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SPACE RESEARCH AND SUSTAINABLE TERRITORIAL DEVELOPMENT

Andrea Salustri[1], Alessandro Locatelli[2], Andrea Appolloni[3]

SUMMARY

The purpose of this research is to illustrate, within the general framework of the knowledge economy, the state-of-art of the space economy and, within it, of space-borne Earth Observations (EO). Indeed, in the current space-time compression, social conflicts should evolve into social cooperation, as all individuals and institutions are called to play a role in the activation of a process of resilient transformation toward sustainable development, i.e. in elaborating a sustainable conception of space and time. Within this general framework, social and territorial inequalities caused by (social and territorial) distance costs should be targeted in order to eradicate persistent forms of marginalization, poverty and exclusion. Specifically, action should be focused on present and future peripheral groups and places, in accordance with the principle of inter and intragenerational equity. Laying on these premises, EO can play a key role in collecting (not only) environmental information at the global scale, providing a crucial contribution in achieving most of the Sustainable Development Goals, as widely documented by the Group on Earth Observations (GEO, 2017). Furthermore, the EO value chain requires the activation of several other sectors, within the space economy and more in general pertaining to the scientific domain, and each of them can generate technological spillovers in many other economic sectors of activity.

[1] Università di Roma "La Sapienza", Facoltà di Giurisprudenza, Dipartimento di Studi Giuridici ed Economici, Istituto di Economia e Finanza, Piazzale Aldo Moro, 5, 00185, Roma, email: andrea.salustri@uniroma1.it.

[2] Fondazione ICSA, Via Sant'Andrea delle Fratte, 24, 00187, Roma, email: alelocatelli_2000@yahoo.it.

[3] Università di Roma "Tor Vergata", Facoltà di Economia, Dipartimento di Management e Diritto, Via Columbia, 2, 00133, Roma, email: andrea.appolloni@uniroma2.it.

1. Introduction

The purpose of this paper is to briefly summarize, within the general framework of the knowledge economy, the state-of-art of the space economy and, within it, of space-borne Earth Observations (EO). The research begins with the analysis of academic literature at the intersection between geographic and economic disciplines (regional economics, economic geography, social geography...) with the aim of identifying the role of spatial issues in the rational organization of human activities. This overview allows to identify how the importance of the space economy mostly depends, apart from its economic and geopolitical relevance, on its pivotal role in abating spatial distances ed in narrowing the existing territorial imbalances, therefore on its role in facilitating the transition of the world economy as a whole and of the interested regional economies toward a pattern of sustainable development.

Laying on these premises, the research briefly defines and illustrates the composition of the space economy at several geographical scales as a specific environment of the general economic framework involving, knowledge, innovation, markets and development. Specific attention is devoted to the analysis of the EO contribution to the process of regional development and, more in general, to sustainable development. Indeed, at territorial and environmental level EO might determine a structural change involving several economic sectors of activity, as widely documented in the collection of success stories published by many international institutions operating in this sector (see, as an example, EC, NEREUS, ESA, 2019, and the EO Wiki Portal maintained by EARSC, available at https://earsc-portal.eu/display/EOSTAN/EO+Wiki).

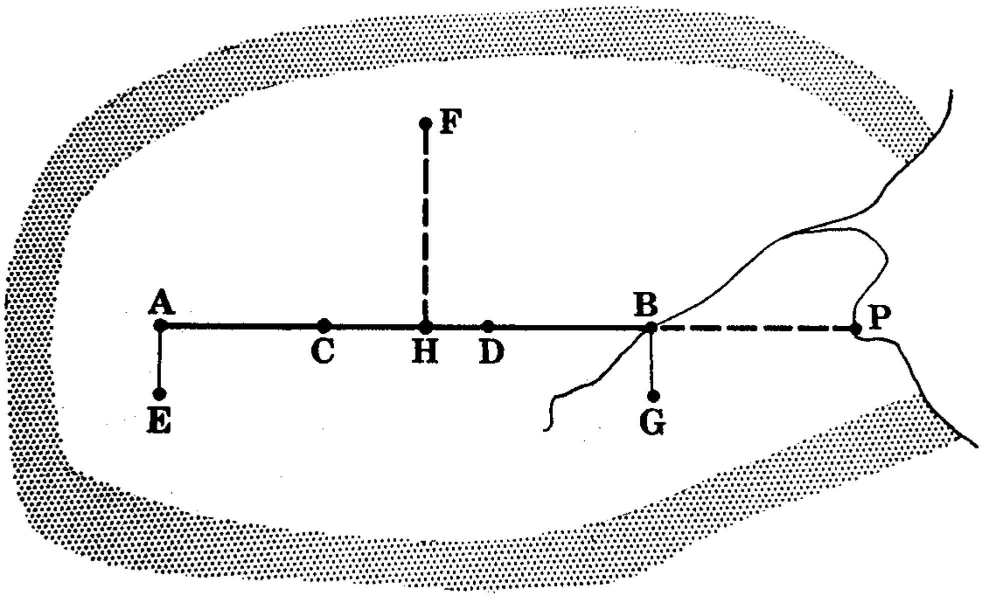
At geographic level it is worth mentioning at least three issues in which EO might innovate. At world level satellite data allow to improve the knowledge of the Earth Systems fostering the achievement of a global model of the Earth's socio-economic-environmental behaviour that might support the identification of a sustainable pattern of development. Similarly, at European level satellite data might, on the one hand, support the design and the implementation of environmental policies and, on the other hand, contribute to narrow spatial distances affecting the European economic networks, therefore facilitating the economic and political process of regional integration. Finally, at national level, the space economy might constitute an important driver of innovation and EO might narrow the urban-rural divides among metropolitan areas, intermediate peripheries and inner areas by improving the physical and digital communications and by innovating the process of territorial and environmental management.

Before facing more accurately each one of the issues discussed, we would like to remind the interesting and hypothetical stylized fact that can be considered at the foundation of modern regional sciences. In his seminal contribution to the regional sciences, Isard (1956) assumed that "economic evolution stems from the action of technologic man upon the elements of his physical environment" (p.1). Laying on this premise, he proposed to analyse how settlement takes place on an "area of varying topography and uneven resource content" initially "isolated from other areas because of the friction of physical distance" (p.2). After a long process of development characterized by several revolutionary and evolutionary phases, the region abandons the phase of isolation when a dominant port *P* emerges, and a diversified transport network evolves. Finally, the "urban-metropolitan region comes to comprise an hierarchy of strategic nodal sites, classifiable by order and degree of dominance", that "viewed from another angle" can be seen as "a network of transport interconnections and hence of interstitial areas subject to hierarchical order" (ibidem, p. 11).

