PART II

*Chapter 6*

# Intensity Indicators: Selected Activities and Outputs in the Space Economy

*The intensity indicators of the space economy are constituted by all the diverse outputs (products, services, science) that are produced or provided by the space sector. These outputs are very diverse in nature, from commercial revenues from industry, scientific productivity such as patents, to number of space missions or space launches. This chapter examines methodological issues specific to a few selected intensity indicators: space manufacturing, space-based applications, international trade in space products, and space-related patents.*

## The manufacturing space industry

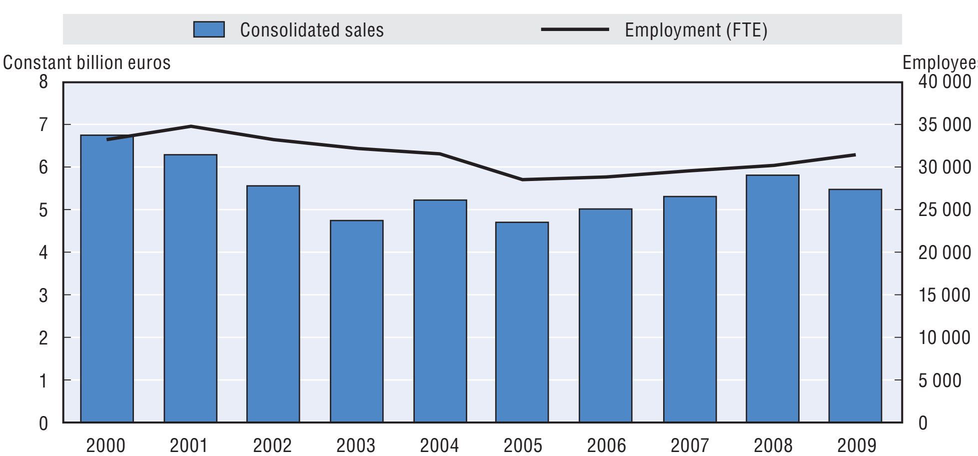
The manufacturing space industry is the industrial activity for which there are the most data available, but there are still clear methodological limitations when trying to make international comparisons.

As mentioned in previous chapters, the current edition of the United Nations International Standard Industrial Classification (ISIC Rev. 4) includes most parts of the space sector under different aggregate categories. There is no specific "space industry" classification in ISIC, and disentangling official space sector statistics from the larger aerospace and defence sectors remains a challenge in most countries. Interestingly enough, this is not the case for Chinese official data, as China has its own statistical classifications system separating space and aeronautical activities. Other methodological issues arise though, as the funding of the Chinese space industry lacks some transparency.

The next three figures provide examples of data available from the European, Japanese and Chinese space manufacturing sectors (note all data are in national currencies).

Figure 6.1. **Consolidated sales and employment by European space companies, 2000-09**

Billions of constant euros and FTE

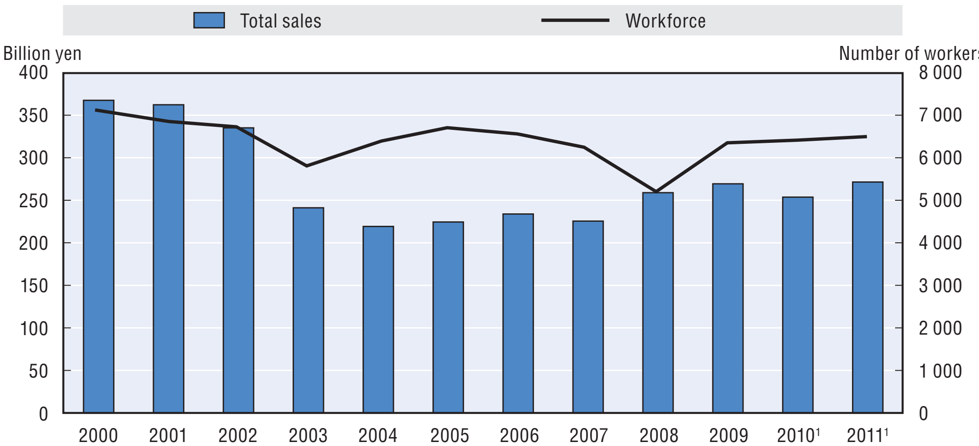



*Source:* Eurospace, 2010 in OECD (2011), *The Space Economy at a Glance 2011*, OECD Publishing, *http://dx.doi.org/10.1787/9789264111790-en*, p. 61.

