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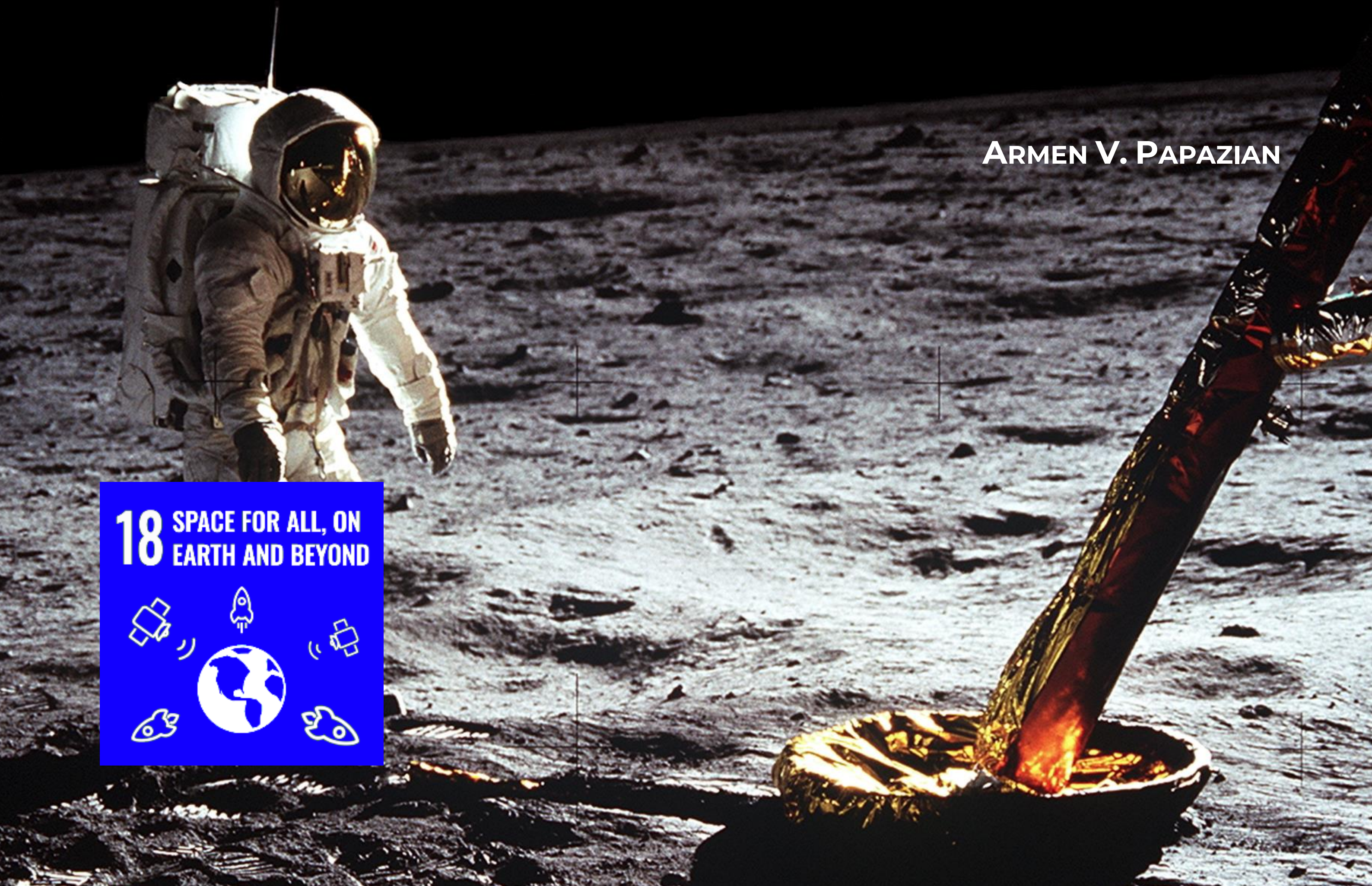
The Monetary Foundations of a Spacefaring Species

Respect, Value, and Explore Space

Armen V. Papazian



Our financial imagination

is as important as our technological imagination

when it comes to extending our reach into the cosmos.

