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Agenda
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Moonshots and market failures: the economics of space

A variety of new and old companies are looking to invest in space applications. From space tourism to on-demand meteor showers for that special occasion, entrepreneurs and investors are trying to understand the economics of space. Investing in space technology is costly and uncertain, but has the potential to generate large economic gains, such as those enabled by GPS technologies, satellite photography and earth observation. What could possibly go wrong? Let's explore that final frontier…

Is the benefit brought about by activity in space worth the cost? Communications applications are bringing improved broadband to remote areas and to passengers on aeroplanes.[1] Earth observation applications can monitor soil and crop conditions to improve agricultural yields or tackle illegal fishing. More and better sensors on satellites are lowering the unit costs of the data they produce—which may spur developments in big data applications downstream.[2]

The technical challenges and risky nature of space missions have traditionally limited the applications of such technologies to publicly funded science or defence and certain commercial uses (such as communications and pay-TV). However, over time costs have been falling and the potential set of applications is expanding. Increasing exploitation of this potential resource brings a new set of economic challenges as well as the more familiar engineering and scientific ones that we associate with getting into space.

No bucks, no Buck Rogers

Space activity has long been associated with extraordinary technical challenges. Often the activity is at the frontier of what is technically possible, requiring significant R&D or high-grade inputs before a project is on the launch-pad. Commercial projects are risky—the lead time and lifecycle of a communications satellite will be far longer than for a similar terrestrial service such as mobile telephony. Opportunities to remedy a miscalculation on a live system are severely limited. The high fixed costs of getting into space are sunk, and occur before any of the applications are realised. Satellite operations can be 'all-or-nothing' propositions in terms of geographical coverage—no service at all until launch, and thereafter very wide (or global) coverage. Without the ability to add small increments of service (such as a city-wide roll-out), it is difficult for operators to test levels of demand and refine business models.

This sounds like the situation with utility networks or large pieces of national infrastructure, where initial investment in sunk assets is high and it is efficient to have only one provider rather than duplicate investments via competition. This is evident in the approach of the European Space Agency (ESA), which uses a 'geo-return' policy to allow European projects to pool their funding and benefit from economies of scale, while awarding contracts back to member states based on their membership payments. Projects such as Airbus's Ariane programme benefit from this European coordination of funding.

However, launch services are becoming more contestable. Some government users of satellites have opened up launch activity to more competition.[3] Also, commercial operators such as SpaceX have innovated to significantly lower the unit costs of launch. Organising this activity as a natural monopoly may not fully exploit the potential efficiency gains from competition. The ESA has recognised that competitive supply via SpaceX in the USA (and hence outside its membership base) has lowered costs. Therefore, on the current Ariane 6 launcher programme, the ESA has moved away from the geo-return concept and opened up the tender process to a wider set of suppliers in order to meet the cost standard set by SpaceX's Falcon 9 rocket.[4]

Houston...we have an economics problem

Commercial and research missions will typically involve developing something new or doing something in a hostile environment, with new extremes of temperature and pressure. State-of-the-art capabilities are required to push the knowledge frontier and, while research and science is an output of the space sector, it is also a key input to the production function of many space applications. Given that many of these applications are not commercial (or, when they are, they have distant and uncertain rewards), market forces may not always be the best mechanism to deliver successful outcomes. Space also exhibits many of the same market failures that we see on planet Earth—while the expensive technology is in orbit, the economics (users, applications, transactions and investors) are still firmly on the ground.

Once systems are live, competition issues may arise. Incumbents may have incentives to restrict access to essential facilities (such as custom equipment or transponders on a satellite), some of which may be required in order to recover their costs. Services delivered in space may have unique features relative to terrestrial alternatives. For example, a closed distribution network may offer more secure communications to military users. The ability to reach remote areas will mean that there are limited alternatives for applications in shipping or on remote oil rigs. Operators of these facilities may have a high degree of market power as a result, depending on the effectiveness and availability of alternatives.