After having illustrated the "birth" and the evolution of a hypothetical region, Isard poses several questions and suggests several theoretical approaches that might provide answers, but to our research descriptive issues are the most relevant: indeed, while the evolution of the ideal-typical region might have reached its final stage at the time when Isard was writing, nowadays at least an additional stage should be considered. Indeed, the rapid development of the space economy initiated during the second half of the XXth century has fostered a process of dematerialization and digitalization of the most advanced regional economies, alimenting the course of globalization. Industrial activities are now widely dispersed across the globe and the most advanced regions are characterized by a widespread production of high value-added services, usually supported by a bulk of innovation-led manufacturing activities. Globalization, therefore, determines at regional level a spatialization of the economic relations, fostering patterns of innovation based on increasing proximity (not necessarily

geographical, more often relational) among the actors involved. Not every region is able to follow spatial innovation patterns, and therefore some kind of between regional inequality is increasing. On the other hand, at regional level technological transfer is not always effective and innovation is often embodied only in market goods and services that result to be too expensive for a wide share of population, alimenting regional processes of social marginalization. Finally, at local level, several inner areas might suffer of scarce accessibility to the regional networks (as an example, following Isard, due to cultural inertia) and, due to increasing distance costs alimented by a process of peripheralization, territorial marginalization might follow an increasing (rather than decreasing) trend.

Figure 1. – Isard's "hypothetical region"



Source: Isard, 1956.

On the other hand, the augmented availability of low-cost resources in marginal areas might foster a process of decentralization of productive activities toward regional peripheries, rather than toward other regions, due to a mix of social proximity and reduced distance costs. Specifically, in the service sector several activities do not generate relevant distance costs (consider, as an example, the production of a software, the advent of digital manufacturing or, the process of implementation of EO services), therefore a process of regional decentralization might allow to gain the benefits of lower congestion and slower territorial dynamics. Without neglecting the opportunities offered by a touristic development, the latter might incentivize the implementation of long-run investments, as for example, those one characterizing the space sector. Therefore, a new industrial nucleus related to the service sector (say, S) might arise somewhere in the periphery, not necessarily close to the main transport infrastructures, generating a new territorial revolution and reshuffling urban ranks due to its high hierarchical relevance. Urban areas might lose their primate over rural suburbs and natural areas, and the new regional core might lose its urban concentration, becoming widely dispersed across the territory. The development of smart cities might be followed by the development of smart landscapes, and both might contribute to the creation of smart territories.

Clearly, this is a (partially) visionary framework that still needs to be confirmed by facts, but indeed this seems to be the revolution induced by progresses achieved in the space sector. In the next paragraphs, therefore, we try to introduce the space economy in the regional sciences literature.

2. A brief literature overview

To better understand the potential relevance of the space economy within the regional sciences it is useful summarize some aspects of the academic debate initiated after the Second World War on the spatial contents of the economic thought. As illustrated by Perroux (1950), a banal sense of space location might create “the illusion of the coincidence of political space with economic and human space”, as we define “the relations between different nations as consisting exclusively of men and things in one space […]. […] This central conception of ‘container’ and ‘contained’ is contradicted on all sides by modern life, especially in its economic aspects” (p.90). More attention, therefore, should be paid to economic spaces, i.e. spaces defined as economic plans, fields of forces and homogeneous aggregates (Perroux, 1950).

Concerning economic plans, the “complex spatial relations of an economy” could be represented in terms of “a simple common concept of distance inputs”, where distance inputs are “the movement of a unit of weight over a unit distance” (Isard, 1951, p.188). Therefore, it emerges the need of accounting for space preferences and to define a measure (the transport rate) of discounting over space (ibidem). With respect to distance inputs, Isard illustrates the existence of scale and substitution effects both in production and consumption activities. Indeed, while scale effects are well-known in economics, it is worth noting how specialization and the extent of production can be represented as a “substitution of distance inputs for various other inputs […], as well as a substitution of inputs in general at the favored sites for inputs in general at the disfavored sites” (ibidem, pp.195-196). Similarly, “[w]ith a fall in the time and money cost of population movement […], a person in general can maintain a given level of social contact (or space preference) and at the same time consume more of other products” (ibidem).

These considerations open a field of analysis “between space and time” (Harvey, 1990). Specifically, rather than being physiscal categories, “each social formation constructs objective conceptions of space and time sufficient unto its own needs and purposes of material and social reproduction and organizes its material practices in accordance with those conceptions” (ibidem, pp.418-419). Laying on this premise, Harvey notices how telecommunications “have altered space and time relations and forced us to new material practices as well as to new modes of representation of space” (ibidem). Indeed, “the experience of […] [time-space compression] forces all of us to adjust our notions of space and time and to rethink the prospects for social actions” (p.426). While Harvey focused his research on the social conflict between capitalism and post-modernism and between space and time, this research addresses a different instance.

Indeed, increasing distance costs toward social and territorial peripheries cause spatial (and temporal) inequalities, and therefore a need for actions aimed at creating opportunities for the disadvantaged and at fostering a higher degree of equal opportunities. In this collective effort, every social paradigm (capitalism, post-modernism, just to name a few quoted by Harvey) has its own role to play. In few recent contributions, Salustri and Viganò (Salustri, Viganò, 2017 and 2018; Salustri, 2019) identify the contribution that non-profit institutions might provide in marginalized and intermediate places to narrow territorial and social imbalances. In this research, instead, we focus on State’s role in “creating and shaping markets” (Mazzucato, 2015), as “the path-dependent direction that the market follows under ‘free-market’ conditions is problematic, particularly when the world is confronted with great societal challenges” (ibidem).

Following Mazzucato, “[w]hat should become more central in the policy debate is how to pick broadly defined directions, within which bottom-up experimentation can take place”, and “how to do so in a way that is democratically accountable and that solves the most pressing social and technological challenges” (ibidem). Furthermore, “public investments should aim […] to do things that are not even envisioned and therefore not done at all” (ibidem), therefore “[a] better way of evaluating a given investment would be to consider the different types of ‘spillovers’, including the creation of new skills and capabilities, and whether it led to the creation of new technologies, sectors and markets” (ibidem).

