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UNDERSTANDING DEMOGRAPHIC DECLINE AND THE MODERN SPACE RACE

April 2023

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HOOVER **HISTORY** LAB

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This brief explores two global trends positioned to drastically impact great power competition and U.S. influence in the international system by 2040. Part I of this analytical assessment explores demographic decline and human capital concerns galvanized by low global birth rates, rising global median age, and the role of urbanization on development. China is poised to experience population stagnation and subsequent decline after reaching its peak in 2028. There are probable economic implications of this demographic reversal which impact great power conflict and American influence. Economically, China's demographic decline may entail the end of China's presence as a leading world economy given that their workforce is set to decline by 23 percent by 2050 while that of the U.S will increase by 30 percent in that same time period. Decreasing urban employment opportunities in China and vast rural underdevelopment in the status quo are extrapolated within our stated 2040 timeline. Part I will also interrogate current and future U.S. and China birth rates relative to OECD nations, the role of immigration in population booms, and the potential for technological innovation to mitigate some of the impacts of staggering global population decline over the next two decades.

Part II delves deeply into the strategic, economic, and military exploration of space by private and governmental entities alike. The scramble for dominance in this new frontier is largely unregulated, crystallizing greater concerns of private monopolies, Chinese aggression, and military attacks through modernized counter-space technologies. Similar to how conquering the seas and the skies opened up immense military and economic opportunities, development in space will unlock a new frontier for both the U.S. and the globe. Dominance and presence in space holds massive implications for numerous critical areas, from telecommunications and military capabilities to resource collection and climate change. As the world moves towards 2040, there are three trends that will define the next two decades in space: lower barriers to entry, privatization of space, and militarization.

PART I: DEMOGRAPHIC DECLINE AND HUMAN CAPITAL

In January 2023, the People's Republic of China (PRC) reported its first population decline in six decades (Yiu et al., 2023). By 2050, China's population is expected to decrease by approximately 200 million people while the U.S. will increase by roughly 30 million (Congressional Budget Office, 2023) (Silver and Huang, 2022). India is projected to usurp China as the world's most populous nation by April 2023 and keep growing well past 2050 (The Economist, 2023).

Declines in population are not without precedent. Mass depopulations from war, famine, genocide, and more have led to short and dramatic collapses in populations throughout history. The last population decline in China was caused by their Great Famine of 1961, the byproduct of communist-created agricultural failures (Yeung, 2023). However, there is little precedent for societies having low birth rates while there is peace and relative prosperity, as is seen at present. Declining birth rates is a global phenomenon but will have asymmetric impacts dependent on nations' unique contexts. China and many Eastern European countries have had sub-replacement birth rates for some years now and are expected to grapple with population decline and its impacts, whether positive or negative, far sooner than the United States (U.S.).

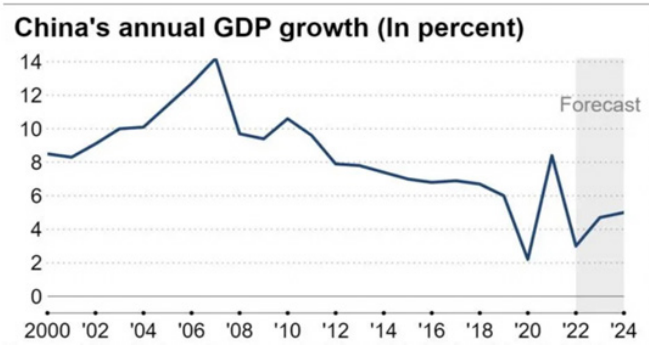
Summary: The Effects of Demographic Reversal on U.S. Power and Influence

- Higher U.S. birth rates relative to OECD nations and China means the U.S. will experience delayed impacts of population stagnation, whether advantageous or otherwise (World Bank).
- Among OECD nations, current trajectories illustrate a correlation between higher birth rates and larger per capita GDP which may or may not be causal (Doepke et al., 2022).
- By 2040, China's population is expected to decrease by approximately 200 million people (World Population Review), while the U.S. will continue increasing in population.
- 2040 demography projections characterize China as a "super-aged society": between 2015 and 2040, China's 65+ population will have ballooned by nearly 150 percent (Eberstadt, 2018).
- By 2050, China's workforce is set to decline by 23 percent while the U.S is poised to increase by 30 percent (Liang and Gibson, 2017).
- Higher rural birth rates in China may exacerbate the existing human capital crisis in educational underdevelopment and low-skilled labor trends (Yan, 2022). Unequal rural population growth may strain already diminished educational and human capital programming, potentially impinging on labor participation rates and per capita GDP (Rozelle and Hell, 2022).
- Population booms in sub-Saharan Africa could force a migration crunch in Europe and North America, expanding the workforce in these rich countries while potentially spurring increased social tensions in countries receiving immigrants.

China derives most of its power globally not from its military, robust though it may be, but from its fast-growing economy. China's GDP has, since 1980, grown over 9 percent annually (World Bank). China has the world's second largest GDP, and it is the largest trading partner of over 120 countries (Green, 2023). More than half of the world's countries trade with China more than they do any other state. China's economic power is mighty, but demographic trends make continued Chinese economic ascendancy more doubtful.

China's fast growth alone is not enough to make it a powerful state in the international system. The marvel of China's rise is attributed to the pace of economic growth and scale of population (Rozelle and Hell, 2020). As China became more productive, its influence on the global stage ballooned. Overshadowed in the 20th century, theorists overwhelmingly postulated that the 21st century will be one of Chinese domination. However, China's demographic reversal poses a significant challenge to this view. China will represent a smaller and smaller portion of the global population and world economy, meaning its relative importance may decline. From 1980 to 2010, economic growth averaged over 10 percent a year. Since 2010, growth has barely averaged above 7 percent (World Bank). While still growing faster than most developed countries, this growth will have to be maintained by a much smaller population in 2040. Even if China keeps growing at a faster rate than the United States, it will have fewer people to exert its economic muscle around the globe especially as the maintenance of an aging population subsumes the middle income nation's already abysmal social infrastructure (Eberstadt, 2018).

