Reframing Space: Macroeconomists Engage Outer Space with the Help of Scenario Planning.

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Introduction

Space has been a source of curiosity for thousands of years. Now lots is changing. In 2031 the International Space Station will be de-orbited and replaced by a commercial enterprise, as private firms conduct activities previously dominated by national space agencies (NASA, 2021).

With the global space sector already growing at a rapid rate (Morgan Stanley, 2020), challenges for global institutions and governance, as well as risks of negative spillovers from space to the global economy, have both given a new impetus for macro-economists to assess the implications.

As a leading and learning institution, to visualise how turbulent, uncertain, novel, and ambiguous (TUNA) factors may affect the space economy, the UK Space Agency (UKSA) carried out its first iteration of scenario planning. The rapid advance into outer space by several new actors where space is becoming increasingly congested may lead to outer space activities bearing all the characteristics of TUNA. To examine the outer space economy through the lens of TUNA and to determine its strategic implications, the Oxford Scenario Planning Approach (OSPA, Ramirez and Wilkinson, 2016) was used in work which was commissioned by the first author and supported by Clift and Ramirez, also co-authors.

It was in particular the acceleration of space commercialisation which gave rise to assessing the overall possible strategic direction which the space sector might take. Emerging signals from the contextual environment coupled with interviews with a wide range of experts and workshops fed into the scenario planning initiative.

Four plausible, but not necessarily probable scenarios were created. They depict worlds which might arise by 2030. These scenarios are not predictions, but divergent possible futures designed to assist the users in the Agency to develop and test more robust strategies.

The four scenarios which were produced are as follows:

Grounded: Most of Low Earth Orbit (LEO: orbits up to 2000km above sea level) becomes unusable.

Power Play: A world where the private sector continues to make headway in space. Tensions between State and private actors increase as the private sector increases its scope and activity.

Renaissance: Space is valuable for earth observation and for some mitigation projects. Space agencies see their role is changing rapidly in a number of ways, and they evolve to survive and thrive in these different conditions.

From Cloud to Nebula: Some industry moves into orbit. For manufacturing of some high value medical and electronic components, free fall (weightlessness) can provide a highly desirable environment. (Lewin, 2018).

Macroeconomists typically do not examine space because they have insufficient knowledge of the potential economic significance. These scenarios raised awareness of how technology and the economics of outer space are becoming imbricated with the economics of earth. The application of the Oxford Scenario Planning Approach provided a means to illustrate the intersection of factors affecting both macroeconomists and space policy makers alike, creating a base for developing common ground, shared language and setting out an opportunity for shared interest and collaboration.

The scenario planning initiative has thus enabled space scientists and economists to see new relationships which link the earth-serving economy and the exo-Earth economy. This connection entails a new economic perspective which serves both. Earth-serving and exo-Earth components both pose opportunities and potential macroeconomic risks for the global (terrestrial) economy which merit further examination. This paper outlines what such an examination might cover.

Scenarios using the Oxford Scenario Planning Approach

Deploying the OSPA provided sensemaking of the future and catalysed the engagement of the two organisations: the UKSA and IMF. Whilst employed by the UKSA and the IMF respectively, the first two co-authors, met at an OSPA course and quickly realised that the application of macroeconomics to space could be a shared interest (Behar and Hlatshwayo (2021) documented the IMF's experience in applying the OSPA scenario planning methodology to macroeconomics.). Accordingly, they produced internal notes for their respective organizations. The UKSA's first iteration of scenario planning inquiry was held in 2019 with the help of the third and fourth authors as members of the consultancy NormannPartners. It included interviews with a wide range of space and non-space professionals, coupled with secondary research. This was followed by dedicated two-day workshops that produced the set of four distinct scenarios introduced above. The scenario set was used in the first instance to draw on strategic implications and test the UKSA's sense of strategic direction for the space sector in which it operates.

