*Chapter 4*

# ICT Supply

*This chapter deals with the supply side of ICT, namely the ICT sector, its impacts, other ICT-producing entities, and ICT patenting activity.*

## Introduction

The first major achievement of the WPIIS[1] came in 1998, when OECD member countries agreed on a definition of the ICT sector as a combination of manufacturing and services industries whose products capture, transmit or display data and information electronically. The definition was based on the International Standard Industrial Classification of All Economic Activities, Revision 3 (ISIC Rev. 3) and was considered to be a first step in obtaining initial measurement of the ICT sector. The definition was revised slightly in 2002, reflecting the release of ISIC Rev. 3.1 (UNSD, 2002).

Recognising the importance of continually reviewing statistical standards, delegates agreed at the outset that periodic reviews of definitions would allow WPIIS to "re-assess the conceptual foundation of its standards, take account of the lessons learned with their implementation and make good use of improvements in the underlying classification systems" (OECD, 2006a). A good opportunity to review the ICT sector definition was presented in 2006, with the completion of revisions to ISIC Rev. 4 (UNSD, 2008). The OECD was an active participant in the ISIC revision process and the classification includes improvements to ICT-related categories. In 2007, a revised definition of the ICT sector based on ISIC Rev. 4 was agreed by OECD member countries (OECD, 2006a).

Revisions made to the first part of this chapter in 2009 mainly reflect changes to the ICT sector definition (per OECD, 2006b).

## The ICT sector definition

ICT production takes place in many industries, either as a principal or secondary output. It is therefore not possible to use industry statistics to get a complete measure of ICT production. Nevertheless, the identification of industries whose principal production is ICT goods or services was thought to be an essential component of an information society statistical framework. It allows for international comparison of the relative importance of these industries and analysis of differences in the industrial structures of countries.

The list of ICT sector activities (industries) was originally decided on the basis of the following set of principles.

- For manufacturing industries, the products of a candidate industry: must be intended to fulfil the function of information processing and communication including transmission and display, *or* must use electronic processing to detect, measure and/or record physical phenomena or to control a physical process.
- For services industries, the products of a candidate industry: must be intended to enable the function of information processing and communication by electronic means.

Changes to the principles were discussed during 2006 and finally agreed in 2007. The main difference was the removal of the second element for manufacturing industries, leading to a narrower definition of the ICT sector, as follows:

> "The production (goods and services) of a candidate industry must primarily be intended to fulfil or enable the function of information processing and communication by electronic means, including transmission and display."

When the first ICT sector definition was developed in 1988, it was recognised that the preferred procedure would have been to first define ICT goods and services, and then to formulate the ISIC classes that had activities (manufacturing, wholesaling, etc.) involving those goods and services. However, in order to obtain an initial set of indicators for the ICT sector in a limited amount of time, the approach taken was to first define the activities, and subsequently work on a list of ICT goods and services that could complement and help to refine the activity-based definition.

At its 2002 meeting, the WPIIS reviewed the definition. The group decided that the definition should not be changed, except to take into account the split of ISIC 5150 *Wholesale of machinery, equipment and supplies* that was introduced in the 2002 ISIC revision (Rev. 3.1). The change made to the ICT sector definition was to replace ISIC 5150 with the two new classes 5151 *Wholesale of computers, computer peripheral equipment and software* and 5152 *Wholesale of electronic and telecommunications parts and equipment*.

The United Nations Statistics Division started revising the ISIC in 2001. The WPIIS Secretariat examined the May 2004 draft of ISIC Rev. 4 and, in late 2004, in consultation with interested member countries, put a submission to the United Nations Technical Subgroup (of the Expert Group on International Economic and Social Classifications) on classes with ICT activities. The OECD submission was generally supportive of the proposed changes affecting the ICT sector, supported proposals previously made (by OECD or others) and proposed some splits, where feasible, to other classes. The OECD submission was generally accepted by the Technical Subgroup.