A lack of standardisation across end-applications such as navigation or telephony can mean that consumers face significant switching costs. The development of 'open' platforms may address this and promote competition in parts of the supply chain. For example, Inmarsat's Global Xpress network will enable third-party equipment manufacturers and service providers to create their own end-user devices and software applications that communicate over the satellite broadband network. The emergence of platforms in space-based services may bring with it benefits in the form of better matching of supply and demand and freedom to innovate, but also challenges seen on open platforms elsewhere, such as access to critical facilities or data.

Any investment with high sunk costs faces the risk that an alternative technology will arrive on the scene and diminish the payback—but, with very high development costs, fast-moving technology and life-spans of ten years or more, space-based operations are particularly exposed to this risk. Operators need to keep an eye not only on the viability of their project but also on the risk of other technologies or solutions usurping their USP. For example, Iridium's first attempt to offer a truly global mobile phone network using a constellation of low Earth orbit (LEO) satellites launched in the late 1990s—just in time for the GSM terrestrial mobile boom.[5] Demand for the additional coverage that Iridium offered was too low, and the venture failed.[6]

Barriers to (re-)entry: market failures in space

At the root of many of these issues is some form of market failure. By this we mean a situation where, if left to the market, participants would deliver outcomes that are sub-optimal. The R&D required to embark on space programmes provides a good set of examples of market failure.

- Technological or knowledge spillovers—left to the market, projects that are unprofitable from a private perspective, but would generate large social benefits, might not be taken forward. For example, a camera developed under the ESA's programme for Earth observation has been adapted to monitor colour faults in textile production.[7] Here, knowledge developed in the space sector is being used to improve production elsewhere in the economy.

- Public goods and appropriability—knowledge and ideas are often non-excludable: it can be difficult for private sector firms to commercialise them by excluding others from using them and making them pay individually for the benefit they receive. A lack of appropriability may limit the incentive to invest in innovation. Services such as the Global Positioning System (GPS) may be difficult to fully exclude, and are effectively a public good in many of the applications they are used in.

- Coordination or network failures—problems can impair firms' ability to coordinate to deliver innovation. Investment in research by one firm could have an impact on the profitability of investment by other firms. 'Thin' markets (i.e. those with few trained workers or where demand is measured in single digits) are likely to be common in the space sector, and exacerbate this problem.

- Imperfect and asymmetric information—owing to differences in information and understanding between funders and those conducting the research, SMEs engaged in high-tech innovative projects with good prospects may find it difficult to obtain funding. Imperfect information will plague many schemes where the time between concept and launch necessitates predictions on the state of demand, cost and competition a long way into the future. The string of past failures in LEO schemes (Iridium, Teledesic and Globalstar) could exacerbate this problem.

DustBusters and ice cream: what are some of the benefits?

These market failures point to some of the wider socioeconomic benefits of space investments and projects. A range of modern conveniences are often attributed to the US and Russian space race. Some of these can genuinely trace their development back to space research efforts (such as freeze-dried ice cream and cordless power tools), whereas others are more apocryphal (Teflon and the space pen). The fact that some of these have an element of urban myth about them belies the fundamental market failure of attribution—it can be difficult to definitively tie end-products to initial research.

Even so, there are clear examples of where end-users have benefited from investments in space activity and research. Consumers may benefit from the way space-sector inputs influence competition and efficiency in downstream markets. Location-based services such as Google Maps enable users to compare products and services while on the move, so that they can make better decisions.[8] These require satellite-based navigation services to pinpoint the user, and satellite-based images to generate the maps.

Getting your investment in space off the ground

Many investments in space suffer from market failures, and government intervention can support welfare-enhancing projects that might not otherwise be viable. Projects such as SpaceX are the exception which prove the rule, relying instead on private investors with long time horizons and a particular risk appetite.