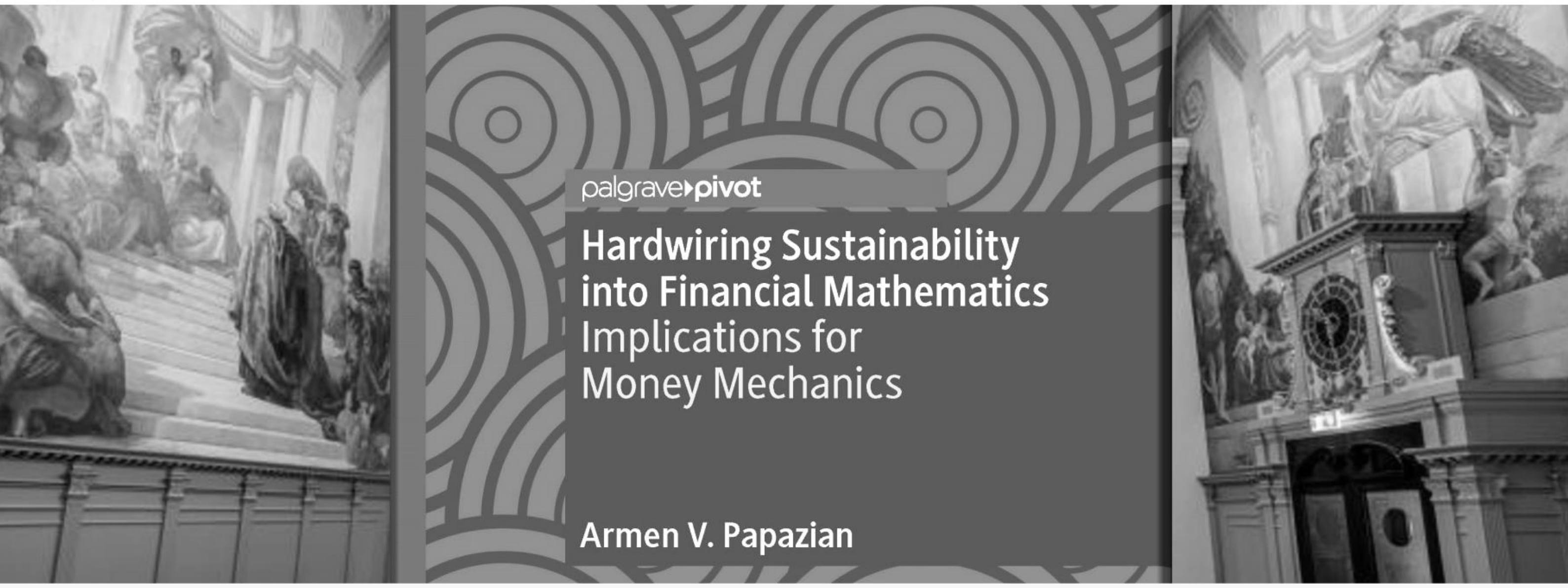
Armen V. Papazian

Starship Congress 2013

Dallas – Texas, USA

Armen V. Papazian is the author of 'Hardwiring Sustainability into Financial Mathematics' (2023) and 'The Space Value of Money: Rethinking Finance Beyond Risk and Time' (2022) and a Founder and Director of the Space Value Foundation. He is a financial economist, author, consultant, and innovator with more than 20 years' experience in sustainable finance, capital markets, and analytics. Armen is a Doctor of Financial Economics from Cambridge University, and the first winner of the Alpha Centauri Prize. More

Article by the Cambridge University Judge Business School
Hardwiring Sustainability



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"Every once in a while, a book comes along that makes a fundamental contribution that is both profound and practical. A book that every member of the National Space Council, including the NASA Administrator and the Space Force Chief of Space Operations should read. *The Space Value of Money* will be of interest to ESG and impact investors, government regulators, financial theorists, and outer space enthusiasts."
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"No doubt, the pressing environmental challenges we face make the concept of the space impact of investments even more compelling."
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"*The Space Value of Money* brings much needed conceptual rigour, whilst further advocating the case for a new paradigm shift in financial valuation. This work gives us the lasting frameworks that aggregate impact across all spatial dimensions. Dr. Papazian culminates over ten years of research in this rich book, providing the springboard for further innovation and system implementation in this area."
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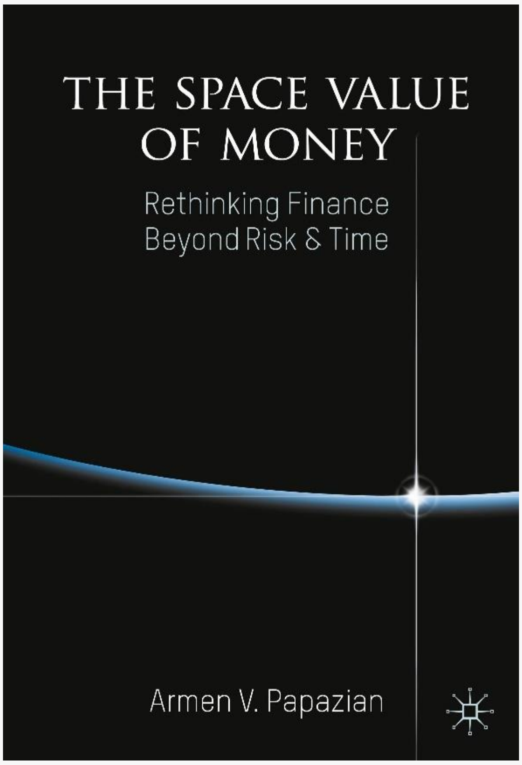
—Dr. Keith Carne, First Bursar, King's College, Cambridge University



“Dr. Papazian’s *Space Value of Money* concept addresses sustainability in microeconomics and macroeconomics—it critically updates and accounts for the additional dimension. This should be compulsory reading for all students of finance and investing.”
—Eoin Murray, Head of Investment, Federated Hermes Limited

“At a time when the climate crisis drives home the point for urgent action, and ESG measurements have come under intense scrutiny, one can hardly overstate the importance of this book. Rigorous and comprehensive, it offers an investment impact measurement methodology and answers the key financial question of our times: how can we fund the transition to a sustainable world? A finance handbook for the future.”