With the changes to ISIC nearly final, WPIIS started work in 2006 on reviewing the definition. The work was finalised and released in 2007, with the result being an ICT definition that looks significantly different from the original 1998 definition. Agreed changes included:

- changes to the principles as outlined above, resulting in the omission of Class 2651 – Manufacture of measuring, testing, navigating and control equipment;
- changes resulting from changes to ISIC Rev. 4, for instance, more ICT-specific classes, especially in Manufacturing; and
- the removal of Manufacture of fibre optic cable from the definition.

The United Nations Statistics Division has explicitly recognised the OECD ICT sector definitions as alternative structures of information and communication technology industries.[2]

Annex 7.A1 provides more information on WPIIS work on the ICT sector including deliberations leading to its agreement, the original (1998), revised (2002) and current (2006-07) definitions of the sector, and some practical notes on data collection.

## Production of ICT goods and services outside the ICT sector

While the WPIIS has focused on the production activity of businesses that comprise the ICT sector, it is acknowledged that they are not the only entities in the economy to produce ICT goods and services. The latter may be produced by other sectors, for instance general government, and by businesses outside the ICT sector. Their output may be ICT products produced for sale or for own use.

Additionally, ICT products that primarily originate from the ICT sector may be produced by organisations in other industries for sale or own use. In particular, "own account" software, that is software development work done by entities for their own use, may be significant for some businesses outside the ICT sector and for general government organisations. Attempts are underway in a number of countries to measure the investment in "own account" software. More information on this subject can be found in Chapter 5.

## The impacts of the ICT sector

The ICT sector may have considerable impacts on economic performance, as it is characterised by very high rates of technological progress, output and productivity growth. These characteristics imply a considerable contribution of the sector to economy-wide performance.

The impacts of the sector can be examined in several ways – directly, through its contribution to output, employment or productivity growth, or indirectly, for example as a source of technological change affecting other parts of the economy.

### *Empirical work*

OECD work has primarily focused on the direct impacts of the ICT sector. For example, in most OECD countries, the contribution of ICT manufacturing to overall labour productivity growth rose over the 1990s (Pilat and Wölfl, 2004). OECD estimates show that ICT manufacturing made the largest contributions in Finland, Hungary, Ireland and Korea, where close to 1 percentage point of aggregate labour productivity growth in the 1995-2001 period was due to ICT manufacturing. The ICT-producing services sector (Telecommunications and Computer services industries) plays a smaller role in aggregate productivity growth, but has also been characterised by rapid progress (OECD, 2003b). Some of the growth in ICT-producing services is also due to the emergence of the computer services industry, which has accompanied the diffusion of ICT in OECD countries. The development of these services has been important in implementing ICT, as the firms in these sectors offer key advisory and training services and also help develop appropriate software to be used in combination with ICT hardware.

### *Measurement issues*

A number of problems affect the measurement of the economic impacts of the ICT sector. First, the official OECD definition of the ICT sector cannot be easily applied to the analysis of output and productivity growth. Analysis of productivity growth requires time series of value added and/or production in constant prices, which implies price deflators for the appropriate industries. These are typically not available for detailed categories and OECD work has therefore primarily focused on the main categories that can be distinguished in the national accounts by activity, *i.e.* ISIC 30-33 (Electrical and Optical

Equipment), ISIC 64 (Post and Telecommunications) and ISIC 72 (Computer and Related Activities).[3]

Second, the available deflators are not always comparable across countries. Several countries use hedonic methods to deflate output for the computer industry (*e.g.* Canada, Denmark, France, Sweden and the United States), whereas other countries use standard deflators. Adjusting for these methodological differences in computer deflators for the purpose of a cross-country comparison is difficult since there are considerable cross-country differences in industrial specialisation. For example, only few OECD countries produce computers, where price falls have been very rapid; many only produce peripheral equipment, such as computer terminals. The differences in the composition of output are typically larger than in computer investment, where standardised approaches have been applied (*e.g.* Schreyer *et al.*, 2003).