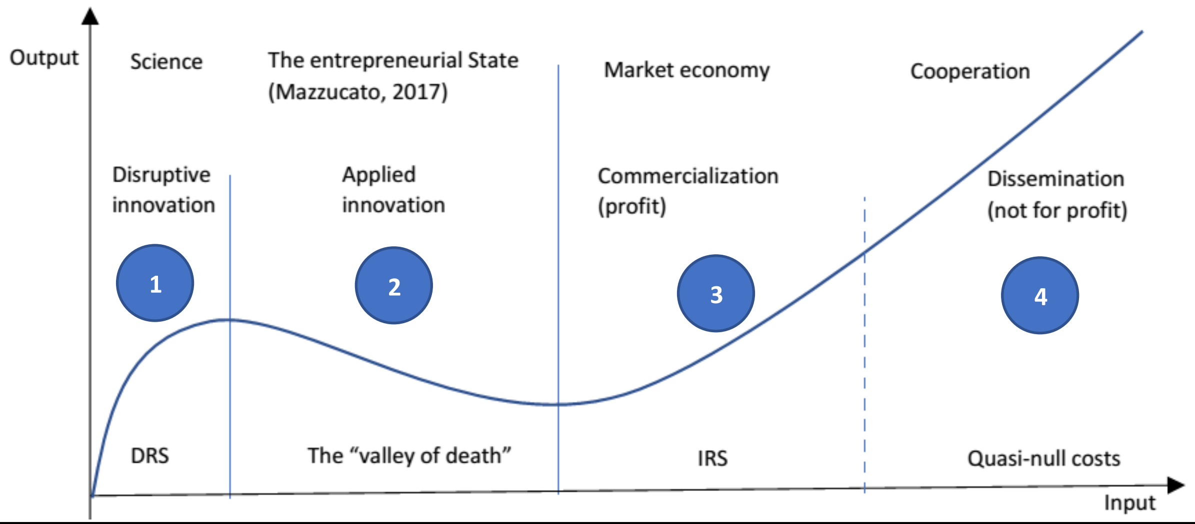
These issues can be easily applied to the space economy. Indeed, in the sector there is a need of State’s intervention aimed at creating and shaping markets to face great social challenges and to identify broadly defined directions in a way that is democratically accountable within which bottom-up experimentation can take place. This is exactly what happened with the adoption of the 2030 Agenda and the definition of the SDGs.

Furthermore, rather than being diminished by rise of the international society, the role of the State is of the utmost importance in implementing the 2030 Agenda both through "transformative public investments" and through regulation aimed at empowering private market and non-market actors (financial intermediaries, profit and non-profit enterprises, cooperatives, associations, individuals…).

Lying on these premises, it is worth noting how EO can play a key role in collecting (not only) environmental information at the global scale, providing a crucial contribution in achieving most of the Sustainable Development Goals, as widely documented by the Group on Earth Observations[4] (2017). Furthermore, the EO value chain requires the activation of several other sectors, within the space economy and more in general pertaining to the scientific domain, for the provision of highly innovative intermediate inputs as ground segment services, launchers, satellites, remote sensing tools, AI algorithms and digital platforms. Each of these inputs is able to generate technological spillovers in many other economic sectors of activity.

Finally, space innovation (and within it, EO-related innovation) seems to follow, as most other innovative sectors, a peculiar pattern of development characterized by initially decreasing returns to scale that, after the crossing of the so called "valley of death", become increasing. This trend can be interpreted either in an institutional perspective, either in terms of time to readiness of the innovation process. Concerning the former, the innovation process begins with a scientific activity that evolves at decreasing returns to scale, after which, as suggested in Mazzucato (2015), the role of the State is of the utmost importance in fostering through adequate investments the passage through the so called "valley of death", i.e. a phase in which returns to scale might be negative or null. After the crossing of the valley of death, innovation evolves at increasing returns to scale, creating a space of economic convenience in disseminating the innovation "embodied" in new products and services within the markets. Finally, increasing returns to scale might determine the achievement of quasi null costs, fostering a phase in which cooperation and solidarity contribute to disseminate the innovation on a wider scale.

Fig. 2 – Returns to scale of the space economy



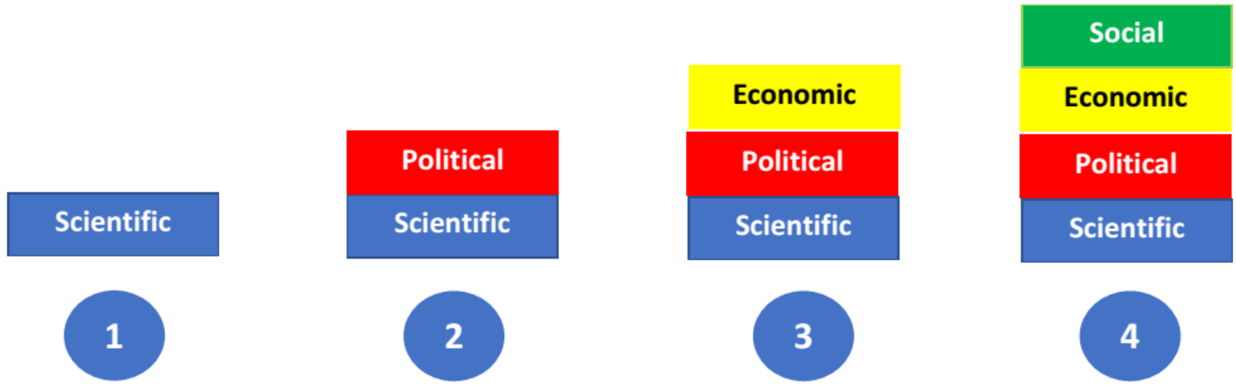
Source: our elaboration on OECD (2016).

