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An Investigation of Turkiye's Space Activities in the Context of Technological Capabilities and Mission-Oriented Tasks

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ABSTRACT

This paper aims to focus on Turkiye's space-related activities, considering the basic pillars and dimensions covered by space activities in the 21st century. Given the structural characteristics of the space economy, the capacity of Turkiye's space activities to involve in global space activities would be investigated. In doing so, this paper suggests that Turkiye's space-related efforts could be worked through with the dynamics of the "space 4.0" stage and a series of institutional changes and strategies accordingly. The paper will be based on the opinion that such tasks contain phenomena that pose grand societal challenges. For this reason, to overcome these challenges, both a long-term perspective and many different disciplines must work together. Given that, the main framework of the mission-oriented tasks could be evaluated for Turkiye's space vision. It would be asserted that mission-oriented tasks related to space-related activities need to consider the technological capacity and the decisiveness of actors that would be involved in these activities. Hence, the technological capacity and the entrepreneurial state approaches to contextualise mission-oriented policies for space-related activities would be utilised. In this context, the decisiveness of the role to be played by the state would be evaluated. It would be concluded that for the purpose of creating new technologies and sectors, the technological capacity approach would be functional in setting up science, technology, and industrial policies related to space-related activities.

Keywords: Technological capacity, The entrepreneurial state, Mission-oriented projects and space economy, Turkiye's space activities

Jel Codes: O3, O5, O32

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1. Introduction

Turkiye's national agency related to aerospace, TSA (Turkiye's Space Agency), was formally founded in 2018. Before that, the story of space-related activities dates back to the 1990s, led by TUBITAK[1] (TUBITAKUZAY, 2007). Moreover, several institutional reforms have been defined at the ministerial level (Ministry of Transportation, Defense, Industry, and Technology) (Özalp, 2009: 225). All these initiatives signify that Turkiye could be included in the list of the new candidate countries that have joined space activities in the 2000s.

Beginning from Turkiye's ninth Development Plan (2007-2013), aviation and space-related economic activities have been classified among the priorities of national development plans. This approach stands out as a part of the importance given to the target of being "national" and increasing the ratio of domestic production and priorities given to innovation-driven strategies. In the context of Science, Technology, and Industry (STI) policies, aviation and space-related activities are classified among the priority sectors connected with the defence industries (11th Development Plan, 2019). It is suggested that a road map should be prepared to increase the possibilities and capabilities and to create the necessary infrastructure for the domestic supply of the materials needed by all sectors (aerospace, aviation, automotive, etc.). Recently at the 11th Development Plan of Turkiye (2019-2023), the main purpose of space-related activities is defined under three main titles as, "i) The National Space Program will be prepared and put in place, ii) The institutional capability of the Turkish Space Agency will be improved, and iii) strengthening the position of Turkiye in the global competition will be provided" (11th Development Plan, 2019: 107).

Briefly, these institutional and political shifts related to Turkiye's space activities point out Turkiye's commitment to space activities. Space activities carried out by countries in the 21st century could be analysed within the scope of "space 4.0" dynamics (Robinson & Mazzucato, 2018). Given the structural characteristics of the space economy, owning high technology and research and development (R&D) content, the capacity of Turkiye's space activities needs to be investigated. To the best of our knowledge, Özalp (2009) and Dede & Akcay (2014) aimed to outline the vision of Turkish space-related activities. Özalp (2009) focused on the national space research program of TUBITAK, considering capacity and capabilities, budgeting, and investment targets in the formation of science, technology, and R&D policies. Dede and Akcay (2014) set up a SWOT (strengths, opportunities, risks, and threats) analysis of Turkiye's space activities that provide a comprehensive framework for the space vision.

This paper suggests that Turkiye's space-related efforts could be worked through with the dynamics of the "space 4.0" stage and a series of institutional changes and strategies accordingly. Given the structural characteristics of the space economy, the capacity of Turkish space activities to involve in global space activities should be investigated in detail. The paper is based on the opinion that space-related activities contain phenomena that pose grand societal challenges (Nelson, 2011) and take into account the decisiveness of the role to be played by the state (Mazzucato, 2013; 2018). Grand societal challenges are defined as permanent social problems related to other problems that require complex, urgent solutions and require different

1 In 1993 The Supreme Council of Science and Technology has chosen space technologies as one of the priority areas. The initiatives led by TUBITAK and "Space Technologies Research Institute" TUBITAKUZAY was founded in 2006. (TUBITAKUZAY, 2007).

disciplines to act together for solutions that affect large segments of society (Mazzucato, 2018). For this reason, to solve these problems, both a long-term perspective and many different disciplines must work together. These conditions make institutional change as necessary as rapid technological change and can force economies toward structural transformation in a certain direction. In this respect, economies need to realise “mission-oriented” tasks to solve great societal challenges. “Mission-oriented” tasks are evaluated together with the entrepreneurial state approach (Mazzucato, 2018). This approach gives the importance of establishing public institutions that play a role in the creation of new technologies and emphasise sectors. The technology capacity approach (Lall, 1992; 1993) and the definition of public institutions’ roles are the basis of mission-oriented policies.

In the following chapters, an outline of the space economy will be summarised, considering the basic pillars and dimensions covered by space activities. Following that, Turkiye’s space activities will be examined based on specific characteristics. In doing so, the paper aims to include the technological capacity and entrepreneurial state approaches in order to contextualiseg mission-oriented policies for space-related activities.