### *Future developments*

There are several issues related to the economic impacts of the ICT sector that would benefit from further analysis. For example, questions can be raised regarding the link between having an ICT sector and benefiting from ICT investment and use. Some analysts have used the experience of a country such as Australia to suggest that having a large ICT manufacturing sector might not always be necessary. However, this hypothesis would benefit from more research as there could be spill-over effects associated with having an ICT manufacturing sector. Moreover, in order to benefit from ICT use, it might be important to have a well-developed domestic industry providing software and computer services to firms using the technology. This hypothesis would also benefit from further analysis.

## ICT patenting activity

### *Introduction*

Patents are an intellectual property right issued by authorised bodies to inventors allowing them to make use of, and exploit, their inventions for a limited period of time (generally 20 years). Patents are granted to firms, individuals or other entities as long as the invention fulfils certain criteria: it must be novel, involve an inventive step (*i.e.* be non-obvious) and be capable of industrial application. The patent holder has the legal authority to exclude others from commercially exploiting the invention during the duration of the patent life. In return for the ownership rights, the applicant must disclose information relating to the invention for which protection is sought. The disclosure of the information is thus an important aspect of the patenting system.

### *Statistical and policy use of patent indicators*

Patents are a key measure of innovation output. They can be used to measure R&D output, knowledge spillovers, inventive performance, as a tool to assess the direction of research, and the strategic aims of companies. Patents can also provide an insight into the level of internationalisation (of innovative activities), co-operation (of R&D activities) and mobility of researchers. Patents data are widely used as a proxy for innovation and Griliches (1990) refers to patents as “a good index of inventive activity”.

Since there are many advantages associated with patents as statistical indicators, they are frequently used, along with other science and technology (S&T) indicators, to measure technical change and inventive activity. It has become standard practice to include a section on patents in national and international S&T publications. Statisticians and researchers are not the only users of patent documents, however. Business managers are increasingly utilising patent documents to monitor the latest technological developments and examine the strategies and directions of competitors.

### *Strengths and limitations of using patent documents for statistical analysis*

Like most statistical indicators, patent indicators have strengths and limitations. The main strengths of patent indicators are:

- A patent document is a rich source of information. It provides a detailed description of the invention; the technological areas to which the invention belongs (*i.e.* patent classes); the scope of the legal protection (*i.e.* claims); citations to previous patents and non-patent literature; information about the inventor and the right holder (*e.g.* name and address); and timeline of the invention (*e.g.* various dates recorded in a patent document);
- Each year a large number of patents are filed with national and regional patent offices. For example, patent applications at the European Patent Office (EPO) and US Patent and Trademark Office (USPTO) account for around 110 000 and 330 000 per year (2000-2004), respectively. This makes patent documents the largest data source on innovation activity. In addition, unlike other data sources, patent data are available for a long time period (*e.g.* the first patent issued by the USPTO dates back to 1836); and
- Patent documents are public and increasingly available over the Internet. This makes them a unique data source from which to gather statistical information at relatively low cost.

However, there are some limitations to the use of patent data, especially for statistical analysis. The main weaknesses of patent indicators are:

- Not all inventions are patentable.
- In many instances, inventors prefer to use other means to protect the invention (*e.g.* secrecy).
- The value distribution of patents is highly skewed, *i.e.* some patents are of considerable (technical and economic) value, but many have little or no value. However, various weighting procedures have been devised to overcome this limitation (*e.g.* citations, patent families, use of renewal data, etc.).
- The propensity to patent differs across countries and industries. This makes it harder to compare and interpret indicators across countries and industries. However, it is possible to deal with this shortcoming by focusing on specific industries and/or by using dummy variables.
- Patents are administrative documents and are not designed for statistical purposes. Therefore certain manipulations are necessary to make the information suitable for statistical use. For example, patent examiners assign patent classification codes to each patent document. The primary aim of this process is to facilitate prior-art searches (not for statistical needs). Therefore, certain manipulation of the classification information is needed to make the information suitable for statistical purposes (*e.g.* deriving patent indicators for specific technological areas).

Despite all these limitations, patents are one of the best available data sources for measuring innovative activity, as highlighted by Griliches (1990): "… patents statistics remain a unique resource for the analysis of the process of technical change. Nothing else even comes close in the quantity of the available data, accessibility, and the potential industrial, organisational, and technological detail."

