

Executive Summary

Do public agencies produce value? The case of value creation in space

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Abstract

In this report, we discuss the notion of value creation in space and the way it has been measured in recent years. We expose the limitations of the current framework for measuring the contribution of the public sector by the academic literature and the European Space Agency (ESA), and examine the implications in terms of ESA's remit. We argue that the public space agencies have had a pro-active role and not a reactive one in the innovation process, which has triggered important transformational changes. We argue in favour of a theory of economic *change* that focuses on a *dynamic* efficiency framework. This framework also emphasises the distinction between incremental innovation, which implies continuous change, and radical innovation, which leads to transformational and unpredictable change. Economic changes also imply the presence of fundamental uncertainty about the effects of public interventions, which means that the predictions of ex-ante outcomes have to be interpreted with caution. We also argue that the sustainability of the system and the vitality of the innovation process require a proper allocation and distribution of resources within the private sector but also between the public and private sector and within the public sector. In other words, the state needs sustainable resources to drive change. As a result, the theory of resource allocation is not to be separate from the theory of economic change (i.e., the formation of the economy).

Keywords: Public value, space, innovation, knowledge, welfare, public sector.

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Executive summary

What is the role of ESA in space?

- Through its collaboration with industry, the research community and other public institutions and its strong involvement in knowledge and technology development, ESA has a global view of the innovation chain and is aware of challenges and opportunities in space to design missions across industries and sectors.
- ESA shapes and creates new markets and crowds in the private sector by leading and investing in all stages of knowledge and technology development for space exploration through internal basic and applied research, drawing detailed procurements with the industry and the research community and providing infrastructure in Space and on Earth.
- In each programme, ESA selects contractors based on their competence and the participation of their country to the programme, thereby encouraging countries' willingness to develop in a specific area according to their national industrial strategy, even when they do not have a comparative advantage.
- Through its rule of geographical returns on investment, ESA ensures that the investment of each country benefits its domestic industry. The balance of risks and rewards between the public and private sector is less obvious, which may ultimately compromise the sustainability of the space innovation ecosystem. Several measures could prevent this such as limiting Intellectual Property Rights (IPRs), price capping on goods and services that rely on technology developed with ESA funding, condition funding on an effort to limit space debris and on firm's investment strategy.
- ESA is very different from NASA because it is an international agency regrouping countries with different economic and political interests, which limits its leadership and control over the allocation of its funds. However, it also restricts capture by short-term national interests, which ensures a greater stability of the decisions. It also enables the coordination of resources and activities across Europe to face increasing competition from other nations, to adapt to the digital economy and to tackle global challenges (e.g. climate change, migrations).
- Despite the growing presence of the private sector in space, the public sector remains the main investor. Private investors mainly fund mature technologies such as satellite telecommunications. Yet, in the US the most important newly established firms founded by wealthy individuals differentiate from other private actors in space by their ambitious, visionary and forward-looking space missions (e.g., SpaceX, Blue Origin, Virgin Galactic). Their strategy goes beyond the typical short-term economic rationale view that was prevailing in the private sector. Furthermore, although the initiative is private, public investments and know-how of public agencies like NASA, particularly in the case SpaceX, were essential for scaling-up. However, the relative contribution of the private and public sector in the investment in these firms is difficult to determine. While they all have benefited from large contracts from US public agencies, such as NASA and the US Air Force, private investments particularly the share coming directly from their owner is not always made public. More data are needed to have a clearer picture of the contribution of the private sector in space.
- The purpose of space agencies is to lead change by defining ambitious goals for space exploration and structuring the ecosystem to achieve these goals. Most investments in basic activities, which are uncertain and do not directly lead to economic rewards, are made by public agencies (e.g. science programmes and basic activities at ESA). These activities are not only crucial to lead change but also to keep pace with technological change. The public sector differs from the private sector because it focuses on long-term objectives to satisfy the public interest. By acting at different stages of the

innovation chain, it has a comprehensive view of the value creation process. These characteristics for scaling-up, create synergies between complementary activities and enable ESA and its partners to exploit feedbacks between applied and basic research. As a result, the role of space agencies goes beyond simply de-risking. Conversely to neoclassical economic arguments, de-risking does not constitute the main justification for the participation of ESA in the space economy.

- To create and shape markets, space agencies require dynamic capabilities to adapt to the constantly changing environment in which they operate. In particular, they require important technical capabilities to accumulate a knowledge base and technical expertise that is essential to scale-up, identify new potential opportunities and create sound partnerships with actors of the ecosystem. For this reason, technical centres at ESA, such as ESTEC, are fundamental for the successful design and implementation of missions in space.