None of this is to say that China will become an unimportant power in world affairs. With over a billion people and a large economy, China will remain a key player in the global system. However, China's demographic collapse and the continued cooling of the economic engine should challenge the prevailing sentiment of China's domination in the 21st century.



China national security Bureau of Statistics, Nikkei Asia. Illustration of China's annual GDP growth

China is not the only country grappling with population collapse. With few exceptions, notably Israel, every country in the OECD currently has a total fertility rate below 2.1 (OECD), which demographers consider the replacement rate. And the trend is going downward. The United States, however, will continue to grow population-wise, due to having one of the higher birth rates among OECD countries as well as higher levels of immigration (World Bank). The United States population is expected to grow in the coming years, while the population of Western Europe will begin declining soon (Eurostat, 2023). This may lead to a de-emphasis away from the European countries economically in the eyes of the United States.

The pivot to Asian markets is increasingly likely, especially if the war in Ukraine alters American perceptions of Europe's strength. Europe's role in the global economy is already diminishing (Guàrdia, 2019), and there is little evidence to suggest that this trajectory will markedly change. While there is a high level of productivity among their citizens, Europe continues to boast among the lowest fertility rates within the OECD fold (World Bank).

Fertility Rates

The population of the United States will continue to increase due to higher birth rates relative to OECD counterparts (World Bank). High birth rates result in a larger net population and a lower median age of the working population. As of 2023, there are 334.9 million people in the United States, surpassed only by India and China (Duffin, 2023). Congressional Budget Office projections illustrate a trajectory of 1.64 births per U.S. woman and a steady increase by 2030 to 1.75 births per woman, which will persist until 2053 (Congressional Budget Office, 2023). These birth rate projections culminate in a total expected population of 369 million people through 2050. U.S. fertility rates remain far below the 2.1 number as the population replacement rate. Average OECD fertility rates have plummeted from 2.84 children in 1970 to 1.59 in 2020 (OECD). Comparatively, World Bank data places China's 2020 fertility rate at 1.28 children per woman, resulting in a marked decline in total population from 1.4 billion in 2022 to the projected 1.3 billion in 2050 (Silver and Huang 2022).

Historically, fertility rates and GDP have been negatively correlated. However, the relationship between these trajectories across OECD nations seems to have changed dramatically in the past two decades (Doepke et al., 2022). As depicted by Figure 1, the OECD nations in 1980 with highest fertility rates had the lowest per capita GDP. In 2000, the inverse is true. The trajectory of Figure 2 is unique to OECD nations as they constitute a far wealthier sample of nations than the rest of the globe and thus have the capacity to expand social and governmental services to accommodate population growth and utilize fertility rates to expand economic production and prosperity.

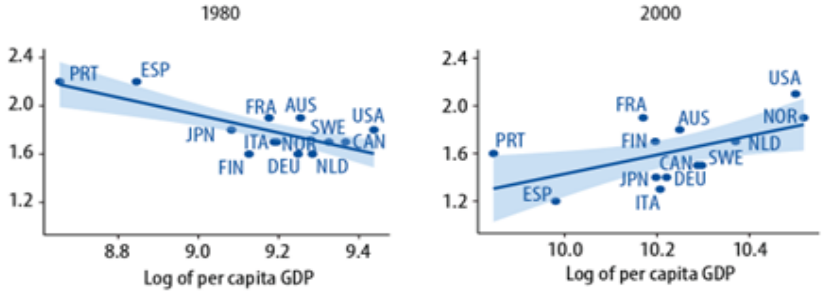
Gradual fertility decline of this nature is unlike any comparable trajectory we have witnessed in modern history. As such, there are substantial limitations in articulating future events with a strong degree of certainty. However, it is clear that pronounced differences in the fertility rates of China (1.28) and America (1.64) will lead to vast, albeit slow, population increases in America and a substantial decrease of China's population by 2040. The intuitive assumption is that a larger workforce will result in larger labor force and thus greater economic growth and productivity. This is substantiated by the 23-percentage projected decline of China's 2050 workforce in line with the decline in overall population. Confounding factors, including the emergence of automation and technological advancements, might mitigate losses caused by diminished fertility rates. Alternatively, nations may change retirement age or the hours of the work week to compensate for financial losses caused by an aging or smaller workforce.

Chart 1

Total fertility rate and GDP per capita in selected OECD countries

In just 20 years, the relationship between per capita income and fertility rates changed dramatically.

(total fertility rate, births per woman)



Source: Doepke and others (2022).

Note: OECD = Organisation for Economic Co-operation and Development. Data labels use International Organization for Standardization (ISO) country codes.

International Monetary Fund, Graph Demonstrating the New Economics of Fertility Among OECD Nations, September 2022