2. The Scope and Basic Characteristics of the Space Economy

Although space exploration is commonly known as a by-product of the Cold War competition between the USA and the USSR, its origin dates back to the military built up for WW2 and began with the development of rockets by Nazi Germany (Devezas et al., 2012: 967). Since then, the space wars have been defined as a part of geopolitical concerns. Guffarth and Barber (2017 cited by Eiriz Gervás, 2021: 39) state that the actors and used technology in the aerospace, civil aeronautics, military aeronautics, and space industries overlap, and they mutually influence each other.[2] These activities have also triggered debates on the purpose of public goods’ creation in space-related sectors. Besides this, the improvements in space exploration cover a process related to the improvements in the defence sector. These origins for strategic (political) and military purposes also mean significant public provisions to high technology and R&D content and a high level of spending in governments’ budgets. Moreover, the role of governments in this field has been important in the creation of science, technology, and innovation policies that also strengthen the foundations of innovation and knowledge led growth patterns.

Beginning from the “space wars,” the understanding of space-related activities has changed over time. The definition and scope of space exploration and its use have different contents depending on the shifts in the international relations and economic structure of space activities. Today the space economy is used as an “umbrella term” that is linked with space-related industries, and even this term captures more complex dimensions. The most common definition of space economy is being developed by the OECD.[3] According to the OECD report (2007: 17), the space economy is defined as;

> “All public and private actors are involved in developing and providing space-enabled products and services. It comprises a long value-added chain, starting with research and development actors and manufacturers of space hardware (e.g., launch vehicles, satellites, ground stations) and ending with the providers of space-enabled products (e.g., navigation equipment, satellite phones) and services (e.g., satellite-based

2 Space related activities are classified under the aeronautical sector in the NACE system.

3 1st space report of OECD was published in 2005. Even though definition of the space economy has changed in space related reports of the OECD.

> meteorological services or direct-to-home video services) to final users. In addition, scientific knowledge is generated by such activities."

Following this definition of the OECD, (2020: 5) the definition of space economy captures a broader approach to space activities such as;

> "The space economy is 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."

These definitions give information on the magnitude and the value creation related to space activities. "Space economy" could be defined as a sector that requires specialisation at the upper-level of technologies and the use of scientific knowledge that challenges the socio-economic structure of societies that have entered space exploration activities lately. The space economy also includes services and products in other fields connected to satellite technology and services such as agriculture, environmental protection, natural resources management, and transportation (OECD, 2020). It is suggested that space exploration can offer opportunities for education, knowledge production, and the strengthening of scientific infrastructure. Besides this, it can contribute to the innovation-driven policies and learning mechanisms of industries. The most commonly identified benefits of space activities include positive impacts on GDP through employment and revenue gains as well as diverse economic benefits (OECD, 2020).

The space market structure comprises of specific characteristics. The most defining feature of the space sector is its high intensity in research and development (R&D) and risks and costs of entry to the market. Entry into the space market is limited due to the risks and transaction costs. This market requires scale intensive and high levels of investments. Only a few firms dominate the world market so that under imperfect competition, the oligopolistic and monopolistic structure is strong. The risks could be classified as concerned with the timing and cost of projects and technical, market, and programmatic conditions. The rate of return of investments ranges from 5 to 20 years, which increases risks (Gurtuna, 2013). Reactions given to the problem of sharing the risks and costs determine the actors' roles in the determination of investment decisions.

The space market is closely linked with high technology content and a high level of human capital specialisation connected with innovation-led strategies (Gurtuna, 2013). The research and development cycles are high compared to other sectors. This sector requires a high level of specialisation and accumulation of knowledge. Hence, investments for research and development creation and STEM (Science, Technology, Engineering and Mathematics) education and the coordination and planning of these activities play an important role for sectors' development.

The fragmentation of production due to globalisation has also affected the market structure and production mechanisms of the space market. Today, value creation segments also define firms' and countries' places in the space economy. Rather than horizontal integration, vertical integration of the sectors in value creation is found to be more detrimental.

Space value segments comprise three main bodies: space infrastructure, ground stations, and launch vehicles and satellites.

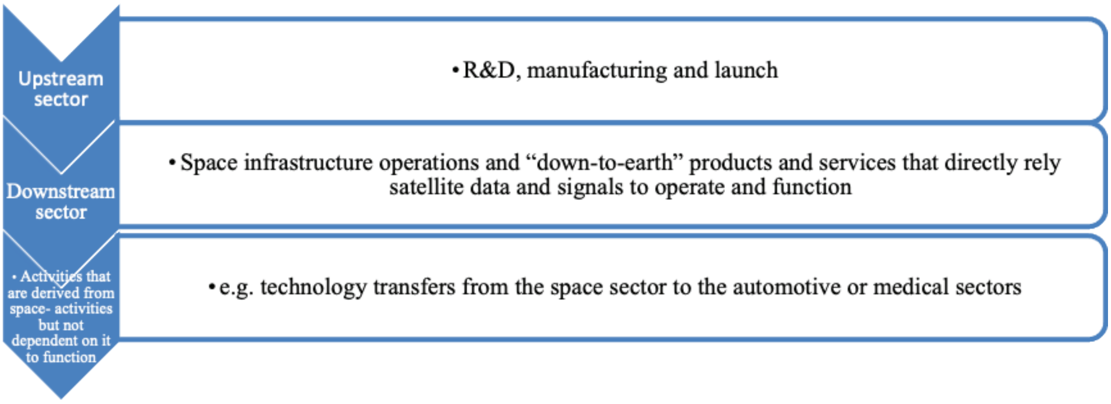

Figure 1. Components of the space economy (OECD, 2020)

Upstream sectors cover space systems, launch activities, ground systems, and related activities. At upstream sectors, knowledge and human capital accumulation are high, and scale-intensive investments are detrimental. In these sectors, value-added creation is high, and the structure and conditions of the public infrastructure are more critical (OECD, 2020; Strada, 2018).

