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Geopolitics and space access: cost asymmetries and strategic dependence

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ABSTRACT

Access to space is now a national security priority, yet its cost varies enormously across nations. Using a novel dataset of over 6740 rocket launches (1960–2025), we estimate country-level launch costs and country-specific experience curves. In 2025, the average costs per kilogram to Low Earth Orbit ranged from $3225 in the United States to over $13,000 in India, with Europe, Russia, China, and Japan in between. Since 2010, only the US and Europe display statistically significant experience curves, with the US improving far faster. These widening asymmetries reinforce strategic dependencies with economic and security implications.

1. Introduction

The dawn of the space exploration era after World War II was powered by the geopolitical competition between the United States and the Soviet Union (Peeters, 2021). From the 1980s onwards, space saw a rise in commercial interest, predominantly led by telecommunications (Pelton, 2016). By now, over 80% of satellites in orbit are commercial (Terzi and Nicoli, 2024), and space is seen as an opportunity for economic growth (Weinzierl, 2018, 2023; Nicoli and Terzi, 2026). However, as much as 95% of space technology can be considered dual-use, meaning it can have simultaneously civilian and military applications (Johnson-Freese, 2006; Pražák, 2021). Positioning systems, Earth observation and space-based telecommunication are critical to battlefield operations and the functioning of modern economies. As a result, having access to and presence in space is now recognised by all major powers as a national security priority (State Council of the People's Republic of China, 2022; National Science and Technology Council, 2023; Draghi, 2024).

Access to space is mediated by rocket launch technology, which is possessed by only a handful of spacefaring nations. Over 100 countries have at least one satellite in space but they rely on these foreign rockets to position their satellites into orbit, generating the potential for strategic dependencies that might be exploited in an era of geoeconomic fragmentation. In addition, providers in some countries – notably the United States – have mastered rocket reusability, driving down the costs of accessing space (Nicoli and Terzi, 2026). This suggests a high heterogeneity of costs across different rocket providers, and implies that simply possessing launch technology is no guarantee of being able to build up a significant presence in space, except at comparatively high cost.

In this paper, we provide a unique economic perspective on these geopolitical dynamics by leveraging a novel database of over 6740 rocket launches from 1960 to 2025, covering sixteen geographical entities including all the major spacefaring nations: US, USSR/Russia, China, India, Europe, and Japan. Cost data was collected from a variety of publicly available sources including government reports, academic papers and public documentation, and standardised to 2024 USD in Low Earth Orbit equivalent.

Using our dataset, we can estimate the average cost by country of sending payload into space. We find that the US has a large cost advantage with respect to other spacefaring nations. In parallel, America increased its share of global payload to orbit to a peak of roughly 80%, followed by a wide margin by China. Europe used to have comparable launch costs to the US in the early 2010s, but has since fallen behind. We conclude by discussing the geopolitical implications of this heterogeneous access to space.

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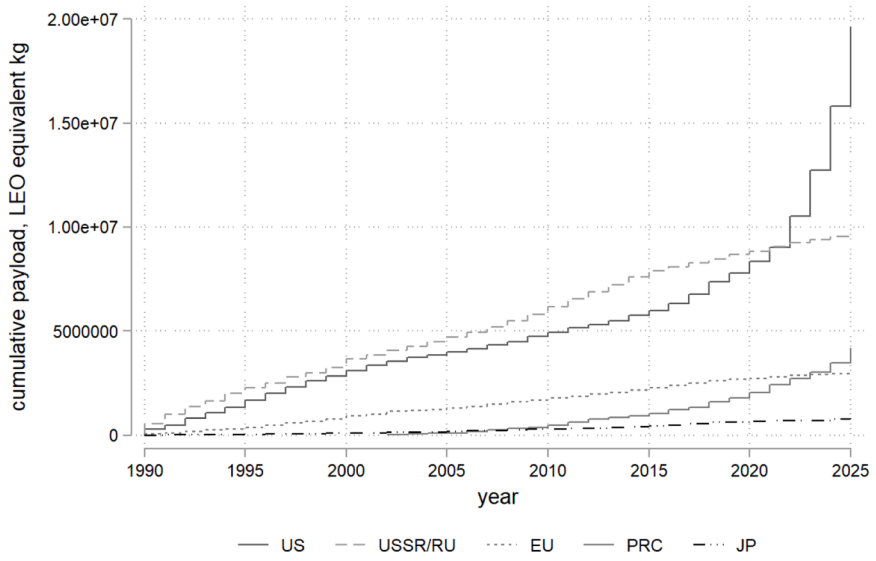


Fig. 1. . Cumulative payload to orbit by country, 1990–2025.
Notes: The chart shows the cumulative payload sent into orbit in Low Earth Orbit (LEO) equivalent kilograms by the five major spacefaring nations since 1990.
Sources: Authors.

