Concept of a Technology Classification for Country Comparisons[1]

Final Report to the

World Intellectual Property Organisation (WIPO)

Ulrich Schmoch

Fraunhofer Institute for Systems and Innovation Research, Karlsruhe, Germany

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1 Comments and suggestions on this paper should be sent to: ipstats.mail@wipo.int

1. Background

International comparisons in economic studies are generally based on sector classifications, for instance, comparisons of production, employment, research and development or foreign trade. Sectors are defined by typical products, but many enterprises produce a broad variety of different products, so that in the real world sectors describe the main economic activities of enterprises.

The production and function of products are based on technologies, and most products use a variety of technologies. In consequence, the notions of “sector” and “technology” describe different aspects of products and must be analysed separately. Patents are oriented towards the legal protection of technologies and therefore the classification of patents is based on technologies or products which use specific technologies. In many cases, the patent classification is quite similar to sector classifications, but they are never identical.

The present study aims to draw up a technology classification for country comparisons. This approach is relevant, as in today's world, a substantial share of economic activity refers to research- and knowledge-intensive goods and services, where technology is a major factor of competitiveness. Technological competence is the basis for engaging in specific product areas and sectors. The analysis of technologies is a first step in describing and understanding the economic activities and performance of countries. The next step – not yet realised in this report – is to establish a concordance between technologies and sectors in order to show how technological competence is transferred into economic performance.

Various technology classifications have been used by different institutions for many years. These classifications generally follow the systematic of specific patent classifications, either the International Patent Classification or the US Patent Classification. However, these classifications have proved to be quite inconsistent in various aspects. This led the Fraunhofer ISI and the Observatoire des Sciences et des Technologies, in cooperation with the French patent office (INPI), to develop a more systematic technology classification based on the codes of the International Patent Classification (IPC). The first version was already published in 1992 and comprised 28 technology classes.[2] Since that time, the classification has been amended several times, and in particular it was extended into a version comprising 30 classes. Many experiences with the advan-

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2 Grupp, H.; Schmoch, U. (1992): Perception of scientification of innovation as measured by referencing between patents and papers, in: Grupp, H. (ed.), Dynamics of Science-Based Innovation. Berlin et al.: Springer.

tages and disadvantages of this classification were made, so that a good basis for further improvement is available. Furthermore, the International Classification was substantially revised in the 8th edition in 2006; in particular, new codes were introduced which are not covered by the old version of the ISI-OST-INPI classification.

The old version of the ISI-OST-INPI classification was conceived in a period where international trade was focussed on a small number of advanced industrialized countries. However, the last decade was characterized by the growing relevance of emerging countries, so that international comparisons have to include a much broader set of countries. An appropriate technology classification has to take this change into account.

To summarize, there are various reasons to draw up a revised technology classification based on IPC codes adapted to the changed framework.

2. Basic requirements

A technology classification for country comparisons should fulfil various requirements which cannot be perfectly achieved, but which should be realized as far as possible.

(1) The classification should cover all technology fields, i.e. all codes of the International Patent Classification.

(2) The size of the fields should be balanced, i.e. very large fields and very small fields, in terms of the number of patent applications involved, should be avoided. The problem with too large fields is that they cover too many technologies and are too heterogeneous. The disadvantage of too small fields is that the number of patent applications concerned is too small for meaningful statistical analysis, particularly in the case of smaller countries.

(3) The classification should be based exclusively on codes of the IPC, for many data sources do not provide useful text elements for more advanced analyses. However, individuals and institutions without detailed knowledge of database searches should be able to utilize the classification.

(4) The level of differentiation should be appropriate. On the one hand, the classification should allow crude analysis based on about 5 groups, on the other hand, a more detailed analysis with about 20 fields should be feasible. This more detailed level is necessary for a better analysis of country structures. However, the number of classes should be below 40 fields, as too many details tend to blur the general structures. Furthermore, it should be possible to present the result for a

country in one bar chart with readable letters. This is a very pragmatic argument, but it has proved to be relevant in the context of country studies.