Downstream activities cover earth observation, global navigation, launch activities, ground system, and related activities. Downstream is where space has the most direct and indirect impact on national and global economies (Strada, 2018). This segment is accepted to be the most attractive and highly competitive segment over the next 20 years (Strada, 2018). Currently, the downstream activities share is rapidly increasing, and commercialisation in these segments is more detrimental.

The upstream segment can be seen as the provision of space technology whereas the downstream segment can be seen as the exploitation of space technology (Strada, 2018). The strategies to coordinate the linkages between upstream and downstream activities are important for designing policies. Upstream activities are expected to create externalities for downstream activities. Hence for value creation and transformation of productive sectors in this field, the vertical integration among these sectors needs to be investigated. Due to these current conditions, vertical industrial policies are more detrimental. Moreover, space-related sectors require "functional upgrading" for catching up with a higher value-added value chain. This fact also increases the importance of innovation and technology policies.

Although space economy activities are known for massive government spending, by the 2000s, government spending approximately only covered 30%, and private sectors covered 70% of the spending. This spending led by private agents is mainly concentrated in downstream sectors. By 2020, total global revenues of the space economy were given as 271 billion dollars whereas the satellite industry owns the highest share (The Space Economy Report, 2020 see in fig.2). Morgan Stanley's (2021) estimates that the global space industry could reach over 1 trillion dollars by 2040 as a sign of expanding opportunities and increasing investments in the space market.

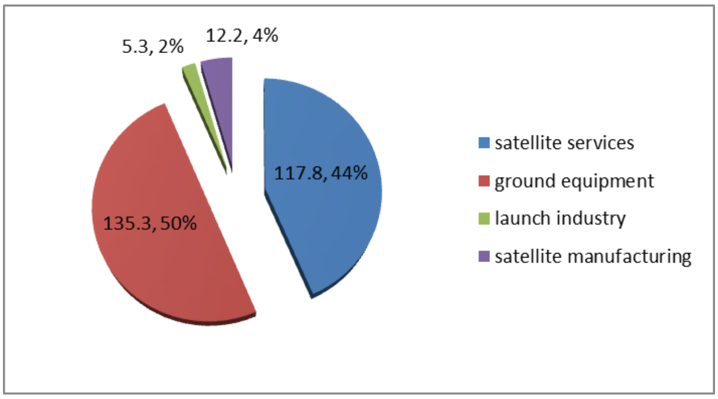

Figure 2. Global space revenues (billion dollars) and % share (The Space Economy Report, 2020)

Space as an "investment" field is expected to have an impact on several industries. Apart from aerospace and defence, IT hardware and telecom sectors are seen as strategic sectors that will determine the future of the space economy. Besides this, satellite broadband internet access, geolocation, and navigation also serve commercial space products and services.

3. Cycles of Space Economy

The stages of space exploration and activities could be analysed under sub-periods due to changes relevant to institutional and technological dimensions within the international system. The OECD classifies the transformation of state activities since it started (1958)[4] under five main cycles. Accordingly, the OECD considers changing dynamics regarding the actors (such as civil, military) that are involved in space activities and the level of the technology used in space exploration. Cycle 3 (1987-2002) is the initial period when commercialisation began. Cycle 4 (2003-2017) and Cycle 5 (2018-2033) comprise of changes in the digitalisation and globalisation of state activities and developments in global value chains. These stages represent an increasing number of actors participating in space activities. Cycle 5 (2018-2033) is mainly characterised by the growing use of satellite infrastructure for mass-market production, the third generation of space stations, and new space activities (OECD, 2016).

Robinson and Mazzucato (2018) analyse space waves in connection with the industrial phases. "Space 4.0" is defined as the recent new wave that is connected with industry waves 4.0 while "industry 4.0" is defined as an "umbrella" term capturing a vision of new technological manufacturing options and the growing interconnectedness of value chains (Robinson & Mazzucato, 2018: 5). "Space 4.0" waves technological level is similar to these. Robinson and Mazzucato (2018) define this process based on the rise of the new wave of space companies and the global trend towards interconnecting and interlinking of industries (industry 4.0). Consequently, increasing emphasis on societal ground challenges accompanies this stage (Robinson & Mazzucato, 2018). The paper mainly prefers to accept the analytical framework of the space waves approach, making it possible to interconnect science, industry, politics, and society.

It could be suggested that the end of the Cold War has been one of the driving forces of this paradigm change. This period also has coincided with changes in international rules of trade (such as the Telecommunication Act of WTO, 1997) and more comprehensive changes in the

4 Pre-space age goes back to 1926.

international trade system that enables a decrease in costs and fragmentation of production into different stages and locations. The unit labour cost and production of satellites have also made competition and entry conditions more attractive. This structure represents large mass manufacture and high production rate and thus a low cost per unit (Robinson & Mazzucato, 2018). It is stated that several technologies, such as data analytics, additive manufacturing, and robotics, have contributed to reducing material costs and production. Currently, the mass production of light satellites (100-400 kg range) that serves the telecommunication field makes the space field more attractive for investments (OECD, 2014).

