

GOVERNMENT INTERVENTION IN THE SPACE SECTOR: POLICY RECOMMENDATIONS FOR TURKEY

UZAY SEKTÖRÜNE DEVLET MÜDAHALESİ: TÜRKİYE İÇİN POLİTİKA ÖNERİLERİ

Türksoy EMEN* 

Abstract

After Russia launched the first satellite, Sputnik I, into Earth orbit in 1957, Space Race started between the US and Russia. Both governments allocated huge budgets for space missions until the second half of the 1970s. But space research didn't remain limited to the two countries over the years; some other countries established their space agencies and started engaging in space activities. At first, NASA was at the center of the US civilian space sector; it coordinated the market purchasing from aerospace firms. But later it changed its strategy and began to collaborate with private space companies in certain space missions using Public Private Partnership method in particular. Some other space agencies also adopted this method. This change has helped to increase investments and has encouraged start-ups to get into the market. Today, the global space economy has reached a significant size along with the increasing number of companies and diversified production. So the governments have intervened in the market not only to correct market failures, which provide a rationale for government intervention but also to create the market. In this context, this study discusses the need for government intervention in the market to create a private space sector in the light of the NASA and ESA experiences, and develops economic policy recommendations for Turkey examining the Decree that has established the Turkish Space Agency formally.

Keywords: Market Failures, the Global Space Economy, Space Research, Turkish Space Agency

JEL Classification: H30, H41, O038

Özet

Rusya'nın, dünyanın ilk yapay uydusu olan Sputnik 1'i dünya yörüngesine fırlatmasından sonra Amerika Birleşik Devletleri ve Rusya arasında bir Uzay Yarışı başladı. 1970'lerin ikinci yarısına kadar süren bu yarışta her iki ülke uzay araştırmaları için büyük bütçeler ayırdı. Ancak uzay araştırmaları bu iki ülkeyle sınırlı kalmadı; yıllar içinde diğer bazı ülkeler de kendi uzay ajanslarını kurdular ve araştırma faaliyetlerine başladılar. İlk başlarda NASA, Amerikan uzay sektörünün merkezindeydi; piyasayı, uzay-havacılık şirketlerinden yaptığı satın almalarla kontrol ediyordu. Ancak daha sonra stratejisini değiştirdi ve bazı projelerini, genelde Kamu Özel İşbirliği yöntemini kullanarak özel şirketlerle beraber yapmaya başladı.

* Dr., Nişantaşı University, Faculty of Economics, Administrative and Social Sciences, Maslak 1453 NeoTech Campus, turksoy.emen@nisantasi.edu.tr

Diğer bazı ulusal uzay ajansları da bu yöntemi benimsediler. Bu politika değişikliği hem yatırımların artmasına yardımcı oldu hem de yeni firmaları piyasaya girme konusunda cesaretlendirdi. Günümüzde küresel uzay ekonomisi, artan şirket sayısı ve çeşitlenen üretimle birlikte önemli bir büyüklüğe ulaştı. Yani hükümetler, yalnızca piyasa aksaklıklarını düzeltmek için değil aynı zamanda piyasayı yaratmak ve şekillendirmek için de piyasaya müdahale ettiler. Bu bağlamda bu çalışma, NASA ve ESA'nın tecrübeleri ışığında, özel bir uzay sektörü yaratılabilmesi için devlet müdahalesinin gerekliliğini tartışmakta ve Türkiye Uzay Ajansı'nın kuruluşuna temel teşkil eden Cumhurbaşkanlığı Kararnamesinin ilgili maddelerini inceleyerek Türkiye'de özel bir uzay sektörü yaratılabilmesi için ekonomik politika önerileri sunmaktadır.

Anahtar Kelimeler: Piyasa Aksaklıkları, Küresel Uzay Ekonomisi, Uzay Araştırmaları, Türkiye Uzay Ajansı

JEL Sınıflandırması: H30, H41, O038

1. Introduction

The initiation of space missions dates back to the 1950s. Russia launched the first artificial satellite successfully in 1957. Launching the satellite, Sputnik I, was certainly a showdown in Cold War era. Russia's move in this field was immediately followed by the US which led to a competition, known as Space Race. Both countries, in this fierce competition, allocated substantial budgets for space missions, the moon missions in particular. Since then, new contenders such as China, Japan, Canada, Germany, France, India, and Israel have joined the race. But the nature of space research activities has changed dramatically over the years. Once space programs were financed and accomplished only by governments, today, private companies have been a part of space activities as well. Because, governments and national space agencies partner with private space companies in most space research activities.

This change was a kind of strategy to create a space sector, and it succeeded; blossoming space sectors in different countries led to the birth of the global space economy. Through the years, the global space economy has flourished attracting a significant number of existing companies and start-ups. According to the Morgan Stanley Report¹, the global space economy is worth about \$340 billion by 2017 and expected to exceed \$1.1 trillion by 2040. The strategy that governments have pursued to create a private space sector has been accomplished by means of the Public Private Partnership (henceforth named P3). In the literature, P3 usually refers to a long-term contractual arrangement for public service delivery between public and private sectors and has been used over 200 years in most countries, particularly in construction projects.

Why have governments changed their strategies and started trying to create a private space sector? It can be certainly due to several reasons, but the most important one is that the sector has huge potential for a new source of revenue. Governments have noticed this, and space activities have partially evolved from space race between countries to competition in the global space economy. In his last book the Future of Humanity, physicist and futurist Michio Kaku² calls this change "renaissance", adding that "daring astronauts are being replaced by dashing billionaire entrepreneurs". Like most sectors, the space sector needed the support of governments while blossoming. Today, the support is proceeding

1 Morgan Stanley (2017). Space: Investment Implications of the Final Frontier, 13-14.

2 Kaku, M. (2018). The Future of Humanity, Doubleday, New York, 46.

intensively and seems a necessity. Because doing business in space sector is more risky compared to conventional sectors and also requires cutting-edge technology and high skilled workers which make it costlier. Another reason why it is costlier is that customers of the products produced in the sector are limited. So governments have intervened in the market and awarded private companies for space missions generally using P3 projects. This strategy has encouraged private companies to get into the market, made them competitive, and eased the hardness of finding new costumers.