The scenarios strengthened knowledge through reframing the future. This uncovered links between disparate subjects such as happiness of humans on earth and outer space activities; while Artificial Intelligence shifts roles and jobs, outer space provides an opportunity for more fulfilling roles using AI. Different aspects of the unfolding nature of space involve rapid expansion and new pathways to a growing exo-Earth economy. The strategic implications this has on earth also required further scrutiny. This initiative broke new ground in recognising novel links between the exo-Earth economy and potential macroeconomic risks. A lack of clear property rights and the challenges this lack entails became evident. The advent of new common goods, their emerging associated legal jurisdictions, and the extent to which global economic co-ordination will be required to govern outer space commons sustainably, were highlighted. Up to now, policymakers and strategists have regarded macroeconomics and space as having limited interactions. Some have applied the notion of macroeconomics more loosely (Thompson, 2009) from each other. With the help of the scenario planning initiative, and as conscious leaders (Renesch, 2014) resolved to see a positive future, they now have a better understanding of how macroeconomics and space are increasingly relevant to each other.

The UKSA produced "interesting research" (Ramirez et.al. 2015) themes for further examination. These were kept innovative and rigorous by using the OSPA. Four main themes emerged from the scenarios for plausible futures:

- The greening of outer space where global space activity choices might have an important impact on the environment.
- The management of spatial debris challenges and the impact it might have on the sustainability of LEO activities.
- Global co-ordination of space activities and the effects it might have on undisrupted operations.
- Governance – which also affects how the financial stability of the space economy might be maintained.

Below is a fuller summary of the four scenarios:

Grounded

Most of LEO becomes unusable due to a Kessler event, an exceptional weather event (e.g. a powerful geomagnetic storm), or a gradual accretion of orbital debris. This causes significant financial impact and curtails many space activities. Space industry struggles to grow. Opportunities increase for space debris clearance ventures, which re-open space.

Power Play

The Private Sector continues to make headway in outer space, dominating that sphere. Tensions between the State and the Private Sector increase in line with private sector growth. Slow moving and powerless global regulation makes it easy for private sector actors to do what they will. Technology development continues accelerating and non-traditional actors join the race for space. This is a highly commercial world where financial risks in space are irrevocably linked to the Earth.

Renaissance

Historical high-use space-based services such as Direct to Home (DTH) broadcasting have declined significantly. Most states recognize the threat of climate change, and space is important for Earth observation and a valuable asset in potential mitigation projects. The roles of Space Agencies across the globe are changing in several ways to thrive in these different conditions.

From the Cloud to the Nebula

Climate change and sustainability are accepted as key global issues. Social capital becomes more important. Responsible regulation is in place for the space industry. Some polluting industries move up into Earth orbit. Some new industries and manufacturing sectors are enabled by access to LEO.

Insights from Scenarios

In this paper we provide examples of the type of insights that the scenarios yielded. The following sections are some key insights derived from using the OSPA.

Collision course

The Grounded scenario considered how exponentially fast growth of the space economy situated in LEO (De Vito,2019) could make the whole sector crash. A major event where two very expensive pieces of kit collide could bring this about and would involve losses of billions of dollars for investors, and have extensive implications for the economy on earth, which depends on satellite communications and GPS to operate effectively. For example, 15% of the UK's earthly economy depends on space activity by one estimate (UK Space Agency, 2018).

'Grounded' reveals how space might be seen as a source of systemic risk to global economic growth and financial stability, particularly so as space becomes increasingly more vital for terrestrial activity and for key communication infrastructures. Shocks could arise from accidents, deliberate actions, or simply confusion. The legal ambiguities in outer space amplify the economic uncertainty from such events. It is no accident that the militarisation of space is one of the 'frontier risks' examined by the World Economic Forum (2021) in its Global Risk Report.