#### *Designing indicators to measure innovative activity: selection of appropriate criteria*

Patent documents are a rich source of information. They include detailed information about the invention (scope of the invention, inventors, owners, etc.), as well as information about the administrative process of the patent office (*e.g.* date of application, the procedure used to file the application, search report, whether an application has been successful or not). The large amount of information can also be problematic, especially in identifying and extracting the relevant information from a complex patent document. For example, many dates are recorded in a patent document (*e.g.* priority date, application date, publication date, grant date). Similarly, for statistical purposes, a patent can be attributed to the country of the inventor, the country of the applicant and the country of the priority application. Which criteria should be used to develop patent indicators to measure innovative activity?

The selection of appropriate criteria for calculating patent indicators is crucial in conveying the correct message. The decision on the selection of the criteria depends on user needs. For example, if the intention is to use patent indicators to measure ownership of patents, then the relevant geographical distribution criterion is the applicant's country of residence. However, if the intention is to measure inventive activity, then the inventor's country of residence is the most appropriate criterion. OECD's patent indicators are constructed to reflect innovative performance, therefore the appropriate criteria used to develop OECD patent indicators are: inventor's country of residence, priority date, and fractional counting (explained in Dernis *et al.*, 2001 and OECD, 2006c).

It should be noted that in many S&T publications, patent indicators are reported according to the grant date. This is partly due to lack of methodological guidelines and the misconception that grant date data are timely relative to the application (or priority) date. However, drawing conclusions about the innovative activity using grant date patent indicators can be extremely misleading because the total number of patents granted is not only a function of the inflow of patent applications, but is also dependent on the number of patent examiners, the budget of the patent office, and other external factors.

#### *Patent indicators by industry*

Unfortunately, patent documents do not include information about the industry to which the patent belongs. This hampers the ability of researchers to develop patent data by industry. Nevertheless, it is "primarily a technical problem" (Griliches, 1990) that can be solved by exploiting the available information from patent documents. For example, patent classification codes[4] that are assigned to each patent document by patent examiners are frequently used to develop industry–patent classification concordances.

There have been a number of endeavours to develop concordance tables to translate patent classification codes into industry classification codes. Although several researchers have attempted to develop a reliable patent–industry classifications concordance table, so far this has proved to be difficult to achieve. Schmookler (1966) was one of the earliest researchers to construct patent data by industries. His approach consisted of reviewing carefully a set of subclasses, sampling a number of patents, and allocating the patents to relevant industries. A similar approach was taken by Scherer (1982) where around

15 000 patents granted by the USPTO were examined to determine the nature of the invention, the industry of origin of the invention, and the anticipated industry of use of the invention. Evenson and Putnam (1988) used data from the Canadian Intellectual Property Office (CIPO)[5] to construct a patent–industry concordance table,[6] widely referred to as the Yale Technology Concordance (YTC). The focus of this article is not to survey the literature therefore other concordance tables[7] based on similar methodologies are not covered here.

The National Bureau of Economic Research (NBER) took a different approach for allocating patents by industries. They started "from patent totals for particular firms and then grouped them into industries according to the firm's primary activity" (Griliches, 1990). However, the main weakness of this approach is that large companies are active in many fields, therefore assigning all the patents of a firm to the sector of its main economic activity may provide a blurred image of the patenting activity.

***Definition of ICT-related patents***

Rather than developing a concordance table between patent and industrial classifications, the OECD adopted a different approach for the definition of ICT-related patents. The strategy is to identify a list of International Patent Classification (IPC) codes that are assigned to ICT-related patents.[8] However, before attempting to identify the IPC codes associated with ICT-related patents, it is necessary to specify what is meant by the ICT sector. The definition of the manufacturing component of the ICT sector developed by the OECD in 1998 (see Chapter 4 for details) has been adopted here for defining ICT patents. OECD's definition of the ICT sector includes: telecommunications equipment; consumer electronics; computers and office machinery; instruments and appliances for measuring, checking and industrial process control; and electronic components.[9]

In the initial phase (2001), the definition of ICT-related patents (*i.e.* the identification of a list of IPC codes associated with ICT patents) was developed on the basis of the following strategies: keyword search, analysis of IPC classes of well-known ICT-related patents and analysis of a sample of patents of companies that are active in the ICT field.[10] The following IPC classes were proposed to be included in the provisional definition of ICT-related patents: G06 (Computing; Calculating; Counting); G11 (Information Storage); and H04 (Electric Communication Technique).[11] This definition was considered to be provisional and further work was expected to be conducted in order to refine the definition. Nevertheless, based on the provisional definition, ICT-related patent indicators were reported in OECD publications (*e.g.* OECD, 2001).

