C
3	D06J	10	C09C	17	H02G	20	E05B	22	F23J	25	A43D
3	D06M	10	C09D	18	B24D	20	E05C	22	F23K	25	B01F
3	D06N	10	C09K	18	B28B	20	E05D	22	F23L	25	B02B
3	D06P	10	C10B	18	B28C	20	E05F	22	F23M	25	B02C
3	D06Q	10	C10C	18	B32B	20	E05G	22	F24F	25	B03B
4	A41B	10	C10H	18	C03B	20	E06B	22	F24H	25	B03C
4	A41C	10	C10J	18	C03C	20	F01K	22	F25B	25	B03D
4	A41D	10	C10K	18	C04B	20	F15D	22	F27B	25	B05C
4	A41F	10	C12S	18	E04B	20	F16B	22	F28B	25	B05D
5	A43B	10	C25B	18	E04C	20	F16P	22	F28C	25	B06B
5	A43C	10	F17C	18	E04D	20	F16S	22	F28D	25	B07B
5	B68B	10	F17D	18	E04F	20	F16T	22	F28F	25	B07C
5	B68C	10	F25J	18	G21B	20	F17B	22	F28G	25	B08B
6	B27D	10	G21F	19	B21C	20	F22B	22	G01G	25	B21B
6	B27H	11	A01N	19	B21G	20	F22G	22	H05F	25	B22C
6	B27M	12	B27K	19	B22D	20	F24J	23	A01B	25	B26D
6	B27N	13	A61K	19	C21B	20	G21H	23	A01C	25	B31B
6	E04G	13	A61P	19	C21C	21	B23F	23	A01D	25	B31C
7	B41M	13	C07D	19	C21D	21	F01B	23	A01F	25	B31D
7	B42D	13	C07H	19	C22B	21	F01C	23	A01G	25	B31F
7	B42F	13	C07J	19	C22C	21	F01D	23	A01J	25	B41B
7	B44F	13	C07K	19	C22F	21	F03B	23	A01K	25	B41C
7	D21C	13	C12N	19	C25C	21	F03C	23	A01M	25	B41D
7	D21H	13	C12P	19	C25F	21	F03D	23	B27L	25	B41F
7	D21J	13	C12Q	19	C30B	21	F03G	24	B21D	25	B41G
9	C10G	14	C09F	19	D07B	21	F04B	24	B21F	25	B41L
9	C10L	14	C11D	19	E03F	21	F04C	24	B21H	25	B41N
9	G01V	14	D06L	19	E04H	21	F04D	24	B21J	25	B42B
10	B01J	15	A62D	19	F27D	21	F15B	24	B23B	25	B42C

Field	IPC	Field	IPC	Field	IPC	Field	IPC	Field	IPC	Field	IPC
25	B44B	27	A45D	33	B60M	37	A61M	42	F01N	44	A63F
25	B65B	27	A47G	33	B61L	37	A61N	42	F01P	44	A63G
25	B65C	27	A47J	33	F21P	37	A62B	42	F02B	44	A63H
25	B65H	27	A47L	33	F21Q	37	B01L	42	F02D	44	A63J
25	B67B	27	B01B	33	G08B	37	B04B	42	F02F	44	A63K
25	B67C	27	D06F	33	G08G	37	C12M	42	F02G	44	B43K
25	B68F	27	E06C	33	G10K	37	G01T	42	F02M	44	B43L
25	C13C	27	F23N	33	G21C	37	G21G	42	F02N	44	B44D
25	C13D	27	F24B	33	G21D	37	G21K	42	F02P	44	B62B
25	C13G	27	F24C	33	H01T	37	H05G	42	F16J	44	B68G
25	C13H	27	F24D	33	H02H	38	F15C	42	G01P	44	C06F
25	C14B	27	F25C	33	H02M	38	G01B	42	G05D	44	F23Q
25	C23C	27	F25D	33	H05C	38	G01C	42	G05G	44	G10B
25	D01B	27	H05B	34	B81B	38	G01D	43	B60F	44	G10C
25	D01D	28	B41J	34	B81C	38	G01F	43	B60V	44	G10D
25	D01G	28	B41K	34	G11C	38	G01H	43	B61C	44	G10F
25	D01H	28	B43M	34	H01C	38	G01J	43	B61D	44	G10G
25	D02G	28	G02F	34	H01F	38	G01M	43	B61F	44	G10H
25	D02H	28	G03G	34	H01G	38	G01N	43	B61G		