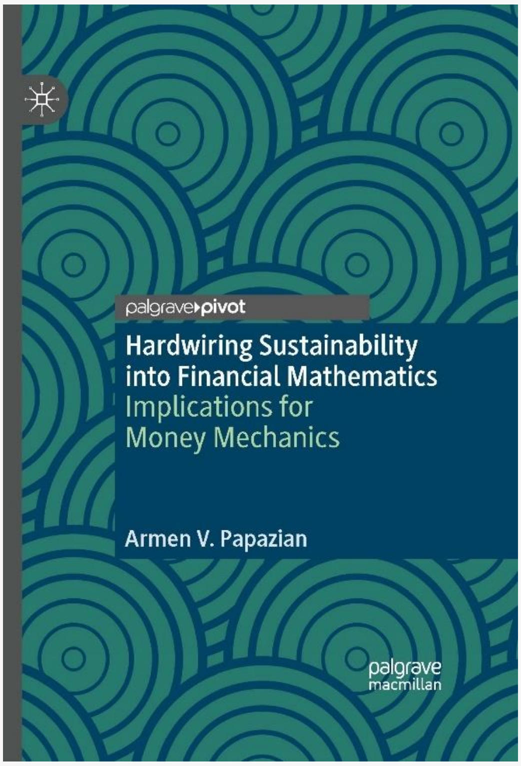
—Dr. Matteo Cominetta, Head of Macroeconomic Research, Barings LLC

“In the bewildering and ever-swelling sea of acronyms that now covers the world of sustainable finance, Dr. Armen Papazian’s laser-like focus on the financial mathematics of investment value and return is a most welcome addition to the profession’s navigation skills.”

—George Littlejohn, Senior Adviser, Chartered Institute for Securities & Investment

“This is a brave book—it highlights inconvenient truths about the financial mathematics of investment that guides the global flow of capital and offers thought through solutions. It is a must read for anyone concerned with planetary sustainability.”

—Adrian Webb, Founder & Director, Space Value Foundation



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Respect, Value, and Explore Space

Armen V. Papazian[1]

Abstract

This white paper discusses the monetary and financial foundations necessary to enable sustainable outer space development and exploration for a species in space using money and monetary incentives to drive and direct its own creativity and productivity. It addresses the main reasons why our current efforts, however valiant, will struggle to deliver the results we seek without the key transformations necessary to unlock our spatial potential from a monetary and financial perspective. It exposes the shortcomings of our current financial value framework, mathematics, and monetary architecture, which together define our markets and investments, and explain our current predicament. It explores and discusses the key structural, institutional, as well as theoretical and mathematical transformations necessary for a sustainable human civilisation capable of sustainable outer space development and exploration. It offers an alternative plausible framework that entrenches respect, integrates the value, and empowers the exploration of space and its many layers.

Keywords:
Space, Risk, Time, Value, Money, Finance, Sustainability, Exploration, Settlement

Cover Image(s) Credit:
NASA (1,2)

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1. Introduction

The unusual starting point of this introduction is designed to contextualise the magnitude of our misconceptions and the nature of the bottlenecks we have created for ourselves. It reveals both the level of underinvestment in outer space exploration and the level of dysfunction in our financial value framework and monetary architecture.

In spite of record growth rates and high expectations of further growth, in 2023, total global government expenditure on outer space development programs and agencies reached US$ 117 billion, slightly surpassing the total revenues of the global toilet paper industry at US$ 107.38 billion (Euroconsult 2023; Statista 2023a).

A species whose public spending on outer space exploration and development barely surpasses what it spends on toilet paper will simply not get very far in outer space. Naturally, this is not to suggest that we should spend less on personal hygiene, although the deforestation impact of toilet paper production is significant, and it is about time we invented sustainable alternatives. Instead, this is about spending more and what is necessary to achieve meaningful breakthroughs and sustainable capacity build up in outer space development, exploration, and settlement. Public spending levels are an important indicator given that, unlike private economy investments and spending, they represent the amounts invested in outer space without any expectations of monetary return.

Meanwhile, the private outer space economy has been growing at a fast pace. According to the Space Foundation, revenues in the sector reached US$ 427.6 billion in Q2 of 2023 (Space Foundation 2023) estimated to reach US$ 1 trillion by 2030 or 2040 depending on sources. While there are many different and unverified projections regarding the future revenues and value of the private outer space economy, one feature seems to be widely accepted: it is growing (Morgan Stanley 2020; Citi 2023; Deloitte 2023; KPMG 2023; PwC-UKSA 2023).

There are of course many reasons for the projected optimism: launch costs, new technologies and breakthroughs, artificial intelligence, growth in satellite and data sectors, additional defence spending, and so on (See EIB 2019 for a landscape of outer space business services, models, and segments). While all of the above explain the positive projections and promise an exciting future, the fact remains that, as of today, the private outer space sector is much smaller than the total revenues of the global advertising industry at US$ 874.47 billion in 2023 (Statista 2023b). We spend more on trying to sell products and services to each other than on building our collective future in outer space. Once again, this is not to argue that we should be spending less on advertising.

This white paper does not discuss the outer space industry and/or economy. It is entirely focused on our monetary and financial foundations, i.e., structures, theories, frameworks, and mathematics, and addresses their impact on our outer space potential and ambitions. How can we invest more, and why we seem unable to do so now, are some of the main discussion topics.

Simply, we must be able to spend and invest what is necessary on outer space development. If humanity is going to be able to sustain lunar habitats and other exploration missions beyond LEO, MEO, and GEO[2], it must be able to finance massive investment programs in order to achieve both the innovations it needs to create the new starships and habitats, but also the on-Earth and off-Earth structures and workforces to sustain and maintain them. This will naturally imply the funding of equally massive R and D and education efforts, a good percentage of which may fail due to the levels of risk involved.

I argue that the suboptimal and inappropriate levels of funding and investment allocated to outer space exploration are linked to and caused by our financial value framework, financial mathematics, and monetary architecture. The content, main arguments, and equations presented are almost entirely based on two recent publications (Papazian 2023, 2022). While both books are central to the key propositions made here, this paper has a narrower focus on a particular aspect of space, i.e., outer space. It addresses the civilisational bottlenecks we face in outer space development and exploration and offers plausible solutions to transcend them. As such, the discussion is directly relevant to planetary sustainability as well.