(5) The content of the fields should be quite distinct from each other. The overlap of technologies cannot be avoided completely. In particular, the new 8th version of the IPC does not differentiate clearly between the main and secondary classifications of patent documents.[3] This implies a relevant overlap of fields in patent searches. However, this overlap should not be too extensive otherwise merging fields is more appropriate than artificially separating them.

Due to these simple requirements, it has to be accepted that a certain heterogeneity within the fields is inevitable. However, in most cases a core area dominates quantitatively, so that the factual heterogeneity is much smaller than assumed. Experience with the former versions of the ISI-OST-INPI classification has shown that the definition of specific fields of special topical interest is not useful, as key words prove to be necessary for more precise descriptions and the absolute number of applications is often too small for meaningful interpretation. In other cases, the topicality of some fields proved to be quite short and they were displaced by other fields. In consequence, the classification should map relevant areas of present technology, but the necessary higher level of aggregation will imply their longer relevance.

As explained above, the present study starts from a former version of the ISI-OST-INPI classification documented in Table 1. The following chapter documents the new version derived from the experiences with the original version and new analyses on the basis of IPC8 codes.

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3 However, at many patent offices, the first code is still used as the main classification, for instance for assigning an application to a specific examination unit.

Table 1: Technology classification of ISI-OST-INPI, update: February 2005

	Area	IPC code
I.	**Electrical engineering**	
1.	Electrical machinery and apparatus, electrical energy	F21; G05F; H01B,C,F,G,H,J,K,M, R,T; H02; H05B,C,F,K
2.	Audio-visual technology	G09F,G; G11B; H03F,G,J; H04N-003,-005,-009,-013,-015, -017,R,S
3.	Telecommunications	G08C; H01P,Q; H03B,C,D,H, K,L,M; H04B,H,J,K,L,M, N-001, -007,-011,Q
4.	Information technology	G06; G11C; G10L
5.	Semiconductors	H01L, B81
II.	**Instruments**	
6.	Optics	G02; G03B,C,D,F,G,H; H01S
7.	Analysis, measurement, control technology	G01B,C,D,F,G,H,J,K,L,M,N, P,R,S,V,W;G04; G05B,D; G07; G08B,G; G09B,C,D; G12
8.	Medical technology	A61B,C,D,F,G,H,J,L,M,N
9.	Nuclear engineering	G01T; G21; H05G,H
III.	**Chemistry, pharmaceuticals**	
10.	Organic fine chemistry	C07C,D,F,H,J,K
11.	Macromolecular chemistry, polymers	C08B,F,G,H,K,L; C09D,J
12.	Pharmaceuticals, cosmetics	A61K, A61P
13.	Biotechnology	C07G; C12M,N,P,Q,R,S
14.	Agriculture, food chemistry	A01H; A21D; A23B,C,D,F,G,J,K, L; C12C,F,G,H,J; C13D,F,J,K
15.	Chemical and petrol industry, basic materials chemistry	A01N; C05; C07B; C08C; C09B,C,F, G,H,K; C10B,C,F, G,H,J,K,L,M,N; C11B,C,D
16.	Surface technology, coating	B05C,D; B32; C23; C25; C30
17.	Materials, metallurgy	C01; C03C; C04; C21; C22; B22, B82