Economists have commonly accepted the rationale of government intervention in markets when market failures arise. But some economists tend to see the intervention necessary in any case. For example Mazzucato, especially in her studies related to space sector, suggests that governments should do more than “fixing” the markets; they should “shape” and “create” them. The point of departure of this study is fundamentally based on this approach.

Turkey doesn't have a developed a private space sector, because it has only a few space companies. And the country has formally established its Space Agency just months ago. In this context, the study aims to examine how Turkey should create a robust and flourishing space sector, sticking to the approach that the government should play an active role in the market. Since the Space Administration has been newly founded, there is no broad literature about its role in the market. Further, due to lack of a large market, no sufficient data is available. Naturally, the study is limited to policy recommendations from the economic perspective rather than data analysis. The study is divided into four sections. After a short introduction in Section 1, Section 2 gives a brief overview of the global space economy to indicate its importance. Section 3 examines the theoretical and practical basis of government intervention in the space market. Section 4 presents policy recommendations for Turkey examining the Decree that has established the Turkish Space Agency formally.

2. The Global Space Economy

The global space economy is growing, and its size and effects have become rather significant. Because once only governments were engaged in space activities mainly due to national pride and security, today, private companies that seek new investment opportunities deal with space as well. So private companies have helped accelerate the activities, which has led to the flourishing space sector. These activities have also an increasing share of global output. Apart from the rising importance in the global economy, it shouldn't be ignored that space activities have externalities, spillover effects, spinoffs and social impacts.

2.1. The Overview of the Global Space Economy

The world witnessed Space Race between Russia and the US since 1957. A year after Russia's success on Sputnik I Mission in 1957, the US Government transformed the National Advisory Committee for Aeronautics that was established in 1915 to make basic research in aeronautics, into NASA (National Aeronautics and Space Administration). Along with the new Administration, according to Weinzierl³,

3 Weinzierl, M. (2018). Space, the Final Economic Frontier, *Journal of Economic Perspective*, Volume 32, Number 2, Spring 2018, 173.

the US government started spending for Apollo program which caused a public-sector centralized model in the US. So this change put NASA at the center of the US space sector; it coordinated the market purchasing from aerospace firms. It would not be wrong to say the same thing for ESA, the European Space Agency that was established in 1975. As Krige et al⁴ said, the implementation of an industrial space policy was central to ESA's mission.

The budgets that were allocated to NASA were considerable in first years. The figures compiled by Aerospace Security⁵ based on data from NASA and Office of Management and Budget of the US Government show that the budget of NASA increased dramatically in the 1960s due to Space Race. While the budget was \$3.6 billion in 1960, it reached \$34 billion in 1965. Since the 1970s, along with the easing of race in space, it stayed partially stable; as the budget of \$20.2 billion was allocated to NASA in 1970, it was \$14.7 billion, \$22.1 billion, \$20 billion, \$22.3 billion in 1980, 1990, 2000 and 2010, respectively. And finally, the Administration's budget was \$21,5 billion in 2018⁶. As for ESA, the budget was \$2,9 billion in 2005; it reached \$3,0 billion in 2008 and grew to \$3,6 billion in 2009. The budget that was allocated to ESA increased to \$4,4 billion in 2015 and to \$5,7 billion in 2019⁷.

Through roughly two decades following its birth with large budgets shown above, NASA mostly conducted space research itself and interacted with a limited market. Other space agencies and/or countries had no different policies than that of NASA in their first years. But for the last couple of decades, a policy change has arisen; governments have been more eager to make private companies a part of space activities, which is discussed in next Sections. This policy change helped the emergence of a private space economy and the New Space movement. The movement, according to McCurdy⁸, aimed to develop a commercialized space industry dominated by private entrepreneurs. The entrepreneurs wanted to place astronauts and machines in space more rapidly and creatively than the national space agencies. Therefore, as Weinzierl⁹ states, the terminology of New Space not only presents a new generation of companies or a steady growth in space-sector revenues but rather a new approach.

Following this policy change the number of companies and their contribution to global output have been steadily increasing. A comprehensive report prepared by Morgan Stanley shows how the private space economy has flourished.

4 Krige, J., et al. (2000). *A History of the European Space Agency 1958 – 1987 (Volume II The story of ESA, 1973 to 1987)*, European Space Agency, The Netherlands, 26.

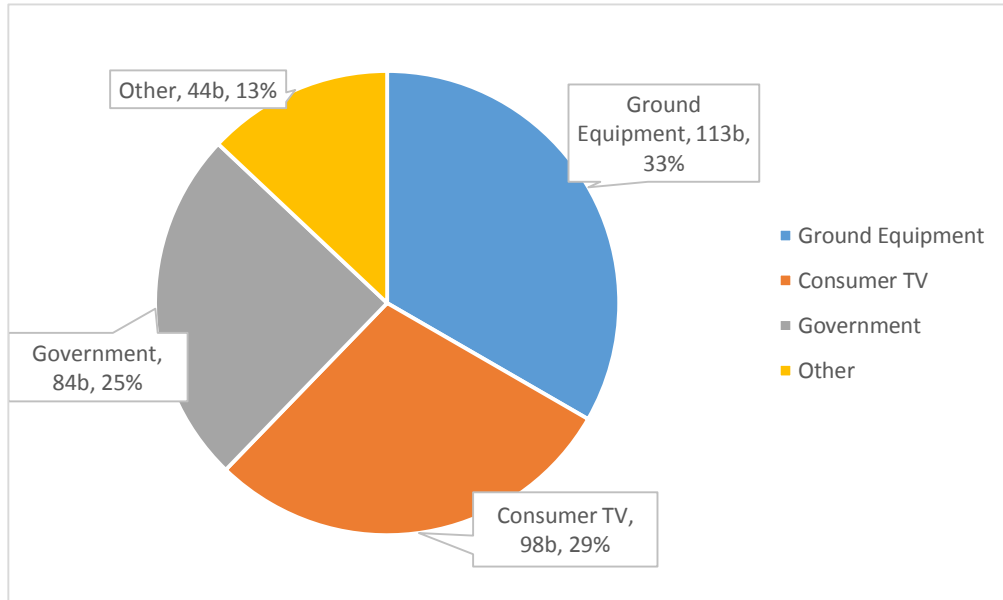
5 Aerospace Security (2019). *History of the NASA Budget*, <https://aerospace.csis.org/data/history-nasa-budget/>, (Accessed on: 17.07.2019).