Under this stage, commercialisation is a significant change. Apart from these, especially, changes in NASA legislation (Commercial Space Launch Act of 1984) are accepted as one of the triggering factors of the commercialisation of space activities. This legislation change of NASA has allowed private firms to enter these sectors and increase cooperation among the public and private agents based on market-creating innovation policies. Consequently, since the Sputnik 1 and Apollo race, space has moved from a fully public sector to a more hybrid structure that mixes public and private actors. This stage could be defined as the increasing role of "market-led" activities within space activities. The commercial space sector is represented by guided missiles and space vehicle manufacturing propulsion units and parts for space telecommunications (George, 2019: 182).

In the previous periods, aerospace and defence industry players tended to benefit the most from the large institutional space program although today, digital manufacturing technologies have started to transform the space sector. New actors, such as billionaires in the USA, have been among the key players of both upstream and downstream activities. Companies' technological bases on information and data analytics and knowledge accumulation also triggered these activities. Projects such as launches and complex satellites require high-level investments that are provided by venture capitalists and large firms such as Amazon and Google (Mazzucato, 2018).

Another emerging field in this phase is related to the dimensions of cooperation among states and even the state and firms. Technology funding has started to play a key role among states and firms. This period includes downstream value creation with new roles for industry and agencies up and down the innovation change. New forms of innovation external to the space sector are important in this context (Robinson & Mazzucato, 2018).

Finally, space exploration activities continue to be part of geopolitical concerns. Currently, official development assistance has been another emerging field for governments' space policies.

Besides this, increasing commercialisation and competition have increased pressures related to both the demand and supply-side under this wave. Commercialisation leads to market creation activities being more detrimental. Public agencies need to seek new ways of innovation policies. In this regard, a synthesis of Keynesian and Schumpeterian approaches to innovation is taught to be functional (Mazzucato, 2013).

The paper would suggest that the new drivers defined under "space 4.0" are also an important proxy for evaluating the targets and strategies of Turkiye's space vision. The inspiration of the paper is to connect the frontiers of "industry 4.0" with "space waves 4.0." Since the late 1990s, Turkiye has been classified among the countries that face premature deindustrialisation (Rodrik, 2004, 2016). Furthermore, Turkiye's industrialisation phase needs to catch up with industry 4.0 whereas in some sectors, it is even at stage 2.0. In this context, it is suggested that Turkiye is also facing a middle technological trap (Akçomak, 2021). In the case of the middle technological trap, developing countries are positioned between national innovation systems and global value chains. Such a position forces developing countries to produce low value-added production and prevents technological learning (Akçomak, 2021: 283). Development space (Wade, 2003) for developing countries under these circumstances seems to be more limited. Selective industrial and technology policies could be more detrimental so that mission-oriented tasks could be utilised for policy space creation.

Given these facts, inevitably, Turkiye's space exploration initiatives are comprised of grand challenges. The vision of space economy requires "space 4.0" dynamics to be integrated into policies. In this context, a redesign of science, technology, and industry policies based on technological capabilities could be considered. It could be suggested that the re-organisation of market-state relations and opportunities for achieving creative capabilities need to be investigated. Summing up, the role of the state and the markets within the mission-oriented policies could be challenged.

Table 1. Industry waves and space waves (Robinson&Mazzucato, 2018:5)

.Industry waves	Space waves
Industry 1.0 – Use of water and steam power	Space 1.0 – Astronomy
Industry 2.0 – Mass production through production lines and electrical energy	Space 2.0 – Space race, Apollo era
Industry 3.0 – Use of electronics for automation	Space 3.0 – ISS era and integrated international initiatives
Industry 4.0 – Connected value chains (Internet of Things, smart factories, internet of services)	Space 4.0 – More nations, more types of space "players", spin-off, spin-in and spillover, meaning space is closer to consumers and society, space tourism

4. Fundamental Framework of the Technological Capability Approach

In this section, the technology capability approach introduced by Sanjaya Lall (1992) will be explained. The technology capability of countries has been defined by Lall (1992) at two different levels: firm-level technological capabilities and national technological capabilities, respectively.

Lall (1992) categorises the firm-level technological capabilities as investment capabilities, production capabilities, and linkage capabilities. When Lall (1992) made this classification, the functions performed, and the degree of complexity was considered. The investment capacity defines the skills which are required to identify, prepare, and obtain technologies. These technologies could be used for purposes such as design, construction, and personnel training during the establishment or expansion of facilities. The investment capabilities determine the appropriateness of scales, the selection of technologies and equipment, the mix of products, and the capital cost of projects. The production capabilities refer to simple capabilities such as quality control, maintenance, operations management, and more advanced skills such as R&D and innovation. The production capabilities of firms determine the working efficiency of both given technologies and the technologies which are imported or copied. The linkage capabilities express the capacities required to obtain skills, information, and technologies from consultants, service firms, technology institutions, and material or component suppliers. The linkage capabilities do not only affect the productivity of firms. The linkage capabilities also contribute to the diffusion of technologies throughout the economy and the development of the industrial structure (Lall, 1992: 168).