25	D02J	28	G05F	34	H01J	38	G01R	43	B61H		
25	D03C	28	G06C	34	H01L	38	G01S	43	B61J		
25	D03D	28	G06D	35	G09B	38	G01W	43	B61K		
25	D03J	28	G06E	35	G09C	38	G12B	43	B62C		
25	D04B	28	G06F	35	H01P	39	G01K	43	B62H		
25	D04C	28	G06G	35	H01Q	39	G01L	43	B62J		
25	D05B	28	G06J	35	H01S	39	G05B	43	B62K		
25	D05C	28	G06K	35	H02J	39	G08C	43	B62L		
25	D06B	28	G06M	35	H03B	40	G02B	43	B62M		
25	D06G	28	G06N	35	H03C	40	G02C	43	B63B		
25	D06H	28	G06T	35	H03D	40	G03B	43	B63C		
25	D21B	28	G07B	35	H03F	40	G03D	43	B63H		
25	D21D	28	G07C	35	H03G	40	G03F	43	B63J		
25	D21F	28	G07D	35	H03H	40	G09F	43	B64B		
25	D21G	28	G07F	35	H03M	41	G04B	43	B64C		
25	E01C	28	G07G	35	H04B	41	G04C	43	B64D		
25	E02D	28	G09D	35	H04J	41	G04D	43	B64F		
25	E02F	28	G09G	35	H04K	41	G04F	43	B64G		
25	E21B	28	G10L	35	H04L	41	G04G	43	E01B		
25	E21D	28	G11B	35	H04M	42	B60B	43	F02C		
25	E21F	28	H03K	35	H04Q	42	B60D	43	F02K		
25	F04F	28	H03L	35	H05K	42	B60G	43	F03H		
25	F16N	29	H02K	36	G03H	42	B60H	44	A41G		
25	F26B	29	H02N	36	H03J	42	B60J	44	A42B		
25	H05H	29	H02P	36	H04H	42	B60K	44	A44C		
26	B63G	30	H01H	36	H04N	42	B60L	44	A45B		
26	F41A	30	H01R	36	H04R	42	B60N	44	A45F		
26	F41B	30	H02B	36	H04S	42	B60P	44	A46B		
26	F41C	31	H01M	37	A61B	42	B60Q	44	A46D		
26	F41F	32	F21H	37	A61C	42	B60R	44	A47B		
26	F41G	32	F21K	37	A61D	42	B60S	44	A47C		
26	F41H	32	F21L	37	A61F	42	B60T	44	A47D		
26	F41J	32	F21M	37	A61G	42	B62D	44	A47F		
26	F42C	32	F21S	37	A61H	42	E01H	44	A63B		
26	G21J	32	F21V	37	A61J	42	F01L	44	A63C		
27	A21B	32	H01K	37	A61L	42	F01M	44	A63D		

Annex 3

Share of industrial sectors within technological fields with reference to the total technological field (vertical comparison in %), concordance matrix

Industrial sectors		Food 01	Tobacco 02	Textiles 03	Wearing 04	Leather 05	Wood products 06	Paper 07	Publishing 08	Petroleum 09	Basic chem. 10	Pesticides 11	Paint 12	Pharma 13	Soaps 14	Other chem 15	Man-m. fibres 16	Plastic prod. 17	Mineral prod. 18	Basic metals 19	Metal prod. 20	Energy mach. 21	Non-sp. mach. 22	Agro mach. 23	Machine-tools 24	Special mach. 25	Weapons 26	Domestic appl. 27	Computers 28	Electr. motors 29	Electr. distrib. 30	Accumaulators 31	Lightening 32	Other electr. 33	Electronic comp. 34	Telecom 35	Television 36	Medical equip. 37	Measuring instr. 38	Industr, control 39	Optics 40	Watches 41	Mot. Vehicles 42	Other transp. 43	Consumer goods 44