6 NASA (2019). *NASA FY 2020 Budget Request*, https://www.nasa.gov/sites/default/files/atoms/files/fy2020_agency_fact_sheet.pdf, (Accessed on: 17.07.2019).

7 ESA (2019). *ESA Budget*, http://www.esa.int/spaceinimages/Images/2019/01/ESA_Budget_2019, (Accessed on: 18.07.2019).

8 McCurdy, H.E. (2019). *Financing the New Space Industry Breaking Free of Gravity and Government Support*, Palgrave Studies in the History of Science and Technology, Switzerland, 2.

9 Weinzierl, 2018, 180.

Figure 1: The Global Space Economy by 2017

Source: Morgan Stanley, 2017, 13.

The space economy reached approximately \$340 billion by 2017 and was dominated by consumer TV and ground equipment. Their shares were \$98 billion and \$113 billion, respectively. The share of governments was \$84 billion and is expected to decrease in the future. The figure above presents only a general view; then, to better understand the structure of the economy, types of companies and their activities, OECD's Report called *The Space Economy at a Glance* should be examined.

Table 1 indicates the diversity of sub-sectors in the global space industry. "Primes" seen in the Table 1 refers to companies that design and assembly complete spacecraft systems for governments and commercial users such as telecommunications, earth observation satellites, launchers, human-rated capsules. "Tier 1" actors design, assembly and manufacture of major sub-systems; they deal with satellite structures, propulsion subsystems and payloads. "Tier 2" actors produce equipment to be assembled in major sub-systems. "Tier 3 and 4" actors specialize in the production of particular electronic, electrical and electromechanical (EEE) components and materials such as cables, electrical switches¹⁰.

¹⁰ OECD (2014). *The Space Economy at a Glance*, 19.

Table 1: Overview of the supply chain in the broader space economy

| Positioning | Actors | Selected Products and Services |
|----------------------|---|--|
| Tiers Three and Four | Scientific and engineering consulting | <ul style="list-style-type: none"> ● Research and development services. ● Engineering services (design, testing...) |
| | Material and components suppliers | <ul style="list-style-type: none"> ● Materials and components for both space and ground systems: passive parts (around 70% of components in space sub-systems: cables, connectors, relays, capacitors, transformers, RF devices...) and active parts (e.g. diodes, transistors, power converters, semiconductors). |
| Tiers One and Two | Designer and manufacturer of space equipment and subsystems | <ul style="list-style-type: none"> ● Electronic equipment and software for space and ground systems. ● Spacecraft/satellite platform structure and data handling subsystem (e.g. on-board computer, interface unit, satellite and launcher electronics). ● Guidance, navigation and control subsystems, and actuators (e.g. gyroscopes, sun and star sensors rendezvous- and docking sensor). ● Power subsystems (e.g. electrical propulsion, power processing unit, solar array systems, photo voltaic assembly). ● Communications subsystems (e.g. receivers and converters, fibre optic gyro, solid state power amplifier, microwave power module, downlink subsystem, transponders, quartz reference oscillators, antenna pointing mechanism). ● Propulsion subsystems (e.g. mono- and bi-propellant systems, apogee engines, thrusters, tanks, valves, electric propulsion systems). ● Other satellite payload's specific subsystems: positioning, navigation timing systems, reconnaissance, surveillance, and ayload data target acquisition; weather and environmental monitoring instruments; scientific/R&D demonstrator and human-rated systems (e.g. payload data handling electronics, navigation clock electronics, cryo cooler, scanning mechanism). |
| Primes | Space systems Integrators/ full systems supplier | <ul style="list-style-type: none"> ● Complete satellites/orbital systems. ● Launch vehicles (and launch services provision in some cases). ● Control centres and ground stations. |
| Operators | Space System Operators | <ul style="list-style-type: none"> ● Launch services provision. ● Satellite operations, including lease or sale of satellite capacity (telecom: commercial FSS and MSS operators; earth observation operators). |
| | Ground system operators | <ul style="list-style-type: none"> ● Provision of control centres services to third parties. |
| Downstream | Devices and equipment supporting the consumer markets | <ul style="list-style-type: none"> ● Chipset manufacturers. ● Satnav and telecom equipment and connectivity devices vendors. |
| | Space-related services and for products consumers | <ul style="list-style-type: none"> ● Direct-to-home providers. ● Very Small Aperture Terminal (VSAT) network providers. ● Location-based signals services providers. |

Source: OECD, 2014, 21.

Apart from suppliers above, there are also varied space companies that operate in different fields, expecting huge profit in the long run. Asteroid mining, for instance, is one of them. A few asteroid mining companies expect to be the first miners in space. Their initial step is to identify asteroids that contain water and precious metals, and then, they plan primarily to extract water from water-rich asteroids. Because water is needed to sustain human life in space. Furthermore, water will be used for producing propellant, breathable air, and growing food. Precious metals are another target. Because some asteroids are predicted to be metal rich bodies. Lewis¹¹ estimates that a random piece of an average asteroid contains rare and precious platinum-group metals several times higher than the richest known ore on Earth. Precious metals can also be used for laboratory equipment and spacecraft components.

11 Lewis, S. J. (2015). Asteroid Mining 101-Wealth or the New Space Economy, Deep Space Industries Inc., 5.

This potential of huge profit in the space economy attracted new investors; space start-ups have dived into the sector enthusiastically. Start-up equity investments reached to \$3 to 3.25 billion in 2018 in the space sector. A significant part of space start-ups have been launched in the US and European countries but are not limited to those; approximately 100 space start-ups have been established in China since 2015 after a new policy has been adopted to foster commercialization in space, for example¹². So it would be no surprise that the production would expand and diversify in the future. The Morgan Stanley Report¹³ estimates that the global space economy will reach \$1.1 trillion by 2040. As the share of governments is expected to become 17% and reach \$181 billion, internet services will take the largest share by 37% and amount to \$412 billion. Needless to say, the flourishing space sector will benefit different sectors and create a new source of revenue for them. For example, the insurance sector is expected to take a share of \$1 billion in the global space economy by 2040, according to the same Report.

2.2. Social And Economic Effects of Space Activities

The global space sector, as figures above put forth, will gain momentum and become one of the major sectors in the world. Aside from its huge potential to generate new revenues, space activities contribute more to society. Lots of social and economic benefits emerge from space activities; the sector is accepted as “the higher end of an important value-added stream of commercial and public/strategic services”¹⁴.

