PART II

Chapter 7

Measuring Socio-economic Impacts from Space Activities

This chapter reviews various types of socio-economic impacts derived from the development of space activities. The main message is that many space-based services have positive impacts on society, but issues concerning economic data definitions and methodologies have to be resolved to allow the benefits to be identified and quantified more precisely.

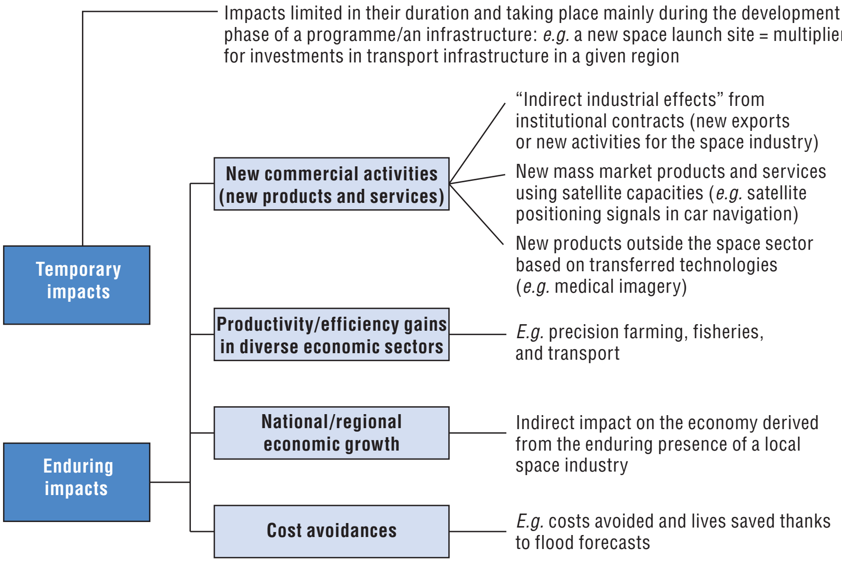
Defining socio-economic impacts from space programmes

The investments in space programmes are often justified by the scientific, technological, industrial and security capabilities they bring. The wish to develop a specialisation may allow a country to participate later on in large space programmes because of its expertise (*e.g.* Canada's expertise in robotics and radar imagery; Norway's expertise in developing satellite telecommunications in difficult environments, such as platforms at sea).

Space investments can also provide socio-economic returns such as increased industrial activity, and bring cost efficiencies and productivity gains in other fields (*e.g.* weather forecasting, telemedicine, environmental monitoring and agriculture previsions). Several space applications have reached technical maturity and have become the sources of new commercial downstream activities, sometimes far removed from the initial space research and development. For example, the growth of positioning, navigation and timing applications, which rely on satellite signals, has spurred new commercial markets (*e.g.* GPS chipsets in smartphones). But as Einstein wrote: "Not everything that counts, can be counted." This is also true for the diversity of socio-economic impacts derived from space activities.

The analytical work done so far on impacts has tended to be based on small-scale/national studies rather than comprehensive exercises repeated over time and based on official statistics. Despite these limitations, research conducted by OECD /IFP has shown that impacts analysed so far can be categorised in four different segments: creation of new commercial products and services (including "indirect industrial effects" from space industry contracts, meaning new exports or new activities outside the space sector), productivity/efficiency gains in diverse economic sectors (*e.g.* fisheries, airlines), economic growth regionally and nationally, and cost avoidances (*e.g.* floods). One major challenge concerns specific measurement issues associated with the "social" dimensions of the impacts, like for example the reduction of the digital divide in rural areas thanks to satellite telecommunications. These are important and valuable social impacts, for which measurement requires further work. The following sections briefly review some of the impacts that have been detected so far.

Figure 7.1. **Review of possible impacts derived from investments in space programme**



Source: OECD (2011), *The Space Economy at a Glance 2011*, OECD Publishing, *http://dx.doi.org/10.1787/9789264111790-en*, p. 79.