Food	01	67	0	3	0	0	0	1		0	2	3	1	6	22	3	3	4	1	0	1	0	1	2	0	2	0	4	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	1	3
Tobacco	02	0	72	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textiles	03	0	2	9	21	0	3	1		0	1	0	1	0	0	0	7	0	1	1	0	0	0	0	0	1	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0
Wearing	04	0	0	1	8	2	0	0		0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leather	05	0	0	1	2	20	0	0		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Wood products	06	0	0	0	0	0	22	0		0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paper	07	0	5	12	11	1	2	20		0	1	0	1	0	0	0	7	5	2	0	1	0	1	1	0	3	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Publishing	08	0	0	0	0	0	0	9		0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0
Petroleum	09	0	0	1	0	0	0	1		59	8	2	2	1	0	12	4	1	3	1	0	0	2	0	1	5	1	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0
Basic chem.	10	9	5	27	3	0	12	18		9	43	37	34	11	8	15	30	6	16	7	2	1	12	6	3	6	3	3	1	1	0	8	3	3	2	0	1	3	4	1	6	0	1	1	1
Pesticides	11	1	0	0	0	0	0	0		0	0	8	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paint	12	0	0	0	0	0	0	1		0	1	1	9	0	1	1	0	0	2	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Pharma	13	10	0	5	2	1	2	3		2	16	39	7	66	5	3	4	3	3	0	2	1	3	7	1	2	0	1	0	0	0	1	0	0	0	0	0	16	11	1	3	0	0	0	1
Soaps	14	6	0	8	26	0	5	6		0	2	4	1	8	48	4	1	7	1	0	2	0	1	0	0	2	0	7	0	0	0	1	0	0	0	0	0	10	0	0	0	0	0	0	5
Other chem	15	3	0	12	0	3	10	10		3	6	2	9	3	15	22	9	2	4	1	1	0	2	0	1	3	8	1	1	0	0	1	2	0	0	0	0	1	1	0	4	0	1	0	0
Man-m. fibres	16	0	3	5	3	1	0	1		0	1	0	0	0	0	0	21	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Plastic prod.	17	0	0	0	5	2	3	0		0	3	0	3	0	0	1	3	24	4	2	6	3	2	0	1	1	0	0	0	0	0	0	1	0	0	0	0	1	1	1	1	0	3	1	1
Mineral prod.	18	0	0	3	0	0	3	2		0	2	0	2	0	0	1	0	1	27	4	2	1	2	0	1	1	4	2	0	0	0	3	1	2	2	0	0	0	2	1	5	0	1	0	1
Basic metals	19	0	0	0	2	0	2	0		2	2	0	1	0	0	2	0	3	5	34	5	1	3	1	8	4	0	1	0	1	2	3	0	1	2	1	0	0	2	0	5	0	1	0	1
Metal prod.	20	0	0	2	0	0	5	0		2	1	0	1	0	0	1	1	7	4	3	30	4	5	1	5	2	26	2	0	1	3	1	0	2	0	0	0	0	1	2	1	0	4	5	6
Energy mach.	21	0	0	0	0	0	5	0		1	0	0	0	0	0	0	0	1	1	2	3	14	5	1	5	2	3	1	0	7	2	2	0	2	1	0	0	0	2	4	0	0	5	5	1
Non-sp. mach.	22	0	0	2	0	0	3	0		1	1	0	1	0	0	0	1	2	2	5	3	7	18	0	3	2	0	2	0	11	5	1	1	7	2	0	0	1	2	3	0	0	1	8	1