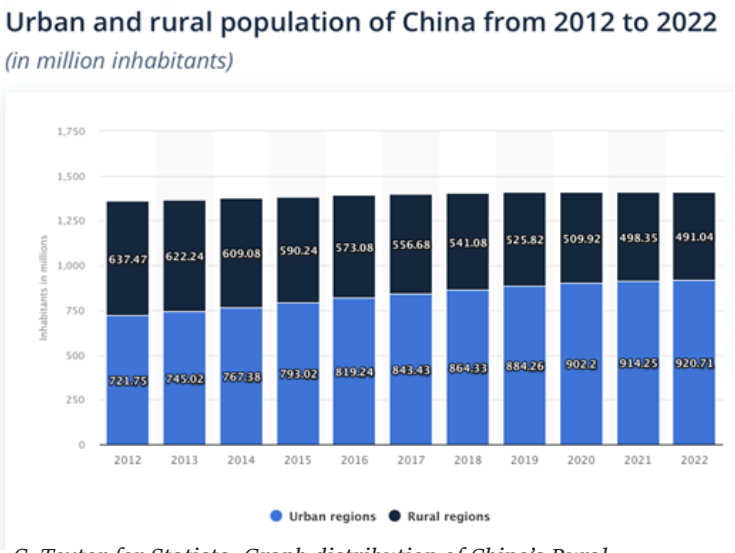
Japan's declining population may prove emblematic for China and many Western countries. Japan has had a declining population since at least 2011, according to the World Bank. Japan has adjusted to this change in part with a high labor force participation (which incidentally makes the birth rate problem worse). For 25- to 54-year-olds in the United States, the labor-force participation rate is 79.9 percent. Japan's is substantially higher, at 86.5 percent (OECD). Japanese citizens are working at higher rates in part because of the demographic crunch. Despite the population declining, tax revenues in Japan have gone up since 2011, from 45.18 trillion yen in 2011 to 64.93 trillion yen in 2020 (Statista Research Department, 2022). While the total impact of Japan's slow demographic march downward remain to be seen, it is clear that imminent disaster is unlikely to occur, even when populations start declining. However, as the population continues to decline in Japan, it will be very difficult to maintain the country's current levels of output and social assistance with far fewer people. Some projections have Japan falling from its current level of 123 million people to fewer than 75 million people by the end of this century (World Population Review). With birth rates continuing to decline and immigration almost non-existent in Japan, the question will likely be the scale of the population decline, not whether it occurs. It will be difficult to maintain the same level of power and economic influence if each worker has to become 50 percent more productive, especially since not all countries will experience this demographic crunch as severely.

As for China, the United States' main rival in the coming years, this demographic crunch could have a similar effect. China's GDP per capita will have to increase far more rapidly than other countries' in order for China to maintain its current economic position in the global economy. Though this has happened over the past thirty years, there are signs of slowing economic growth in China. If China wishes to overtake the United States as the predominant economic power, its citizens will need to become far more productive than they currently are and ramp up that increase, as there will be fewer of them to generate that level of output.

Rural and Urban Dispersion

China has considerably higher rural fertility rates but larger numbers of people living in urban epicenters due to employment opportunities. As of 2022, 491 million people live in China's rural areas compared to 920 million in urban areas (Textor, 2023). This is down from 498 million and 509 million in 2021 and 2020, respectively. Mass migration towards urban epicenters for employment has steadily increased over the last decade.

This trend may soon be disrupted as China's urban employment rate fell for the first time in six decades at the onset of 2023 (Cash, 2023). Heightened wage rates for low-skilled labor have spurred an exodus of major production facilities out of mainland China, producing a surplus of low-skilled laborers relative to employment opportunities (Rozelle and Hell, 2020). If urban employment opportunities continue to plummet, we may see the stagnation of rural to urban migration or a potential shift to rural population dominance. The rural-to-urban migration pattern



C. Textor for Statista, Graph distribution of China's Rural versus urban development, 2022

of the status quo has had an undue impact on childhood development and safety as 50 percent of migrant families have left behind school-aged children in their quest for employment in urban areas (The Economist, 2021). Estimates put this number as high as 61 million children (Shani, 2021).

There is a considerable birthrate divide between rural and urban women in China. The gap in fertility is estimated at 0.56 children, which corresponds to urban and rural fertility rates of 1.54 and 2.05, respectively (Liang and Gibson, 2017; He et al. 2019). Credible and nuanced data on more recent fertility rates do not exist; however, China's total fertility rates would not indicate that the rural or urban populations have greatly increased their fertility rates since 2019. A 2022 survey conducted in Shandong found that 11.2 percent of participating rural women indicated a willingness to have three children compared to only 4.3 percent of urban women (Yan, 2022).

Rural children are educated and socialized within rural infrastructure. The rural-urban educational divide is stark and has culminated in a human capital crisis in the status quo, likely to be exacerbated by higher rural birthrates in the next two decades. 70 percent of China's workforce has not attained a high school education which places the nation among the ranks of Turkey, Thailand, South Africa amongst other middle-income nations (Rozelle and Hell, 2020). All sources of China's human capital crisis indicate stark rural underdevelopment, which future demographic trends will only exacerbate.

Immigration

The United States has among the highest fertility rates within the OECD but still falls short of the 2.1 replacement rate. The United States' projected population growth by 2050 is partially attributable to high immigration rates (McHugh, 2021). The United States is the largest recipient of permanent immigrants of any country in the world (International Organization for Migration). This factor will remain a strategic advantage to the United States if it can continue to expand its economically productive population in the coming decades.

Today, less than 5 percent of the United States' foreign-born population comes from Africa. However, this percentage will surely grow in the coming years if current trends hold. In 1980, there were fewer than 150,000 immigrants from Africa in the United States. At present there are over 2 million (Lorenzi & Batalova, 2022). Considering that, in the coming years, the African continent will remain a place with high birth rates and low economic opportunity for its citizens, many more Africans will migrate to the West, including the United States. The effects for the United States will depend on the societal and political response to this increase in immigration. With more people, Africa will likely grow in importance, and more remittances from immigrants in Western countries could help bolster the African economy, although the corresponding brain drain may deplete human capital enough to render these remittances useless. Immigration to the United States in the 19th and early 20th centuries was led by Europeans, in the late 20th century by immigrants from Latin America and Asia. In the coming century, African migration will play a much bigger role in America's immigration story. America could benefit from Africa' population boom if it allows for Africans to migrate easily and bolster America's stagnant birth rate.