In 2003, a consultant,[12] with an extensive knowledge of patent classification systems, was engaged by the OECD to undertake further work to refine the definition of ICT-related patents. The aim was to develop a definition at a more detailed level of IPC codes than the earlier definition (which is at a highly aggregated level). The search strategy adopted for identifying ICT-related patents was based on the consultant's identification of the relevant IPC codes rather than the keyword searches that are based on official public documents.[13] For identifying the appropriate IPC codes for ICT-related patents, the consultant scanned the whole IPC classification using a top-down approach. The search started at the section level, followed by sub-sections, classes, sub-classes, groups, and finally sub-groups. This resulted in the identification of the appropriate IPC codes that should be included in the definition of ICT-related patents.

Table 4.1 below provides the details of the IPC codes included in the OECD's current definition of ICT-related patents.[14] This definition is more detailed than the earlier one,

### Table 4.1. Definition of ICT-related patents, based on IPC codes[1]

| IPC code | Details[2] |
|---|---|
| **Telecommunications** | |
| G01S | Radio navigation |
| G08C | Transmission systems for measured values |
| G09C | Ciphering apparatus |
| H01P, H01Q | Waveguides, resonators, aerials |
| H01S003-025, H01S003-043, H01S003-06, H01S003-085, H01S003-0915, H01S003-0941, H01S003-103, H01S003-133, H01S003-18, H01S003-19, H01S003-25, H01S005 | Semiconductor lasers |
| H03B-D | Generation of oscillations, modulation, demodulation |
| H03H | Impedance networks, resonators |
| H03M | Coding, decoding |
| H04B | Transmission |
| H04J | Multiplex communication |
| H04K | Secret communication |
| H04L | Transmission of digital information |
| H04M | Telephonic communication |
| H04Q | Selecting, public switching |
| **Consumer electronics** | |
| G11B | Information storage with relative movement between record carrier and transducer |
| H03F, H03G | Amplifiers, control of amplification |
| H03J | Tuning resonant circuits |
| H04H | Broadcast communication |
| H04N | Pictorial communication, television |
| H04R | Electromechanical transducers |
| H04S | Stereophonic systems |
| **Computers, office machinery** | |
| B07C | Postal sorting |
| B41J | Typewriters |
| B41K | Stamping apparatus |
| G02F | Control of light parameters |
| G03G | Electrography |
| G05F | Electric regulation |
| G06 | Computing |
| G07 | Checking devices |
| G09G | Control of variable information devices |
| G10L | Speech analysis and synthesis |
| G11C | Static stores |
| H03K, H03L | Pulse technique, control of electronic oscillations or pulses |
| **Other ICT** | |
| G01B, G01C, G01D, G01F, G01G, G01H, G01J, G01K, G01L, G01M, G01N, G01P, G01R, G01V, G01W | Measuring, testing |
| G02B006 | Light guides |
| G05B | Control and regulating systems |
| G08G | Traffic control systems |
| G09B | Educational or demonstration appliances |
| H01B011 | Communication cables |
| H01J011, H01J013, H01J015, H01J017, H01J019, H01J021, H01J023, H01J025, H01J027, H01J029, H01J031, H01J033, H01J040, H01J041, H01J043, H01J045 | Electric discharge tubes |
| H01L | Semiconductor devices |

1. This definition was developed, on behalf of the OECD, by Ulrich Schmoch, Fraunhofer Institute for Systems and Innovation Research (Schmoch, 2003). Only three sub-classes were affected by the changes in IPC (8th edition): H01S003-06 replaces H01S003-063 and H01S003-067; H01S003-0915.
2. For full details of the IPC codes, see: *www.wipo.int/classifications/ipc/en/*.

developed in 2001, and like the OECD's definition of the ICT sector, it covers a wider range of ICT domains. ICT patent indicators, based on this definition, have appeared in several OECD publications (for instance, OECD, 2003a, 2005 and 2006c).