IV.	**Process engineering, special equipment**	
18.	Chemical engineering	B01B,D (without -046 to -053), F,J,L;B02C; B03; B04; B05B; B06; B07; B08; F25J; F26
19.	Materials processing, textiles, paper	A41H; A43D; A46D; B28; B29; B31; C03B; C08J; C14; D01; D02; D03; D04B,C,G,H; D05; D06B,C,G,H,J,L,M,P,Q; D21
20.	Handling, printing	B25J; B41; B65B,C,D,F,G,H; B66; B67
21.	Agricultural and food processing, machinery and apparatus	A01B,C,D,F,G,J,K,L,M; A21B,C; A22; A23N,P; B02B; C12L; C13C,G,H
22.	Environmental technology	A62D; B01D-046 to -053; B09; C02; F01N; F23G,J
V.	**Mechanical engineering, machinery**	
23.	Machine tools	B21; B23; B24; B26D,F; B27; B30
24.	Engines, pumps, turbines	F01B,C,D,K,L,M,P; F02; F03; F04; F23R
25.	Thermal processes and apparatus	F22; F23B,C,D,H,K,L,M,N,Q; F24; F25B,C; F27; F28
26.	Mechanical elements	F15; F16; F17; G05G
27.	Transport	B60; B61; B62; B63B,C,H,J; B64B,C,D,F
28.	Space technology, weapons	B63G; B64G; C06; F41; F42
VI.	**Consumption**	
29.	Consumer goods and equipment	A24; A41B,C,D,F,G; A42; A43B, C; A44; A45; A46B; A47; A62B,C; A63; B25B,C,D,F,G,H; B26B; B42; B43; B44; B68; D04D; D06F,N; D07; F25D; G10B,C,D,F,G,H,K
30.	Civil engineering, building, mining	E01;E02;E03;E04;E05;E06;E21

3. New concept of an IPC-based technology classification

The suggested new version of the technology classification is documented in Table 2. Compared to the ISI-OST-INPI classification, the area of information technology is broken down into more fields and thus differentiated at a finer level. Furthermore, the general area of process engineering is completely abandoned, as the fields covered had unclear references to mechanical engineering or chemistry. For the present version, new fields with a definite relation either to mechanical engineering or chemistry were introduced.

In order to illustrate the quantitative implications of the new definitions, Figure 1 and Figure 2 show the outcome for international (PCT) applications of the priority year 2005. The searches for this analysis were performed using IPC8 codes. As the IPC8 does not distinguish between main and secondary classifications of patent documents, all classifications of the applications were taken into account.[4] Due to the multiple classifications of documents they are sometimes associated with more than one technical field, but the effect is limited. The overlap or the double counting rate is at a level of 20 percent. To avoid such double counting, it is possible to use the first classification codes exclusively which are equivalent to the former main classification at many patent offices. However, the relative distribution of the applications to fields on the basis of the first code is largely equivalent to that with the inclusion of all codes.

The content of each field and the reasons for their specific definition are explained in the following:

1. Electrical machinery, apparatus, energy: the field primarily covers the non-electronic part of electrical engineering, for instance, the generation, conversion and distribution of electric power, electric machines but also basic electric elements such as resistors, magnets, capacitors, lamps or cables. This field is often associated with “traditional” electrical engineering, but the high patent activity shows that technological innovation is still very important.

2. Audio-visual technology: audio-visual technology is largely equivalent to consumer electronics. The relevant IPC codes primarily refer to technologies and only sometimes products are directly addressed (H04R Loudspeakers …, H04S Stereophonic systems)

3. Telecommunications: telecommunications is a very broad field covering a variety of techniques and products. The IPC codes are often quite technology-oriented, so that it is difficult to separate relevant product/applications areas such as mobile communication in a clear-cut field.

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4 See footnote 3.

With almost 6 percent of all applications in 2005, telecommunications is one of the largest fields of the suggested classification.

4. Digital communication: in the ISI-OST-INPI classification, this field was part of telecommunications. At present, it is a self-contained technology at the border between telecommunications and computer technology. A core application of this technology is the internet.

5. Basic communication processes: in the ISI-OST-INPI classification, this field was part of telecommunications. It covers very basic technologies such oscillation, modulation, resonant circuits, impulse technique, coding/decoding. These techniques are used in telecommunications, computer technology, measurement, control. However, the explicit link to these fields by multiple classification is moderate, in the case of telecommunications 2.4 percent. So the definition as a separate field is justified. However, with 0.9 percent of all applications in 2005, it is the smallest fields of the present version of the classification.

6. Computer technology: this field is the largest of the proposed classification with 6.4 percent of all applications in 2005. Its size is already reduced by extracting field 7. The core area of C06F (Electrical digital processing) is defined in a very technical way (Arrangement for programme control, methods and arrangements for data conversion …), so that a further break-down is difficult. It may be possible to separate specific application fields such as image data processing, recognition of data or speech analysis, but then these special fields may become too small.

