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Assessing the full effects of public investment in space☆

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ABSTRACT

Many space-related impact studies have been carried out in the past, but there is no conclusive, comprehensive evaluation of the economic and social effects of public investments in space. Such evaluations are not easy to perform, for several reasons: the space sector is not a recognised category in official statistics; social benefits, which are likely to be very important, are hard to assess; and impacts from R&D are complex and occur in the long term. However, important steps can be made towards better evaluation of impacts. The full set of impacts of space investments may be simultaneously evaluated from both a 'bottom-up' and a 'top-down' perspective. In the bottom-up perspective, each effect is measured separately, while the top-down perspective provides a framework for integrating the effects. Although both perspectives have their own advantages and drawbacks, combining them yields both detailed and integrated results. Our discussion of the bottom up approach starts by identifying an extensive list of impacts. Next, data availability issues and methodological improvements are identified, leading to recommendations on programmes to collect data and perform case studies. Finally, suggestions are made for presenting impacts in the form of a scoreboard. The core of the top-down evaluation methodology proposed is social cost benefit analysis. Effects are weighted, where possible, on the basis of observed market prices or other estimations of monetary values. For effects that are hard to measure or monetize, multi-criteria analysis can be applied using surveys and expert opinion. Our core recommendations are to clearly define the space sector, to collect additional data, and to use improved methodologies. Social, strategic and environmental impacts deserve special attention, aiming at a more comprehensive coverage of impacts. Comprehensive evaluations can contribute to more upport for space expenditures.

1. Introduction

In 2012, two research reports were completed that designed methodologies to evaluate the economic and social benefits of public investments in space (Hof et al. [1]; Simmonds et al. [2]). These reports resulted from parallel studies, commissioned by ESA, and carried out respectively by SEO Economic Research in the Netherlands, and Technopolis Ltd. in the UK. The aim was to provide suitable, academically satisfactory methodologies for undertaking comprehensive assessments of the economic and social effects of public investments in space related activities in Europe. This article summarises results from these two studies.

Space systems are becoming increasingly important to society, with applications in, for example, consumer products, manufacturing industries, professional and government services, intelligence and defence. Major sectors of the economy and many citizens depend on space systems and space-based technologies. Many of the services we take for granted in everyday life depend on space to function properly, from telecommunications to television and from weather forecasting to global financial systems.

At the same time, in an economic crisis, almost every government outlay comes under scrutiny and space investments are no exception. When space investments are co-funded by many different countries, things become even more complicated, as each

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country obviously has a particular interest in the impacts on its own economy. However, evaluation of publicly-supported space activities has received much less attention than evaluation in other policy areas, such as transport, education or health. This is also the case if we compare space to other areas with extensive public support for science and R&D such as the EU Framework Programmes for research and technological development.

Many space-related impact studies have been carried out in the past, but these have a rather variable scope, ranging from:

- Individual countries, e.g. British National Space Centre [3]; Danish Agency for Science [4]; Davies [5]; Department for Business Innovation and Skills [6]; Ecorys [7]; FAA [8]; Futron [9]; Hallonsten et al. [10]; Goss Gilroy Inc. [11]; Oxford Economics [12]; RPA [13]; The California Space Authority [14]; UK Space Agency [15].
- Specific economic sectors, e.g. ASD-Eurospace [16]; Bullock et al. [17]; ESA [18]; European Commission [19]; Micus [20]; Patureau et al. [21]; Pira [22]; SIA [23]; VEGA and Booz Allen Hamilton [24].
- Space programmes, e.g. Booz & Co [25]; European Commission [26]; Hertzfeld [27,28]; NDP Consulting [29]; NIAG [30]; PWC [31]; PWC, ESYS, DNV [32]; Sadeh [33]; Schnee [34]; Smith et al. [35]; Tavana [36].
- Space centres, e.g. NASA [37–40].
- Macroeconomic studies which often work with rather general multipliers, e.g. Oxford Economics [12]; Department for Business Innovation and Skills [6]
- Microeconomics research which is often very informative but has a rather narrow focus (e.g. Amesse et al. [41]; Bach et al. [42]; Bach, Cohendet and Schenk [43]; Brendle, Cohendet and Larue [44]; Cohendet [45]).