In effect, a single collision in the earth's orbit can render critical infrastructure unusable (Radermacher, 2016). Weinzeirl (2018) described an incident where space debris destroyed a Chinese weather satellite. Any of the 128 million pieces of debris larger than 1mm in the earth's orbit can cause - and many have already caused - damage when travelling at orbital speeds of around 17,500 mph (European Space Agency, 2020). In addition, the increase in the number of small satellites in operation, combined with those destroyed or more or less abandoned but still in orbit ("space junk"), render more and more parts of outer space "unusable" (OECD, 2020) for others.

As congestion in the parts of space which are occupied is increasing, so are the risks of a collision. Launches from the UAE, China, and the USA to Mars in July 2020 highlighted growing ambitions across the globe (Amos, 2020, NASA 2020). For the period until 2030, there are at the time of this writing (February 2022) at least 95 planned missions to the Moon

and 11 planned missions to Mars (Bryce, 2020). NASA has been successful in its touchdown on Asteroid Bennu to collect samples.

Like Earthscapes, Spacescapes have a dual use – civil and military (Vlasic in Jasani, 1991). The strategic and commercial value offered by outer space assets implies that space might more and more become an arena with contested access (Cardin 2004). Thus, the use of anti-satellite technologies designed to purposefully disable or destroy satellites will intensify global terrestrial tensions (National Intelligence Council, 2017). Arguably, this has already begun to happen, with the Russian Federation intentionally destroying one of its own satellites in a missile test (Economist, 2021), causing ISS astronauts and cosmonauts to take precautions against a potential debris strike. Defensive moves to protect space assets could trigger accidental collisions, with knock-on effects to other satellites, disruptions to terrestrial communications, and a rapid acceleration of the space arms race.

The 'Grounded' scenario thus underlined both the operational challenges for, and the economic effects of space collisions. These could play out in several ways which depend on the economic structure and norms at the time of that future event. Increasing risks translate to both higher insurance and launch costs, which negatively impact economic activities directly associated with space, as well as the number of suppliers to the space industry, while raising input costs for those reliant on the space economy. The costs of doing business in space itself rise in this scenario, negatively impacting global investor sentiment. Although there are parallels with extant geopolitical conflicts, the absence of precedent and of an accepted and shared binding legal framework makes the effects of a collision more likely to be acute and persistent. In financial markets, periods of elevated global uncertainty tend to prompt a "flight to safety" as investors sell riskier assets (even if unrelated to the origin of the risk) and use the proceeds to buy less volatile assets. A serious collision would cause investors to re-evaluate investments in the space economy and other risky sectors, and it would increase the cost of financing for government budget deficits in countries with higher risks.

Exo-earth economy

In another scenario, 'Renaissance', it becomes evident that new exo-earth opportunities for resource extraction beyond our traditional jurisdictions have become plausible. A current manifestation of this can be seen in the space ventures with long time horizons to Venus and Jupiter already being examined (Bachelor, 2018).

The ‘Power Play’ scenario questions assumptions held by many actors in the space economy, often implicitly. Historically, space has been governed by nation states. In this scenario, with increasing commercialisation of space, novel actors play a dominant role where geopolitics are no longer dominated by nations. Private actors are here negotiating new boundaries with each other, boundaries that have in the past been navigated only by governments and their agencies. Although technological advancement is a primary preoccupation of such firms today, broader regulatory issues become more relevant in this scenario, not least for those financing these activities.

Space is already showing signs of demands for more collaboration and co-ordination to exploit positive externalities (A positive externality arises when an agent’s individual cost-benefit calculation doesn’t fully internalize the broader benefits to society). In the Power Play scenario, positive externalities increase quickly. As this scenario sets it out, opportunities arising from co-ordination and complementarity (e.g., between low-cost launching and in-space manufacturing) could well become large ones, and sooner than expected. Co-ordination in turn would not be easily solved without further considerable market concentration, locking-in this scenario for a considerable time (if it indeed arises) with a self-fulfilling feedback loop.