7. IT methods for management: a major improvement of IPC8 is the introduction of the sub-class G06Q “Data processing methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes”. This field represents software for these special purposes. In most countries, business methods are not patentable, but if they are admitted, they are registered in this sub-class. In any case, the size of this field is relevant with 1.2 percent of all applications in 2005. A combination of the fields 3 to 7 represents information technology in general. As the overlap is limited, this can be done by simple addition. The correct way is to combine the fields without double counting (unit)

8. Semiconductors: the field comprises semiconductors including methods for their production. Integrated circuits or photovoltaic elements belong to this field. The field includes micro-structural technology (B81), as the number of applications in this sub-field is too small for a separate field.

9. Optics: this field covers all parts of traditional optical elements and apparatus, but also laser beam sources. In recent years new optical technologies such as optical switching have become more relevant.

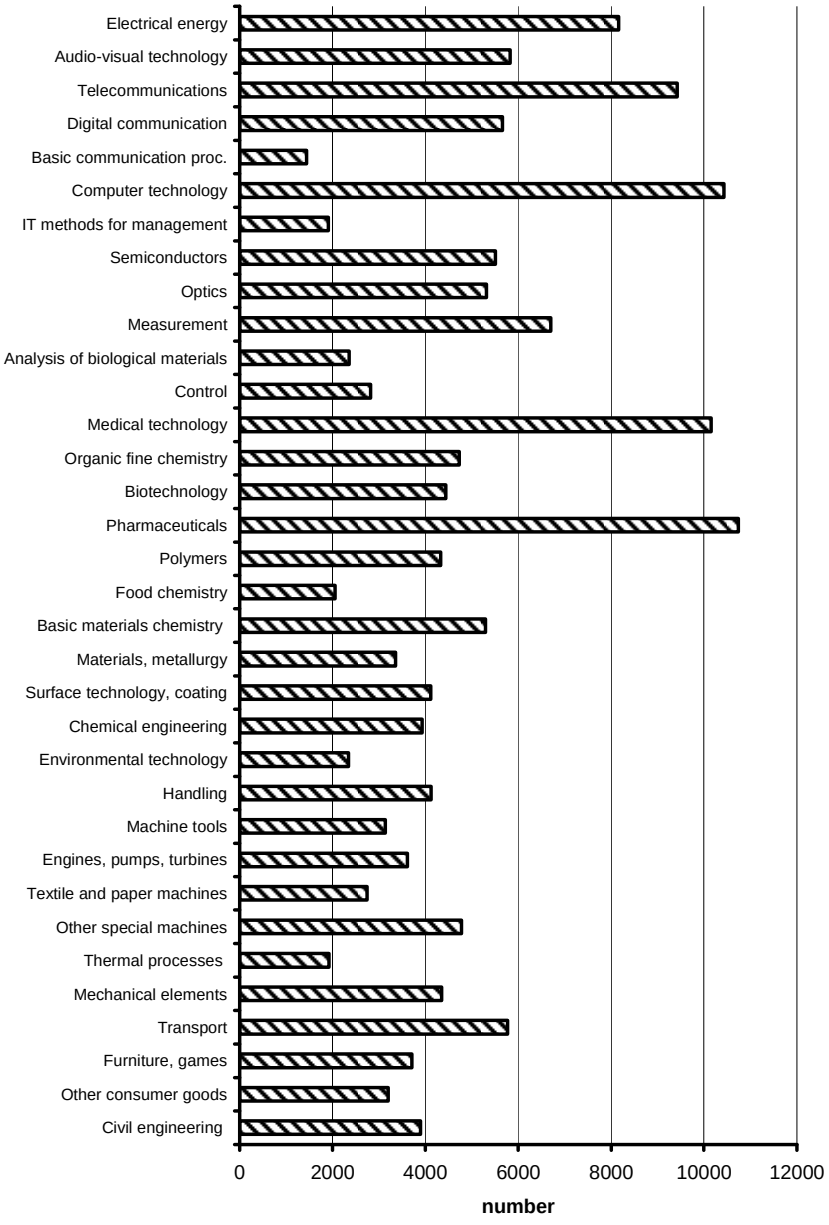
Table 2: New concept of technology classification, update: May 2008