Technological Innovation

Robots and other innovations have the potential for nations to utilize technological advancement to mitigate economic losses spurred by aging or declining populations. Many fear that the rise of robot technologies and artificial intelligence will render many current jobs obsolete in the coming years. However, throughout history the technological revolution has tended to increase output and the number of jobs available. More people are employed today with a far greater number of people than in the past. No prior technology has left millions systemically jobless permanently. If the coming AI/robot revolution is the exception to this rule, then China and other countries with declining populations could see an advantage. However, if this new technology actually expands output and the subsequent need for labor, then the United States will maintain an edge in economic competition.

PART II: THE SPACE RACE

I. Lower Barriers to Entry

In 2011, NASA retired its space shuttle program. At the time, a single flight cost an average of $1.6 billion, or nearly $30,000 per pound of payload (Roberts and Kaplan, 2022). Today, Rocket Lab, an aerospace company that was founded in New Zealand and is currently headquartered in Long Beach, California, charges just $5 million per flight, or roughly $10,000 per pound of payload. Rocket Lab provides launch services to Earth orbit for small satellites, which range from nanosatellites the size of a loaf of bread to spacecraft the size of a mini-fridge (Chow, 2022). Elon Musk's SpaceX charges $62 million per launch of its medium lift Falcon 9, or around $1,200 per payload to reach low-Earth orbit (Chow, 2022).

In addition to the launches themselves being more affordable, the cost of the satellites themselves have decreased as well, with some models going for as low as $50,000 (Betancourt, 2014). In the past decade, a myriad of factors have driven this dramatic decline in spacecraft production and launch costs. Some of the most critical advancements are highlighted below.

Decreasing Size

One of the most obvious shifts in launches in the past decade is in the size of the spacecraft being sent into orbit. Increased computing power, shrinking sizes of microprocessors, more efficient solar panels, and an overall miniaturization of space-related technologies has allowed for the mass emergence of small satellites (Eftimiades, 2022). While older satellites could reach the size of garbage trucks and cost as much as $400 million, satellites are now commonly the size of a microwave, costing as little as $1 million or less, making them affordable to even college classrooms (Davenport, 2021). These small satellites, known as SmallSats, have become the most common satellites in orbit due to more affordable build, launch, and operating costs (Introducing the Small Satellite Revolution, 2023). As the advantages of small satellites have emerged with more clarity, even governments are transitioning to these SmallSats (Weisberger, 2022). Growing demand has small satellites gearing for an era of mass manufacturing that will only further drive down costs (Segert and Attara, 2019). One notable effect of the increasing affordability and decreasing size of satellites is the emergence of satellite constellations. It was better to position massive satellites that cost nearly half a billion dollars each as far from the Earth's surface as possible into the geostationary orbit to ensure greater coverage and synchronize orbits with the Earth. However, with smaller and chapter satellites, it is now economical to launch "constellations" of small satellites into low-earth orbit and cover the same area as a large satellite in geostationary orbit. This also improves latency, as the satellites are now much closer to Earth. This constellation formation was first adopted by SpaceX, but Amazon, OneWeb, and China's Aerospace and Technology Corporation all have plans of sending thousands of their own satellites into space (Lesiv, 2023).

Modularity and Automation

Improvements in the standardization of space-related production and modular design shifts have allowed for increased pace of production, scalability, and mitigation of supply chain risk that have all proved to be cost effective (Harebottle, 2021). Production lines like those of aerospace company NanoAvionics, which keeps about 80 percent of the flight-proven architecture for satellite buses consistent for each mission (Harebottle, 2021), have greatly streamlined production. The space industry is going through a Henry Ford Moment, and companies from York Space Systems to Blue Canyon Technologies to Apex Space have all released satellite versions of the Model T (Lesiv, 2023).

Increased automation use in satellite manufacturing has also facilitated significant advancements. European aerospace corporation Airbus has seen reductions in production time from 30 months to 18 months through improvements in manufacturing techniques (Harebottle, 2021). China has also recently unveiled its first smart small satellite production line that utilizes smart machinery and full automation in all key production processes, increasing production efficiency by a supposed 40 percent (A sneak peek into China's first smart satellite production line, 2022). Despite these advancements, automation is still limited in implementation (Segert and Attara, 2019), and further progress in automation will undoubtedly continue to expand manufacturing capabilities.

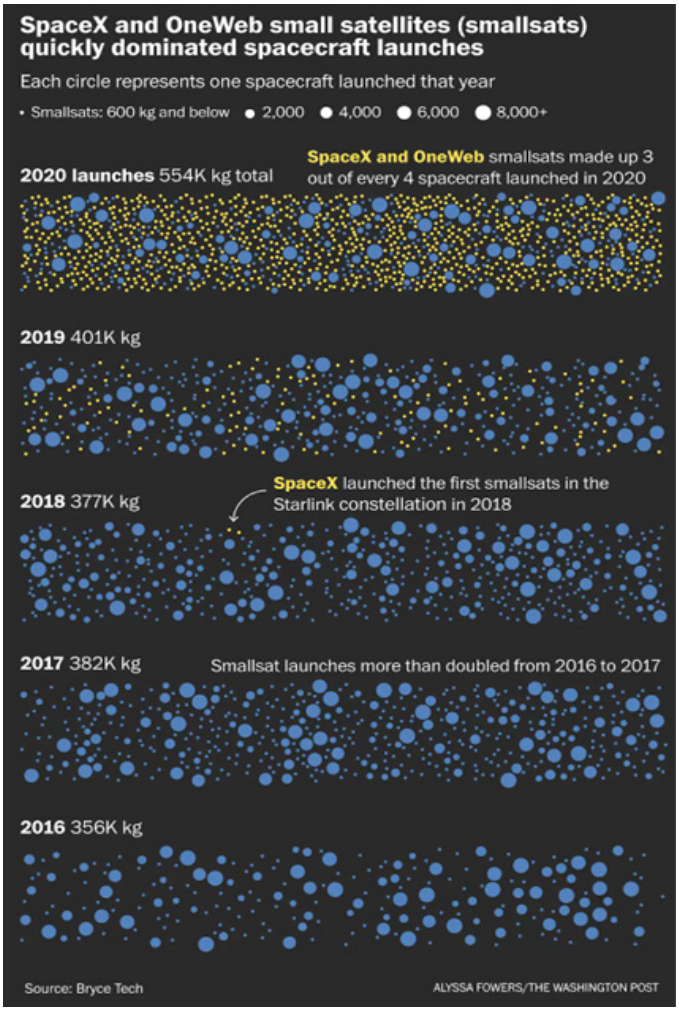


Diagram showing spacecraft launches from 2016-2020 (Davenport, 2021)