### *Future developments*

Since mid-2003, the OECD has been disseminating ICT patent statistics that are calculated according to the definition shown in Table 4.1. and it intends to use this definition for the near future. A new IPC classification system (IPC 8th edition) entered into force on 1 January 2006. The new edition of the IPC will be subject to continuous revisions at the advanced level and these will be directly applied to patent documents retrospectively. Therefore, the accuracy of the present definition of ICT patents needs to be checked on a regular basis.

Future reviews will also take into account the revisions to the OECD definition of the ICT sector finalised in 2006 (see this chapter) as well as revisions to the OECD classification of ICT products finalised in 2007 (see Chapter 2).

### *Notes*

1. Then the *Ad Hoc* Meeting on Indicators for the Information Society under the aegis of the ICCP Statistical Panel.
2. For example, *http://unstats.un.org/unsd/cr/registry/docs/i31_ict.pdf*.
3. These are references to the 2002 definition of the ICT sector.
4. The most widely used patent classification system is the International Patent Classification (IPC), which is a hierarchical system that divides technology into eight sections with almost 70 000 fields or groups. However, other patent classifications are also in use at the national and regional level. For example, EPO patent documents are classified according to ECLA codes (the patent classification system of the EPO). Similarly, USPTO patent documents are classified according to USPC codes (the patent classification system of the USPTO).
5. The Canadian Intellectual Property Office (CIPO) simultaneously assigned codes for the technology field (IPC codes), the industry of manufacture (IOM) and the sector of use (IOU) to each granted patent (around 30 000 patents) during 1975-95.
6. This was based on the tabulated information on all 30 000 patents to determine the probability that a patent with a specific IPC code has a particular IOM-SOU combination.
7. Notable examples are: Verspagen *et al.* (1994); Johnson (2002); Schmoch *et al.* (2003), and USPTO USPC-SIC concordance table (see Hirabayashi, 2003).
8. The advantage of using the IPC classification system is that it is used by a large number of patent offices, which makes it possible to derive internationally comparable ICT-related patent statistics for a large number of countries and/or patent offices.
9. The OECD definition of the ICT sector was revised in 2006 (reflecting the revision to ISIC Rev. 4) and no longer includes manufacturing of instruments and appliances for measuring, checking and industrial process control.
10. This work was conducted by a patent examiner from the Japanese Patent Office (JPO) who was on secondment to the OECD.
11. For full details of IPC codes, see: *www.wipo.int/classifications/ipc/en/*.
12. Dr. Ulrich Schmoch from Fraunhofer Institute Systems and Innovation Research, Karlsruhe, Germany (Schmoch, 2003).
13. The keyword search strategy is not preferred here because the legal requirements of disclosure with regard to titles and abstracts are not very strict. In certain circumstances, keyword searches might be preferable because the patent classification does not cover new technology areas (classification systems tend to lag behind the development of technology areas). If a keyword search is necessary, then it should be conducted on databases with good facilities for such searches.

14. Note that in some cases there was no clear cut association between IPC codes and ICT industries. In particular for the following cases: H03B, H03C, H03D, H03H, H03M, H04L, G11B, H03F, H03G, H03J, H04H, H04N, H03K, H03L; the decision to assign the IPC codes to a particular sector (*e.g.* H03B to telecommunications rather than consumer electronics) was taken according to the main focus of the code.

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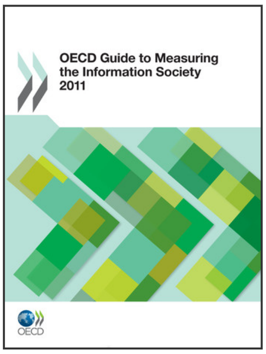


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