Indeed, our current efforts, however valiant, will struggle to deliver the results we seek without the key transformations necessary to unlock our spatial potential from a monetary and financial perspective.

The paper proposes key structural, institutional, as well as theoretical and mathematical transformations necessary for a sustainable human civilisation capable of sustaining outer space development, exploration, and settlement.

The rest of the paper is structured as follows:

Section 2 - Space: starts by defining space and outer space in order to contextualise the discussion and presents a snapshot of humanity's dismal record when it comes to its treatment of space and its many layers, our physical context of matter that includes outer space.

Section 3 – Spaceless Financial Value Framework: discusses our current financial value framework built around risk and time, without space, and reveals the key reasons why our value framework, principles, and mathematics of value and return act as structural impediments to outer space development and exploration.

Section 4 – Spaceless Monetary Architecture: discusses our debt-based monetary architecture where money creation is founded on debt instruments valued in a risktime universe. It exposes three systemic challenges and identifies our current monetary architecture as an evolutionary bottleneck.

Section 5 – Introducing Space: introduces the principle, equations, and instruments necessary to transform our financial value framework and monetary architecture in order to enable and empower our outer space ambitions and unleash our spatial potential.

Section 6 - Conclusion: summarises the argument and concludes the paper.

[2] Low Earth Orbit, Medium Earth Orbit, Geostationary Orbit.

2. SPACE

To appropriately diagnose our predicament, we must begin by clearly defining space and outer space. Very often, in government, industry, and academia, the word space is used to refer to outer space and/or both terms are used interchangeably. In this paper, outer space is only one layer of space, however vast.

2.1. Space and Outer Space

Space is defined as our physical context of matter stretching from subatomic to interstellar space and every layer in between and beyond, where outer space is but a segment. In the below figure (Fig.1), I present a layered conceptualisation of space. Fig. 1 depicts layers of space we have come in direct contact with physically or through our technologies. Naturally, the inner layers of our planet, like the layered core, are not affected directly - for further examples of our reach please see Papazian (2022).

Fig. 1 Space Layers and Outer Space
(Source: Adapted from Papazian 2023, 2022)

Naturally, every layer of space in Fig. 1 can be further broken down into sublayers, and sublayers can be further defined into further layers. Indeed, outer space is a vast landscape far beyond interstellar space, including our galactic context and the many billions of galaxies in the observable universe. Table 1 provides additional details on the continental crust and the hydrosphere on Earth. The table also provides examples of lakes and vegetation revealing that a fine-tuned conceptualisation of each sublayer is also possible when relevant. Naturally, this applies to all depicted layers.

Table 1 Sublayers: Hydrosphere and Continental Crust
(Source: Papazian 2023, 2022)

Space Layers	Sub-Layers	Sub-Layer Type Examples
	Seas, Lakes, Rivers, Ice Sheets	Tectonic lakes
		Volcanic lakes
	Oceans	Glacial lakes
	Epipelagic Zone - The Sunlight Zone	Fluvial lakes
Hydrosphere	Mesopelagic Zone - The Twilight Zone	Solution lakes
	Bathypelagic Zone - The Midnight Zone	Landslide lakes
	Abyssopelagic Zone - The Abyss	Aeolian lakes
	Hadal Zone - The Trenches	Shoreline lakes
		Organic lakes
		Anthropogenic lakes
		Meteorite lakes
	Land Surface	Tundra
	Mountains	Taiga
	Built Up	Temperate broadleaf and mixed forest
		Temperate steppe
		Subtropical moist forest
	Vegetation	Mediterranean vegetation
		Tropical and subtropical moist forests
Continental Crust	Cropland	Arid desert
	Soil	Xeric shrubland
	O Horizon - Organic Layer	Dry steppe
	A Horizon - Top Soil Nutrient Layer	Semiarid desert
	E Horizon - Eluviation Layer	Grass savanna
	B Horizon - Subsoil Mineral Layer	Tree savanna
	C Horizon - Regolith Layer	Tropical and subtropical dry forest
	R Horizon - Bedrock Layer	Tropical rainforest
	Deep Crust	Alpine tundra
		Montane forest

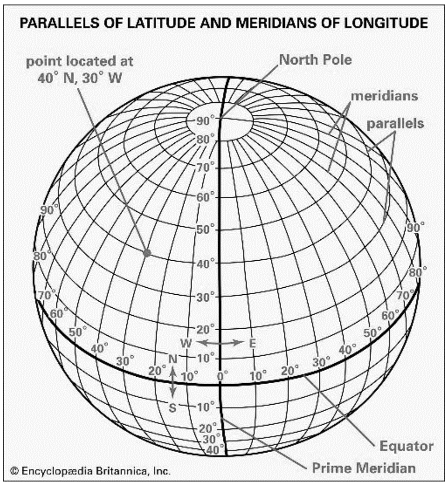
Another important clarification concerns the boundaries of the space layers. Where does the atmosphere end and outer space begin exactly? We know that at the edge of the exosphere, Earth's atmosphere loses density gradually. In other words, the start and end points of these layers are conceptually defined. For example, the Kármán line, 62 miles above sea level, named after Theodore von Kármán, is not a physical line. It is a conceptual line that is said to define the outer edge of national airspace and the beginning of outer space, originally conceived through his work on defining the theoretical boundary between aeronautics and astronautics.