	Area, field	IPC code
I	**Electrical engineering**	
1	Electrical machinery, apparatus, energy	F21#, H01B, H01C, H01F, H01G, H01H, H01J, H01K, H01M, H01R, H01T, H02#, H05B, H05C, H05F, H99Z
2	Audio-visual technology	G09F, G09G, G11B, H04N-003, H04N-005, H04N-009, H04N-013, H04N-015, H04N-017, H04R, H04S, H05K
3	Telecommunications	G08C, H01P, H01Q, H04B, H04H, H04J, H04K, H04M, H04N-001, H04N-007, H04N-011, H04Q
4	Digital communication	H04L
5	Basic communication processes	H03#
6	Computer technology	(G06# not G06Q), G11C, G10L
7	IT methods for management	G06Q
8	Semiconductors	H01L
II	**Instruments**	
9	Optics	G02#, G03B, G03C, G03D, G03F, G03G, G03H, H01S
10	Measurement	G01B, G01C, G01D, G01F, G01G, G01H, G01J, G01K, G01L, G01M, (G01N not G01N-033), G01P, G01R, G01S; G01V, G01W, G04#, G12B, G99Z
11	Analysis of biological materials	G01N-033
12	Control	G05B, G05D, G05F, G07#, G08B, G08G, G09B, G09C, G09D
13	Medical technology	A61B, A61C, A61D, A61F, A61G, A61H, A61J, A61L, A61M, A61N, H05G
III	**Chemistry**	
14	Organic fine chemistry	(C07B, C07C, C07D, C07F, C07H, C07J, C40B) not A61K, A61K-008, A61Q
15	Biotechnology	(C07G, C07K, C12M, C12N, C12P, C12Q, C12R, C12S) not A61K
16	Pharmaceuticals	A61K not A61K-008
17	Macromolecular chemistry, polymers	C08B, C08C, C08F, C08G, C08H, C08K, C08L
18	Food chemistry	A01H, A21D, A23B, A23C, A23D, A23F, A23G, A23J, A23K, A23L, C12C, C12F, C12G, C12H, C12J, C13D, C13F, C13J, C13K
19	Basic materials chemistry	A01N, A01P, C05#, C06#, C09B, C09C, C09F, C09G, C09H, C09K, C09D, C09J, C10B, C10C, C10F, C10G, C10H, C10J, C10K, C10L, C10M, C10N, C11B, C11C, C11D, C99Z
20	Materials, metallurgy	C01#, C03C, C04#, C21#, C22#, B22#