Box 7.1. **Space applications and cost benefit analysis**

The most common economic measurement for any technology's value is the calculation of benefits to costs. In theory, to calculate the ratio, it is necessary to divide the benefits (*e.g.* improved productivity, decreased cost of operations, increased revenue and better customer satisfaction rates when applicable) by the costs of deploying the system (*e.g.* hardware, software, maintenance, training and so forth). However space systems are by nature multifaceted and rely often on lengthy research and development. The challenge of putting a monetary value on the technologies and services they deliver remains a complex and often subjective exercise. As discussed in OECD (2008), monetary or financial valuation methods fall into three basic types, each with its own repertoire of associated measurement issues and none of them entirely satisfactory on its own. They include: direct market valuation (*e.g.* market pricing), indirect market valuation (*e.g.* replacement cost) and survey-based valuation techniques (*i.e.* contingent valuation and group valuation). One option is to use several of these methods in parallel to test assumptions and the resulting impacts of a given space application. Ongoing work in OECD is devoted to conducting case studies on selected space applications, in order to provide a source of comparative national experiences and lessons learned when trying to apply the different methodologies to the study of impacts.

New commercial/industrial activities

In a majority of countries, space programmes are contracted out to industry. The ability of firms to secure new customers or create new activities has been studied over the years, and although impacts may vary depending on the country and the level of its specialisation (*e.g.* applications versus manufacturing), there are several examples of positive industrial and economic returns from space investments, not only in countries with large space manufacturing industry but also in countries with smaller specialised space programmes. Follow some examples quoted in OECD (2011):

- Norway – which has a small but active space programme – has detected a positive multiplier effect since the 1990s, *i.e.* in 2009, for each million Norwegian kroner of governmental support through the European Space Agency (ESA) or national support programmes, the Norwegian space sector companies have on average generated an additional turnover of NOK 4.7 million, usually as new exports or new activities outside the space sector. This spin-off effect factor is expected to climb further as Norwegian space sector develops new products and services (Norwegian Space Centre, 2010).
- In Belgium, the same type of multiplier has been detected. In 2010, for each EUR million of governmental support through ESA, it was found that EUR 1.4 million have been generated by the Belgian space industry (Capron *et al.*, 2010).
- In Denmark, where some 25 companies are active in the space sector, each EUR million of Danish contributions to the European Space Agency has generated a turnover of EUR 3.7 million on average. Increased competencies within space activities through involvement in ESA projects is seen by the industry as facilitating the development of competencies in other sectors than the space sector (Danish Agency for Science Technology and Innovation, 2008).

R&D and innovation play an important role in many industries, although the derived competitiveness seems to be strongly affected by the size of the domestic market, this is true also for the space sector. However spillovers are sometimes as important as the direct effects. And this is an argument for public support of R&D in private firms (Fagerberg, 1996). The studies conducted by these countries have used different methodologies (*e.g.* input-outputs analysis, surveys). Already in the 1990s, the BETA (Bureau d'Économie Théorique et Appliquée) of the University Louis Pasteur had developed a methodology extensively applied to assess indirect economic effects of European Space Agency contracts in European member countries (BETA, 1989, 1997). Results showed already positive effects of ESA contracts for firms active in Europe and in Canada (Cohendet *et al.*, 2002).

Concerning space technology transfers to diverse economic sectors, many studies of "spin-offs" have been conducted in the United States since the 1960s (such as outputs from NASA's Apollo programme), focusing on the transfers from space-related hardware and know-how to other sectors (NASA, 2010). The value of spin-offs is however not easily quantifiable, and at times oversold concepts have been detrimental (*e.g.* Teflon as space technology). There are currently more than 1 600 NASA-derived technologies that have been transferred to other sectors, bringing efficiency gains particularly in medical imagery (*e.g.* Hubble telescope's optics used for increased precision in microinvasive arthroscopic surgery).

Box 7.2. **Science and space exploration as key drivers of space programmes**

Countries with space programmes are increasingly investing in down-to-earth space applications (*e.g.* telecommunications, earth observation) for strategic and economic reasons. Nevertheless, science and space exploration remain key drivers for investments and constitute an intensive activity for major space agencies and industry (OECD, 2011). Space sciences and planetary missions have developed markedly over the years, with new actors joining in. This trend is reflected in the current and planned robotic exploration missions of the solar system, in which the United States, Canada, Europe, Japan, China and India are active players. In addition to those robotic missions targeted at extraterrestrial bodies, more than a dozen space science satellites are orbiting the earth, while dozens of ground-based telescopes are managed internationally. More countries than ever are also investing in indigenous human spaceflight capabilities. Over the past couple of years, a new generation of professional astronauts was selected in the United States, the European Space Agency member states, Canada and China.