A layered conceptualisation of space is exactly that, a conceptualisation of our physical context of matter, and the start and end points of space layers are also human inventions. Our physical reality of matter is far more malleable than what our conceptual boundaries and lines suggest.

Similarly, another conceptual line and point that shape our understanding of terrestrial space is the Prime Meridian. The Prime Meridian, epitomised by the Greenwich laser beam, at 0° longitude, helps us structure and navigate our productive lives on planet Earth (See Fig. 2).

This imaginary point/line on Earth, in space, defines our maps and our clocks, and acts as a structural pillar of the entire world economy, and yet, it is conceptually projected onto our physical context.

Fig. 2 Prime Meridian
(*Source: Britannica 2023a*)



While we will come back to the Prime Meridian and the layered conceptualisation of space later on in the discussion, in the next section, through a selection of aspects, I discuss humanity's treatment of space, including outer space.

2.2. Human Productivity and Impact on Space

Human activity, productive or other, affects all of the space layers depicted in Fig. 1, directly and or indirectly. We have rovers on mars and on the moon, and Voyager 1 crossed into interstellar space in 2012. Moreover, our daily economic productive activities affect our atmosphere, our hydrosphere, and even outer space. To briefly describe our impact on space, I discuss a few key aspects.

2.2.1. Climate Change

One of the most documented and commonly discussed impacts we have had is on our climate. Global warming due to Green House Gas emissions (GHG) is a hot topic of concern. Indeed, the evidence confirming human responsibility for climate change has been overwhelming (IPCC 2022, 2021, 2018, 2013). IPCC (2023) summarises the challenge as follows:

> Human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming, with global surface temperature reaching 1.1°C above 1850–1900 in 2011–2020. Global greenhouse gas emissions have continued to increase, with unequal

historical and ongoing contributions arising from unsustainable energy use, land use and land-use change, lifestyles and patterns of consumption and production across regions, between and within countries, and among individuals. (IPCC 2023, 4)

Since the Paris Agreement (UNFCCC 2015), the reduction of GHG emissions has become an integral part of daily business and financial rhetoric. Reaching the target, to keep world temperature increases below *2°C* above preindustrial levels and ideally limit the temperature increase to *1.5°C*, has become a defining theme across many fields and industries.

Fig. 3 Atmospheric CO2 Levels
(*Source: NOAA 2024*)

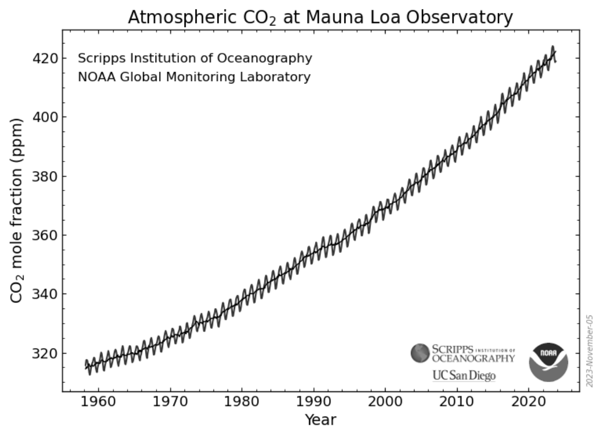
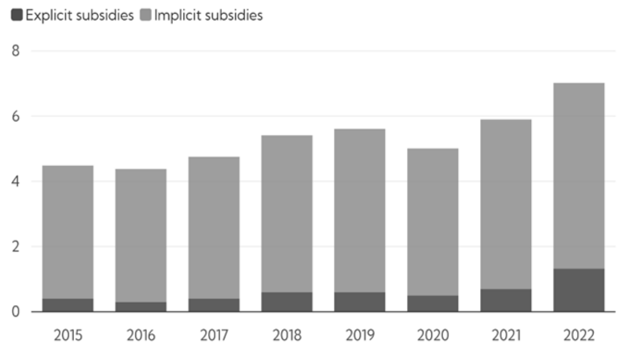


Fig. 4 Fossil Fuel Subsidies
(Source: IMF 2023a)



Unfortunately however, despite all the rhetoric and many initiatives, we have not changed our trajectory yet. Emissions are still going up (Fig. 3), fossil fuel subsidies are at a record level (Fig. 4: $7 trillion in 2022), the UK government has recently approved hundreds of new licenses for oil and gas exploration in the North Sea, and we continue to destroy our atmosphere despite the evidence, the raging climate crisis, and the presence of many alternatives.

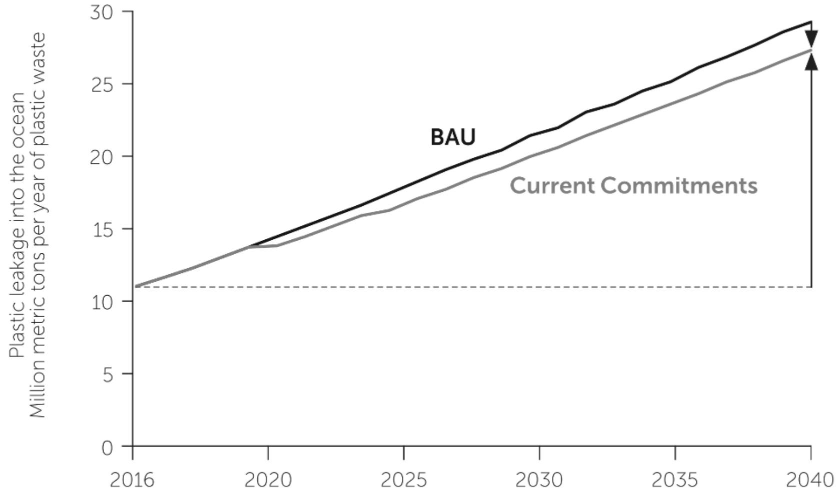
DESPITE ALL THE RHETORIC AND MANY INITIATIVES, WE HAVE NOT CHANGED OUR TRAJECTORY YET.