It is worth noting how, in the evolution of the innovation process, the single stages are cumulative rather than substitutive, and that creates an incentive to reach the final stages of the process, as they contribute to

[4] "In adopting the 2030 Agenda for Sustainable Development, world leaders recognized the important role that Earth observations and geospatial information could play in making the whole framework feasible through the provision of essential evidence, including the tracking of Indicators over time, and supporting the implementation of solutions to reach specific Targets. Effective use of the information in Earth observations can have a transformational impact on many of humanity's most significant challenges, such as helping scientists globally, resource and planning managers and politicians better monitor and protect fragile ecosystems, ensure resilient infrastructure, manage climate risks, enhance food security, build more resilient cities, reduce poverty, and improve governance, among others" (GEO, 2017).

consolidate the previous ones either in terms of production activities, either in terms of benefits. Specifically, as illustrated in Figure 3, the initial stage of the innovation process mainly generates scientific benefits, the second adds political benefits, the third adds economic benefits and the fourth adds societal benefits. In a societal perspective, therefore, the most important gains are those achieved after that the innovation process has reached its maturity, i.e. with the consolidation of the commercialization phase.

Fig. 3 – The cumulative nature of space innovation benefits



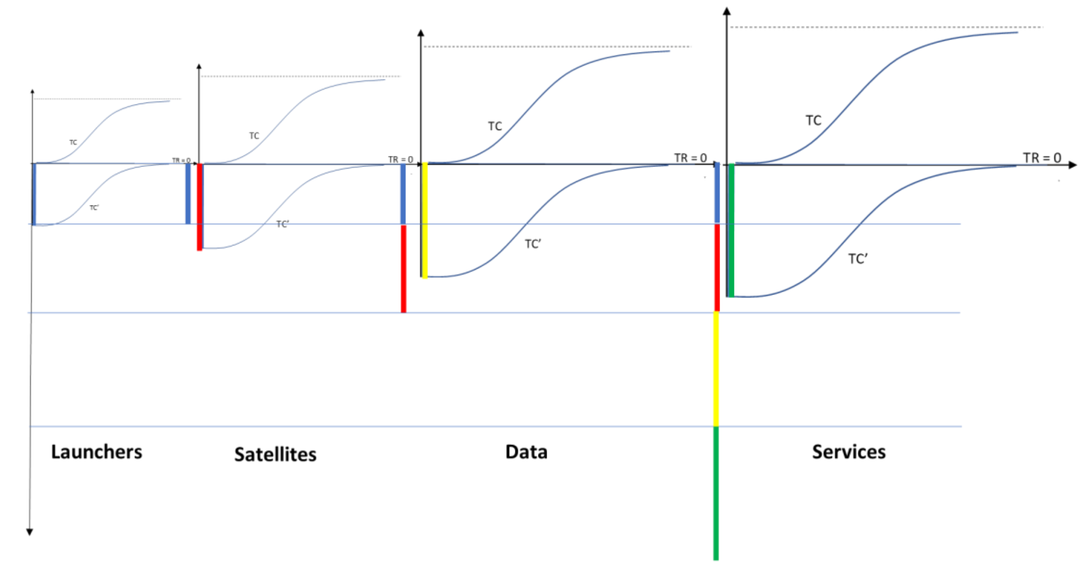
Source: our elaboration.

This is particularly evident with respect to the EO value chain, roughly involving at least four intermediate outputs: launchers, satellites and remote sensing tools, data collection and storage, production of EO-related services. Considering each stage as an independent production process, it is worth noting how the issues presented in Figure 2 imply that each stage follows a dynamic logistic cost function, i.e. that to make the innovation process achieve its final stage it is required a fixed cumulative budget (even if probably hard to estimate). This peculiar feature might allow the State to subsidize the upstream innovation processes by allocating a fixed budget, therefore facilitating the implementation of downstream innovation processes. Even if the sequence is not so deterministic in practice (as an example, the construction of satellites initiated well before the end of the innovation process concerning launchers; furthermore, the magnitude of budgets does not need to be incremental, as well as the length of the innovation process),

Figure 4 simply illustrates how, while upstream sectors become commodities and costs decrease, value added goes downstream in new and more applied businesses. Finally, the achievement of increasing returns to scale and the adoption of free and open policies "secure" the upstream at a fixed cost increasing its strategic relevance (consider, as an example, the effects open data sharing as illustrated in GEO, 2015). However, while moving downstream, value added becomes more widely dispersed, as the number of individuals achieving private benefits due to the innovation process increases, but the private benefits achieved by each individual on average are often of a lower magnitude. Therefore, the implementation of *ad hoc* information and communication technologies (ICTs) and social networks is of the utmost importance to interact with a wider (and less inclined to pay for the gains achieved due to increasing free riding opportunities) public of beneficiaries.

Lying on these premises, in the following paragraph we provide some general definitions and a historical and institutional picture of the space economy, and within it, of the EO value chain.

Figure 4 – the EO value chain



Source: our elaboration.

3. A general overview of the space economy: the state-of-art and a historical perspective

According to the OECD, the space economy can be defined as "the full range of activities and the use of resources that create and provide value and benefits to human beings in the course of exploring, understanding, managing and utilising space. Hence, it includes all public and private actors involved in developing, providing and using space-related products and services, ranging from research and development, the manufacture and use of space infrastructure (ground stations, launch vehicles and satellites) to space enabled applications (navigation equipment, satellite phones, meteorological services, ecc.) and the scientific knowledge generated by such activities" (OECD, 2012). Several classifications of the activities that might be included within the space industry have been proposed, and to the purpose of this research the most appropriate seems to be that one adopted in the Catalogue of the Italian Space Industry (ITA-ASI, 2019), that considers seven application domains:

- Earth observation systems;
- Satellite navigation systems;
- Telecommunication systems;
- Space transportation, launch and re-entry systems;
- Human exploration, space station, capsule manned;
- Integrated applications and services, security;
- Observing the Universe, science and robotic exploration.