Reusability

The reusability of parts has fundamentally changed the economics of launch. Whereas previously, customers had to pay the entire price of the rocket for just one payload launch, companies have been able to drive down costs of launch through the reuse of launch parts. So far, companies like Blue Origin and SpaceX have been able to successfully reused first-stage boosters and fairing rocket parts, otherwise known as the rocket's nose cone (Lag, 2020). The next step for the industry is completely reusable rockets. The cost of these rockets could be amortized over numerous different flights, and the predicted savings are enormous. The Starship, which SpaceX aims to be its first fully-reusable rocket, could be 200 times cheaper per flight than current vehicles (Brown, 2022).

Vertical Integration

The vertically integrated production line of launch vehicles is considered the largest factor behind decreased launch costs. Vertical integration has traditionally come with the benefits of access to economies of scale, improved quality control, increased market power, decreased supplier risk, and lower transaction costs. Pioneered by SpaceX, vertical integration of the launch industry has resulted in significant improvements in cost-efficiency and production reliability, allowing SpaceX to price its launches at a third the price of its competitors (Matthews, 2018).

This vertical integration activity in the launch sector has also driven consolidation in the satellite sector. Following the lead of SpaceX, companies like Planet, Satellogic, and Capella Space now all produce small satellites entirely in-house. Such companies are now starting to move upstream, further integrating towards the development and manufacturing of not just small satellites, but satellite components (Williams et al, 2018). Desire to integrate is further driven by the shift from single, highly capable spacecraft to large, disaggregated satellite constellations, which contribute to the need for scalability and assured quality of parts (A Different Approach: Vertical Integration in Satellite Manufacturing, 2019). Spaceworks Enterprises analysts have found that in-house production of satellite components can increase reliability by up to 97 percent (Williams et al, 2018), and although it presents

high upfront costs, it is likely that more vertical integrations will be seen in various space-related technology industries as they try to access such advantages.

Continued Advancement and Implications for the Future

As these advancements continue to progress, it is expected that spacecraft launch and construction costs will continue to accelerate downwards. SpaceX's Musk has stated confidence in a spacecraft launch that costs less than $10 million within the next two to three years (Duffy, 2022) and plans eventually to lower the cost of their Starship vehicle's to under $2 million (Brown, 2019), or around $220 per pound of payload (Lesiv, 2023). Leveraging these innovations in tandem will likely result in even better payoffs, and the consequences of such combinations will emerge in the next couple years. Companies like Relativity Space, for instance, are already planning to use artificial intelligence, automation, and 3D printing to build fleets of fully reusable, low-cost rockets (Brukardt, 2022). The continued rapid deceleration in space-related technology costs forebodes several likely scenarios for the next two decades.

The decreased barrier to space has attracted the attention of actors from both the public and private sectors. Now that technological development has made getting to the moon cheaper than ever before, countries like Japan, Korea, India, and the United Arab Emirates are joining Russia and the United States in sending sessions to the moon (Pickrell, 2022). In competition with Musk's Starlink satellite constellation system, China plans to launch nearly 13,000 satellites as a part of its own GW constellation. As both the economic and military advantages of such constellations become more prominent, as demonstrated by Starlink's importance to the Ukrainian war effort (Roulette, 2023), it is likely that other state actors with enough power and resources will attempt to secure access to satellite constellations of their own. The private sector has also shown increased interest in space, and the development and implications of this trend are further highlighted in 'Privatization of Space."