Space activities unarguably aim to benefit human beings who live on Earth, creating new technologies and finding new solutions to unsolved problems. To better understand their benefits, for example, it would be helpful to glance at the applications of NASA-derived technologies. They are as follows¹⁵: health and medicine, transportation, public safety, consumer, home & recreation, environmental and agricultural resources, computer technology and industrial productivity. The NASA-derived technologies cause economic growth and a high quality of life. They create new jobs and markets, increase efficiency, and improve competitiveness, which lead to economic growth. They also improve safety, bring out new products to markets, extent and save lives, help develop green technology, and support environmental cleanup, which naturally results in a high quality of life.

Another example of benefits of space research to humanity is International Space Station (ISS). It was launched in 1998, orbits around the Earth, and is a kind of science lab. 15 countries are part of the ISS and work together to create innovative technology and more. According to Rai et al¹⁶, there are 5 main benefits that stem from research on ISS: human health, Earth observation and disaster response, global education, innovative technology, and economic development of space. But, how

12 OECD (2019). The Space Economy in Figures-How Space Contributes to the Global Economy

13 Morgan Stanley, 2017, 9-14.

14 Aerospace (2017). The State of the European Space Industry in 2016, Facts and Figures Press Release – June 2017, 1.

15 Comstock, D. (2010). The Socio-Economic Benefits of Space Technology Applications and Spinoffs, United Nations/Turkey/European Space Agency Workshop on Space Technology Applications for Socio-Economic Benefits, Istanbul, 2.

16 Rai, A., et al. (2016). Expanded Benefits for Humanity from the International Space Station, Acta Astronautica, 126 (2016), 465-472.

does research on ISS contributes to human health? For example to support astronaut health, biological and physiological investigations are carried out on ISS. The results of investigations benefit the Earth, leading new ways and techniques to understand, mitigate, and cure some illnesses. For instance, they help mitigate bone loss, understand bacterial behavior, and create innovative techniques for wound-healing.

The benefits of space activities are not limited to the countries that heavily engage in space research; the countries that lack of space research also take advantage of space activities under some programs. For example, projects under the UK Space Agency International Partnership Program, which is a five-year and £152 million program, aim to deliver a sustainable, economic or societal benefit to developing countries. Projects have a wide range of targets including improving agriculture, reducing deforestation, improving disaster response, reducing maritime pollution and illegal fishing, optimizing renewable energy, and improving resilience to climate change¹⁷.

3. Government Intervention in Space Market

The growing space sector and benefits of space activities unsurprisingly have been steadily attracting governments and investors. The number of governments that engage in space activities has been increasing, so have private companies. Due to growing and diversifying of the space market, government intervention, at least for regulation, seems to be needed. But in some countries, governments have adopted varied policies different from the traditional one, which is fixing the market; they have struggled to create and shape the market,-a policy that enables governments to play a more active role in the market.

3.1. Government Intervention to Correct Market Failures in Space Market

The first fundamental theorem of welfare economics is that if the economy is competitive and satisfies certain conditions, it is Pareto efficient. Pareto efficiency is a term commonly used in welfare economics and refers to an economic situation, where no one can be made better off without someone being made worse off. But in fact, markets are hardly competitive. According to Stiglitz and Rosengard¹⁸, there are six conditions in which markets are not Pareto efficient: i) failure of competition ii) public goods iii) externalities iv) incomplete markets v) information failures vi) unemployment, inflation and disequilibrium. These conditions are referred to as market failures and pave the way for government intervention.

As in other markets, governments intervene in the space market to correct market failures. First of all, competition must be established in the market. Because the space sector in most countries is an infant one, and there are limited number of companies that operate in the market. This could

17 UK Space Agency (2018). UK Space Agency International Partnership Programme-Space for Agriculture in Developing Countries, UK, 6.

18 Stiglitz, J., Rosengard, J.K. (2015). Economics of the Public Sector, Fourth Edition, W. W. Norton & Company Inc., New York, 89-93.

lead to monopolies and oligopolies, which distorts prices and output, and which causes economic inefficiencies. For example, NASA¹⁹ has been struggling to boost competition in the space market for years. It partners with private companies to transfer technological know-how and encourages competition between them especially in low Earth orbit (LEO) projects. So American companies with the support of NASA lower their costs, and this makes challenging space missions realistic and attracts new investors.

Similarly, governments intervene in the market due to some goods that are not supplied by the market or supplied inadequately. Samuelson²⁰ first called them collective consumption goods, and today, they are known as public good. National defense is a classic example of public good and accepted as pure public good, because it is characterized by non-rival consumption and non-excludability. Today, it is accepted that national defense is one of the major triggers of space research, since the space-based systems have become gradually crucial in national defense. Most countries are funding big projects to put military communication satellites into orbit, which gives them the ability for global communications and for surveillance and reconnaissance. Satellites are also used for navigation and positioning functions. According to WorldAtlas²¹, the US leads the way in military satellites. The country has 123 military satellites in orbit by 2018. Russia follows the US by 74 satellites, and China is the third with 68 satellites. Aside from satellites, some countries have funded space weaponry programs. For example a NATO Report²² shows that China and Russia have been developing modern warfare programs to diversify their military capabilities. US and China have invested in the ASAT (anti-satellite weapons) program, a program that develops anti-satellite weapons to destroy satellites in orbit for military purposes. But the most significant step has been taken by the US in this field. President of the US signed an order in 2019 to establish a space force. The new branch of the military is planned to deter and counter threats in space.

These examples mentioned above are parts of national defense, and due to their characteristics, they are carried out in the realm of governments and are called public good. Similarly, basic research is accepted as another public good. National space agencies do research and share outputs and results with the public; they cooperate with national and international educational institutions, which helps spreading knowledge. Most national space agencies have education programs, – an effort that allows people to access knowledge and develop themselves. For example ESA has education programs that enable young people and teachers enhance their competence in science and technology²³.

Externalities are another reason that constitutes the government intervention rationale. Mostly, the actions of one firm or one individual affect other firms and/or individuals. For example if a firm

19 NASA (2013). Emerging Space-The Evolving Landscape of the 21st Century American Spaceflight, 3-4.

20 Samuelson, P.A. (1954). The Pure Theory of Public Expenditure, *The Review of Economics and Statistics*, Vol. 36, No. 4 (Nov., 1954), 387.