StatLink http://dx.doi.org/10.1787/888932576624

Figure 6.2. **Consolidated sales and employment by Japanese space manufacturing companies, 2000-11**

Billions of Japanese yen and number of workers

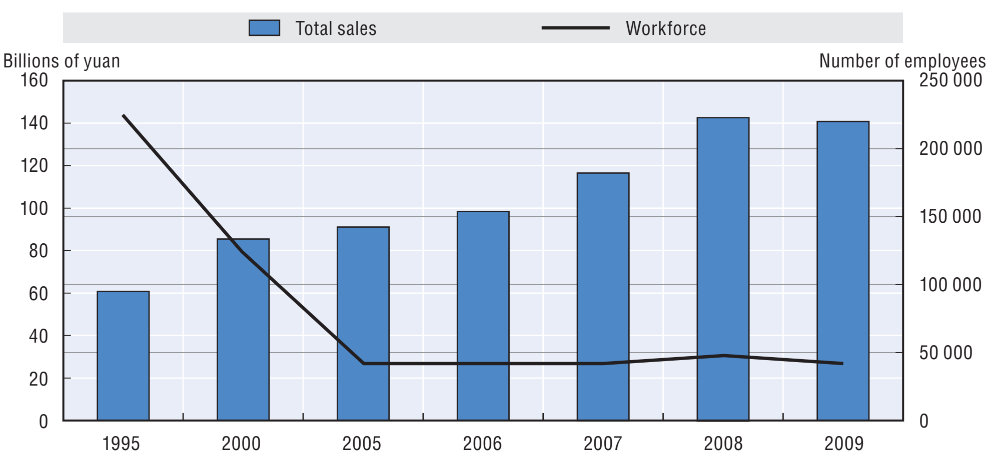



*Source:* Adapted from SJAC, 2010 in OECD (2011), *The Space Economy at a Glance 2011*, OECD Publishing, *http://dx.doi.org/10.1787/9789264111790-en*, p. 61.

StatLink http://dx.doi.org/10.1787/888932576643

Figure 6.3. **Revenues of Chinese companies involved in spacecraft manufacturing and number of employees, 1995-2009**

Billions of yuan and number of employees



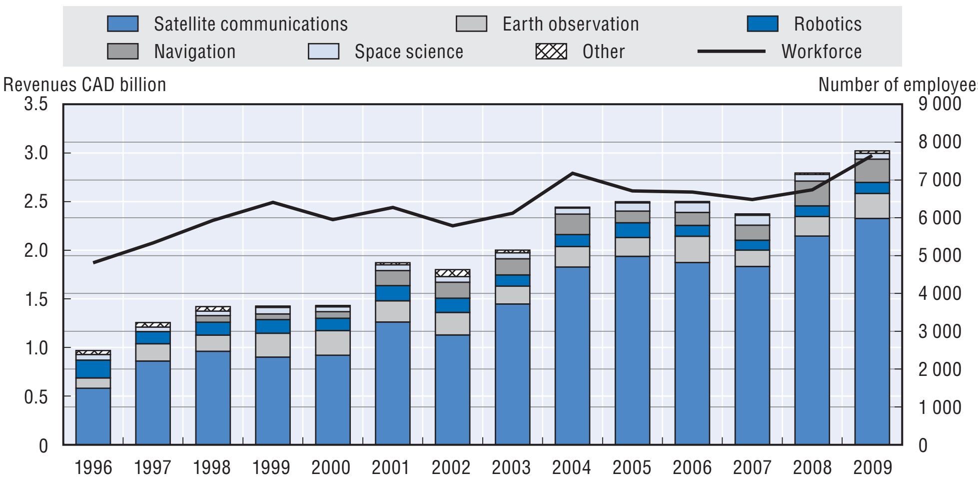

*Source:* Based on data from the Chinese National Bureau of Statistics data, 2010 in OECD (2011), *The Space Economy at a Glance 2011*, OECD Publishing, *http://dx.doi.org/10.1787/9789264111790-en*, p. 103.

StatLink http://dx.doi.org/10.1787/888932576662

Other surveys include larger segments of the value chain to map services derived from the uses of space assets. This is the case for countries with small space manufacturing sectors, but active on specific segments (*e.g.* robotics) and homes to dynamic space applications providers, like Canada and the United Kingdom. The two figures below provide data on their respective space sector, which in that case encompasses more than just actors in space manufacturing (*i.e.* the upstream segment in UK statistics).