Notwithstanding the relative stability of its structure, the space economy is continuously evolving due to several streams of innovation[5], and it appears now "to be on the verge of a new cycle of its development […] characterised by the ever-growing uses of satellite infrastructure outputs (signals, data) to meet societal challenges, like helping bridge the digital divide and contributing to mitigate climate change with global satellite monitoring"[6]. Clearly, the OECD Space Forum alludes to the wide field of opportunities opened by the rapid development of most of the space activities that can be classified under the wide umbrella of Telecommunications and Earth Observation (EO) and their potential to pull additional innovations within both

[5] Specifically, the OECD Space Forum recognizes the relevance of three drivers of innovation: the persistence and inclusiveness of national security and science objectives; the expansion of downstream innovations and the pursuit of human space exploration

[6] (ibidem).

the space economy itself (i.e. in the satellites and launchers sectors) and several other sectors of economic activity (i.e. Big Data analytics, AI, digital platforms…). Furthermore, Telecommunications and EO are also able to "push" innovation in most sectors of economic activity, and several examples are illustrated in the already mentioned Wiki EO Portal maintained by EARSC and in the Report "*The ever growing use of Copernicus across Europe's Regions. A selection of 99 user stories by local and regional authorities*" (EC, NEREUS, ESA, 2019). In brief, the impact of the space economy on society goes far beyond the space sector itself, as it includes consistent surpluses and pervasive spillovers on several economic sectors of activity, and a strategic relevance in addressing the most pressing societal challenges, especially when considering topics of environmental and territorial nature.

To the purpose of this research, we do not analyse more in depth the Telecommunications domain and we focus on the analysis of EO, due to its relevance in the implementation of the 2030 Agenda. According to European Commission, "the term 'Earth observations' refers to measurements of variables related to the various components of the system Earth (e.g. oceans, land surface, solid Earth, biosphere, cryosphere, atmosphere and ionosphere) and their interactions. These measurements are obtained by individual or combined, fixed or mobile sensing elements, being instruments or human observers, either in situ or through remote sensing" (EC, 2014). This operational definition of EOs introduces the distinction between "in situ observation" and "remote sensing", where the former are "observations captured locally, i.e. within few kilometres of the object or phenomenon being observed", while the latter "encompasses observations made at a larger distance" and refers typically to "space-borne Earth Observations" (ibidem).

Due to the focus on the space economy, in this paper by EO we mean space-borne EO, but this epistemological reductionism should not lead to overlook that EO is indeed a widely articulated domain, including also ground-based, airborne and seaborne observations, but also other sources of data (models and simulators, drones, internet objects, personal mobile devices, social media). Therefore, when assessing the impact of space-borne EO on society, only incremental benefits and costs should be considered with respect to the other available source of Earth Observations. Lying on these premises, and before analysing more in detail the Italian space economy, it is worth summarizing several historical issues, mainly concerning the development of the world and European space economy, that might allow to better interpret the findings illustrated in the following paragraph.

3.1. The space history in a European perspective

The early history of space research has been illustrated by Krige and Russo in a two-volumes contribution published in 2000. Following a European perspective, in the first volume they narrate all the milestones leading to the foundation of the European Space Agency (ESA) and of its precursors (ESRO and ELDO), illustrating the geopolitical, economic and technological reasons laying at the foundations of European countries decisions. ESA's history is framed within the international evolution of the space race, and the overlay of international, European and national issues provides an interesting analytical perspective on the space economy.

At the beginning of the space race, Krige and Russo place the work of pioneers in Russia, in Germany and in the USA that inspired, between the two World Wars, the formation of a number of rocket societies, that, however, were not able to sustain viable programmes of research and development in this sector, as the military, instead, did during the Second World War. After the end of the war, both the USA and the Soviet Union undertook major initiatives that gave rise to a new era in missile development: while becoming obsolete as weapons, inter-continental and intermediate-range ballistic missiles became an efficient and diversified family of boosters for launching military and civil satellites (Krige and Russo, 2000).

During Fifties, the Soviet Union was considerably ahead the USA in the deployment of rockets and led the space race for almost a decade. To narrow the gap, in January 1958 the USA instituted the Advanced Research Projects Agency (ARPA) (see also Mazzucato, 2015) within the Department of Defense, and few months later the already existing National Advisory Committee on Aeronautics (NACA) was turned in the National Aeronautics and Space Administration (NASA) to take over all aspects of the American space programme except those having direct military applications (Krige and Russo, 2000).

At the beginning of Sixties, also some of the major European countries (UK, France and Italy) entered the space age. By 1960, the UK agreed a cooperative programme with NASA consisting in the launch of three satellites with UK instruments on board. On 1965 France placed the first satellite in orbit, becoming the third space power, even if in 1964 Italy had already placed in orbit the satellite San Marco-1 in partnership with NASA. In 1961, the European industry created Eurospace, an international institution gathering all the leading companies in aircraft and missile manufacture with the aim of promoting the development of aerospace activities in Western Europe. Almost in the same period, several initiatives were undertaken for pooling European resources in a collaborative effort in space to narrow the gap with the USA and the Soviet Union, and they led to the creation of ESRO and ELDO (ibidem).

Since the beginning, NASA and ESRO joint their effort in space research, but cooperation was clearly asymmetric due to the different amount of resources held, and ESRO was often in a weak position when negotiating the use of NASA's facilities. Specifically, European "independence" was impossible without of powerful European launcher (ibidem). Furthermore, in the mid-1960s, the space industry became "a domain of commercial and social importance" (ibidem), due the possibility of using it for a variety of purposes (including telecommunications, meteorology, navigation…) and therefore ELDO, due to its industrial nature, grew of importance. Unfortunately, the history of ELDO in the 1960s was one of "technological failure, cost overruns and political dispute" (ibidem).

At the beginning of Seventies, ESRO's Member States committed themselves to the development of applications satellites in the fields of telecommunications, aeronautical navigation, and meteorology, along with a mandatory space programme, and in 1973 the Ariane and Spacelab projects were agreed. Few years later, in 1975, the ESA Convention was signed by ten European states[7], and ESA formally came into being at the end of 1980. After an initial period characterized by the implementation of previously agreed programmes, during Eighties a new long-term plan was adopted, including the decision to develop Ariane-5 and to participate in the International Space Station. In the meanwhile, space activities had shifted from science towards applications of satellites and space transportation systems (ibidem), as for example, Earth Observation and telecommunications.

The second volume written by Krige and Russo illustrates the development in all sectors of space activities. Due to the limited purpose of our research and to the relevance that this sector of space research had at European level, we instead focus only on EO development.