Recent evidence already demonstrates congestion and overuse of space in a ‘tragedy of the commons’ (Frischmann et.al. 2019) sense, which co-produces many types of negative externalities. Just as *Grounded* assessed the economic risks of a collision, *Power play* highlights other “commons” problems. Two examples are a lack of responsibility for polluting the night sky with excessive light, and filling up the remaining usable parts of the space environment with debris. Debris problems can be mitigated through monitoring of the larger objects, provided that organisations such as NASA accept such a role, and that the role is accepted by relevant stakeholders, which is not the case today. In the same way, the private sector could develop viable solutions for debris removal – such as Clearspace (UK Space Agency Press Release 2021) – paid for by those sharing the commons. Again, this is not the case today.

Governance and fiscal implications

Legal frameworks and regulations that deliberately preclude property rights in space limit the incentives to pay for such services by individual actors. Although space analogies to the allocation of property rights on earth (both land and sea) could conceivably be developed, the regulatory landscape of space is currently based on the 1967 Outer Space Treaty Article 2, which precludes appropriation. The article establishes space as free for exploration and use by all nations, but no country may claim sovereignty of outer space or a celestial body. Closer to earth, there are no clear legal distinctions between airspace and outer space, giving rise, for example, to the 1976 Bogota Declaration by some countries concerning the sovereignty over geostationary satellites directly above their territories (Gilliver, 2021). This situation poses various co-ordination challenges about the desired manner of activities. In support of the treaty update process, another set of scenarios could be used to address challenges (Parson and Reynolds, 2021) such as regulatory lag and rethinking property rights. As space operations expand, international law and regulation are not being updated at the same pace. Upgrades inclusive of property rights would better facilitate private endeavours while protecting the public interest.

Property rights systems on earth could also form a framework for those on other celestial bodies. The United States Space Act of 2015 grants the first user rights to natural resources - though not the underlying celestial body (Leon, 2018). After the US passed the law, Luxembourg followed suit to prepare for space resource extraction such as asteroid mining (Luxembourg Space Agency, 2020). However, more creative adaptation might be needed for orbit as well as outer spaces, where the illusion of stationarity does not hold. A UN Committee approved only non-binding guidelines for good behaviour in space in 2019 (Foust, 2019). Several countries have formed shared principles, grounded in the 1967 Outer Space Treaty, to create a safe and transparent environment which facilitates exploration, science, and commercial activities for all of humanity to enjoy (UKSA and NASA, 2020). Even with such a treaty in place, clear binding law is yet to be drafted (Alexandre, 2020) to clearly split the space “commons” into sections to provide means that bring about more regulatory confidence for resource exploration.

Another possible solution to the commons problem is a Pigouvian tax (Nellor and McMorran, 1994). For example, space users could be taxed for their presence or for their debris, thereby funding clean-up efforts as well as reducing incentives to pollute. Making this work, however,

requires setting up a multilateral space taxing authority (and a regulatory authority). The growing need for centralised provision for monitoring debris and for rubbish collection thus remains a challenge. "Anti-litter" enforcement may be the only option to avoid expensive consequences, albeit a still very difficult system to design, test, enact, and govern.

Space could also present fiscal risks to terrestrial governments. Taxes discourage unwanted behaviour and simultaneously finance governments but, if excessive, could stifle growth in that sector.

Most countries currently tax companies only on profits generated within that country ("territorial basis"), but some nations tax resident companies on their global profits regardless of where the activity occurred ("worldwide basis"). As a result, some firms can be taxed twice, although this effect is mitigated by bilateral tax treaties. Competing claims on taxes could extend into space, but extending such treaties could be complicated because, unlike on earth, even the territory is not defined. For example, though the parties to the Bogota Declaration might say some of the satellite activity is on their territory for tax purposes, the tax residence of the operator has so far been the only relevant factor (Gilliver, 2021). For how long will location be deemed irrelevant for tax collection; and when might earth-serving activity located in space become subject to multiple tax bills from multiple countries for the same activity?