21 Worldatlas (2019). Countries by Number of Military Satellites, <https://www.worldatlas.com/articles/countries-by-number-of-military-satellites.html>, (Accessed on: 30.08.2019).

22 NATO (2017). The Space Domain and Allied Defense, NATO Parliamentary Assembly-Defense and Security Committee Report, 6.

23 Talevi, M. (2016). ESA Education Activities, 7th CCI Co-location Meeting ESRIN, ESA, 6 October 2016, 2.

could impose a cost on others and not compensate it, negative externalities would arise. To deal with negative externalities, for instance, a tax once was offered by Pigou. A Pigouvian tax equals the harm that the firm imposes on other firms or individuals. Such a tax is commonly discussed in pollution problem that our planet faces. For example, if a firm pollutes, and the pollution causes a harm of \$100 per unit of pollution, then the firm should pay a tax of \$100 per unit of pollution²⁴. Space debris, in this manner, is accepted as another kind of pollution today. According to United Nations Office for Outer Space Affairs (UNOOSA), 8608 satellites have been launched so far, and 5164 of them are still in orbit²⁵. The growing satellite number leads to the space junk problem. It is estimated that there are approximately 300,000 pieces of debris in orbit, which are of enough size to destroy a satellite in collision. So the Pigouvian tax on polluters could help ease the space debris problem. It raises the private cost of further polluting certain orbits, and polluters bear the private and social cost of their actions, which results in a more efficient allocation of resources²⁶. Another way to deal with the space debris problem is regulations. National and international regulations can play a major role to ease the problem. The Inter-Agency Space Debris Coordination Committee of ESA, for example, has been struggling to mitigate the debris problem by cooperating with a number of organizations for years. Additionally, some spacefaring nations have implemented national laws to handle the problem. However, all these efforts do not yet appear to be sufficient for international consensus on space debris problem.

The cases above are just a few examples for the rationale of government intervention. But governments should do more than fixing the market especially in the case in which no space market and/or mature market is available.

3.2. Government Intervention to Create Space Market

The space sector is research and technology, requires highly-skilled employees and carries high operational risks. These factors increase the need of seed capital and constitute a sectoral challenge for entrepreneurs. Then, if governments are eager to have a robust private space sector, they should take more responsibility. Mazzucato, in her book *The Entrepreneur State*, advocates²⁷ that governments shouldn't only be fixing the market, they should create the market as well. So governments should become "entrepreneurs" and "market creators". According to Mazzucato, governments should also take risk, that is, they should become "risk taker". For example, a public venture capital doesn't hesitate to invest in risky fields contrary to private venture capitals. Investing in higher risk fields, the public venture capital shows patience and expects lower returns. These features differentiate the public venture capital from the private one, and should be taken into account while comparing the two. She also claims that some research and innovation projects carried out by governments were

24 Masur, J. S., Posner, E. A. (2015). *Toward a Pigouvian State*, University of Pennsylvania Law Review, Vo. 164, 95.

25 UNOOSA (2019). *Outer Space Objects Index*, http://www.unoosa.org/oosa/osoindex/index.jsp?lf_id=, (Accessed on: 30.08.2019)

26 Salter, A. W. (2015). *Space Debris-A Law and Economics Analysis of the Orbital Commons*, Mercatus Working Paper, Mercatus Center, George Mason University, Virginia, 11.

27 Mazzucato, M. (2013). *The Entrepreneur State*, Anthem Press, UK and USA.

behind the success of certain products made by the largest companies in the world, that is, “It was the visible hand of the State which made these innovations happen”.

Undisputedly, innovation is an inevitable necessity in the space sector. In another study²⁸, Mazzucato says that innovation is needed at the center of growth policy to shape and create markets. Focusing on just traditional roles of the government like “administering”, “fixing” and “regulating” moves us away from thinking about “how to allow public sector vision, risk-taking, and investment to lead and structure the necessary transformational changes”. Mazzucato and Robinson recommend this market creation approach to ESA. They say²⁹ that ESA’s Space 4.0³⁰ provides opportunities for ESA to shape and create the market, so ESA should focus on creating and shaping the markets rather than fixing them, which is the traditional method.

But how should it be done? What is the best method to create a space sector and a robust space market in a country? It seems that Public Private Partnership (P3) is a proper method for the governments to create and shape the market. Today, the countries that actively deal with space activities have tended to create a private space market through P3 Projects. “A P3 is a long-term contractual arrangement for the delivery of public services where there is a significant degree of risk sharing between the public and private sectors” (Commonwealth Secretariat, 2010: 8). NASA and ESA have preferred this method as well; in due course they have changed their strategies cooperating with private companies in some space missions through P3 projects. This approach has encouraged existing companies to invest in the space sector and helped increase the number of space start-ups. In their another study Mazzucato and Robinson (2018: 166-177) define NASA’s new strategy, saying that NASA has changed its policy that aimed to create market through procurement policy and started creating an ecosystem with a mix of private, not-for profit and public actors in LEO; that is, its role evolved from “an orchestrating/directing role to a more facilitating one by driven commercialization needs”.

Indeed, P3 projects are not peculiar to space sector; they have been used by most countries especially in construction projects for years. But the nature of space projects is different from that of traditional construction projects. Therefore, P3 projects in space sector should be considered and examined distinctively. According to Jones³¹, traditional construction projects are structured to provide functional support from operation and maintenance to concession agreements; but a P3 space project contains various arrangements for sharing risk and know how through cooperative research, as Space Act Agreements are or longer fix term development agreements. He says that the objectives of a P3 project in space sector could include: i) Mission Support—to advance science, space exploration, or

28 Mazzucato, M. (2016). From Market Fixing to Market-Creating: A New Framework for Innovation Policy, Industry and Innovation, Volume 23, Issue 2, 80.

29 Mazzucato, M., Robinson, D. K. R. (2016). Market Creation and the European Space Agency: Towards a Competitive, Sustainable and Mission-Oriented Space Eco-System, The Final Report for ESA, 62.

30 ESA defines Space 4.0 as follows: “Space 4.0 era is a time when space is evolving from being the preserve of the governments of a few spacefaring nations to a situation in which there is the increased number of diverse space actors around the world, including the emergence of private companies, participation with academia, industry and citizens, digitalisation and global interaction.”, <https://www.esa.int>, (Accessed on: 30.08.2019).