3.2. Earth Observation in Europe

During Seventies space-borne Earth Observation grew of importance due to several technological innovations introduced in its value chain and due to an increased capability of developing and managing integrated models of the Earth system. During Eighties, the reports on "Global Change: Impacts on Habitability" (Goody, 1982) and on "Earth System Science Overview: A Program for Global Change" (NASA Advisory Council Earth System Sciences Committee, 1986) gave birth to the NASA Earth Observing System (EOS) programme (Simmons *et al*., 2016). During the same years, ESA published the report "Looking down, looking forward" (ESA SP-1073, 1985), defining a vision for Earth sciences and applications that led to the adoption of the Living Planet programme (ibidem). In 1986, the European Organisation for the Exploitation of Meteorological satellites (EUMETSAT) was established to run operational meteorological satellite systems. Since 2001, EUMETSAT contributes to the operational monitoring of climate and detection of global climatic change (ibidem).

At the end of Nineties, several institutions within the European Union committed themselves to improve space-borne Earth Observations to contribute on global environmental monitoring, and this process led in 2001 to the establishment of the Global Monitoring for Environment and Security (GMES) programme, formerly renamed Copernicus. Copernicus complemented and substantially extended the EO programmes established in support of weather forecasting and related climate monitoring, and, nowadays, it implements EO on an

[7] The ten European States were Belgium, Denmark, France, Germany, Italy, The Netherlands, Spain, Sweden, Switzerland, and the United Kingdom. Ireland signed the text few months later. Canada became a Cooperating State in 1978, while Austria signed an Association Agreement with ESA in 1979. Norway was involved as Observer.

operational basis supplying atmospheric, land and marine services, and cross-cutting services including one on climate change (ibidem).

Nowadays, many national and international space agencies operate time-limited research missions for several purposes (short-term measurement of quantities not covered by the operational programmes, understanding processes and enhancing modelling, development and demonstration of new capabilities…), and the CEOS virtual constellations provide an organisational framework to coordinate all these activities. Specifically, CEOS maintains an on-line "Mission, Instruments and Measurements" data base, which provides information gathered from its members. This initiative, and other with similar purposes, are of the utmost importance, as currently no single nation or region of the world might develop and operate a full Earth observing system (ibidem). Lying on these considerations, in 2003 the Group on Earth Observations (GEO) was established. The latter is an ad hoc intergovernmental group of more than a hundred countries and the European Commission plus more than a hundred Participating Organisations envisioning a future where common decisions and actions are informed by coordinated, comprehensive and sustained Earth observations. GEO is creating the Global Earth Observation System of Systems (GEOSS) to better integrate observing systems and share data by connecting existing infrastructures using common standards[8]. Its activities are organised into eight societal benefit areas (SBAs) where EO plays a key role in decision making.

3.3. ESA recent history

The ESA web Portal[9] provides a brief excursus of ESA recent history, characterized by the progressive deepening of EU/ESA cooperation under the Framework Agreement which entered into force in May 2004. Under this agreement the European Commission and ESA coordinate their actions through the Joint Secretariat. The Member States of the two organisations meet at ministerial level in the Space Council, a meeting of the EU and ESA Councils. Finally, "ESA maintains a liaison office in Brussels to facilitate relations with the European institutions"[10].

Within this general institutional framework, in 2007 the Space Council adopted the European Space Policy, unifying the approach of ESA with those of the European Union and their member states. Specifically, the "European Space Policy sets out a basic vision and strategy for the space sector and addresses issues such as security and defence, access to space and exploration" [11]. Furthermore, "following the entry into force of the Lisbon Treaty in December 2009, the European Union has an explicit competence in space which calls for the development of a European space programme to entail further cooperation between the EU and ESA"[12].

Finally, the Europe's Space Strategy approved in 2016 delivers a range of actions which allow Europeans to fully seize the benefits offered by space, create the right ecosystem for space start-ups to grow, promote Europe's leadership in space and increase its share on the world space markets. Moreover, the new strategy intends to encourage the commercial use of space data by the public and private sectors. Through the European Defence Action Plan, the Commission also launched a GovSatCom initiative to ensure reliable, secured and cost-effective satellite communication services for EU and national public authorities[13].

4. A focus on Italy

In this paragraph we try to illustrate some specific features of the Italian space economy and its international relevance within the space sector. Indeed, Italy has an outstanding record in space research, as it has been the third country in the world to launch and operate a satellite (the "San Marco 1", see paragraph 3) and it has been among the founding members of the European Space Agency (ESA), of which nowadays is considered the

[8] https://www.earthobservations.org/geo_community.php
[9] https://www.esa.int/About_Us/Welcome_to_ESA/ESA_and_the_EU
[10] Ibidem.
[11] https://www.esa.int/About_Us/Welcome_to_ESA/European_Space_Policy
[12] https://www.esa.int/About_Us/Welcome_to_ESA/ESA_and_the_EU
[13] https://www.researchitaly.it/en/projects/new-space-policy-for-europe/

third major contributor. Furthermore, nowadays Italy is one of the few countries in the world having a complete value chain of products and services in the space sector.

Since 1988, the Italian government is supported in its space policy by the Italian Space Agency, whose purpose is to coordinate all of Italy's efforts and investments in the space sector that had begun in the 1960s. Nowadays, ASI is one of the most significant players in space science both at European and international level. At European level ASI has a key role, as Italy is the third contributor to the European Space Agency, while at international level ASI is directly involved with NASA.

As indicated in the ASI's statute, ASI's mission is to promote, develop and disseminate, with the role of agency, the scientific and technological research applied to the field of space and aerospace and the development of innovative services, by pursuing objectives of excellence, coordinating and managing national projects and Italy's participation in European and international projects, in the framework of coordination of international relations by the Ministry of Foreign Affairs, while improving the competitiveness of the Italian industrial sector.

To achieve its mission, consistently with the national research programme (NRP) and in the context of the international space programmes, the agency prepares a ten-year Strategic Vision Document (SVD). The SVD is broken down into strategic goals, strategic areas, strategies and objectives. The strategic goals reflect the broader needs and the long-term vision that the agency needs to consider in order to fulfil its mission. The achievement of the strategic goals can be obtained/reached through missions, programmes and initiatives that concern various Strategic Areas. For every strategic area, the reference framework of national capabilities and potential is defined, both in terms of responsibilities and results already achieved and of developments being studied or implemented. The Strategies define ASI's initiatives for fulfilling the strategic goals, indicating the direction in which ASI will operate in order to achieve the mission and the strategic goals. Furthermore, the strategies are broken down into objectives, which are the basis of the Three-year Activity Plan (TAP) and the Integrated Performance Plan (IPP), an annual operational planning tool that, also by defining an appropriate metric, aims to measure and assess the Agency's management performance.