On the other hand, government collection of revenue is undermined by Base Erosion and Profit Shifting, which is a form of tax avoidance achieved by designating value creation in a particular territory, such as an offshore tax haven. Digitalization presently facilitates avoidance because, unlike the production of physical goods or in-person services, the location of value creation is less clear cut. By one estimate, about 40 percent of multinational profits are shifted to tax havens, and corporate income taxes alone decline by 10 percent as a result (Tørsløv, Wier, and Zucman, 2021.) The international community is working to reduce avoidance through various measures that include imposing a global minimum corporate tax (OECD, 2021).

Rezoning economic and social activity into outer space

Value is already being created in space through the deployment of satellites, and the scenarios suggest the development of significant manufacturing in orbit. As the industry matures, how fast will the manufacturers and satellite operators relocate their tax residence to an offshore tax haven and pay low taxes even if the product is being assembled above, and service sold to, a high-tax country? And what if the manufacturing is only possible because of critical refuelling provided on the moon's surface? This example illustrates how firms could claim a significant proportion of value added doesn't happen on earth. Similar arguments might be made with more conviction for activities in the exo-earth economy. How would the tax and legal system respond to the creation of tax havens "off planet" and not merely offshore? Beyond profits, how will terrestrial governments agree a system of tax collection and revenue sharing on the activity (e.g. sales in space, royalties for mining on a celestial body) if the most basic jurisdictional and property rights are not yet established?

In the absence of measures to capture potentially sizable tax revenue from space activity, governments might need to increase other potentially distortionary taxes, raise fiscal risks by borrowing more, or spend less on health, education, or social programs. Moreover, if public investment in space results in low returns in the form of taxes, it may become economically unsound compared to other forms of investment. Governments may be persuaded to cede the provision of traditionally public infrastructure to the private sector, which would in turn challenge the legitimacy of future taxes on space activity.

On the spending side, governments risk building space-related infrastructures with larger-then-anticipated upfront costs that fail to deliver the anticipated gains, and/or quickly become obsolete. The maintenance or disposal of such investments requires considerable additional resources. Economists can assess such risks using the sub-discipline of Public Financial Management (R. Allen et.al., 2013) and should be doing so as of now. Relatedly, at this stage it remains unclear how fiscal incentives and industrial policy work when applied to extra-terrestrial initiatives. For example, the Powerplay scenario considers the question of whether governments should subsidise activities located in space. An instance might be a case for a Special Economic Zone (SEZ) in orbit in the future. If this were to be pursued, should it be jointly funded by multiple governments to leverage complementarities while reducing individual fiscal risks? A question that remains to be studied seriously is what lessons learned from the multiple mistakes of earthly SEZs apply in space?

Turning from fiscal to monetary and exchange rate concerns, another issue that remains to be studied is the medium of exchange that might be appropriate. Would the private sector cultivate their own currencies - as the British East India Company once did when it explored "new" destinations (Erikson, 2014)? Whether public or private, how closely would those currencies be linked to terrestrial ones, if at all? For example, would the exchange rate(s) be fixed, flexible, or even backed by those used on earth? To inform the right policy, existing theories on optimal currency areas (Mundell, 1961) could be called upon, revised, and extended.

At even longer horizons, if self-sustaining habitats are developed in space and on other celestial bodies, people who occupy them may become detached from their origins on Earth. This logically could be especially so for people who are not born on Earth, but in an artificial habitat. Micro-evolutional changes are to be expected, as an earlier piece in this journal has proposed, generating mental and physical differences between Earthbound people and those who live exo-earth (Saniotis et. al., 2016). For such communities, the notion of being bound by a medium of exchange which is terrestrial in origin and control may not only be unnatural but also unduly onerous. Space taxes levied by earth could also come to be seen as unjustified despite their original rationale, especially if there is no perceived benefit for those novel space communities who pay the taxes (Boston Tea Party, 1773). Thus, the more clearly that activity is identified as part of the exo-earth economy, the more strongly is the need to challenge implicit earlier assumptions that efforts to capture revenues to fund activities on earth are legitimate, and the question arises concerning who will have the legitimacy or the means to levy taxes.