31 Jones, K. L. (2018). Public-Private Partnerships: Stimulating Innovation in the Space Sector, Center for Space Policy and Strategy, USA, 4.

national security and defense, ii) Functional Support such as communications, Earth observation, space logistics, iii) Technology Advancement such as proto-typing or developing new technologies, iv) Space Industrial Base to promote a competitive and robust commercial space sector.

NASA has completed a lot of successful P3 projects so far. The Commercial Orbital Transportation Services Program, for instance, is one of them and accepted as one of the most successful P3 projects achieved by NASA. The program has yielded two commercial resupply vehicles and added two launchers to the US fleet in a shorter time than NASA could alone. It has also accomplished with a cost reduction of 20 to 1³². NASA, in its P3 projects, have mainly two models to encourage commercialized space activities. The traditional model used by NASA is a cost-plus method that reimburses companies the cost of a project plus a guaranteed profit. But this model is criticized since it rules out competition and leads to inefficiency. Along with the new Space Act Agreements of the US, NASA has adopted a new model in which NASA pays in increments once milestones are met. In this new model, management and design are undertaken by private companies; they just get advice and support from NASA when they need³³.

Transcending the traditional methods like fixing the market seems necessary for governments to create a space sector. Governments should correct market failure, but at the same time they should be an active player in the market and cooperate with private companies through P3 projects to bring out and shape the commercialized space sector.

4. What Should be the Role of the Turkish Government in the Space Market

Turkey didn't have a national space agency, but the country has taken an important step recently to establish it. A presidential decree³⁴ was published in Turkey's Official Gazette on Dec. 13, 2018 announcing that the Turkish Space Agency has formally been established. The Decree consists of 13 articles and reveals details about the Agency such as its duties and units. This step hopefully shows that the Turkish Government has noticed the importance of space research and put its enthusiasm for being a part of national and international space activities.

The duties of the Turkish Space Agency are defined in Article 4 in the Decree. According to the Article 4, the first duty of the Agency is to build a National Space Program. The Program will be built in accordance with the policies determined by the President of the country. It will most likely put a perspective that shows the targets of the Agency in the short and the long run comprehensively.

According to the same Article, one of the priorities of the Agency is to carry out manned and unmanned space missions for scientific and R&D purposes. The Article also states that the Agency will organize public institutions in their projects that aim to boost economic development, ensure national security and public health, detect and mitigate disasters, increase productivity in agriculture

32 Utrilla, C. M. E. (2017). Asteroid COTS: Developing the Cislunar Economy with Private-Public Partnerships, *Space Policy*, 39-40 (2017), 14.

33 Anderson, C. (2013). Rethinking Public-Private Space Travel, *Space Policy*, 29 (2013), 268.

34 Türkiye Uzay Ajansı Hakkında Cumhurbaşkanlığı Kararnamesi, Cumhurbaşkanlığı Kararnamesinin Sayısı 23.

and etc. All statements denoted above clearly indicate that the Agency aims to conduct its own research and space missions, and contribute to provision of public good from security to public health, using government funds. As emphasized in Section 3, militaries have relied increasingly on space systems in the world. In this manner, the Agency should aid to boost the capability of the Turkish Armed Forces by producing satellites and new space systems. The increasing capability of the Armed Forces that is boosted by space systems would increase the quality of public good provision. Similarly, public health and natural disaster relief are also for the public good. Satellites provide precious timely information to disaster relief officials in their efforts to deal with the disaster damages. Then, the Agency should produce satellites and put them into orbit to identify disasters and ease public health problems that arise after the disaster, which are accepted as public good.

In addition, Article 4 states that the Agency will do basic research and support R&D projects. This statement clearly mandates that the Agency will produce for the public good directly. Because, as pointed out earlier, basic research and knowledge are public good. Markets are insufficient to do basic research and produce knowledge, and so this gap should be filled by the Agency. But, results of the research projects and scientific knowledge must be shared with society effectively. Basic research should be done partnering with universities, an approach that is already stated in the Article. In his last book *Brief Answers to the Big Questions*, theoretical physicist Stephen Hawking³⁵ says that space programs would excite young people and help them enter a wide range of sciences, not just space science. Indeed, encouraging young people to engage in science must be the duty of public institutions. Article 4 states that the Agency will be a pioneer in encouraging people to enter space science. It is clear that as Hawking emphasizes, such an effort wouldn't be limited to space science, but encourage people to deal with all kinds of sciences.

Hiring highly educated and skilled people could be another contribution of the Agency. As is known, space sector hires highly skilled workers across the world. For example in the UK space sector, 3 in 4 hold a higher education degree. And they are also highly productive; labor productivity in the space sector by 2015 was £140,000, which is more than three times the national UK average of £46,000³⁶. So the Turkish Space Agency could hire well-educated and high-skilled workers in Turkey, who have strived to find jobs that are commensurate with their training and experience. Due to lack of a large market based on space research and cutting-edge technologies, some highly educated people have either worked out of their fields or migrated to other countries. The Agency could keep such skilled people at home and contribute to easing of the unemployment problem.

As discussed above, the Turkish Government will likely intervene in the market through the Agency, due to market failures. However, it appears that the intervention will often stem from the needs of public good. There is no indication to deal with externalities in the Decree; but it seems that the authority to make regulations is assigned to the Agency. In addition, there is only one statement within duties of the Agency, on establishing competition and creating an industry. Article 4 states

35 Hawking, S. (2018). *Brief Answers to the Big Questions*, Bantam Books, New York, 107.

36 London Economics (2016). *Return from Public Space Investments-An Initial Analysis of Evidence on the Returns from Public Space Investments*, Final Report, UK, 16.

that the Agency will strive to create a “competitive space industry”. This statement is the only one that refers to a private space industry. It hopefully seems that the government has noticed the importance of the potential of a private space industry. But the statement is a bit shallow, and must be explained broadly in the National Space Program to show that the government is eager to play an active role to create and shape the market, for example as in the US. In National Aeronautics and Space Act of 1958, Section 203 states the functions of the Administration (NASA), saying “seek and encourage, to the maximum extent possible, the fullest commercial use of space”. Additionally, the National Space Policy of the United States of America that was issued in 2010, manifests one of the principles of national space policy as follows³⁷: “A robust and competitive commercial space sector is vital to continued progress in space. The United States is committed to encouraging and facilitating the growth of a U.S. Commercial space sector that supports U.S. needs, is globally competitive, and advances U.S. leadership in the generation of new markets and innovation-driven entrepreneurship”. Similar statements should be added to the Turkish National Space Program, and these statements should clearly show that the Agency will make an effort to create a competitive space sector, encouraging existing companies and start-ups to get into the market.