Figure 6.4. **Canadian space sector revenues by activity sector and employment, 1996-2008**

Revenues in CAD billion and number of employees

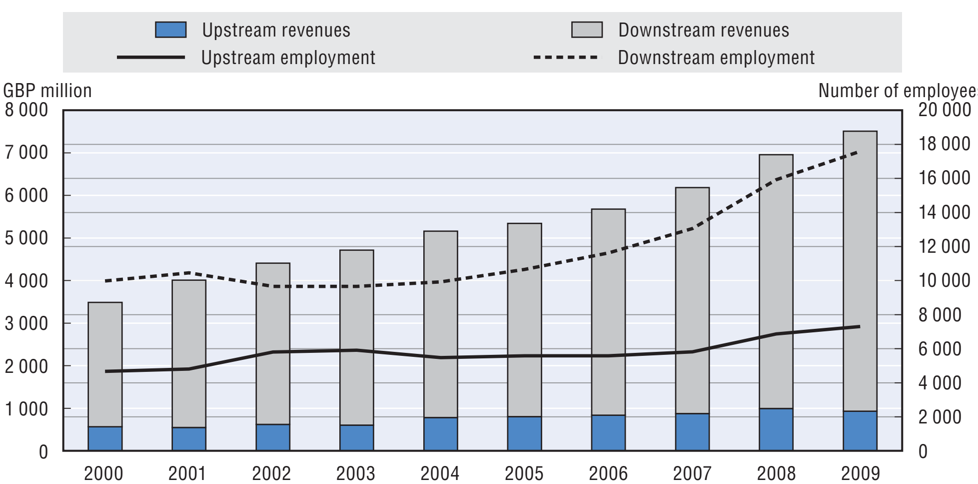



*Source:* CSA, 2010 in OECD (2011), *The Space Economy at a Glance 2011*, OECD Publishing, *http://dx.doi.org/10.1787/9789264111790-en*, p. 95.

StatLink http://dx.doi.org/10.1787/888932576681

Figure 6.5. **Revenues and employment in the UK space sector**

In millions of GBP and percentage




*Source:* UK National Space Agency, 2010 in OECD (2011), *The Space Economy at a Glance 2011*, OECD Publishing, *http://dx.doi.org/10.1787/9789264111790-en*, p. 97.

StatLink http://dx.doi.org/10.1787/888932576700

When collecting and examining space manufacturing data, in addition to common methodological questions seen in Chapter 4 (*i.e.* evaluating data sources, taking into account exchange rates and double counting) the following issues arise:

- Data providers use very diverse methodologies and statistical categories to collect data, which make international comparability challenging. But they also have different timelines (based often on different fiscal years) and sometimes do not conduct surveys regularly. For example, Eurospace, The Canadian Space Agency, and the Society of Japanese Aerospace Companies all conduct annual surveys of the space sector. On the contrary, the UK National Space Agency, working with diverse private data providers, conducts industry surveys every two to three years.
- When surveys examine in more details the space sector's value chain, they can provide annual data on prime contractors and major subcontractors (*e.g.* Eurospace surveys). But frequently, estimates for the space manufacturing industry often lack:
  - ❖ Revenues from lower-tier subcontractors and vendors.
  - ❖ Revenues for specific associated activities of non-engineering firms (marketing, finance, public relations, etc.).

Since the first issue of *The Space Economy at a Glance* (2007), more data providers have made a move to make their data more transparent (*e.g.* mentioning current versus constant currencies, using inflation deflators). Efforts are also ongoing inside the International Astronautical Federation to discuss statistical methodological issues to promote and facilitate international data comparisons in the space community.

## Space-based applications and derived services

There is a wide diversity of space-related products and services, many of which are commercial in nature, while others have known market failure and require support from governments to sustain their public good impacts. Space-based applications all require specific satellite capacities to function, such as a satellite data link or signal (*i.e.* telecommunications, navigation, Earth observation).

Telecommunications represent the main commercial space market, benefiting from growing mass markets (satellite television broadcasting) and a robust demand from institutional users (defence, new customers in the developing world, development of anchor contracts). The geopositioning market is also a growing new segment building on satellite positioning, navigation and timing signals (with products such as the now common car-navigation). It represents some USD 15 billion in revenue in 2009. With the advances in smartphones and other mobile products, all offering geopositioning capabilities, more growth is expected. Another field of applications include the satellite Earth observation sector, a market valued in 2009 at some USD 900 million to USD 1.2 billion. Finally others, derived from the main space manufacturing and space applications sectors, include for example the space insurance industry, which generates around USD 750-800 million a year. As a case study, the satellite telecommunications sector is reviewed in more details in the next paragraphs.