ESA's evaluation framework and its limitations

- Regarding its impact assessment framework for its activities and member state investments, in the last decades, ESA has promoted a harmonised evaluation framework relying on metrics based on welfare economics principles and five types of effects: scientific, technological, economic, strategic and societal. Independent evaluation studies also show an effort in accounting for value creation that cannot be quantified such as inspiration and awareness about space and Earth generated by ESA activities. In addition, the agency acknowledges a lack of transparency in the methodologies and aims to institutionalise the evaluation process by systematising the data collection process and enhancing cooperation between the actors of the ecosystem. However, the structure of ESA into separate and independent programmes restricts its capacity to collect and harmonise data and to evaluate globally its activities. Finally, ESA also intends to establish better feedback mechanisms on best practices between the actors of the ecosystem.
- Although ESA acknowledges the fact that it shapes and creates new markets, its evaluation framework does not fully capture this dimension of value creation because it mainly measures short-term and incremental changes. To measure impacts, most studies rely on impact evaluation methodology, which assumes a given and constant production structure, and some on ex-ante cost-benefit analysis, which implies to discount the future values. Furthermore, the details on the methodology used are often not publicly available.
- Evaluations focus on the incremental variation of inputs and outputs without putting attention to the process of transformation, particularly structural changes. Most evaluations are programme-specific, making it difficult to capture innovation chain dynamics and synergies between programmes. The nature of the relationship between actors is not documented to inform on success, failures or obstacles in different types of partnership.

An alternative evaluation framework

- An important basis for evaluation is the clarity of purpose, a direction, a hierarchy of desirable outcomes, a clear and transparent timeline and a target population defined in the mission's statement. The definition of the mission relies on several criteria: universality, fairness and accountability (Coyle and Woolard, 2010). ESA's mission is to enhance space knowledge and technology to tackle big societal challenges, foster European industrial competitiveness and European autonomy to access and use space in a sustainable way. As a result, the target population is wide and diverse.

- Evaluation is based on the capacity of a public agency to achieve the outcomes set out by the mission effectively and efficiently. Efficiency needs to be understood as dynamic efficiency, which implies to account for the long-term dynamic characteristic of the innovation process.
- When evaluating the value created by a public agency and the impacts it has, it is important to identify the target population. At ESA, we identify four main overlapping groups: the industry, the scientific community, society and each member. Because ESA acts on several stages of the innovation chains, several *overlapping* impacts were identified by the agency in its evaluation reports: scientific, technological, strategic, economic and societal.
- Evaluation is based on ex-post and in-itinere indicators. Ex-post indicators are more relevant because the impacts of space programmes are only visible years or decades after investment. Intermediary outcomes (in-itinere indicators) provide valuable information to ensure that activities lead to changes in the direction established by the mission and enables the evaluation process to be iterative by revising indicators in the process and allowing public agencies to learn from successes and failures. Intermediary outcomes, such as the evolution of knowledge and technical competences, are also useful for accountability and legitimacy purposes.
- Innovation drives countries' competitiveness and industrial development. As a result, a particular attention to innovation dynamics and knowledge development is fundamental to design a sound industrial policy. Regarding evaluation, a focus on dynamic efficiency and on processes leading to changes rather than on inputs and outputs independently is important because innovation is a cumulative, collective and uncertain process. This can be done by studying innovation dynamics in the space context by examining past missions to understand the specific characteristics of innovation in space and the condition of success and failure (in terms of the actors involved and their relationship, funding sources, technical and organisational obstacles). A focus on processes also implies to have a holistic view of the innovation chain to conduct evaluations beyond programme-specific activities and goals to account for synergies and bottlenecks between programmes.
- To capture value creation at ESA, three dimensions are important to measure: (i) structural changes at different stages of the innovation chain instead of short-term and incremental changes, (ii) the direction of change, change leading to the creation of public value in line with the mission's goals and (iii) the nature of relationships between the different actors of the space innovation eco-system.
 - Measuring structural changes consists of mapping changes in different stages of the innovation chain (knowledge, technology and economy) and identifying complementarities and synergies between spheres (feedback mechanisms). Feedback mechanisms are not one-directional but complex and the boundaries between innovation stages are blurry. While the discovery of a new principle offers new avenues for solving existing technical problems, technologies sometimes even precede the establishment of principles and technical problems encountered in applied research can trigger basic research find new principles to solve these. It entails identifying the emergence of new knowledge and technological fields and the extent of their generality and originality. Measuring structural changes can rely on the study of scientific publications or patent network citations.
 - Measuring the direction of change, leading to the creation of public value implies acknowledging the subjective and multidimensional nature of value. The definition of the mission statement defines the strategic aims and values of the public agency, which ultimately depends on a judgement. In the case of ESA, expert judgment plays a central role because technological innovation is at the core of the process and innovation is cumulative. National industrial strategies reflecting the national interest of member states also influence this judgement. It involves accounting for direct value as well as its building blocks (indirect value), and thereby to focus on processes rather than final outcomes, often measured in terms of economic value. Prices are an imperfect proxy of value because of the existence of rents. While satisfaction surveys and or the analysis of social media data can be used as an alternative measure of value, the presence of

fundamental uncertainty adds complexity to its measurement. Finally, to prevent a bias towards what can be measured, the evaluation framework should acknowledge *all* dimensions of value. For instance, ESA generates value by inspiring people, by showing the world new horizons and new possibilities they would have not imagined in Space and on Earth.

- To evaluate the contribution space agencies in value creation, it is important to understand how value is generated and by whom because it is a cumulative and collective process. This implies (i) identifying the actors involved in the innovation chain and the nature of their relationships and (ii) evaluating the sustainability of the ecosystem by comparing risks and rewards measured in the first step.