The national technological capabilities are the second level of technology (technical) capabilities of countries, which have been defined by Lall (1992). Lall divided the technology capacity of countries into three sub levels. These levels are capabilities, incentives, and institutions. Relationships between the incentives, institutions, and capacities play an important role in developing countries' industrial capacity (Lall, 1992: 169-170).

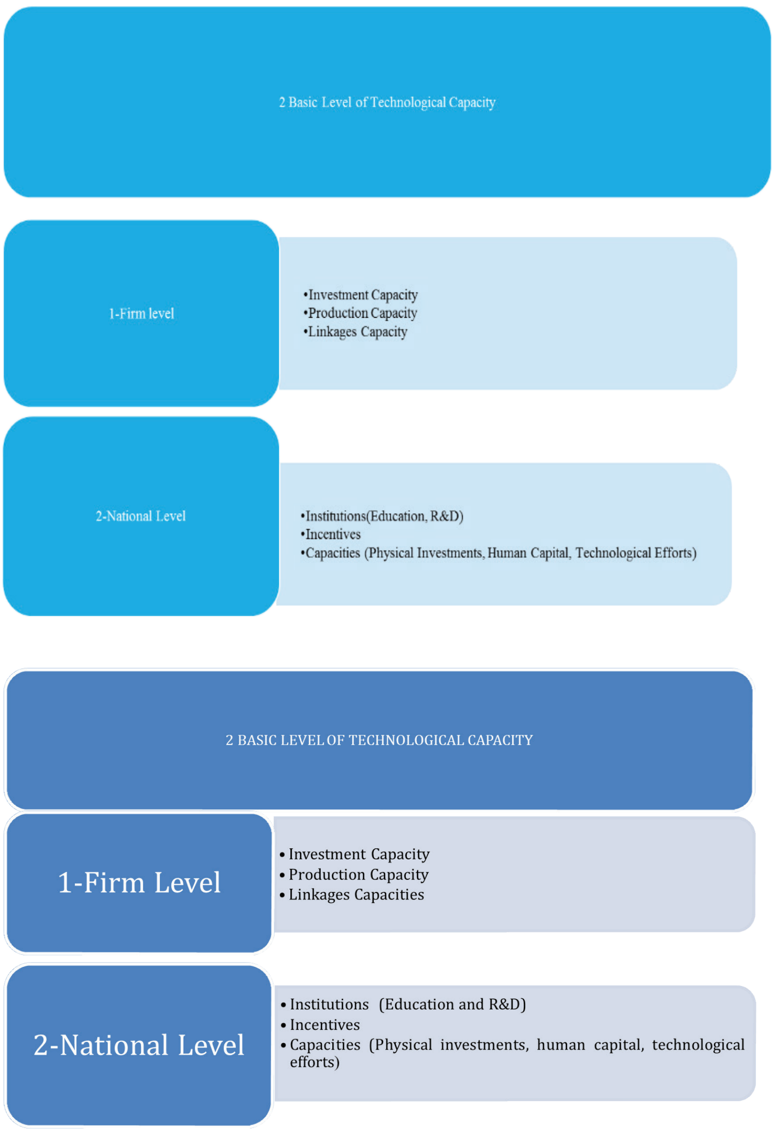

Figure 3. Technological capacity on a national level (Lall, 1992)

The institutions, which are the first sub-level of the national technological capabilities of countries, have been defined narrowly by Lall as organisations that support the development of industrial technology. The institutions which operate in areas like education, training, R&D, finance, standards, and measurement are important parts of the national technological capabilities of countries. Both private and public sectors could establish these institutions. The main purpose of public institutions is to close the gap caused by the inability of markets to provide the necessary inputs for industrial development. Therefore, governments have to play an important role in establishing essential institutions for industrial development (Lall, 2001: 17).

The incentives are the second sub-level of the national technological capabilities of countries. Different forms of incentives are effective in the process of investing in the technology capacity of firms. The incentives could be divided into three groups in terms of economic policies. The incentives which relate to macroeconomic policies are the first group. The second group of incentives is linked to the foreign trade regime of the countries. International competition compels firms to improve their design capacities continuously and to have more flexible organisational structures. The last group of incentives are related to local competition policies. Encouraging competition at the local level through free entry and exit to markets plays a critical role in accumulating national technological capabilities. In contrast, restriction of local competition causes a delay in the technology capacity accumulation process in firms (Lall, 1993: 730-735).

The capabilities are the third sub-level of the national technological capabilities of countries that were defined by Lall (1992). The capabilities are divided into three groups: physical investments, human capital, and technological efforts. Although physical investments, human capital, and technological efforts have different characteristics, they are strongly interrelated. (Lall, 1991: 134-135).

The capital that emerges from the physical investments is the simplest capability that countries could have. Plants and equipment are needed for industries to exist. The use of financial resources and the acquisition of necessary technologies play an important role in the accumulation and effective use of physical capital (Lall, 1992: 170).

Lall defined human capital in a broad context. In this framework, not only the skills acquired during formal education but the capabilities gained during working in the workplace also constitute a country's human capital. Firms that operate at advanced technology levels need a highly skilled workforce. However, firms that operate at simple technology levels could carry out their activities with a low skilled workforce. While the education at primary and secondary school levels are sufficient for the early stages of industrialisation, the more advanced stages of industrialisation require a workforce with higher education degrees. For this reason, the education systems of the countries are very important for the training of the workforce needed by industries. The education system of countries should aim not only to increase the number of people who graduate but also to raise the quality of the education provided (Lall, 1993: 735-736). The skills which are acquired at the workplace also constitute the human capital of the countries as well as the education that is given at schools and universities. Therefore, specifically, developing countries should pay attention to the policies that lead to increased skills acquired in the workplace (Lall, 1998: 226).