In coherence with this general framework, it is worth noting how, in 2015, the Italian government has adopted the National Strategic Plan for Space Economy, allocating a national budget of about 4.7 billion euro for investing in the space sector, half of which financed with additional national and regional public funds and half with ordinary resources. The Plan aimed at integrating the territorial development policies and the space policy within the National Strategy of Smart Specialization, based on a unique and integrated value chain, from research to production. The National Strategic Plan expects the Space Economy to enabling an economic cycle characterized by a positive feedback loop based on the widespread diffusion within the economic system of innovative services. To this purpose, the Plan recognizes how both the supply and demand side are important, and the user uptake (i.e., the active involvement of users in the service design and implementation phase) is considered of the utmost importance[14].

The Plan is articulated in five (initially, six) sectors of activity and it is now partially merged in the Italian National Operative Plan on Enterprises and Competitiveness 2014-2020[15]. Currently, to the best of our knowledge only one Detailed Operative Programme (POD) out of the five initially expected has been deliberated by the Surveillance Committee instituted by MISE concerning the programme *MirrorGovSatCom* (see also 3.3.). Within this general framework, the EO domain is included in the programme for Copernicus support (so called *mirror Copernicus*). Indeed, Italy has contributed to Copernicus' upstream sector by financing all mandatory and several optional programmes and many Italian companies have obtained important industrial commitments. Furthermore, Italy participates to the Copernicus Upstream toward the Copernicus contributing mission (CCM) involving the satellite constellation Cosmo Sky-Med. Second, the Italian Copernicus component includes the national collaborative ground segment coordinated by the Italian Space Agency (ASI), that must distribute data to the national community through a mirror archive and, if possible, generate and redistribute near-real time data directly acquired. Indeed, through the Space Centre for Earth

[14] In brief, the plan adopts a strategy coherent with Mazzucato's vision of the State's entrepreneurial role and of a forward looking and participated knowledge and innovation system.

[15] https://ec.europa.eu/regional_policy/en/atlas/programmes/2014-2020/italy/2014it16rfop003

Observation, ASI is expected to deliver data and services in the whole Mediterranean area, providing support during emergencies through both real-time and historical data. Furthermore, at national level the collaborative ground segment is an opportunity for both public institutions and the service industry, and ASI might incentivize the production of new EO services. Moreover, Italy participated in the Copernicus Service Component by financing several programmes and many Italian companies have obtained important industrial commitments, but the Italian positioning is still too focused on the institutional core services. Also, Italy is involved in the development and implementation of Copernicus downstream services, where several European and national funds opportunities are active. Finally, Italy is involved in Copernicus in situ Component through ISPRA and several national partners, but a misalignment between Copernicus data and the INSPIRE directive has created some difficulties in the process of data collection.

4.1. The Italian institutional heritage in the space sector

Due to its longstanding involvement in space research, Italy currently hosts a number of national and international institutions involved this sector and several activities related to the most important research institutions in Environmental Sciences.

The most important national institutions involved in the space economy are:

- the "Piero Fanti" Space Centre located at Fucino (Abruzzo), hosting the Galileo Control Centre (GCC);
- the ASI Centre of Space Geodesy and the ASI Space Centre for Earth Observation, both located in Matera (Basilicata);
- the Italian Aerospace Research Centre (CIRA), located in Capua (Campania);
- the "Luigi Broglio" ASI Space Centre located at Malindi (Kenya) and managed by the University of Rome "La Sapienza" through the Research Centre of the San Marco Project (CRSPM).

The most important international institutions located in Italy are, instead:

- ESRIN (the ESA Centre for Earth Observation), located near Rome in Frascati, and
- the European Commission Joint Research Centre (JRC), located at Ispra (Varese).

The history of ESRIN deserves further analysis. Going back to the European space history, it is worth noting how, during the negotiations for the foundation of ESRO, Italy asked to establish a laboratory in its territory, and the Council approved the foundation of ESLAR, a laboratory for advanced research, later renamed ESRIN. Specifically, its function was "to undertake laboratory and theoretical research in the basic physics and chemistry necessary to the understanding of past and the planning of future experiments in space". Therefore, a small team was installed in temporary accommodation in the Park hotel near Frascati (Rome), and quickly arranged a first conference on plasma physics (the characteristics of a plasma most nearly corresponding, on a laboratory scale, to those of space) (Krige, Russo, 2000). It took some time to find a permanent site for ESRIN, but finally the cornerstone of the new building was laid in 1968.

In 1971, it was realised that the scientific work made at ESRIN was not directly related to the ESRO operational programme, therefore the Council decided to terminate the ongoing scientific activities. However, the Italian delegation refused to accept ESRIN's liquidation, and, at the end of a negotiation, accepted to close the laboratory in exchange for the relocation in ESRIN of the Documentation Service and of a new computer and a software group (ibidem). In 1975[16], the SDS on-line database became one of the world's largest, and all data acquisition and data entry was centralised at Frascati. In 1976, considerable progress was made on the definition of the Earthnet programme, aimed at providing European users with imagery generated by NASA remote-sensing satellites and at promoting the use of such data for research and application purposes. In 1981, ESRIN's activities had significantly expanded, therefore it became possible to consider it as a support Establishment rather than as a basic activity. By 1986, it became largely accepted that ESRIN should in future play an important role in payload data handling, using its expertise acquired in many years of data processing activities.

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[16] Data on the history of ESRIN has been found on the ESA Annual Reports Archive, available at https://www.esa.int/About_Us/ESA_Publications/ESA_Publications_Annual_Report/(archive)/0

At the beginning of Nineties, core innovations were experienced especially in the field of EO. With the launch of the ERS-1 satellite in 1991 for the first time ESRIN supported ground facilities during the operational phase of a satellite. In 1992, two new departments were created, one covering Exploitation, and the other concerning Projects & Engineering, while 1993 saw the operational success of the Processing and Archiving Facilities. During the same year, ESRIN consolidated its position as "The gateway to Earth Observation from space". With the successful launch of ERS-2 in April 1995, the continuation of the Agency's Earth Observation Programme and ESRIN's supporting activities were assured.