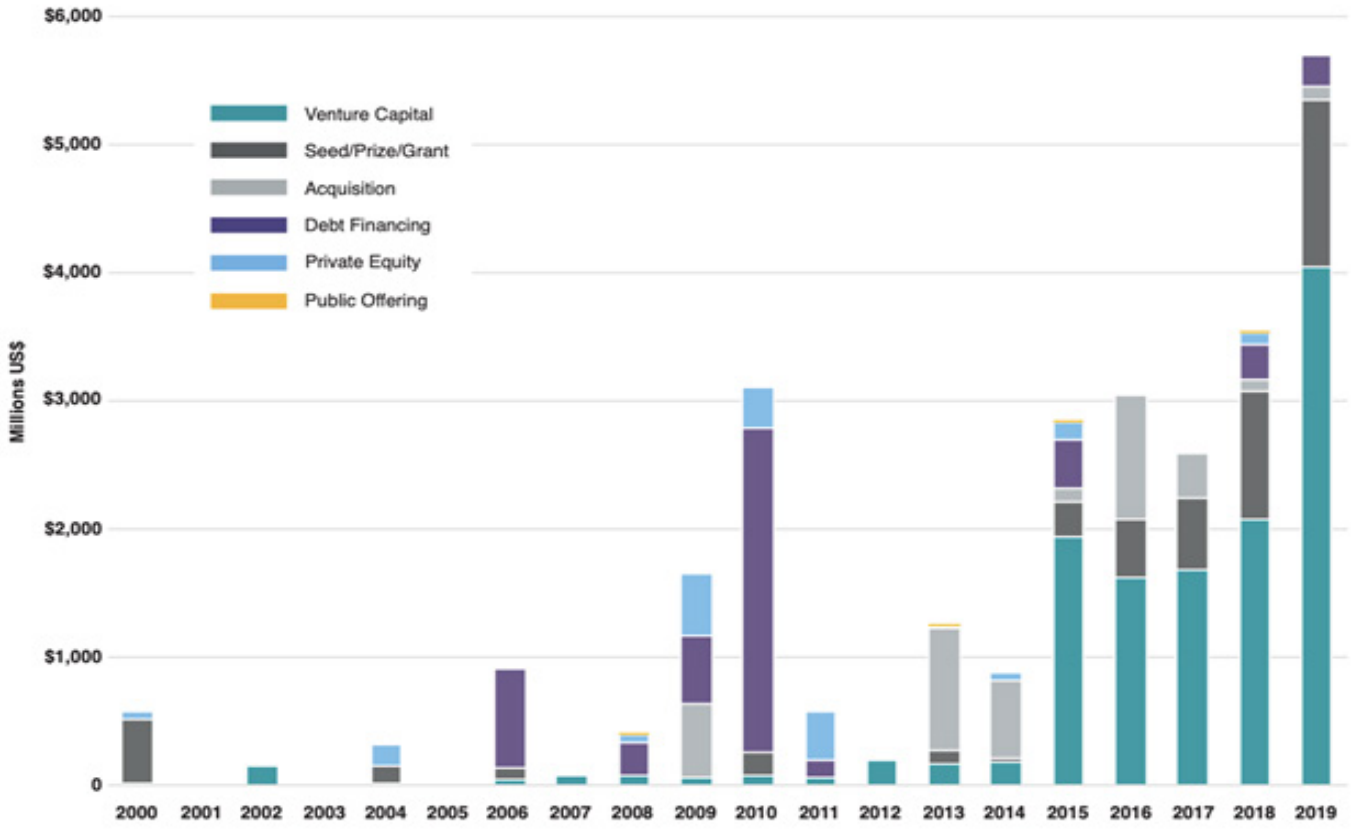
A concern that has emerged with increased space activity is a potential overcrowding of the Earth's orbit. Earth's low earth orbit, the prime destination for satellite constellations, is already getting crowded. In 2021 alone, 1,702 new satellites were launched into orbit, bringing the total satellite count to 4,852, nearly double what it was in 2018 (Chow, 2022). Starlink has already secured permission for over 12,000 new satellites, and Musk has alluded to plans to launch 30,000 more (Young, 2022). If all planned satellite constellation networks move forward, that would bring the total number of satellites in that area of space to nearly 100,000 (Young, 2022). In addition to the low-earth orbit, the geostationary orbit is also filling up. There are just 1,800 viable geostationary orbit slots, and as of 2022, 541 of them are already occupied by active satellites; claims to a majority of the slots that offer access to large markets have also already been filed by countries and private companies (Ogden, 2022). The potential overcrowding of space brings about several worries, including increased risk of collision and competition for bandwidth. As the current dominant space power, the U.S. may find itself at a loss without the proper legal frameworks in place to deal with such scenarios.

II. Privatization of Space

Private space companies have been emerging rapidly in recent years, bringing significant innovation and competition to the space industry. According to a report by Bryce Space and Technology, $5.7 billion was poured into space ventures in 2019, a 34 percent jump from 2018 (Bryce Space and Technology).

SpaceX is one of the most well-known private space companies, having achieved several significant milestones in space exploration. In 2020, SpaceX became the first private company to launch astronauts into orbit and dock with the International Space Station (NASA, 2020). Additionally, SpaceX has been able to significantly reduce the cost of launching payloads into space. For example, the cost of launching a Falcon 9 rocket with a reusable first stage is approximately $62 million, which is significantly less expensive than the $152 million cost of launching a comparable rocket with a non-reusable first stage (Tangermann). Additionally, SpaceX has announced plans to develop a lunar lander in partnership with NASA as part of the Artemis program, which aims to send humans back to the moon by 2024 (NASA, 2021).

Blue Origin is another private space company that has made significant contributions to the industry. In 2015, Blue Origin became the first private company to successfully launch and land a reusable rocket (Cofield). Virgin Galactic, the space subsidiary run by Richard Branson's Virgin Group, has also made significant strides in space exploration. The company aims to offer commercial space flights to paying customers, with the goal of eventually making space tourism accessible to a wider audience. In 2021, Virgin Galactic conducted a test flight of its SpaceShipTwo vehicle, which reached an altitude of 53.5 miles (Roulette).



The mix of investment types in space companies varies from 2000 to 2019 (Bryce Space and Technology).

Outpacing Governmental Organizations

These private space companies have demonstrated significant success in achieving space exploration and providing cost-effective launch services. Their success has challenged the traditional methods of government-run space programs and has led to greater competition and innovation in the industry. For instance, NASA estimates that switching to a private rocket, such as one from SpaceX or Boeing, over their own internal Space Launch System (SLS) has the potential to save the agency more than $700 million (Sheetz, 2019).

Private companies are incentivized to develop cost-effective and efficient technology due to their focus on profitability and competitiveness. For example, SpaceX's reusable Falcon 9 rocket has significantly reduced the cost of launching payloads into space, as mentioned earlier. In addition, Blue Origin and Virgin Galactic are attempting to kickstart the space tourism industry, which can only be made possible by decreasing costs. A seat on the VSS Unity is roughly $250,000, and passengers have paid up to $28 million for a ticket on Blue Origin's New Shepard (The Planetary Society). In the next decade, we can expect these prices to dramatically drop as new innovations are introduced.

Private space companies have also shown a higher level of agility and flexibility in the development and execution of space missions compared to government-run space programs. SpaceX's iterative design approach allows for rapid testing and development of spacecraft, which has contributed to its success in achieving several significant milestones in space exploration, as mentioned earlier. By maintaining a hardware surplus, they can afford to complete many more launches and tests than government entities (Berger). Furthermore, private companies have the flexibility to pivot their business strategies quickly in response to changing market conditions. For example, SpaceX successfully launched two NASA astronauts to the International Space Station in May 2020, despite the logistical challenges posed by the pandemic (Sheetz, 2020).