21	Surface technology, coating	B05C, B05D, B32#, C23#, C25#, C30#
22	Micro-structure and nano-technology	B81#, B82#
23	Chemical engineering	B01B, B01D-000#, B01D-01##, B01D-02##, B01D-03##, B01D-041, B01D-043, B01D-057, B01D-059, B01D-06##, B01D-07##, B01F, B01J, B01L, B02C, B03#, B04#, B05B, B06B, B07#, B08#, D06B, D06C, D06L, F25J, F26#, C14C, H05H
24	Environmental technology	A62D, B01D-045, B01D-046, B01D-047, B01D-049, B01D-050, B01D-051, B01D-052, B01D-053, B09#, B65F, C02#, F01N, F23G, F23J, G01T, E01F-008, A62C
IV	**Mechanical engineering**	
25	Handling	B25J, B65B, B65C, B65D, B65G, B65H, B66#, B67#
26	Machine tools	B21#, B23#, B24#, B26D, B26F, B27#, B30#, B25B, B25C, B25D, B25F, B25G, B25H, B26B
27	Engines, pumps, turbines	F01B, F01C, F01D, F01K, F01L, F01M, F01P, F02#, F03#, F04#, F23R, G21#, F99Z
28	Textile and paper machines	A41H, A43D, A46D, C14B, D01#, D02#, D03#, D04B, D04C, D04G, D04H, D05#, D06G, D06H, D06J, D06M, D06P, D06Q, D99Z, B31#, D21#, B41#
29	Other special machines	A01B, A01C, A01D, A01F, A01G, A01J, A01K, A01L, A01M, A21B, A21C, A22#, A23N, A23P, B02B, C12L, C13C, C13G, C13H, B28#, B29#, C03B, C08J, B99Z, F41#, F42#
30	Thermal processes and apparatus	F22#, F23B, F23C, F23D, F23H, F23K, F23L, F23M, F23N, F23Q, F24#, F25B, F25C, F27#, F28#
31	Mechanical elements	F15#, F16#, F17#, G05G
32	Transport	B60#, B61#, B62#, B63B, B63C, B63G, B63H, B63J, B64#
V	**Other fields**	
33	Furniture, games	A47#, A63#
34	Other consumer goods	A24#, A41B, A41C, A41D, A41F, A41G, A42#, A43B, A43C, A44#, A45#, A46B, A62B, B42#, B43#, D04D, D07#, G10B, G10C, G10D, G10F, G10G, G10H, G10K, B44#, B68#, D06F, D06N, F25D, A99Z
35	Civil engineering	E02#, E01B, E01C, E01D, E01F-001, E01F-003, E01F-005, E01F-007, E01F-009, E01F-01#, E01H, E03#, E04#, E05#, E06#, E21#, E99Z

Note: This table is available in Excel format on: www.wipo.int/ipstats/en/statistics/patents
Users are requested cite WIPO as the source in the following manner: “Source: WIPO IPC-Technology Concordance Table”.

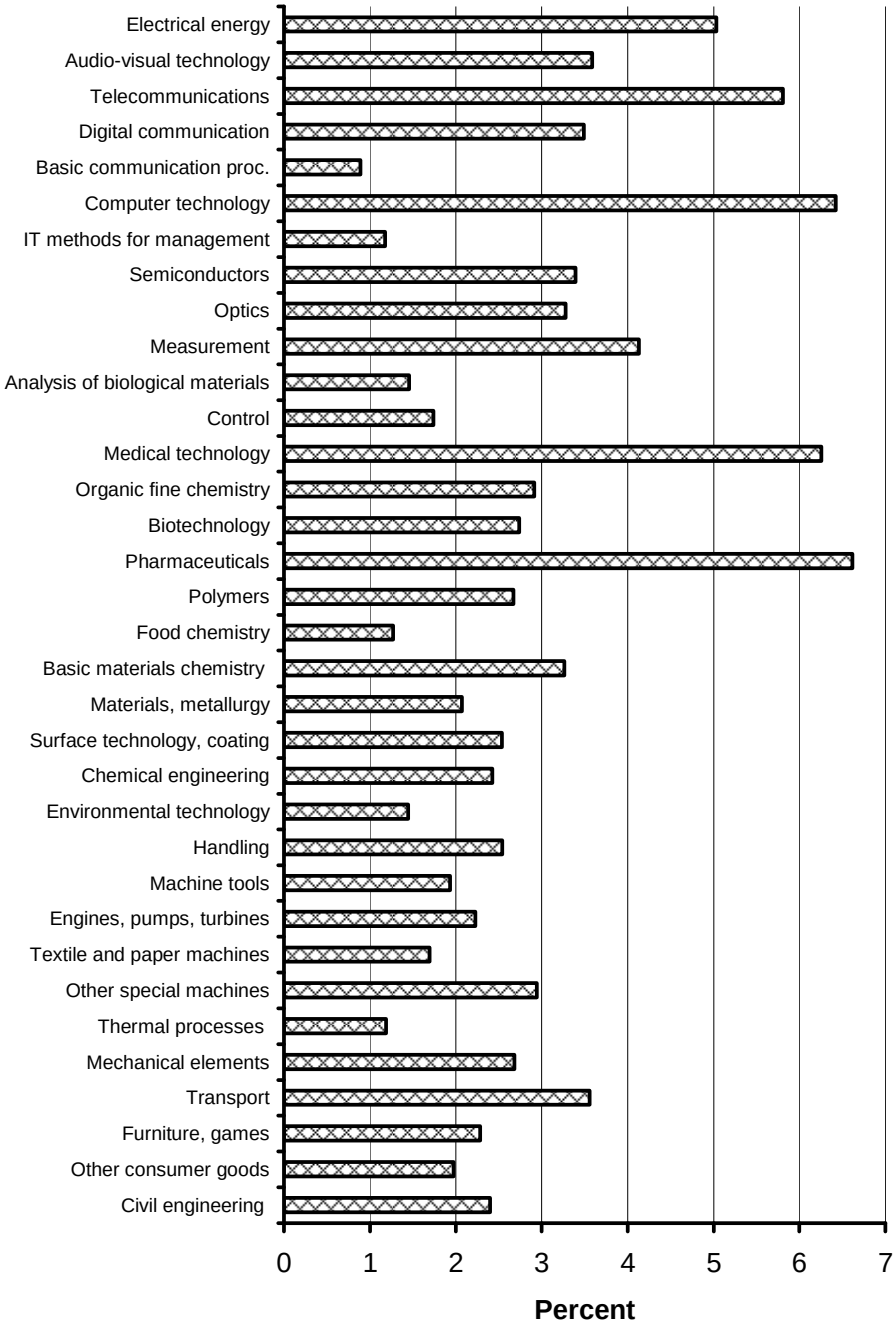
Figure 1: Distribution of International Applications of the priority year 2005 on technology fields[5] according to the definitions of table 2, absolute numbers