Technological efforts refer to the production, design, and research activities of firms. These activities, which firms carry out, are supported by the technology infrastructure of countries. The technology infrastructure of countries comprises of the information standards, scientific information, and services provided by public institutions (Lall, 1992: 170). It is very difficult to measure the technological efforts of countries. Although R&D expenditures could not fully demonstrate all of the technological efforts of countries, it is the best indicator of countries' technological efforts since it allows comparisons between countries (Lall, 1998: 230).

The incentives, one of the sub-levels of the national technological capabilities of countries, vary very little among countries that implement export-led growth strategies. For this reason, the differences between the national technological capabilities of countries are mainly determined by the institutions and the capabilities (Lall, 1991: 131).

5. The Entrepreneurial State

The intervention of the state in markets could be explained through three different approaches: market failures, national innovation systems, and an entrepreneurial state. The first of these approaches, market failures, accepts public intervention in the economy only in cases where markets do not allocate resources effectively. The national innovation system approach mainly states the importance of system failures (Mazzucato, 2018: 807). The national innovation system approach emphasises the significant impact of both the creation of new institutions and the more effective functioning of existing institutions on the development of the innovative capacity of countries (Mazzucato & Semieniuk, 2017: 32).

The market failures and the national innovation system approaches fail to explain the important role that the state could play in major societal challenges because of their perspectives. The national innovation system and the market failures approaches do not sufficiently emphasise the effective role that the public sector plays in the creation of new markets and industries. Therefore, these two approaches fail to adequately explain the role which is played by the state in the grand societal challenges. The Entrepreneurial State is the third approach that provides rationality for the public sector intervention in the markets. The entrepreneurial state approach differs from the other two approaches in the state's role in grand societal challenges.

Grand societal challenges are permanent social problems that affect large segments of society. Different disciplines need to act together to resolve the grand societal challenges because these are complex problems linked to other problems and require immediate solutions. These characteristics of grand societal challenges explain why countries that have succeeded in sending humans to the moon have not been successful in solving problems such as poverty (Nelson, 2011: 689). Therefore, long term perspectives and cooperation among different disciplines are required to solve grand societal challenges. For this reason, economies undergo a structural transformation in a certain direction. This situation necessitates both technological change and institutional change. Therefore, it is crucial that policies that are developed to solve grand societal challenges have to mobilise a wide variety of sectors (Mazzucato, 2016: 144).

Implementing mission-oriented projects is very important in mobilising different sectors for a solution to grand societal challenges. Countries need an entrepreneurial state in order to realise mission-oriented projects (Mazzucato & Penna, 2016: 34). The entrepreneurial state approach rejects the view that only the private sector takes risks. According to this approach, the public sector is more willing to invest in new and high-risk areas than the private sector. The public sector recognises and understands the importance of the new sectors which contain high risk but have strategic importance before the private sector does. As a result of this situation, the state eliminates long term risks and uncertainties in these new sectors through public investments. Public investments and government intervention played an important role in the emergence of many sectors in the past where the private sector did not invest because it saw low-profit opportunities in the early stages. Today, in the early stages of technology development, states provide financial support to newly established firms and invest directly in risky sectors. Therefore, according to the entrepreneurial state approach, the role of states is not just to fix market and system failures. The public sector should take the lead in the creation and reconstruction of new industries and markets (Laplane & Mazzucato, 2020: 4).

The entrepreneurial state approach argues that states need to invest along the entire supply chain due to the leading role of the public sector in the creation of new industries and firms. For this reason, states should also implement policies such as the procurement of new technologies from small and medium-sized firms, providing financial support to newly established firms, and investing directly in basic sciences. Public institutions play an important role in the implementation of these supply and demand sides policies. The position of institutions such as NASA, DARPA, and NIH in the national innovation system of the USA could be given as an example of this situation. These institutions both successfully carry out mission-oriented projects and are in a leading position in the creation of new sectors and technologies. For this reason, institutions like NASA, DARPA, and NIH do not just fix market and system failures (Mazzucato&Semieniuk, 2017: 28). Hence, the entrepreneurial state approach particularly underlines the role played by public institutions in creating new sectors and technologies.

The entrepreneurial state approach regards the public sector's search for new sectors and its importance to experimentation as the basis of its success due to the uncertainty of the innovation process. Public institutions need to have a sufficient absorptive capacity to explore and invest in new sectors and technologies. Therefore, the state must increase its absorptive capacity to fulfil its entrepreneurial role (Mazzucato, 2018: 807). The entrepreneurial state approach expresses that the public sector's adoption of a portfolio approach while making investments contributes significantly to the process of increasing the state's absorptive capacity. In the portfolio approach, the public sector could compensate the losses incurred due to the investments that have been made with the gains obtained from successful projects. The public sector could also raise its ability to learn through unsuccessful projects. This situation also causes the state to develop its absorptive capacity (Mazzucato et al., 2020: 42)

6. Turkiye's Space Economy Frontiers

The basic figures used for a quick review of countries' positions and roles within the space economy could be summarised as: the share of budget expenses in the GDP, the revealed technological advantage,[5] the trade balance in the space aviation sector,[6] the R&D expenses, the number of launched

5 This figure is calculated as the share of patents of an economy in space-related technologies relative to the share of total patents belonging to the economy.