Emergence of New Industries

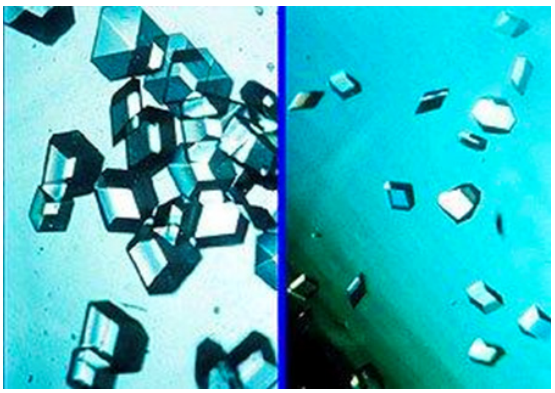
The emergence of private space companies has also led to the creation of new industries and the development of new technology. Asteroid mining has the potential to provide a vast array of resources, including water, metals, and minerals, that are becoming increasingly scarce on Earth. Private space companies such as AstroForge have

Astronauts Doug Hurley and Bob Behnken aboard the SpaceX Crew Dragon, the spacecraft that carried them to the ISS as part of NASA's Commercial Crew Program (image from NASA).

developed technology and business models aimed at extracting these resources from asteroids. In 2023, AstroForge hopes to launch two missions this year, one of which will involve a vehicle named "Brokkr-2". Brokkr-2 is planned to scout deep space and visit a target asteroid. AstroForge plans a historic retrieval mission sometime in the mid-2020s (Mack).

Space manufacturing is another industry that has emerged due to the privatization of space. The ability to manufacture goods in space has numerous advantages, such as reduced transportation costs, lower environmental impact, and the ability to produce goods that are difficult or impossible to manufacture on Earth. Several private companies, such as Varda Space Industries, aim to build space stations dedicated to using microgravity to manufacture fine goods, such as computer chips, fiber optics, and pharmaceuticals (Sheetz, 2021).

These new industries not only have the potential to revolutionize the space industry but also to impact Earth-based industries. For example, asteroid mining could provide a sustainable source of rare metals and minerals, while space manufacturing could lead to new, more efficient manufacturing techniques and reduced environmental impact.



For example, insulin crystals grown in space (left) are larger and have better molecular structure than those grown on Earth (right), aiding drug design (NASA).

Looking Ahead

One potential concern with the privatization of space is that private companies could potentially monopolize access to space, thereby restricting access to only the highest bidders. As the space industry grows, larger companies may acquire smaller competitors, reducing the number of players in the market. Additionally, some private companies may hold a significant advantage over others due to their extensive resources and expertise, which could create barriers to entry for new companies. If a single company were to gain a dominant market position, they could potentially control access to space and dictate prices, which could restrict access to smaller companies and academic institutions.It is therefore important for regulatory bodies, such as the Federal Aviation Administration's Office of Commercial Space Transportation, to monitor the market and ensure that competition remains accessible and fair. Additionally, the government can play a role in promoting competition and accessibility by providing funding and support for smaller companies and academic institutions, thereby reducing barriers to entry and promoting a healthy market.

The lack of regulations is another significant concern. Unlike government-run space programs, private space companies are not subject to the same level of oversight and accountability. This could lead to safety and environmental concerns, particularly if companies prioritize profits over safety. Private space companies may be tempted to cut corners on safety measures in order to reduce costs and increase profits. For example, if a private space

company were to launch a satellite that malfunctioned and collided with another satellite or piece of space debris, the consequences could be catastrophic.Private space companies could also potentially pollute the space environment with waste, fuel, and other materials, without any accountability for the environmental impact. The accumulation of space debris is also a growing concern, as private companies launch more and more satellites into orbit. Without regulations to manage the disposal of these satellites and other space debris, the space environment could become increasingly cluttered and hazardous to future space missions.

Regulatory bodies should be established to oversee private space companies, monitor their activities, and enforce safety and environmental regulations. Regulatory frameworks should establish guidelines for the responsible use and management of space resources, such as the moon and asteroids.

III. Militarization of Space

In 2018, President Trump issued the United States' first National Space Strategy. The United States has historically treated space as a domain of exploration, as well as a technology race, but has done little to protect these systems. Throughout the Cold War, the technology required to pursue a military strategy in space was deemed too risky to test due to the collateral damage it might cause. In the future, that may no longer be the case. Over the past decade, China, Russia, France, the UK, and the U.S. have established Space Forces (or similar) organizations, and that number is expected to increase over the next few decades. India recently conducted an anti-satellite weapons test, and Iran also launched its first military satellite in 2020. Recent Defense Intelligence Agency reports have indicated that China has been developing signal jammers designed to target military reconnaissance platforms, specifically space-based communications. China's increasing focus on achieving control of the LEO (Low Earth Orbit) space has not gone noticed in the West (Defense Intelligence Agency, 2022). Space may be the new domain of modern military struggle as it has now become a critical factor in influencing the outcomes of states and rules of war. In the future, countries will collaborate internationally in space exploration for national recognition, scientific, and economic benefits. Government funding will still be the primary source for large-scale activities, but commercial entities will play a significant role in advancing space technology.