2.2.2. Plastic in our Oceans

Currently, there are an estimated 50-75 trillion pieces of plastic and microplastics in our oceans (IOC-UNESCO 2022). According to recent research done by Pew Charitable Trusts, 11 million metric tons of plastic waste entered the ocean in 2016, and the number is set to rise to 29 million metric tons per year by 2040 under business-as-usual conditions. A chilling summary of the untenable trajectory is described as follows:

> We estimate that 11 million metric tons of plastic entered the ocean from land in 2016, adding to the estimated 150 million metric tons of plastic already in the ocean. Plastic flows into the ocean are projected to nearly triple by 2040 to 29 million metric tons per year. Even worse, because plastic remains in the ocean for hundreds of years, or longer, and may never biodegrade, the cumulative amount of plastic stock in the ocean could grow by 450 million metric tons in the next 20 years— with severe impacts on biodiversity, and ocean and human health. (PEW 2020, 25)

Fig. 5 Plastic in our Oceans under Business As Usual Conditions
(*Source: PEW 2020*)



Carbon in the atmosphere and plastic in the ocean are but two examples of the many cases of waste and pollution. Further examples on chemical waste, or municipal solid waste figures, reveal the same trends. "More than two billion metric tons of municipal solid waste (MSW) are generated worldwide every year, and this figure is expected to increase by roughly 70 percent by 2050" (Statista 2023c). Similarly, figures on sewage in our rivers and beaches, microplastics in our water and food chains, etc., depict the same upward trend in environmental degradation and ecological destruction.

2.2.3. Biodiversity Loss

Another key example of our destructive impact on space is the devastating rates and extent of biodiversity loss experienced across planet Earth (IPBES 2019). White et al. (2021) summarise the biodiversity challenge as follows:

> Despite increasing recognition of its importance, biodiversity is in precipitous decline (Díaz et al., 2019; Tittensor et al., 2014). Recent reports estimate that 75% of the terrestrial environment and 66% of the marine environment have been severely altered by human activity (Halpern et al., 2015; IPBES, 2019; Venter et al., 2016), and that between 1970 and 2014 populations of monitored species have declined by an average of 70% (WWF, 2018b). This decline is largely driven by the continued growth of the global economy (Hooke et al., 2012; IPBES, 2019; Maxwell et al., 2016). From aquaculture and forestry to mining, consumer goods, and infrastructure, industrial development across sectors is closely tied to biodiversity loss. Business operations and supply chains act to increase the production and movement of goods, often at the expense of natural ecosystems through increasing habitat loss, fragmentation, pollution, invasive species introductions, and overexploitation (Díaz et al., 2019; Krausmann et al., 2017). (White et al. 2021)

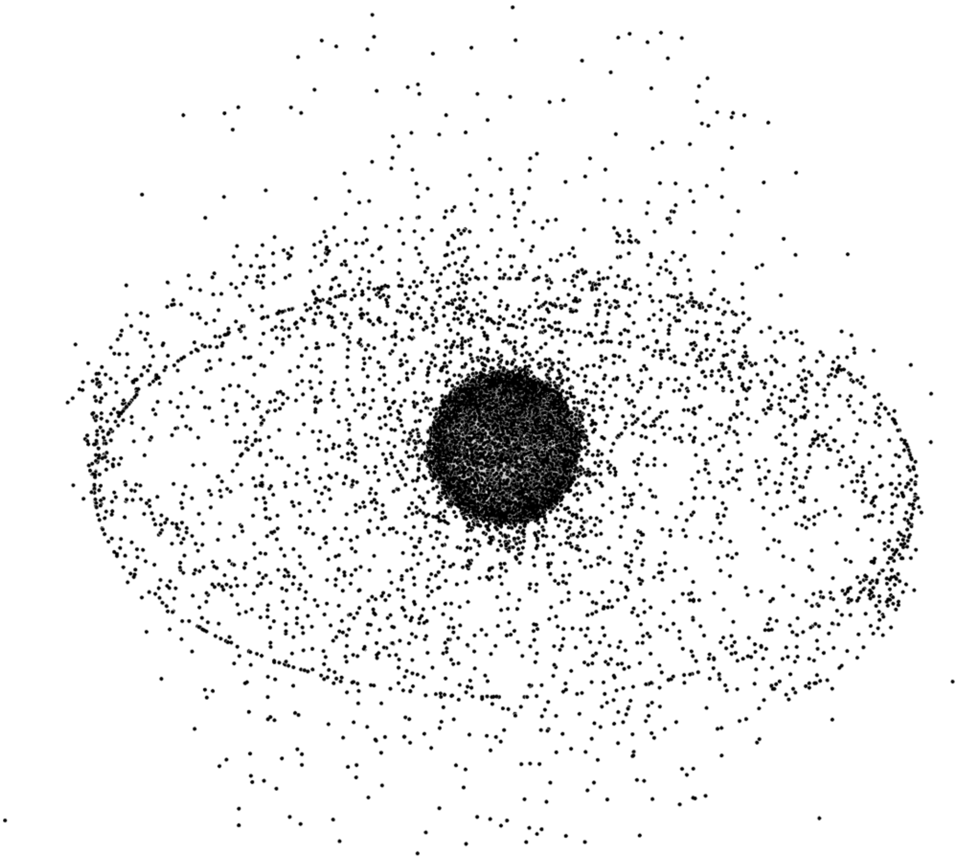
While not a pollution impact as such, like carbon and plastic, the relentless upward trend in biodiversity loss is another well documented and disappointing instance of human impact on space.