Agro mach.	23	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	1	0	63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Machine-tools	24	0	0	0	0	0	15	0		0	0	0	0	0	0	0	0	1	2	4	4	1	1	0	20	3	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Special mach.	25	2	11	2	0	0	5	5		7	1	0	3	0	0	1	2	7	1	11	2	5	8	2	11	40	2	1	2	2	0	0	0	2	6	0	1	0	3	4	1	0	2	3	6
Weapons	26	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Domestic appl.	27	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	35	1	2	1	1	0	1	0	0	3	1	0	3	0	0	0	0	2
Computers	28	0	0	2	0	0	2	10		1	1	0	14	0	0	9	0	1	2	4	5	3	5	0	4	8	2	4	47	12	14	8	4	20	31	21	25	2	11	18	19	22	3	7	1
Electr. motors	29	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	6	1	1	0	2	0	0	0	0	0	1	0	0	0	0	0
Electr. distrib.	30	0	0	0	0	0	0	0		1	0	0	0	0	0	1	0	2	0	1	1	5	2	0	4	1	0	1	1	4	13	5	2	4	2	1	1	1	1	9	1	0	1	0	0
Accumaulators	31	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	2	0	0	0	0	0	0	0	0	0	0	0	0
Lightening	32	0	2	0	0	0	0	0		0	0	0	0	0	0	0	0	1	1	1	2	1	0	0	1	0	0	4	1	5	5	0	41	6	3	1	2	1	1	1	1	0	1	0	0
Other electr.	33	0	0	0	0	1	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	2	3	0	1	0	1	1	0	0	0	0	0
Electronic comp	34	0	0	0	0	0	0	1		0	0	0	0	0	0	1	0	1	2	4	1	1	1	1	3	1	2	2	10	7	23	3	3	6	20	7	5	1	5	5	5	2	2	0	1
Telecom	35	0	2	0	3	1	0	1		1	1	0	1	0	0	1	0	2	4	3	2	2	2	0	3	1	3	9	17	7	7	29	18	12	14	52	29	2	9	7	15	3	1	2	1
Television	36	0	0	0	0	0	0	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	9	1	1	4	1	3	3	5	23	0	1	2	3	1	0	2	1
Medical equip.	37	0	0	1	3	0	0	0		0	0	1	0	1	0	1	0	1	0	0	0	1	1	0	0	1	1	1	0	0	0	0	1	0	0	0	1	49	4	1	1	0	0	0	2
Measuring instr.	38	0	0	0	0	0	0	1		3	0	0	2	1	0	0	0	1	0	0	0	1	1	0	1	1	5	1	1	1	1	0	0	2	1	2	1	2	10	3	2	2	0	0	1
Industr, control	39	0	0	0	0	1	0	0		1	0	0	0	0	0	0	0	1	0	0	0	2	1	0	1	0	1	1	1	3	2	0	0	1	0	0	0	0	3	8	0	2	2	0	0
Optics	40	0	0	0	0	0	0	4		1	0	0	1	0	0	14	0	2	2	1	0	0	0	0	2	1	0	0	3	1	0	1	1	0	1	0	4	1	3	2	18	0	0	0	0
Watches	41	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	1	61	0	0	1
Mot. Vehicles	42	0	0	1	0	0	0	0		1	1	0	1	0	0	1	1	6	3	5	15	38	12	3	12	2	7	4	1	18	15	7	8	14	3	4	2	0	10	14	2	2	60	7	3
Other transp.	43	0	0	1	0	12	0	0		2	3	0	1	0	0	2	1	2	4	4	2	6	3	1	7	2	21	2	1	4	1	1	4	6	2	1	1	1	6	5	2	1	5	53	1
Consumer good	44	0	0	0	14	57	0	1		0	0	0	2	0	0	0	0	1	1	0	1	1	1	6	0	0	0	2	0	0	0	0	3	0	0	0	0	1	0	0	0	0	1	2	55
Total		100	100	100	100	100	100	100		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Technological fields