Regional/national economic growth

The macroeconomic impacts of space programmes at regional or even national levels have been measured in countries with significant space industry (manufacturing and/or services), such as the United States, France and most recently in the United Kingdom. Economic impacts analysis is not unique to the space sector, and similar studies on economic spillovers are regularly conducted for the automobile industry, the oil industry or the defence sector (*e.g.* economic effects of large military bases).

- In France, several regional studies were conducted over the years on French Guyana, an overseas department where the European spaceport is located (INSEE, 2010). The share of value added due to space activities accounted for 21% of French Guyana's GDP on average during the decade 1965-75. With the advent of commercial launcher and Arianespace, the economic importance of space has risen sharply in the early 1990s (28.7% in 1991). It began to decline in 1994 (25.7%), and accelerated again in 2002-03 with new Ariane 5 launches (INSEE, 2008). French Guyana exports predominantly consist of space transportation services sales by Arianespace. The ratio of exports to GDP is much higher than what is found in other exports of French Guyana.

- In the United States, home of the biggest space industry in terms of employment and revenues, the most recent FAA study on the wider national economic impacts of the US commercial space activities has shown a rather stable multiplier ratio since 2002 (FAA, 2010). In 2009, for every dollar spent commercial space transportation industry, USD 4.9 resulted in indirect and induced economic impact. Using the same modeling techniques as the ones used for the aeronautic industry, the results show that many economic sectors may be impacted by commercial space activities, as they provide goods and services, directly or indirectly, to the space industry. In 2009, the Information Services industry was the most affected group in terms of additional economic activity, earnings and jobs, generating over USD 65.4 billion of revenue, over USD 15.3 billion in earnings, and creating 213 230 jobs.
- In the United Kingdom, where the downstream space services' sector have been growing steadily (boosted by the satellite communications sector), a national economic impacts study was also conducted recently. Including both upstream and downstream actors (from satellite manufacturers to operators and providers of services), the space industry's value-added multiplier on the British economy has been estimated to be 1.91 and the employment multiplier to be 3.34 (Figure 14.2). The space industry's direct value-added contribution to GDP was estimated at some GBP 3.8 billion and the indirect economic impacts amounted to an additional GBP 3.3 billion (*i.e.* space industry's spending on non-space UK inputs). The total UK-based employment supported by the space industry was estimated to be 83 000 in 2009 (UK Space Agency, 2010).

The American and French economic impact studies apply different input/ output methods, while the United Kingdom analysis is based on the results of industry survey responses. The FAA uses the Regional Input-Output Modelling System (RIMS II) developed by the Department of Commerce, Bureau of Economic Analysis. The French national statistical office INSEE has used different impacts methodologies over time. Input-output analysis specifically shows how industries are linked together through supplying inputs for the output of an economy. Factors that can be used to construct indicators of productivity are for example employment, expenditures, income, production of goods and services and competitiveness. Such factors are of interest at both the national and regional levels. Results of these analyses are derived from macroeconomic data such as changes in GDP, which can then be compared to changes in capital. The challenge when interpreting the material is to find the causal linkages between the programme/ infrastructure investments and the rise in productivity. However, the findings of these studies are sometimes contentious, and highly dependent on the choice and evaluation of appropriate variables over long periods, as well as the calculations used to assess their cause and effect mechanisms.