Satellite communications' services have historically been aggregated in official statistics with other data. Since the latest ISIC revision, a new international classification for satellite communications have been created, but it takes time and efforts to include new categories in national surveys. At international levels, both the International Telecommunication Union (ITU) and the OECD publish annually indicators on communications and satellite communications indicators, for which data times series already exist, as shown in the table below (OECD, 2007). In general, private surveys and consulting reports provide the most up-to-date information on the communications market, although difference in proprietary definitions and methodologies can cause difficulties to data users (*e.g.* revenues in current or constant prices. See Chapter 4 for review of methodological caveats).

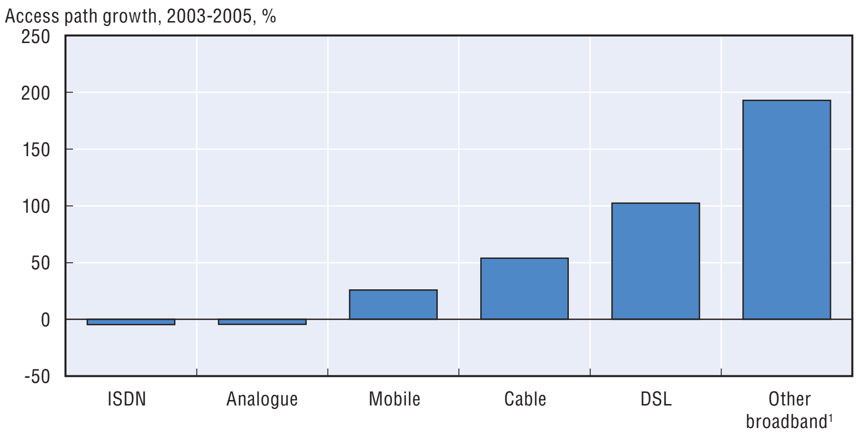
Table 6.1. **ITU indicators including data about satellite usage**

| ITU Code | Indicators | Description |
|---|---|---|
| 965m | Total number of multi-channel TV subscribers | This is the total number of multi-channel TV subscribers (both terrestrial and satellite); (see below: 965m = 965c + 965s). |
| 965c | Number of terrestrial multi-channel TV subscribers | Number of terrestrial multi-channel TV such as cable TV, digital terrestrial TV, Microwave Multi-point Distribution systems (MMDS) and Satellite Master Antenna Television (SMATV) subscribers. |
| 965s | Direct to Home satellite antenna subscribers | The number of subscribers to a home satellite antenna that can receive television broadcasting directly from satellites. |
| 965cp | Homes passed by multi-channel TV | Number of households that have a multi-channel (both terrestrial and satellite) television connection whether they are subscribing or not. |
| 4213ob | Other fixed broadband Internet subscribers | Internet subscribers using fixed broadband technologies (other than DSL, cable modem and leased lines) to access the Internet. This includes technologies such as satellite broadband Internet, Fibre-to-the-home Internet access, Ethernet LANs, fixed-wireless access, Wireless Local Area Network, WiMAX, etc. Speeds should be equal to, or greater than, 256 kbit/s, in one or both directions. It would exclude those users of temporary broadband access (*e.g.*, roaming between PWLAN hotspots), and those with Internet access via mobile cellular networks. |

*Source:* Adapted from ITU (2010), "World Telecommunication/ICT Development Report 2010", *Monitoring The WSIS Targets: A mid-term review*, International Telecommunications Union, Geneva.

An example of aggregated data is presented in the next figure. Since satellite broadband is for the time being relatively marginal compared to other broadband technologies, it is often included in the most recent broadband technologies category, which includes fibre broadband connections, broadband wireless access, and satellite broadband. These "other broadband" technologies (compared with more known technologies such as cable, DSL, etc.) which are regrouped under the ITU Code 4213ob (see Table 6.1) make up only 6% of all broadband lines in the OECD area, although the percentage is growing steadily, as shown in the figure below.