The usage of ERS-based information in pre-operational applications increased during 1996, and most of the facilities of the ERS Ground Segment were modified and upgraded to manage the higher data and service requirements and, where applicable, to handle data from the new sensors. Commercial exploitation via the ERS industrial data consortium showed a steady growth, and ESRIN became very active in enhancing the awareness of existing and potential users of today's capabilities for exploiting EO data. In 1999 ESRIN acquired the Integrated Project Team managing the Vega Small Launcher Development Programme, and its presence introduced a completely new set of activities, including specialist project reviews and regular progress meetings with European industry.

Following a re-organisation of the Directorate of Earth Observation Programmes, in 2001 two EO Departments were established at ESRIN: the Science and Applications Department and the Ground Segment Department. In addition to operation and exploitation of the ERS and third-party missions, these Departments were now also responsible for Envisat mission operations and services. The ESA ground segments were extended to include new missions such as Alos, CryoSat, and GOCE. The International Charter for Space and Major Disasters and the programme for Global Monitoring for Environment and Security (GMES) complemented the EO programmes. In 2004, the arrival of the new Director of Earth Observation Programmes and Head of ESRIN gave new impetus to the establishment and, at the beginning of 2005, ESRIN was ESA's leading centre for Earth Observation. In the same year, the ESRIN Satellite Multimedia Infrastructure responded to a number of requests for support from external institutional and commercial users, such as the French and Italian Civil Protection Authorities.

In 2009, ESRIN's core role as payload operations centre for ESA's Earth Observation missions was strengthened and extended by the start of the operational exploitation phases of the first three Earth Explorers (GOCE, SMOS e CryoSat-2). In the GMES programme, work continued on preparing ground segment operations for several of the satellites in the upcoming Sentinel suite, and on further Earth Explorer missions (swarm planned for 2012 and ADM-Aeolus in 2014). Science and application development were pursued further on site, as was management of the International Charter Space and Major Disasters. Sentinel-1, -2 and -3 procurement activities in the area of Ground Segment, Processing and archiving Facilities and Network were completed in 2013.

In 2011, VEGA's maiden flight successfully took place, and soon the VERTA programme developed new launches. The first of the VERTA flexibility demonstration flights carrying the ESA mission Proba-V successfully took place on 2013. At the end of the year, a contract was signed between the commercial operator Arianespace and the launcher prime contractor ELV for the procurement of a batch of 10 launchers to be launched between 2015 and 2018. Finally, the ESA SSA NEO Coordination Centre was opened on 22 May 2013 at ESRIN. This centre is the central access point to a network of European NEO data sources and information providers. It will also support the scientific research needed to improve NEO warning services globally.

5. Concluding remarks

Since the second half of the XXth century, the space economy has fostered a process of dematerialization and digitalization of economic activities, alimenting the course of globalization. Globalization is determining at regional level a spatialization of the economic relations, fostering patterns of innovation based on the increasing proximity among the actors involved. On the other hand, however, some kind of between and within regional inequality is increasing, as well as a process of territorial polarization. Indeed, few regions are able to

follow the spatial patterns of innovation, and a wide share of population is excluded from access to the innovations embodied in market goods and services. Finally, at local level, several inner areas suffer of scarce accessibility to the regional networks.

In this scenario, the augmented availability of low-cost resources in peripheral areas might foster a process of decentralization of productive activities toward regional peripheries, and a process of regional decentralization might allow to gain the benefits of lower congestion and slower territorial dynamics. The latter might incentivize the implementation of long-run investments, as for example, those one characterizing the space sector, and urban areas might lose their primate over rural suburbs and natural areas.

In brief, the impact of the space economy on society goes far beyond the space sector itself, as it includes consistent surpluses and pervasive spillovers on several economic sectors of activity, and a strategic relevance in addressing the most pressing societal challenges, especially when considering topics of environmental and territorial nature. To the purpose of this research, among the application domains we have focused on the analysis of EO, due to its relevance in the implementation of the 2030 Agenda.

During Seventies space-borne Earth Observation grew of importance due to several technological innovations introduced in its value chain and due to an increased capability of developing and managing integrated models of the Earth system. During Eighties, the NASA Earth Observing System (EOS) programme was established, as well as the Living Planet programme and the European Organisation for the Exploitation of Meteorological satellites (EUMETSAT). Finally, at the end of Nineties, several institutions within the European Union committed themselves to improve space-borne Earth Observations to contribute on global environmental monitoring, and in 2001 the Global Monitoring for Environment and Security (GMES) programme, formerly renamed Copernicus, was established. Nowadays, CEOS virtual constellations provide an organisational framework to coordinate all the missions operated by many national and international space agencies. Furthermore, the Group on Earth Observations (GEO), established in 2003, is creating the Global Earth Observation System of Systems (GEOSS).

Going back to the analysis of the space economy, it is worth noting how, at European level, in 2007 the Space Council adopted the European Space Policy, unifying the approach of ESA with those of the European Union and their member states. Furthermore, the Lisbon Treaty (entered into force in 2009) provides the European Union with an explicit competence in space. Finally, in 2016 the Europe’s Space Strategy was approved and, through the European Defence Action Plan, the European Commission launched the GovSatCom initiative.

At national level, instead, it is worth noting how, since 1988, ASI has been supporting the Italian government in its space policy, especially in its relations with ESA and NASA. To achieve its mission, ASI prepares a ten-year Strategic Vision Document (SVD), and, in coherence with this general framework, in 2015 the Italian government has adopted the National Strategic Plan for Space Economy, allocating a national budget of about 4.7 billion euro for investing in the space sector. Within this general framework, the EO domain is included in the programme for Copernicus support (so called mirror Copernicus).

Finally, Italy currently hosts a number of national and international institutions involved in space research, and the most important international institution located in Italy is ESRIN (the ESA Centre for Earth Observation), located near Rome in Frascati. ESRIN has consolidated its position as “The gateway to Earth Observation from space” during Nineties, and, in, has acquired the Integrated Project Team managing the Vega Small Launcher Development Programme. In 2004, the new Director of Earth Observation Programmes and Head of ESRIN gave new impetus to the establishment and, at the beginning of 2005, ESRIN became ESA’s leading centre for Earth Observation. In 2011, VEGA’s maiden flight successfully took place, and in 2013 ESRIN acquired the ESA SSA NEO Coordination Centre.

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