2.2.4. Outer Space Debris

Interestingly, even our valiant ambitions for outer space development, with global successes and failures, have continuously contributed to the pollution of our outer space environment, leaving a trail of debris behind that now pose serious risks to all missions.

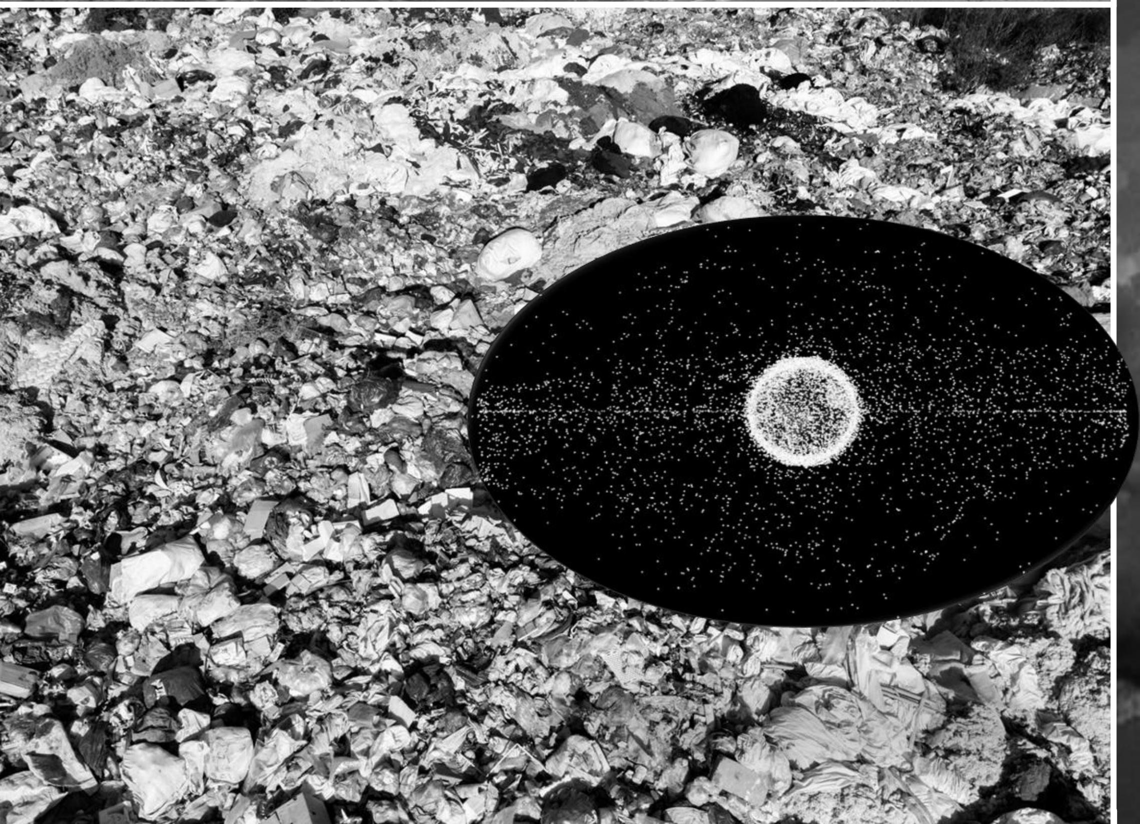
Currently, an estimated 36,500 space debris greater than 10 cm, and 130 million space debris from 1 mm to 1 cm are in orbit (ESA 2023). NASA estimates that the total exceeds 9000 metric tonnes (NASA 2023).

Fig. 6 Outer Space Debris - High Earth Orbit
(*Source: Adapted from NASA 2009*)



HUMAN PRODUCTIVITY IS EVIDENTLY OBLIVIOUS TO ITS SPACE IMPACT AND UNCONCERNED WITH HOW IT AFFECTS THE MANY LAYERS OF SPACE IT TOUCHES, AND HOW IT ENDANGERS ITS VERY OWN EVOLUTION AND CONTINUITY.

This section discussed a select number of human impacts on the wider context of space, our physical context of matter stretching from subatomic to interstellar space and every layer in between and beyond, where outer space is but a segment. Naturally, other examples affecting other space layers can also be presented. Human productivity is evidently oblivious to and unconcerned with how it affects the many layers of space it touches, and how it endangers its very own evolution and continuity.



Littering Every Space Layer We Touch

3. Spaceless Financial Value Framework & Mathematics

In this white paper, and recently published books (Papazian 2023, 2022), I argue that this neglect and disrespect of space, where outer space is but a segment, is born out of a conceptual and theoretical omission in our financial value framework. Our financial value framework ignores space, as analytical dimension and our physical context stretching from subatomic to interstellar space and every layer in between and beyond.

Our financial value framework, in academia and industry, in theory and practice, is built entirely on Risk and Time, *without* Space, and it is designed to serve the mortal risk-averse return-maximising investor. Planet and humanity are immaterial and absent from our equations. This focus on risk and time is explained and mirrored by the two key principles of value that define the theory, practice, research, and education of finance.