Figure 6.6. **Growth in communication access paths by technology, 2003-05**




1. Other broadband include fibre broadband connections, broadband wireless access, and satellite broadband.

*Source:* OECD (2007), *OECD Communications Outlook 2007*, OECD Publishing, *http://dx.doi.org/10.1787/comms_outlook-2007-en*.

StatLink http://dx.doi.org/10.1787/888932576719

As another example, the table below presents market data for a particular segment of the satellite telecommunications value chain: the "very small aperture terminal" or VSAT industry. A VSAT is a two-way satellite ground station with a dish antenna, used for communications (fixed or on the move in the case of mobile maritime communications), to transmit narrowband data (such as credit card transactions), and now extensively to receive and send broadband data. It is estimated there are more than 500 000 terminals installed in more than 120 countries and the number is growing, as the provision of satellite Internet access to remote locations and mobile users expands (Global VSAT Forum, 2011).

Table 6.2. **Data on the VSAT industry (2010)**

| Enterprise and Broadband Star Data Systems | |
|---|---|
| Total Number of Enterprise VSAT Terminals Ordered | 2 276 348 |
| Total Number of VSATs Shipped | 2 220 280 |
| Total Number of Sites in Service | 1 271 900 |
| Market Shipments 3 Year CAGR | 13.1% |
| VSAT Revenues | |
| All Service Revenues | USD 5.46 billion |
| TDMA & DAMA Hardware Revenues | USD 964.0 million |

*Source:* Comsys (2010), *Annual VSAT Report, 11th edition*, Report prepared by Simon Bull, Comsys, London.

When collecting/interpreting data for satellite communications, one should recall that:

- The satellite telecommunications' value chain is complex, and public and private data providers use very different definitions when looking at the industry.
- Notwithstanding possible double counting issues, data providers tend to aggregate all industry revenues, so that precise revenue streams are often lost in the analysis. For example, some direct-to-home (DTH) television providers lease transponders, while other DTH providers own their satellites. Aggregating all the revenues occults this distinction, which may be important for other actors in the value chains.

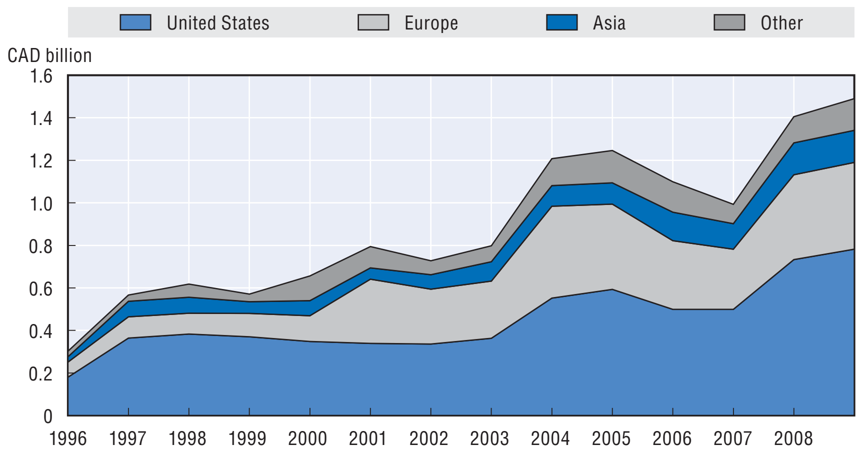
## International trade in selected space products

Not many space products and services are fully commercial, as most are strategic in nature and not freely traded (*see section 2.2 concerning space products in international statistical classifications*). In *The Space Economy at a Glance 2011*, a partial overview of existing trade data is provided by examining the exports of one commodity code with significant space components from the International Trade in Commodity Statistics (ITCS) database (OECD, 2011). The Commodity Code used is 7925 "Spacecraft (including satellites) and spacecraft launch vehicles". Based on available ITCS trade data, France, the United States, Belgium, Italy and Germany lead the exports of spacecraft and spacecraft launch vehicles. Concerning importers, a vast diversity of OECD and non-OECD countries appear, reflecting the emergence of new actors in space activities. But the data remain limited.

In most countries, the information on imports and exports of goods come from customs declarations (United Nations Statistical Commission, 2008). Due to confidentiality issues, countries may not report some of their detailed trade, and imports reported by one country may not coincide with exports reported by its trading partners. Differences can be due to various factors including national trade valuation (imports/exports including or excluding "cost, insurance, and freight"), differences in inclusions/ exclusions of particular commodities, or timing.