Space Race II

The Space Race of the 20th century could be seen as a technological arena for Cold War competition—the Soviet Union launched Sputnik in 1957, the world's first artificial satellite. In response, the U.S. created NASA. Over the next few decades, Americans and Soviets launched animals and then men, first into space and then eventually, on July 16th, 1969, a man on the moon. Ever since then, although there have been missions, the space race has largely been out of sight. China and Russia have now re-focused on returning to the moon and have plans to construct an International Lunar Research Station by 2035. The U.S. also has a similar project, the Artemis program, whose goal is to establish a permanent base camp on the Moon and eventually facilitate human missions to Mars. The U.S. is working with 23 other countries bound by the Artemis Accords. This new race will shift into focus over the next decade, with the Americans having the theoretical edge in timeline, but the success of these technologies is yet to be determined. If successful, the winner might begin to exploit the Moon's natural resources. Space is becoming increasingly utilized during military operations, exercises, and logistics around the world. Until recently, not much has gone into discussing the idea of counterspace, to degrade or damage space services, either temporarily or permanently (Nagashima, 2020). This may include physical or cyberattacks against ground sites which support space operations, space-based weapons that can deliver payloads onto other satellites or the ASAT missile, which is used to attack satellites in LEO. It is also theorized that by firing a nuclear weapon to detonates in high altitude, it would create widespread electromagnetic disruptions in satellite systems. China and Russia value space-based superiority, so expect both countries to continue to integrate their space systems into their militaries.

Space-Based Military Technologies

Space-based technologies are slowly integrating into most of our social and economic sectors, such as medical, disaster response, financial transactions. Many technologies used by militaries in space are also used by civilians in everyday life. Remote-sensing is defined by the tracking and gathering of data: from a civilian standpoint, this means the monitoring of weather or disaster operations, and from a military one, observing troop movements in real-time as well as observing related events and locations. Military satellite communications allows for greater mobility over distances and also eliminates the need for ground-based infrastructure, arguably making it more useful against current world adversaries. Today, PNT (positioning, navigation, and timing) services transmit timing signals for air, land, and sea navigation, as well as asset tracking and precision weapons guidance. Advanced technologies such as sensors, automation, AI, and hypersonic capabilities will transform conflict over the next two

decades, with proliferation to smaller states and non-state actors. Cyber attacks will target connected military and governmental networks. Countries that disperse their networks and build redundancy will be better positioned for future conflicts. Real-time detection and processing may be revolutionized by sensors and data analytics, but AI and algorithmic decision-making aids will remain crucial. The speed of these technologies may raise the risk of miscalculation and inadvertent escalation to full-scale war, requiring increased protection of information and assets in space and enhanced agility and flexibility of military networks.

Global Threats

As mentioned, China and Russia will continue to push their technological frontiers. During the last 10 years, China has doubled its launches per year, sending 541 satellites into orbit for reconnaissance or intelligence gathering (Baier, 2023). By 2040, China is expected to emerge as the primary challenger to the United States in space across commercial, civil, and military realms. China will pursue an autonomous trajectory in space technology development and forge partnerships with foreign actors in Chinese-led space initiatives. The adoption of Chinese space services globally will offer an alternative to Western options. However, the PRC military continues to rely on covert and overt acquisition of foreign space and counterspace technologies in order to modernize (Atlantic Council, 2023). These improvisations have allowed China to leapfrog development by a few years. Today, it operates more than 60 communications satellites and has an intelligence, surveillance, and reconnaissance satellite fleet of more than 250 systems (compared to the U.S. 500), but are expected to add to that each year. Russia, although more narrowly focused and fiscally limited in comparison to China, has traditionally seen space as a measure of prestige and of strategic importance. Although they openly support the space arms control agreement, they are developing an arsenal of counterspace capabilities in order to attack U.S. and allied assets. Space exploration is no longer limited to scientific discovery, with human activity transitioning to security and commerce. Commercial activity is expanding and will require security operations to protect it and facilitate routine space activity. Economic activity is expected to expand to cislunar space over the next three decades. The evolving nature of space activity raises questions about its definition and regulation. Space's importance for Earth's security will eventually be matched by the need to secure economic activity in space.

CONCLUSION

While this analytical assessment grapples with two tangential and seemingly unrelated issue areas, the probable economic and social effects of global population collapse and demographic reversal may well implicate the race for military domination in space. China's leapfrogged and rapid development in the past two decades greatly enabled their attempts to control LEO space, establish a Lunar Research Station and develop counter-space technologies. However, China's January 2023 human capital reports provide a potential glimpse into the nation's future. Projected economic stagnation, due to the reduction of China's workforce by 23 percent and net population decline of 200 million by 2050, is likely to stunt the leapfrogged development enjoyed in the past decade. While China clearly understands space as an arena of military and strategic importance, the question remains whether the nation has the capacity to maintain their current level of technological production and ascent to space dominance amidst humanitarian crises in rural areas, abysmal birth rates, and a wavering per-capita GDP. Aging populations exert a strong negative influence on innovation while straining social, economic, and medical infrastructure. By 2050, China's 65+ population is expected to balloon by 150 percent. How might this super-aged population compete in the scramble for space and international hegemony without compromising cutting edge innovation and performance?

The arenas of space competition and demographic reversal are subject to a confluence of confounding variables and contingencies. The lack of historical precedent for fertility rate declines amidst relative global peace has complicated analysts' predictions of future trends. However, it is evident that decades of sub-replacement birth rates in China and Europe have reached a crystallizing point, while Africa's population continues to grow at a rate that cannot be supported by the current social, educational, and economic opportunities available across the continent. In the scramble for space hegemony, lower barriers to entry have flooded the arena as Japan, Korea, India, and the United Arab Emirates have begun sending sessions to the moon alongside the U.S. and China. In the U.S., spacecraft launch and construction costs have continued to accelerate downwards, which has prevented untenable market monopolies from emerging. Private companies are increasingly outpacing governmental organizations, and the ungoverned nature of space may crystallize monopolies, thereby restricting access to the highest bidders. Ultimately, space militarization continues to grow in importance for nations' strategic dominance. Although analysts postulate that China will assume and maintain space-based superiority, this seems increasingly unassured amidst the nation's human capital and demographic challenges.

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