Governments may intervene where it can be shown that, first, a market failure exists, and, second, public investment would deliver good value for money from a societal perspective relative to a scenario of 'do nothing'. Most governments have a cost–benefit framework for assessing the costs relative to the benefits of a scheme. The UK government has a particularly advanced appraisal system based on a 'Five Case Model' that covers commercial, strategic, economic, financial, and management aspects.[9] For the economic case, the scheme costs must be outweighed by benefits over a suitable appraisal period.

Quantifying these expected costs and benefits is a challenge, especially when the services and applications involved are many years into the future. The attribution problem for R&D and spin-offs means that measuring their impact is difficult. In particular, those assessing the business case will focus on 'additionality'—or what the scheme will bring over and above an alternative investment or in the absence of an investment (the 'do nothing' scenario).

Economic modelling is often used in developing the but-for, or counterfactual, scenario on which to build the analysis. Articulating how the benefits link to a specific market failure is critical in building both the economic and strategic case.

Applicants must also recognise the potential for competition, well before lift-off. Policymakers and applicants need to show that any 'leakage' of state funding into a contestable sector is doing more good than harm. For instance, an investment in a ground facility that could then be used to provide commercial services may give rise to state aid concerns.[10]

Concluding remarks

As technology is refined and costs fall, investors are realising the large potential in space. Although we are seeing more private sector activity, such as SpaceX, investing in space projects can be high-risk, and the inherent market failures often mean that in some instances government involvement is critical in achieving take-off.

The inherent large cost of space projects means that they can sit between the efficiency of having one provider and achieving the benefits of competition between multiple suppliers. As costs fall more projects become viable, so getting the right market design is important if we are to push that final frontier.

While space projects are often associated with large feats of engineering and pushing the boundaries of technology, they also create challenges that economics, developed here on earth, can help to overcome.

[1] Ofcom (2017), 'Space Spectrum', Strategy document, 19 January.

[2] Satellite Applications Catapult (2015), 'An Introduction to Earth Observation (EO)', presentation to Ofcom, 27 July.

[3] Davenport, C. (2015), 'ULA bows out of Pentagon launch competition, paving way for SpaceX', *Washington Post*, 16 November.

[4] Rumpf, C. (2015), 'Increased competition will challenge ESA's space authority', *The Space Review*, 2 February, www.thespacereview.com/article/2687/1.

[5] The global GSM connection base grew from 10m subscribers in 1995 to 600m subscribers in 2000. See GSMA, 'History', www.gsma.com/aboutus/history.

[6] Millard, D. (2016), 'Iridium: story of a communications solution no one listened to', *New Scientist*, 3 August, www.newscientist.com/article/mg23130850-700-iridium-story-of-a-communications-solution-no-one-listened-to/, accessed 8 November 2017.

[7] See European Space Agency, 'Benefits of technology transfer', www.esa.int/Our_Activities/Space_Engineering_Technology/TTP2/Benefits2.

[8] For more information on the role of Geo services see Oxera (2013), 'What is the economic impact of Geo services?', prepared for Google, January, https://www.oxera.com/Latest-Thinking/Publications/Reports/2013/What-is-the-economic-impact-of-Geo-services.aspx.

[9] HM Treasury (2015), 'Public sector business cases using the five case model: updated guidance (2015)'.

[10] In order for the aid to be found to be compatible with state aid rules, economic and financial analysis would be needed in order to demonstrate that the aid is limited to the minimum amount necessary; the aid measure is appropriate; the aid creates an incentive effect; the aid is unlikely to distort competition and trade; and any compliance measures are warranted. As an example, in 2015 the European Commission investigated whether a grant of £50m provided by state authorities for the design of a space launcher engine was in line with state aid rules. For further details, see European Commission (2015), 'State aid: Commission approves £50m UK support for research and development of an innovative space launcher engine', 14 August, http://europa.eu/rapid/press-release_IP-15-5495_en.htm.