Source: PCTFULL (STN), computation by Fraunhofer ISI

5 Note that technology field “surface technology, coating” includes “micro-structure and nano-technology (as reported in table 2). IPC codes for micro-structure and nano-technology (B81 and B82) were recently introduced into the (IPC) classification.

Figure 2: Distribution of international applications of the priority year 2005 to technology fields[6] according to the definitions of table 2, relative values



Source: PCTFULL (STN), computation by Fraunhofer ISI

[6] See footnote 5.

10. Measurement: this field covers a broad variety of different techniques and applications. It would be possible to differentiate special sub-fields such as measuring of mechanical properties (length, oscillation, speed …), but these sub-fields are generally too small.

11. Analysis of biological materials: this is the largest sub-field of "measurement" and was defined as a separate field. It primarily refers to the analysis of blood for medical purposes. In many cases, biotechnological methods are addressed.

12. Control: In the ISI-OST-INPI classification, this field was part of measuring & control. In recent years the part of control has become quantitatively more important, so that an independent field is justified. The field covers elements for controlling and regulating electrical and non-electrical systems and referring test arrangements, traffic control or signalling systems etc.

13. Medical technology: Medical technology is generally associated with high technology. However, a large part of the class A61 refers to less sophisticated products and technologies such as operating tables, massage devices, bandages etc. These less complex sub-fields represent a large number of patent applications, and the total field is the second largest of the suggested classification with 6.3 percent of all applications in 2005.

14. Organic fine chemistry: without further limitations, the applications in organic chemistry primarily refer to pharmaceuticals. More than 40 percent of the applications have an additional code in pharmaceuticals. As such a large overlap of fields is less appropriate for a classification system, all documents with co-classification in A61K were excluded. The major exception is the group A61K-008, which refers to cosmetics.

15. Biotechnology: biotechnology is defined as a separate field, although it is linked to a variety of different applications. Like organic chemistry or computer technology, it is a crosscutting or generic technology. However, the overlap with pharmaceuticals is too large, with a share of nearly 30 percent. Therefore, as in organic chemistry, applications with explicit co-classification in A61K are excluded.