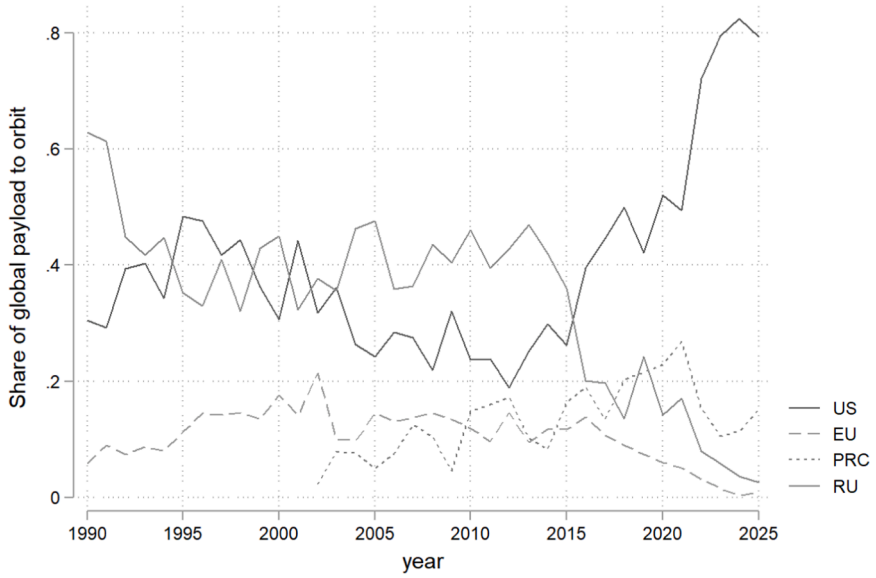


Fig. 2. . Share of the global payload to orbit by country, 1990–2025.
Notes: Total yearly payload for rockets of the US, Europe, China and Russia, expressed as a share of world total.
Sources: Authors.

This paper contributes to at least two strands in the literature. It links economic and geopolitical considerations, following the increasing hollowing out of a rule-based global order (Aiyar et al., 2023; Clayton et al., 2023). The second relates to the economics of space (Adilov et al., 2022; Corrado et al., 2023; Gatti and D'Ottavio, 2025; Kantor and Whalley, 2025).

2. Analysis

While the first space flight was over six decades ago, our data shows that space has recently entered an exponential growth phase (*SI Appendix*, Figure S1). However, this growth is not evenly distributed across countries. Fig. 1 illustrates this by charting the cumulative payload sent into orbit using launchers from different countries since the end of the Cold War. As European nations launch through the European Space Agency (ESA), we have aggregated them together.

It is worth highlighting how Russia and the US were effectively tracking each other until 2003. Then the Columbia disaster led to a two-year pause and a subsequent scale down in the Shuttle programme which retired in 2011 without a heavy-lift replacement ready. US launch cadence took off again in 2016, on the back of the success of SpaceX in mastering reusability and launching its Starlink satellite constellation (Weinzierl and Rosseau, 2025). China is a more recent member of the club of large spacefaring nations, but has quickly accelerated the pace of launches, surpassing Europe in 2023 in terms of cumulative payload sent to space.

Another way to look at it is to analyse the shares of yearly global payload captured by selected spacefaring nations (see Fig. 2). Some interesting patterns emerge. Notably, between 1995 and 2012, the US share of global payload collapsed from almost 50% to a trough of <20%,

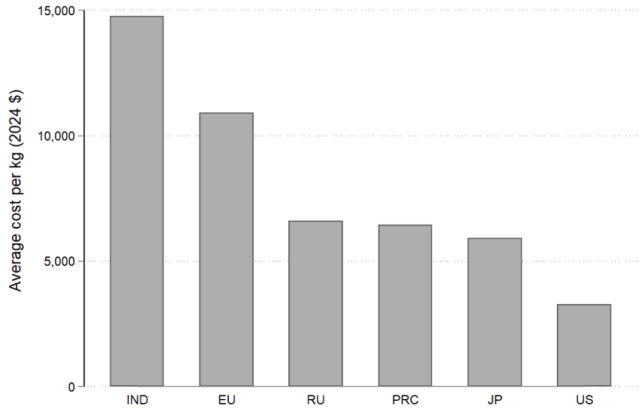


Fig. 3. . Average cost per kg in 2025, by country.
Notes: Payload-weighted average launch cost per kilogram in 2025, computed across the rockets operated by India, Europe, Russia, China, Japan, and the US.