Outer space and justice

The 'Cloud to Nebula' and 'Renaissance' scenarios challenged other assumptions also, such as how might intergenerational exo-earth equity be recalibrated. This concerns paying off the substantial debt utilized to finance space activity, depletion of resources (e.g., water, metals on asteroids) that might have otherwise still been available to future generations, and using up available space in the most useful orbits. Another question which arose was what type of terrestrial firms might be too big to fail in space. Many current space ventures including those aiming to ensure the survival of the human race are financed by billionaire entrepreneurs. Not only do they have considerable control over their companies, they also exert systemic influence over global economic activity. If systemic companies were to go bankrupt because of spectacular failures in space ventures, this could not only affect the exo-earth economy but also

have large negative spillovers on earth. Do such risks make enough of an economic and legal case for forcing such companies to reduce their exposure to very big bets? It is entirely plausible as illustrated in Grounded and Power Play scenarios that companies with major investments in space will become more powerful than nations. An excellent historical example is that of the British East India Company from 1600 to 1874 (Erikson, 2014). Such questions illustrate interesting governance issues which are yet to be addressed not only in political terms but also in macro-economic ones.

Economic monitoring of exo-earth activity explored with the scenarios also implies facing data challenges and opportunities. Measurement issues for current countries' balance of payments include how far existing legal frameworks and principles extend as humankind reaches the outer limits of the atmosphere. There are questions how far into outer space territorial laws may apply. In deeper space, a country's territory may include parts that are currently not legally permissible for a terrestrial nation to claim ownership/sovereignty, such as a natural (i.e., not an artefact) asset in space. Which, if any, new property rights system will have been defined matters, as well as how real is its applicability. It is already unclear how US notes or coins left on the moon would be treated in the balance of international payments, which is a statement of transactions between one country and the rest of the world, not least because the sovereignty of territory on the moon is not clearly established. Additional monitoring from space brings forth new big-data sources for economic surveillance as is already the case when using light imagery, but this would extend into all kinds of fields further, such as into valuable crop or even trade volume monitoring (Moran et.al., 2020).

Summary of insights:

Collision course	A major event where two pieces of kit collide could bring this about and would involve losses of billions of dollars for investors, and massive implications for the economy on earth.
Exo-earth Economy	New exo-earth capabilities for resource extraction beyond our traditional jurisdictions may become possible.
Governance and Fiscal Implications	Activities in space could present fiscal risks to terrestrial governments. Taxes may discourage unwanted behaviour and simultaneously finance governments but, if excessive, could stifle growth in that sector. Eventually there would be problems with jurisdiction and enforcement.
Rezoning economic and social activities	There are questions about tax and legal system responding to the creation of tax havens "off planet". Beyond profits, there are gaps in understanding how terrestrial governments may agree a system of tax collection.

Outer space and justice	If systemic companies were to go bankrupt following spectacular failures in space ventures, this might affect not only the exo-earth economy but also have large negative spillovers on earth.

The scenarios have reframed the approaching future opportunities and challenges, and perhaps most importantly, the means to bring together space and macroeconomics. It is no longer possible to pretend that splitting the exo-earth economy and its governance challenges from the highly connected earth economies is possible. This is particularly so in the TUNA conditions that space economics inhabits and will continue inhabiting for some considerable time.

Concluding remarks

There are rapidly increasing activity levels, as well as the number of participants in space. This growth is currently driven mainly by private-sector reductions in launch costs. The space sector is predicted to become a trillion-dollar economy by 2040 (Morgan Stanley, 2020). It is also plausible that faster-than-anticipated space activity will form two distinct and yet inter-related branches – terrestrial and extra-terrestrial economics.