There is no conclusive, comprehensive evaluation of the economic and social effects of space activity, and in particular the social effects of space investments are rarely studied. This is unsatisfactory, as this may be where space has a comparative advantage over other sectors competing for public investment. Moreover, the existing studies use different, incommensurate, and incomplete data, and therefore cannot be aggregated to provide a coherent, overall picture of the impact of the space sect OECD [46] asserts 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".

We recognise that the diversity of impacts of space investments renders meaningful quantification of all of them difficult or impossible, a situation common to the evaluation of public sector investments generally (see e.g. Stiglitz [47]). Our objective in this paper is to attempt a systematic articulation of the impacts and to put forward our assessment of the most appropriate methodologies for their analysis and evaluation.

Section 1 describes the broad range of impacts of civil space investments. Section 2 compares methodologies to assess these impacts, from both a bottom-up and a top-down perspective. Section 3 presents a proposal for better evaluation, and section 4 our broad conclusions.

2. Space investments and their impacts

2.1. Overview

In Europe, public investments in space are dominated by the European Space Agency and national space agencies. Other important sources of public investment are the European Union, EUMETSAT and regional agencies striving to stimulate economic development through support for their local space sector. In some countries, these civil programmes are complemented by substantial additional investment from defence ministries. The great majority of this investment is directed to the European space sector, i.e. the private businesses and public research organisations that design, build and fly space missions. It also includes (inter) governmental organisations, a proportion of which conduct substantial space activities in-house, whether that is carrying out research or running missions. Overall, the space sector comprises the following activities:

- production and operation of space infrastructure and systems
- technology development and service demonstration
- space-based research
- administration of space budgets.

Space investments result in physical space-based systems and services, and new knowledge that can then be deployed by a wider group of economic actors for further economic and social purposes. This flow of investments (inputs) through activities and outputs to impacts is illustrated in.Fig. 1. It should be stressed that the mechanisms relating inputs to impacts are frequently indirect and occur over variable timescales.

In assessing the effects of space programmes, it is important to clearly define the policies (projects) involved, and also the counterfactual: the situation without the policy. Appraisal of policies may take place after they have been implemented (ex post) or before (ex-ante). A core concept in appraisal is attribution: whether certain changes which occur are caused by space programmes or not.

2.2. Classification of impacts

As indicated in Fig. 1, impacts may broadly be divided into the economic, social, strategic and environmental. Table 1 presents an alternative overview of the impact categories, distinguishing between *quantifiable* and *unquantifiable* effects, and showing their links to specific economic actors – the space sector itself, other economic sectors and, through the wider economy, individual citizens.

Space investments impact on a number of economic sectors, both upstream as suppliers to the space sector (backward linkages) and downstream, as recipients of inputs from the space sector (forward linkages). Examples of the latter include telecoms, navigation, and other areas of aerospace (Deloitte [48]). Examples of the value of information provided by the space sector are given in Macauley [49] and Laxminarayan and Macauley [50]. In analysing benefits, it is very important that 'double counting', whereby essentially the same impact is credited to both space and the linked sector, is avoided.

Within quantifiable impacts, two types of economic impact may be identified. The *first type* comprises impacts which occur within markets, such as profits generated by the upstream and downstream space sectors (direct impacts), their supply chains and clients (indirect impacts) and subsequent impacts on the wider economy (induced indirect impacts). Included in this category are benefits from R&D which are traded in markets, such as in paying for the use of patented technology. As indicated above, in the analysis of these effects in different parts of the economy it is very important to avoid double-counting of benefits. The *second type* comprises economic effects that are not traded in markets (external impacts), and depend on the particular goods and services resulting from the public investments. Benefits in this category include cost savings and unpaid benefits of R&D, within the space sector ('spin-in') or elsewhere ('spin-off').