These official trade data need therefore to be completed by other data, gathered by space agencies and industry associations, particularly for countries that are strong exporters of space technologies and/or services. For example Canada's trading partners are tracked by the Canadian Space Agency annually, as shown in the figure below.

Figure 6.7. **Canadian space sector's export revenue by destination, 1996-2009**




*Source:* Canadian Space Agency, 2010 in OECD (2011), *The Space Economy at a Glance 2011*, OECD Publishing, *http://dx.doi.org/10.1787/9789264111790-en*, p. 95.

StatLink http://dx.doi.org/10.1787/888932576738

## Innovation for future economic growth: patents

A patent is a legal title granting its holder the exclusive right to make use of an invention for a limited area and time, it is part of his/her intellectual property rights (IPR). An invention needs to fulfill three criteria to be granted a patent: 1) novelty, 2) inventive step, and 3) industrial applicability. All patent applications and granted patents are published. They provide a useful indicator of innovative developments in all areas of technology, and they can indicate the level of innovative activity in a particular market, region or country. In the field of space technology under-representation of innovative activity within patent systems may be more marked since much dual-use space research and development is subject to secrecy.

In *The Space Economy at a Glance 2011*, space-related patents were identified using a combination of codes from the International Patent

Classification (IPC) and key word searches in the patent title (OECD, 2011). The classification B64G: "Cosmonautics; vehicles or equipment thereof" was used as a starting point. It covers a large array of space-related systems and applications (including satellites; launchers; components; radio or other wave systems for navigation or tracking; simulators). The box below summarises the methodology used to extract data from the OECD Patents Database.

Box 6.1. **Defining space-related patents**

Space-related patents are defined using a mixture of International Patent Classification (IPC) codes and keywords. More work is ongoing to refine the definitions with keywords.

- B64G "Cosmonautics; vehicles or Equipment thereof" is the principle IPC class used, which covers technology related to developing and maintaining space-based systems; space exploration and peripheral equipment related to cosmonautics.
- In order to also capture patents relating to applications relying on space-based technology, patent applications with the following IPC classes were chosen:
  - B64 Aircraft; Aviation; Cosmonautics.
  - C06 Explosives; Matches.
  - F41 Weapons.
  - F42 Ammunition; Blasting.
  - G01 Measuring; Testing.
  - G08 Signalling.
  - H01 Basic electric elements.
  - H02 Generation, conversion, or distribution of electric power.
  - H03 Basic Electronic Circuitry.
  - H04 Electric Communication Technique.
  - H05 Electric techniques not otherwise provided for.

Using the different IPC classes mentioned above, the following keywords were used:

For general satellite technologies patents:

- "satellite"
- "spacecraft"
- "rocket"
- "space"
- "launcher"

Box 6.1. **Defining space-related patents** *(cont.)*

For satellite navigation patents:

- "GPS"
- "navigation"
- "positioning"
- "timing"

For satellite Earth observation patents:

- "earth observation"
- "remote sensing"
- "meteorology "
- "optical "
- "radar "
- "lidar "

For satellite communications patents:

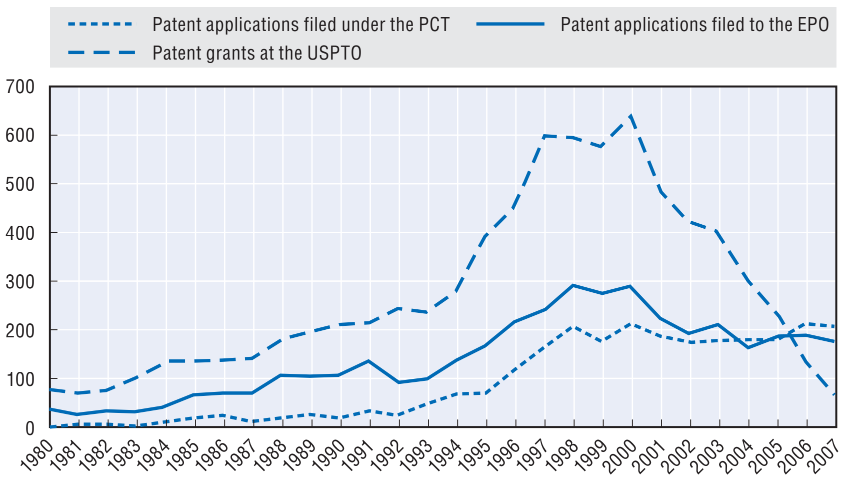
- "communication + satellite"
- "multiplex"
- "broadcast + satellite"
- "broadband + satellite"
- "television + satellite"
- "transponder"

In this analysis no adjustments have been made for inventions filed at both European Patent Office (EPO) and United States Patent and Trademark Office (USPTO), although the results also include space-related patent applications filed under the Patent Co-operation Treaty (PCT).