Turkey has only a few space companies, and the biggest one has already a public shareholder. They mainly engage in satellite services, and are also government contractors. To increase the number of space companies and create a private space sector, as asserted in Section 3, the government should play an active role in the market as “market creator and shaper”. And it should award private companies with P3 projects. This method seems the best way to encourage companies to get into the market. Turkey has a long history of P3 projects, particularly in infrastructure. Today, the country is one of the top five countries in P3 infrastructure projects in the world by 2018³⁸. Turkey has a deep experience in P3 projects, P3 should be carried out cautiously in space sector due to the different nature of space programs as discussed in Section 3; laws, regulations and procedures should be rearranged in accordance with the nature and necessities of the sector. Sadeh says³⁹ that “space systems are difficult to execute and easy to derail”. So everything must be done accurately in space programs; otherwise, it could lead to significant wasted resources and program failures. For instance, Nardon and Venet asserts⁴⁰ that the failure of the Galileo PPP negotiation recalls that in satcom industry particularly, public authorities lacked of experience because a few P3-based space projects were launched. Another point is that risks specific to the satcom industry have to be taken into account in addition to the usual risks associated with P3s. Obviously, executing a P3 project in space sector requires specific experience peculiar to space activities.

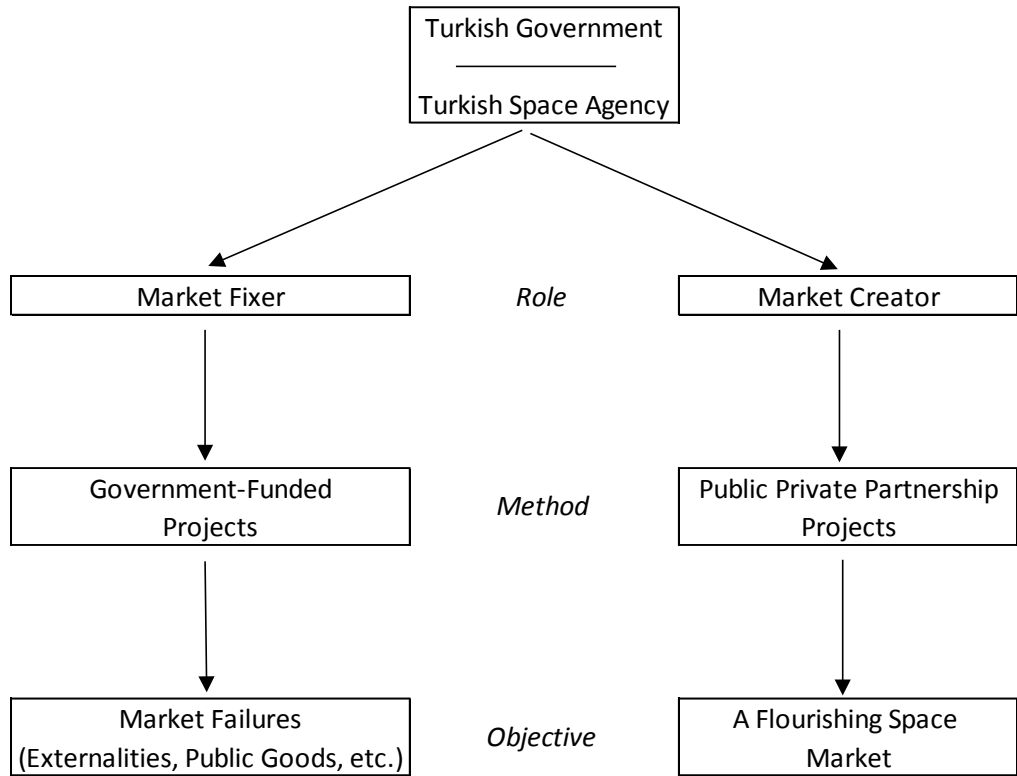
37 National Space Policy of the United States of America, June 28, 2010, 3.

38 World Bank (2018). Private Participation in Infrastructure (PPI), H1 2018 Report, 1.

39 Sadeh, E. (2015). Public Private Partnerships and the Development of Space Launch Systems in the United States, *Astropolitics The International Journal of Space Politics & Policy*, 13: 1, 104.

40 Nardon, L., Venet, C. (2011). The Development of Public-Private Partnerships in the European Satcom Sector, *Actuelles de l’Ifri, The Europe & Space Series*, No. 4, 5.

Graphic 1: The Proper Role for the Turkish Government in the Space Market



Therefore, as is shown in Graphic 1, the Turkish Government should have two roles in the market: correcting market failures, and creating and shaping the market. In the first role, the government would be “market fixer”; it would carry out space programs using public funds. It would contribute to the provision of public good, ease externalities, ensure competition, – the efforts that are made to fix market failures.

In the second role, the Government would create and shape the market through the Turkish Space Agency. The Agency should cooperate with private companies to produce public good and other services. And the best method to do this is P3 projects. Through P3 projects, the Agency would encourage new companies to get into the market, which would help create a private space sector. On the other hand, the Turkish Government could trigger the sector using traditional methods like financial incentives. For example in the US, some States implement tax credit programs, R&D tax credits, incentive packages for high-paying jobs or exemption and advantage zones⁴¹. But it should be accepted that these policies would be insufficient for creating a flourishing space sector. Instead, as emphasized above, the government should take an active role, become a player, and partner with

41 Federal Aviation Administration (2009). State Support for Commercial Space Activities, US, 5.

private companies in the market using P3 projects. Partnering with private companies through P3 projects would trigger the sector and encourage new companies to get into the market. Both roles, market fixer and market creator, would help create a robust space sector in the country.