Using the OSPA has assisted the UKSA in creating four scenarios, illustrating plausible future worlds where outer space might see new forms and magnitudes of power play between state and non-state actors. This helped the UKSA to consider futures where near-earth space is deemed unusable due to human activities. In addition, it identified opportunities and requirements for public sector agencies to adapt to achieve success in these changing environments. Applying the method revealed the need for better preparation for humankind's possible rezoning and the placement of polluting and other industries in outer space. These reimagined futures provide alternative frames in which new strategic implications for outer space can to be considered.

As space increasingly touches more aspects of human society, the space sector is no longer limited to scientists and engineers. Space is already connecting more spheres and can be expected to further blur the lines between disciplines, including social sciences, political activities, manufacturing, financial services, life sciences, ethics and the arts.

Using OSPA has provided a framework to examine novel questions space poses for macroeconomists. Scenario Planning has revealed a need for more interaction between space

industries and macroeconomics. The scenarios have shown how an earth-serving space sector might plausibly become much more important to the global economy. It is also clearly applicable within a broadening range of economic sectors. The productivity benefits of space can become much more globally significant. Policymakers have an opportunity to use scenario planning in support of creating a more sustainable space policy, and particularly so for the more uncertain and novel areas (Cornelisvan et. al., 2018).

Alongside this growing economic importance are the increasingly detrimental - and costly - implications of an accident in orbit. Analogous to the now more frequently identified risks of pandemics, hindsight may conclude that prevention is an increasingly superior investment to a cure (Wellers, 2017). As we have demonstrated, conceivable futures allude to opportunities and risks that require international collaboration and co-ordination which as of this writing remain very limited (Pascale, 2018). Examples are a space "commons" problems, challenges to terrestrial government revenue, questions of how to best incentivize economic clusters in space, and unresolved issues such as what currency or alternative to currency would work best in future off-world communities.

Challenges for international co-ordination and co-operative relations are many, but addressing them offers an opportunity to preserve the space environment for future exploratory missions (NASA, 2020). Some missions can potentially enable considerable economic growth. Parallels with climate change policy and co-ordination efforts may provide useful testing grounds for developing outer space governance policy. Great opportunities lie ahead for space-faring nations and the private sector to get these matters right before negative cost feedback loops impede sustainable activity for many years to come.

Scenario planning provides a common language to bring future plausible space and macroeconomic spheres closer together. The current situation poses opportunities for various actors and in particular conscious leaders (Renesch, 2014) and policymakers to call upon and commission more scenario planning (Roney 2010) to consider policy, strategy, governance, and regulatory frameworks. The current situation also encourages academics to do more research bridging economics and space.

Space activities have gained momentum from engagement with a variety of actors, and they have stimulated social, economic, technological, and philosophical debates. Using scenario planning has surfaced clearer views of contrasting and plausible future possibilities, helping its

users to reframe how space and macroeconomics interact. This has supported unravelling connections between topics not foreseen and conceptualised, in particular, the link between macroeconomics and outer space. This new perspective has tested thinking and potential future actions by different institutions such as the IMF and the UK Space Agency and forged links though novel thinking.

It is easy to hold and maintain assumptions and a single view of the future based on the past. The OSPA allows reframing and reperception to reveal various developments not previously envisaged. Therefore, if one sees the world economy with Blake's 'single vision' (Blake, 1802) through one mechanistic view of the world (that of Isaac Newton in Blake's case), it becomes uncomfortable to challenge assumptions. This also translates into visualisation of alternative scenarios of an exo-earth economy and the emerging macroeconomic risks. This discomfort leads people to avoid addressing the difficult but important questions we consider in this paper.

The new and complex dimensions of the space economy may not be visible yet, but reframing the present with the help of divergent scenarios (Ramirez & Wilkinson, 2016) supports the development of robust strategy. Exploring alternatives to long-held assumptions regarding the exo-earth economy also benefits from the scenarios. This applies also to emerging and plausible new future jurisdictions, aiming to enable the peaceful creation of a more stable and sustainable macroeconomic policy which maintains the responsible development of the commons that is outer space.

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