The PCT offers applicants the possibility to seek patent rights in a large number of countries by filing a single international application with a single patent office (receiving office). Data on the number of PCT patent applications are more internationally comparable because they avoid home country advantages and cover inventions that are potentially worth patenting in more than one country. A methodological issue concerns the visible downturn of patent applications after 2001 (see Figure below). This is mainly due to delays in updating patent databases and also the time-lag at the USPTO between the application of a patent and its granting. Thus, the downturn should not be misconstrued as a recession in terms of space-related patenting activities. As in the case of other sectors, space patents tend to become international in nature. The Canadian Space Agency, in its annual space industry survey, is also seeing more multi-country patents being reported over the years.

Figure 6.8. **Evolution of space-related patents, 1980-2007**

Number of patents filed by patent offices and priority date




*Source:* OECD, *Patent Database*, August 2010 in OECD (2011), *The Space Economy at a Glance 2011*, OECD Publishing, *http://dx.doi.org/10.1787/9789264111790-en*, p. 71.

StatLink http://dx.doi.org/10.1787/888932576757

The number of space-related patents has almost quadrupled in fifteen years when looking at the applications filed under the PCT. Analysis of patents provides some insight into innovative activities concerning the electrical and mechanical machinery and equipment required for space-based systems (satellites, launchers) as well as the downstream applications, such as telecommunications navigation systems. It remains that patent data have advantages and disadvantages for illustrating inventive activities, as reflected in the table below.

Another possibility to track innovation is to use bibliometric (or publication) data. Bibliometric data are used to capture research and development activities closer to basic science while patent data highlight activities further downstream from basic science. The multitude of articles, notes, letters and reviews that are published daily in scientific journals, along the numerous citations between these publications, provide a paper trail of the development, structural relationships, and diffusion of scientific knowledge. Publications and their citations are also often used as indicators for the performance of the public research system of countries or specific universities and institutes. Publication databases are very large and can

### Table 6.3. **Patent data's advantages and disadvantages in reflecting inventive activities**

**Advantages**

- Patents cover a broad range of technologies for which there are sometimes few other sources of data (*i.e.* nanotechnology).
- Patents have a close (if imperfect) link to invention. Most significant inventions from businesses are patented, whether based on R&D or not.
- Each patent document contains detailed information on the invention process: a reasonably complete description of the invention, the technology field concerned, the inventors (name, address), the applicant (owner), citations to previous patents and scientific articles to which the invention relates, etc. The amount of patent data available to researchers is huge. More than one million patents are applied for worldwide each year, providing unique information on the progress of invention. Patent data are public, unlike survey data which are usually protected by statistical secrecy laws.
- The spatial and temporal coverage of patent data is unique. Patent data are available from all countries with a patent system. They are available – sometimes in electronic form – from first patent systems, which go back to the 19th century in most OECD countries.
- Patent data are quite readily available from national and regional patent offices. The marginal cost for the statistician is much lower than for conducting surveys although it is sometimes still significant (data need to be cleaned, formatted, etc.). Unlike survey data, collection of patent statistics does not put any supplementary burden on the reporting unit (*e.g.* business) because the data are already collected by patent offices in order to process applications.