6 Spacecraft (including satellites) and spacecraft launch vehicles (code 7925)

satellites, and the top producers in space literature (OECD, 2007). Based on these figures, Turkiye's position regarding space exploration activities could be ranked at the initial stage.

The major strength of Turkiye's space activities could be defined as related to the government's commitment, motivation, and support (Dede & Akcay, 2015). In addition to these, up till now, the experiences related to know-how could not be ignored. Beginning from BİLSAT,[7] the initiatives of the increasing share of domestic production and experiences in this field have gained speed.[8] These improvements could be investigated in detail considering the implementation of the innovation policies and spill-over effects in related sub-sectors.

The weakness of the innovation system, the need for increased research and development in information technologies, and the inefficient use of human resources[9] are defined among the main obstacles of the sectoral development of aviation and space sectors (OİK, 2018). Besides this, the weakness of space activities lies in the lack of coordination in the space/satellite planning process. The problems related to the lack of human resources, expertise, and the infrastructure of domestic launching services (Dede & Akcay, 2014) need to be focused on in detail.

Given these facts, the analytical framework of the technological capacity approach could be functional in setting up strategies and defining innovation capabilities. By the establishment of the TSA, it could be suggested that intervention in these fields would be more critical, adding that the dimensions of the intervention and coordination of policies are expected to be more important.

TSA responsibilities are defined as being "for the preparation of the strategic plans governing the medium- and long-term goals on aeronautics and space technologies, basic principles and approaches, objectives and priorities, performance indicators as well as the methods to achieve these goals and the distribution of resources" (TSA, 2019*)*. Later on, it was declared that the TSA would be in charge of preparing the National Space Program of Turkiye (TSA, 2020).

While Turkiye has already announced the activities that would be carried out in the aviation and space sector as: sub-meter observation satellite and sub-systems, communication satellite and sub-systems, a satellite launch system, satellite data processing, storage and information support systems, and domestic aircraft and helicopter design and production (OIK, 2018, the TSA (2021) has announced a national space program and missions covered by this program under ten titles (see figure 4). The linkages between these given sectors and missions need to

7 Turkiye launched its first satellite, Turkstat 1A in 1994. Currently Turkiye has communication satellites; Turksat 3A, Turksat 4A, Turksat 4B, Turkstat 5A. Turkiye also has three observation satellites: Gokturk-1, Gokturk-2, and RASAT. Turkiye's satellite development efforts have increased since 2000's and earth observation satellites have come to the front. BILSAT – developed through technology transfer, several components of which were designed by TUBITAK UZAY, was launched in 2003 as Turkiye's first earth monitoring and remote sensing satellite. Using the skills and capabilities acquired during the development of BILSAT; RASAT has been designed and produced by TUBITAK UZAY. RASAT has been launched for the first time 2011 as the first national and domestic micro-scale satellite in Turkiye. Gokturk-2 was launched in 2012 and known as the first national satellite designed by Turkish engineers. Another "national" satellite, Turkstat 6A is planned to launch in 2022 (TUBITAKUZAY, 2021).

8 Accordingly, since 2014 in the sub-group of aircraft and spacecraft and related machinery manufacturing, production index has increased even more that the other transportation vehicles manufacturing (OIK, 2018)

9 While only one of 27000 people in Turkiye is an aircraft/aviation/space engineer, this ratio is 1/7000 in the USA. While only one person out of 21000 is an active licensed aircraft maintenance technician (mechanical, avionics and technical services), this ratio is 1/2060 in the USA (OIK, 2018).

be considered regarding the weaknesses and targets of the space activities. In this context, clear and specific targets relevant to these missions and sectors could be defined based on the pillars of technological capabilities and entrepreneurial state approaches.

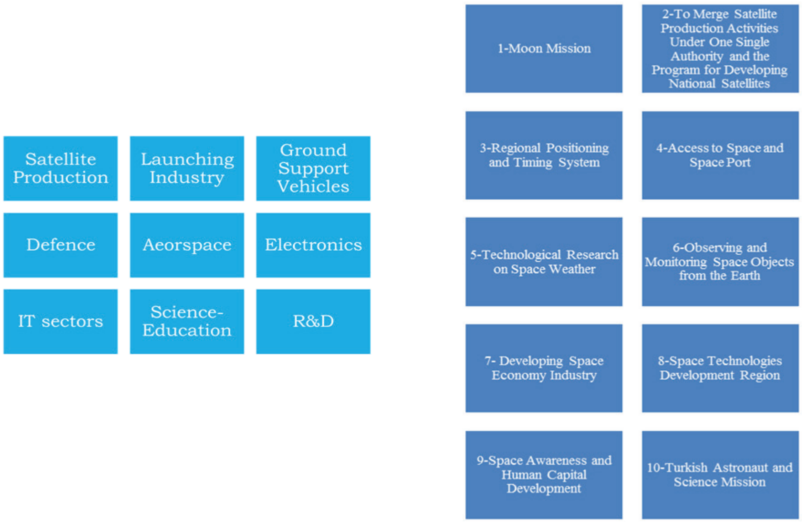

Figure 4. Turkiye’s space-related missions (TSA, 2021) and relevant sectors

Based on mission-oriented innovation policies, it is expected that the TSA would be the key agent in policymaking. Mission-oriented innovation policies are based on large projects with public and private funding that seek to produce a technological breakthrough and shift the international technological frontier, leading to global leadership in strategic sectors. It could be underlined that creating linkages between non-space innovation systems and the space innovation system is critical (Mazcuatto, 2018). Besides this, the coordination of long-term infrastructures with public-good characteristics should be given importance to catalyse and govern space-oriented innovation systems (Robinson & Mazcuatto, 2018).