where c_t is the average launch cost in year t, m_i is the maximal payload capacity launched in year i and β is a constant cost improvement rate (see Table 1, column 1). However, in Terzi and Nicoli (2026) this experience curve was estimated at the aggregate world level. Here, we leverage the granularity of our data to verify whether spacefaring countries individually displayed a comparable experience curve, and what the country-specific cost improvement rate was over the last 15 years.[1] More formally, we re-estimate [1] for each spacefaring nation and compute a country-specific β (see Table 1, columns 2–7). Two findings are worth highlighting. First, and more prominently, only the US and Europe display a statistically significant rate of cost improvement since 2010. This could be for several reasons: some countries such as India have an overall launch cadence that is too small to walk down a cost curve; others, like China, are still testing multiple launch technologies as part of a broad expansion of their space programme; still others, such as Russia, have phased out their lowest cost-per-kg Proton rocket but failed to successfully phase in its intended successor Angara rocket, with the result that it is now relying on more expensive old Soyuz rockets.

Table 1
Estimations of the cost improvement rate for the world, and selected nations.

	(1) ln(costs)	(2) ln(costs)	(3) ln(costs)	(4) ln(costs)	(5) ln(costs)	(6) ln(costs)	(7) ln(costs)
ln(cumulative payload)	−2.115***	-.566***	−2.018***	.381	-.076	-.084	-.099
	(.119)	(.126)	(.353)	(.293)	(.080)	(.118)	(.413)
constant	45.939***	17.838***	42.003***	2.362	10.081***	10.592***	10.613**
	(2.083)	(1.863)	(5.802)	(4.942)	(1.151)	(1.456)	(5.379)
Country	World	EU	US	RU	PRC	IND	JP
Sample size	16	16	16	16	16	16	16
R^2	0.956	0.568	0.772	0.049	0.075	0.030	0.005

Note: Newey-West HAC standard errors in parentheses. * p < 0.1; ** p < 0.05; *** p < 0.01.
Notes: Estimation of equation [1] for the world and selected nations (Europe, US, Russia, China, India, Japan) over the period 2010–2025. Newey-West HAC standard errors in parentheses. * p < 0.1; ** p < 0.05; *** p < 0.01
Source: Authors.

far below Russia and only a few percentage points above China and Europe. Since then, it accelerated rapidly to a peak of over 82% in 2024, where it stabilised. As a result of this rapid expansion, Europe's and Russia's share of world total have collapsed to only a few percentage points. The only large spacefaring nation that is managing to buck this trend is China, which peaked in 2021 at around 27% of world total, declined in the following years, but has now picked up pace again in 2025.

Our dataset indicates that the average cost of launching one kilogram of payload to orbit in 2025 was 3868$/kg. However, global averages hide a significant heterogeneity across countries. Average costs of sending a kilogram to orbit are as high as 13,302$/kg for India and as low as 3225$/kg for the US, with Europe (9897$/kg), Russia (6682 $/kg), China (5809$/kg), and Japan (5287$/kg) in between (see Fig. 3). The very high figure for India might be counterintuitive as it stands in stark contrast with the narrative of the country's frugal space programme (Corrado et al., 2026). However, this is a result of focussing on small rocket sizes, which implies that, albeit being low by international standards, fixed costs get amortised over a limited payload (see *SI Appendix*, Figure S2).

Launch cadence also plays a role in determining a country's cost per kg In a companion paper, we showed how space launch technology follows almost perfectly Wright's Law (see Eq. (1)), meaning that costs are a constant function of cumulative payload to orbit (Terzi and Nicoli, 2026). More formally,

$$\log(c_t) = \theta + \beta \log\left(\sum_{i=0}^{t} m_i\right) + \varepsilon_t \quad (1)$$

The other interesting finding that stems from Table 1 is the fact that the cost improvement rate for the world (column 1) is even steeper than that for the US. This reflects a composition effect, as an increasing share of global payload has shifted from more expensive domestic launchers to cheaper (US) providers.

The power of steep experience curves can quickly be grasped with a comparison between two specific spacefaring nations. The US and Europe had similar average launch costs in 2012–13 (Fig. 4, Panel A). Since then, however, a widening gap emerged, with the result that it is now over three times more expensive on average to send a kg of payload to orbit using European rockets rather than US ones. The reason for this can be seen in Fig. 4, Panel B, which displays the experience curve for both spacefaring nations. Europe displayed a flat experience curve for a good part of the 2010s, as it stuck to its Ariane 5 rocket, while the US was innovating, and eventually introducing reusability through SpaceX's Falcon 9.