**Disadvantages**

- Not all inventions are patented. Inventions with few economic possibilities may not justify the cost of patenting. Strategic considerations may lead the inventor to prefer alternative protection (secrecy), with the result that the patent data do not reflect such inventions (*e.g.* Pavitt, 1988).
- The propensity to file patent applications differs significantly across technical fields. For instance, in the electronics industry (*e.g.* semiconductors) a patented invention can be surrounded by patent applications on incremental variations of the invention, with a view to deterring the entry of new competitors and to negotiating advantageous cross-licensing deals with competitors. As a result of this "patent flooding" strategy, some technical fields have a larger number of patents than others. Companies' propensity to patent also differs: new or small and medium-sized enterprises (SMEs) – notably those that lack large-scale production – have more difficulty covering the costs of a patent (although national policies attempt to deal with this problem by providing SMEs with subsidies or discount rates).
- Several studies have shown that the value distribution of patents may be skewed. Many patents have no industrial application (hence, are of little or no value to society), whereas a few have very high value. Nonetheless, the disclosure of information represents a benefit for society, as it increases the stock of knowledge. With such heterogeneity, simple patent counts can be misleading. This is not specific to patents, but a reflection of a prominent feature of the inventive process which also applies to R&D expenditure (which often results in little success, but sometimes in huge success).
- Differences in patent law and practices around the world limit the comparability of patent statistics across countries. It is therefore preferable to use homogenous patent data (coming from a single patent office or single set of patent offices).
- Changes in patent laws over the years call for caution when analyzing trends over time. The protection afforded patentees worldwide has been stepped up since the early 1980s, and companies are therefore more inclined to patent than before. The list of technologies covered has grown longer over time and in some countries now includes software and genetic sequences, which were previously excluded. Other variables, such as office administration, can have a substantial impact on patent counts, notably patents granted, during a particular time period.
- Patent data are complex, as they are generated by complex legal and economic processes. It is therefore important to take into account all of these factors when compiling and interpreting patent data, as failing to do so could lead to erroneous conclusions.

*Source:* OECD (2009), *OECD Patent Statistics Manual*, OECD Publishing, *http://dx.doi.org/10.1787/9789264056442-en*.

sometimes be poorly indexed as they collect data from various journals with different indexing systems and nomenclatures. The delimitation of subsets of publications of specific scientific fields are typically been done using advanced keyword search algorithms that also consider cross-citation patterns and expert opinion. This type of activity would be useful to try and track innovation derived from space research.

Box 6.2. **Advantages and limitations of bibliometric data**

**Advantages:**

- Publications are closely linked to research activity.
- They have been subject to peer-review for quality control.
- They cover a broad range of scientific disciplines.
- Publication data are available as long time series.
- They are publicly available at a low cost.

**Limitations:**

- Publication databases are biased in favour of English-language journals as the mainstream outlets.
- They combine different journal-specific databases whereby targeted searches are cumbersome.
- Publication data only cover the codified aspects of scientific research.
- Citation data may not only reflect genuine interrelationships and quality of research.
- Publication behaviour and propensities may vary significantly across disciplinary fields.

*Source:* Palmberg *et al.* (2009), "Nanotechnology: An Overview Based on Indicators and Statistics", *OECD Science, Technology and Industry Working Papers*, No. 2009/07.

This chapter has highlighted a number of indicators with their associated measurement issues, but there are many more as demonstrated by the ones presented in the publication *The Space Economy at A Glance 2011*. Future revisions to this *Handbook* will most likely feature more indicators.

## *References*

Comsys (2010), *Annual VSAT Report, 11th edition*, Report prepared by Simon Bull, Comsys, London.

Global VSAT Forum (2011), *About the VSAT Industry, website*, London. Available: *www.gvf.org* [*Accessed March*].

ITU (2010), *World Telecommunication/ICT Development Report* 2010, Monitoring The WSIS Targets: A mid-term review, International Telecommunications Union, Geneva.

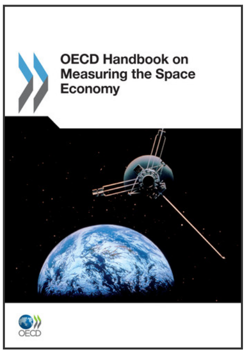
OECD (2007), *OECD Communications Outlook 2007*, OECD Publishing, *http://dx.doi.org/10.1787/comms_outlook-2007-en*.

OECD (2009), *OECD Patent Statistics Manual*, OECD Publishing, *http://dx.doi.org/10.1787/9789264056442-en*.

OECD (2011), *The Space Economy at A Glance 2011*, OECD Publishing, *http://dx.doi.org/10.1787/9789264111790-en*.

Palmberg, C., H. Dernis and C. Miguet (2009), "Nanotechnology: An Overview Based on Indicators and Statistics", *OECD Science, Technology and Industry Working Papers,* No. 2009/07.

United Nations Statistical Commission (2008), *Updated System of National Accounts (SNA): Chapter 14: The supply and use tables and goods and services account*, United Nations Economic and Social Council, Statistical Commission, Thirty-ninth session, 26-29 February 2008, Item 3(d) of the provisional agenda, New York.


OECD Handbook on
Measuring the Space
Economy