As stated in the previous sections, space economy, unlike many other fields, is costly and has high risks. While evaluating the trade-off of the cost and benefits, the burden of the costs could also be criticised at the initial stage of space exploration. Therefore, the planning and coordination of strategies for this sector are very important in terms of performance, sustainability, and transparency. The topics related to the risks, the costs of the investment, and strategies gain more importance considering the constraints of the Turkish economy in the field of upper-level technology production. For this purpose, mission-oriented innovation policies and the “market creation” strategies need to be considered so that at the initial stages of the investments, the state is expected to play an important role as a “market creator” and a “risk-taker.” In order to carry out and coordinate mission-oriented policies the “entrepreneurial state” is expected to react to these policies as an important actor.

As stated in the previous chapters, space activities require large-scale investments. Risks related to budget planning and technical failures could be faced during these stages so that the entrepreneurial state could fulfil the risks and the costs. Commercialisation could be underlined to create threats for space exploration activities at the initial stages of space exploration. Given the structure of value chains and the technological infrastructure of private companies in global space, latecomers’ direct procurement of the given services could have risks. Public procurements considering the mission-oriented innovation policies and for increasing creative technological capacity need to be considered. International cooperation between the government and firms should have the basics of creating spill-over effects and increasing creative capacity rather than the procurement of services directly. Furthermore, the actors involved in space activities could guarantee the projects' sustainability, and in this case, the TSA is expected to be the key player.

Opportunities in this field could be summarised as the need for improvement in manufacturing communication and imaging satellites through national means and exporting those products and services developed to other countries while also providing improvements in infrastructure (Dede & Akcay, 2014). It could be stated that space exploration would have great impacts on the economy if it is planned in the "right" way, so public agencies would play critical roles within the mission-oriented policies. Dede and Akcay (2014: 2) define the strategic management of space technologies as an important phase in the capacity building efforts of the nation. Özalp (2009) also underlies that the initial initiatives led by TUBITAK have an understanding of defining science and technology goals that would affect social life. In this regard, strategies and policies to support space science, life science, and earth sciences could be included in mission-oriented policies.

7. Conclusion

This paper intends to take into account the general framework of Turkiye's defined space activities and the main characteristics of Turkiye's technological capabilities. Accordingly, it aimed to generate ideas on policies and strategies related to space. Given the fact that Turkiye is a "latecomer" in space exploration activities, within this phase, Turkiye could have opportunities but also constraints. Based on the defined targets of space activities and the weaknesses related to technological capacity, the necessity of "mission-oriented" policies comes to the fore, and the role of the public inevitably is taken into consideration.

Therefore, the defined policies need to challenge the given socio-economic structure. In this context, public agencies' role in determining the strategies for space activities could be contextualised by considering the basic propositions of the "entrepreneurial state" approach. It is foreseen that the public agencies will undertake important functions in the coordination of policies and the adoption and dissemination of innovation-oriented strategies. "Entrepreneurial state" practices, within the framework of mission-oriented policies, are based on the necessity of the public in order to have a function that creates markets and undertakes risks in the financing, especially early-term investments. Beyond these, the "entrepreneurial state" could have the function of regulating markets. The basic framework proposed by the technological capacity approach (Lall, 1992) is suggested to be functional in improving Turkiye's capabilities, considering the sectoral dynamics and specialisation structure in space-related activities. Accordingly, Turkiye's capabilities related to technology are defined by analysing the production, investment, and linkage capacities of firms and institutions while at the national level, physical investments and human capital conditions are taken into account. In doing so, the following predictions could be summarised;

- Determining specific and clear targets for space within the framework of mission-oriented policies (for 5-10-20 years targets) is detrimental.
- Determining the firms' capacities (production, investment and connection) within the technological capacity approach framework and accordingly planning the sectoral priorities are required.

- Space-related targets should focus on learning by doing mechanisms of firms both at the international and national levels.
- Public procurement policies could be designed considering the technological capabilities, and legal regulations could be redefined accordingly.
- On a sectoral level, the government's role in coordinating the markets is critical. In this context, either "market regulatory" or "market creation" roles' of the government could be clearly defined according to the needs.
- The state is expected to take active roles in the financing of initial and early-stage investments.
- Determination of risks and costs at the sectoral level is critical for defining and coordinating the targeted policies.
- The target of increasing the institutional effectiveness of the state for R&D and innovation creation and public roles determining the direction of technology could be the priority.
- Aviation and space engineering education could be organised in a way that will contribute to the specialisation.
- Design of science and education policies in line with the targets for the space field could be included in the missions,
- The conditions that ensure the sustainability of the strategies should also be guaranteed by the space-related agencies.
- The dimensions of international cooperation need to be considered regarding the spillover effects within the internal structure of space-related sectors.
- The institutional continuity, transparency, and the target of increasing social welfare should not be ignored.

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