This gap could partially narrow going forward, as ESA rolled out its new and somewhat cheaper Ariane 6 rocket in 2024, following over a decade of development. However, Ariane 6 remains single-use, and its launch cadence is expected to be limited (with four launches in 2025 and eight planned for 2026, before an anticipated stabilisation at ten per year thereafter), suggesting the gap with the US in the cost of accessing

[1] The experience curve is calibrated over a trimmed dataset starting in 2010 due to the fact that in Terzi and Nicoli (2026, SI Appendix, Fig S5) we showed how the overall experience curve of space displayed a structural break in that year.

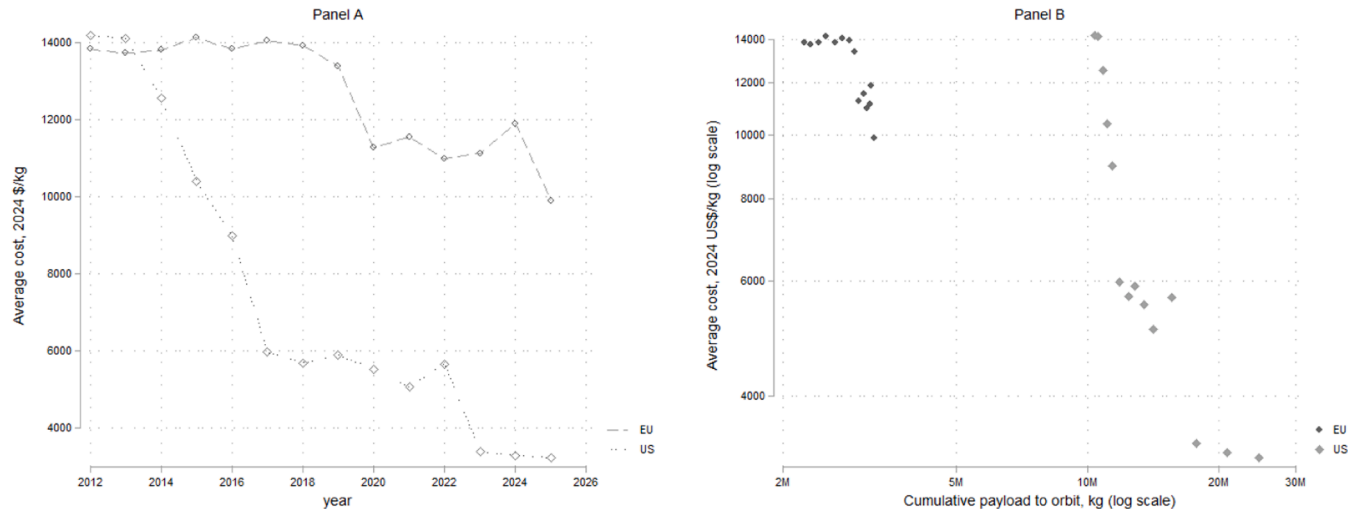


Fig. 4. . Comparison of costs over time (Panel A) and experience curves (Panel B), US and Europe.Notes: Panel A indicates the evolution of average cost per kg for Europe and the US over the period 2012–2025. Panel B reports the experience curves of Europe and US over the same time period.
Sources: Authors.

space is likely to remain significant over the foreseeable future.

3. Conclusion

While there are several countries with the domestic capacity to access space, this paper shows how heterogeneous the economic picture across nations is. Specifically, we have detailed how average costs of bringing payload to orbit vary between countries. This has significant policy implications. Until now, most companies have relied on the cheapest available technology to send satellites into space. The result is that, according to our estimations, one single American company – SpaceX – was responsible for 75% of global payload to orbit in 2025 (Marcuzzi and Terzi, 2026). Going forward, it is not implausible that a US administration might decide to weaponize this dependency or use it as a bargaining chip to coerce other nations.

Although it might look like several other launchers are available globally, our analysis shows that the average launch cost would increase significantly were countries to decide to rely on their domestic rocket technology for reasons of strategic autonomy, rather than make use of cheap US technology. These higher costs could hamper their ability to expand and maintain a significant infrastructure in space. Looking specifically at Europe, for now the continent is stuck between a rock and a hard place, having to choose between continuing to depend on lower-cost American launch technology and relying on expensive, poorly scalable domestic technology to expand its strategic presence in space. For the medium term, it underscores the importance for non-US powers of developing cheap, domestically controlled reusable launch technology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.econlet.2026.113182.

Data availability

Data can be accessed here.

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