5. Conclusion

This study has developed economic policy recommendations for creating a space sector in Turkey. Examining the experiences of different countries and the Decree that has established the Turkish Space Agency formally, the study has suggested that the Turkish Government should have two roles in the market: correcting market failures and creating the market. The Decree allows Turkish Space Agency to intervene in the market to correct certain market failures such as public good. But due to the lack of a large space market, the Turkish Government should play a more active role to create it through the Turkish Space Agency. The study has concluded that the Agency's role to create and shape the market should be emphasized in the National Space Program, and that the best method that can be assigned to the Agency to create a robust space market is P3 projects. This method would encourage companies to get into the market, which would increase the number of companies and lead to a growing space sector. Future studies should focus on how to design P3 projects in the Turkish space sector.

References

- Aerospace (2017). The State of the European Space Industry in 2016, Facts and Figures Press Release – June 2017, p.1.
- Aerospace Security (2019). History of the NASA Budget, <https://aerospace.csis.org/data/history-nasa-budget/>, (Accessed on: 17.07.2019).
- ANDERSON, C. (2013). Rethinking Public-Private Space Travel, *Space Policy*, 29 (2013), 266-271.
- Commonwealth Secretariat (2010), Public-Private Partnerships Policy and Practice: A Reference Guide, Edited by HK Yong, Commonwealth Secretariat, United Kingdom,
- COMSTOCK, D. (2010). The Socio-Economic Benefits of Space Technology Applications and Spinoffs, United Nations/Turkey/European Space Agency Workshop on Space Technology Applications for Socio-Economic Benefits, Istanbul.
- ESA (2019). ESA Budget, http://www.esa.int/spaceinimages/Images/2019/01/ESA_Budget_2019, (Accessed on: 18.07.2019).
- European Space Agency Handbook (2011). Strategic Information and Contact, International Business Publication, Washington D.C., USA-Belgium.
- Federal Aviation Administration (2009). State Support for Commercial Space Activities, US.
- HAWKING, S. (2018). Brief Answers to the Big Questions, Bantam Books, New York.
- JONES, K. L. (2018). Public-Private Partnerships: Stimulating Innovation in the Space Sector, Center for Space Policy and Strategy, USA.
- KAKU, M. (2018) The Future of Humanity, Doubleday, New York.
- KRIGE, J., RUSSO, A., SEBESTA, L. (2000). A History of the European Space Agency 1958 – 1987 (Volume II The story of ESA, 1973 to 1987), European Space Agency, The Netherlands.
- LEWIS, S. J. (2015). Asteroid Mining 101-Wealth or the New Space Economy, Deep Space Industries Inc.

- London Economics (2016), Return from Public Space Investments-An Initial Analysis of Evidence on the Returns from Public Space Investments, Final Report, UK.
- MASUR, J. S., POSNER, E. A. (2015). Toward a Pigouvian State, *University of Pennsylvania Law Review*, Vo. 164, 93-147.
- MAZZUCATO, M. (2013). *The Entrepreneur State*, Anthem Press, UK and USA.
- MAZZUCATO, M. (2016). From Market Fixing to Market-Creating: A New Framework for Innovation Policy, *Industry and Innovation*, Volume 23, Issue 2, 79-103.
- MAZZUCATO, M., ROBINSON, D. K. R. (2016). Market Creation and the European Space Agency: Towards a Competitive, Sustainable and Mission-Oriented Space Eco-System, *The Final Report for ESA*.
- MAZZUCATO, M., ROBINSON, D. K. R. (2018). Co-Creating and Directing Innovation Ecosystems? NASA's Changing Approach to Public-Private Partnership in Low-Earth Orbit, *Technological Forecasting Social Change*, 136 (2018), 166-177.
- MCCURDY, H.E. (2019). *Financing the New Space Industry Breaking Free of Gravity and Government Support*, Palgrave Studies in the History of Science and Technology, Switzerland.
- NARDON, L., VENET, C. (2011). The Development of Public-Private Partnerships in the European Satcom Sector, *Actuelles de l'Ifri, The Europe & Space Series*, No. 4, p. 5.
- NASA (2013). *Emerging Space-The Evolving Landscape of the 21st Century American Spaceflight*.
- NASA (2019). *NASA FY 2020 Budget Request*, https://www.nasa.gov/sites/default/files/atoms/files/fy2020_agency_fact_sheet.pdf, (Accessed on: 17.07.2019).
- National Space Policy of the United States of America, June 28, 2010.
- NATO (2017). *The Space Domain and Allied Defense*, NATO Parliamentary Assembly-Defense and Security Committee Report.
- OECD (2014). *The Space Economy at a Glance*.
- OECD (2019). *The Space Economy in Figures-How Space Contributes to the Global Economy*
- RAI, A., ROBINSON, J.A., BROWN, J.T., BUCKLEY, N., ZELL, M., TASAKI, K., KARABADZHAK, G., SOROKIN, I.V., PIGNATORA, S. (2016). Expanded Benefits for Humanity from the International Space Station, *Acta Astronautica*, 126 (2016), 463-474.
- SADEH, E. (2015). Public Private Partnerships and the Development of Space Launch Systems in the United States, *Astropolitics The International Journal of Space Politics & Policy*, 13: 1, 100-115.
- SALTER, A. W. (2015). *Space Debris-A Law and Economics Analysis of the Orbital Commons*, Mercatus Working Paper, Mercatus Center, George Mason University, Virginia.
- SAMUELSON, P.A. (1954). The Pure Theory of Public Expenditure, *The Review of Economics and Statistics*, Vol. 36, No. 4 (Nov., 1954).
- STANLEY, M. (2017). *Space: Investment Implications of the Final Frontier*.
- STIGLITZ, J., ROSENGARD, J.K. (2015). *Economics of the Public Sector*, Fourth Edition, W. W. Norton & Company, Inc., New York.
- T.C. Resmi Gazete, 13 Aralık 2018.
- TALEVI, M. (2016). *ESA Education Activities*, 7th CCI Co-Location Meeting, Esrin (ESA Centre for Earth Observation).
- UK Space Agency (2018). *UK Space Agency International Partnership Programme-Space for Agriculture in Developing Countries*, UK.
- US National Aeronautics and Space Act of 1958.

- UTRILLA, C. M. E. (2017). Asteroid COTS: Developing the Cislunar Economy with Private-Public Partnerships, *Space Policy*, 39-40 (2017), 14-19.
- WEINZIERL, M. (2018). Space, the Final Economic Frontier, *Journal of Economic Perspectives*, Volume 32, Number 2, Spring 2018, 173-192.
- World Bank (2018). *Private Participation in Infrastructure (PPI)*, H1 2018 Report.