Efficiency/productivity gains

The amount of efficiency and productivity gains derived from the use of space applications across very diverse sectors of the economy keeps growing over the years. From agriculture to energy, institutional actors and private companies are using satellite signals and imagery with usually positive returns. Satellites can also play a key role in providing communications infrastructure rapidly to areas lacking any ground infrastructure, contributing to link rural and isolated areas with urbanised centres:

- Positioning and navigation efficiencies. Adoption of satellite navigation-related technologies in fishing fleets began in the mid-1980s, and general technology rollout and adoption began in the mid-1990s all over the world. Based on efficiency gains studies, the fishing power of the commercial Australian fleet increased since the uptake of GPS and plotters. The cumulative addition to fishing output that were conservatively attributed to the use of GPS plotters was estimated at 4.14% of output in 2007, equivalent to around AUD 88 million at 2007 prices (OECD, 2008b).
- Higher perspectives from space. The specific topographic perspectives brought by earth observation and navigation satellites allow cost-efficiencies. In India, a large petrochemical group uses remote sensing to plan several pipeline routings for the transportation and distribution of natural gas/hydrocarbons. Building a geographic information system with imagery from the Indian Cartosat-1 satellite and cadastral data, the company's field work time was reduced from 90% to less than 15% from previous conventional surveys (usually only 1.5 to 2 km were covered per day compared with more than a hundred of kilometres with satellites). Updates in the imagery database will help monitor the pipeline routing areas and create long-term time series (Indian Space Research Organisation, 2010).

In the case of space applications, the study of productivity gains are often conducted as ad hoc reports, therefore methodologies may vary and render difficult international comparability. The OECD is building up a database of existing indicators, as to provide access to data and methodological information.

Judging from the different types of impacts presented, space applications and diverse programmes in the space sector have been the focus of many socio-economic studies over the years. However, all such studies face inherent limitations, very similar to those in other types of public R&D impacts analysis (see box below). When assessing the results of these studies there is often a reluctance to link socio-economic outcome measures too directly to a research programmes or a given space application, as there are many intervening steps that may distort the causal link. One option is to use several assessment methods in parallel to test assumptions and the resulting impacts of a given space application or programme.

Box 7.3. **Challenges encountered when analysing the impacts of R&D programmes**

- **Causality.** There is typically no direct link between a research investment and an impact. Research inputs generate particular outputs that will then have an impact on society. As it is indirect, this relationship is difficult to identify and measure. It is also almost impossible to isolate the influence of one specific factor (research output) on one impact, because the latter is in general affected by several factors that are difficult to control for.
- **Sector specificities.** Creation and channelling of output to the end-user will differ depending on the research field and industry. This renders ineffective the use of one single framework for assessment.
- **Multiple benefits.** A basic research impact may have several dimensions, not all of which are easily identified.
- **Identification of users.** Identification of all end-users who benefit from the research outputs can be difficult and/or costly, especially in the case of basic research.
- **Complex transfer mechanisms.** It is difficult to identify and describe all the potential mechanisms for transferring research results to society. Some studies have identified mechanisms of transfer between businesses or between universities and businesses. These models are mainly empirical and often reveal little of the full impact on society of such transfers.
- **Lack of appropriate indicators.** Since appropriate benefit categories, relevant transfer mechanisms and end-users are often lacking, it is also difficult to define and measure appropriate impact indicators related to specific research outputs.
- **International spillovers.** The existence of knowledge spillovers has been well documented and demonstrated. As a result, specific impacts could be partially the result of internationally performed research instead of national research investments.
- **Time lags.** Different research investments vary in the time it takes them to have an impact on society. Any measurement may thus prove premature, especially in the case of basic research.
- **Interdisciplinary output.** Research outputs, *e.g.* improved skills, may have different impacts, and it may be difficult to identify them all in order to evaluate the contribution of the specific output, let alone that of the research investment.
- **Valuation.** In many cases it is difficult to come up with a monetary value of the impacts so as to make them comparable. Even if identifiable, noneconomic impacts may be difficult to value. There have been some attempts to translate some of these impacts (such as the economic savings associated with a healthy population or the calculation of opinion values) into economic terms, but these have typically remained partial and open to subjectivity.

Source: OECD (2008), "Assessing the Socio-economic Impacts of Public R&D: Recent Practices and Perspectives", in OECD, *OECD Science, Technology and Industry Outlook 2008*, OECD Publishing, *http://dx.doi.org/10.1787/sti_outlook-2008-41-en.*

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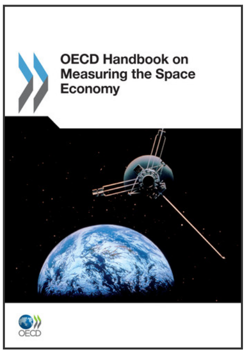

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