16. Pharmaceuticals: this field refers to an area of application, not a technology. However, the key sub-class A61K is primarily organized by technologies (e.g., medicinal preparations containing inorganic active ingredients …). Cosmetics are explicitly excluded from the field; these represent about 10 percent of all applications classified in A61K.

17. Macromolecular chemistry, polymers: this field contains the chemical aspects of polymers. Machines for producing articles from plastics are classified in B29 and not included.

18. Food chemistry: this field represents 1.3 percent of the applications in 2005 and is one of the smallest fields in this classification. However, the growth of this field is remarkable, so that a

higher weight can be assumed for the next years. Machines for food production are not included, but classified as part of field 28 (other special machines).

19. Basic materials chemistry: This field primarily covers typical mass chemicals such as herbicides, fertilisers, paints, petroleum, gas, detergents etc.

20. Materials, metallurgy: This field covers all types of metals, ceramics, glass or processes for the manufacture of steel.

21 Surface technology, coating: The coating of metals, generally with advanced methods represents the core of this field (C23). Furthermore it covers electrolytic processes, crystal growth and apparatus for applying liquids to surfaces. This field may be qualified as the high-tech part of field 20.

22 Micro-structure and nano-technology: This field covers micro-structural devices or systems, including at least one essential element or formation characterised by its very small size. It includes nano-structures having specialised features directly related to their size.

23. Chemical engineering: This field covers technologies at the borderline of chemistry and engineering. It refers to apparatus and processes for the industrial production of chemicals. Some of these processes may be classified as physical ones.

24. Environmental technology: This field covers a variety of different technologies and applications, in particular filters, waste disposal, water cleaning (a quite large area), gas-flow silencers and exhaust apparatus, waste combustion or noise absorption walls. However, it is not possible to define measuring of environmental pollution by IPC codes in a clear cut way.

25. Handling: This field comprises elevators, cranes or robots, but also packaging devices. So in terms of research intensity, the field is quite heterogeneous.

26. Machine tools: The field is dominated by patent applications referring to turning, boring, grinding, soldering or cutting with a focus on metals.

27. Engines, pumps, turbines: This field covers non-electrical engines for all types of applications. In quantitative terms, applications for automobiles dominate.

28. Textile and paper machines: The fields 27 and 28 cover machines for specific production purposes. Textile and food machines represent the most relevant part of these machines and are classified separately.

29. Other special machines: see field 26.

30. Thermal processes and apparatus: The field covers applications such as steam generation, combustion, heating, refrigeration, cooling or heat exchange.

31. Mechanical elements: The field covers fluid-circuit elements, joints, shafts, couplings, valves, pipe-line systems or mechanical control devices. The focus is on engineering elements of machines such as joints or couplings.

32. Transport: the field covers all types of transport technology and applications with dominance of automotive technology. In principle, a separation of rail traffic and air traffic would be feasible, but the associated fields would be too small. In both cases, this is due to a low propensity to patent. The samples are quite small and not representative of the total technological activities in these sub-fields.

33. Furniture, games: this field represents the main parts of consumer goods in terms of the number of patent applications. The other consumer goods are a mix of many different technologies, all of them with low quantitative weight. Therefore a further differentiation is not useful. Even furniture and games combined comprise not more than 2.3 percent of all applications in 2005.

34. Other consumer goods: this field primarily represents less research-intensive sub-fields.

35. Civil engineering: the field covers construction of roads and buildings as well as elements of buildings such as locks, plumbing installations or strongrooms for valuables. A special part refers to mining which may be important for some countries. In general, the importance of mining is so low that the definition of a separate field is not justified.

All in all, the suggested classification fulfils all general requirements formulated above. Some amendments concerning the assignment of some IPC codes to specific fields may be possible, but will not change much in terms of quantitative weight. The major aim of this classification is to provide a basic tool for the analysis of country structures and international comparisons, notedly for the determination of specialisation profiles. Some users may be interested in more detailed information as to specific fields and sub-fields. In this case, the suggested classification can be used as starting point to analyse particular topics at a lower level of aggregation.