Our financial value framework, in academia and industry, in theory and practice, is built entirely on Risk and Time, without Space, and it is designed to serve the mortal risk-averse return-maximising investor.

3.1. The Risk and Time Value of Money

The two key principles of value that define the analytical framework in the finance discipline and industry are: 1) Risk and Return, and 2) Time Value of Money (See Table 2). These principles are rationally designed to serve the mortal risk-averse return-maximising investor, not Earth and not the human collective.

Table 2 The Core Principles of Finance Theory and Practice*
(Source: Papazian 2023)

Stakeholder	*Risk*	*Time*
Mortal Risk-Averse Return-maximising Investor	***Risk and Return***: The higher the risk the higher the expected return— given the risk-averse nature of investors, higher risks imply higher expectations of reward.	***Time Value of Money***: A dollar ($1) today is worth more than a dollar ($1) tomorrow— because a dollar today can earn interest/return by tomorrow and be more than a dollar by tomorrow.

I describe the risk averse investor as 'mortal' given that risk and time are very mortal concerns. "An immortal investor would be far less concerned with time and/or risk. This is important to note because from the perspective of the human collective, which can procreate and secure its continuous existence, evolutionary continuity in space would most likely take precedence to individual risk and time concerns." (Papazian 2023, 13)

> In truth, these principles of value discriminate against our evolutionary investments. The biases these principles introduce are revealed through a basic profiling of the risk and time features of our evolutionary challenges/investments – the Net Zero transition is one such challenge, but it is not the only one. All our evolutionary challenges require investments in the present that carry *very high risks* and *distant returns* - features that are

> negatively priced based on the current principles of value that underpin the equations we use and teach in the field.
>
> The current principles of value in finance theory leave our evolutionary investments in a blind spot. By negatively pricing distant returns and high risks, our financial value framework misprices our evolutionary investments. In fact, today, our evolutionary investments become plausible and 'affordable' only when they can be made to make sense within the preference framework of the mortal risk-averse return-maximising investor. A theoretical and practical misconception that could well explain our current predicament. (Papazian 2023, 14)

Outer space development and exploration is an evolutionary challenge (Papazian 2022) that involves very high risks and very distant returns – features that are negatively priced thanks to the core principles of finance. As such, we should not be surprised with the figures presented at the very beginning of this paper. When our core principles of finance discriminate against our evolutionary investments, allocating resources to a highly risky and long horizon vision and/or plan is an institutional, theoretical, and mathematical challenge for finance theory and practice.

The above challenges presented by our core principles of value in finance are critical but only one part of the theoretical fog that has led to the destruction of our ecosystem, as well as the neglect of space, outer space, and our key evolutionary investments.

THE CURRENT PRINCIPLES OF VALUE IN FINANCE THEORY LEAVE OUR EVOLUTIONARY INVESTMENTS IN A BLIND SPOT. BY NEGATIVELY PRICING DISTANT RETURNS AND HIGH RISKS, OUR FINANCIAL VALUE FRAMEWORK MISPRICES OUR EVOLUTIONARY INVESTMENTS.

3.2. Equations without Space

A spaceless financial value framework has led to a space-blind financial mathematics. Our equations of value and return are built entirely around risk and time, without any context parameters. Through the abstraction of space as an analytical dimension and our physical context, finance has also abstracted our responsibility for space impact. Interestingly, space impact is one key component abundantly present in outer space development projects.

In Table 3 you can find a sample of bond, stock, asset, firm, option, and cash flow valuation equations.[3] The equations reveal a financial mathematics without *any* contextual parameters, without space, or outer space. From subatomic to interstellar space, our financial value framework ignores our context, and serves the mortal risk-averse return-maximising investor in a risktime universe (See Papazian, 2023, 2022 for a detailed discussion).

By omitting the analytical dimension of space, our physical context, our financial value framework and mathematics also ignore our responsibility for space impact. Space impact is not considered relevant to the value and return equations in finance. Given that the principles they are built on negatively price distant cash flows and very high risks, outer space development and exploration projects, abundantly endowed with space impact, face

[3] The risk and time focus of the finance discipline is also revealed through the vast literature on stock market predictability, market efficiency, random walks, and overreaction (Papazian, 2022; See also Fama, 1970; Fama and French, 1992, 1993, Malkiel, 1973, De Bondt and Thaler, 1984; Dissanaike, 1994,1997, Harvey et al., 2016; Xi et al., 2022; and others)

structural discrimination. Considering the levels of risk involved and the actual time horizons involved in outer space development and exploration projects, we can see how prohibitive our current financial framework and mathematics are. This also explains why billionaires are the main private players in our current private outer space economy. But even the billionaire funded endeavours must make and keep themselves relevant to the risk and time framework to survive, even if through adjacent projects, companies, and cash flows.

Table 3 Sample Finance Equations: Bonds, Firms, Stocks, Assets, Options
(*Source: Adapted from Papazian 2023*)

Sample Bond Valuation Equations
$$Bond\ Price = \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} + \frac{P}{(1+r)^n}$$ $$Bond\ Price = \sum_{t=1}^{n\times m} \frac{CF_t}{\left(1+\left(\frac{r}{m}\right)\right)^t} + \frac{P}{\left(1+\left(\frac{r}{m}\right)\right)^{n\times m}}$$ $$Bond\ Price = \left(\frac{C}{m}\right) \times \left(\frac{1-\left(\frac{1}{\left(1+\frac{r}{m}\right)^{n\times m}}\right)}{\left(\frac{r}{m}\right)}\right) + \frac{P}{\left(1+\frac{r}{m}\right)^{n\times m}}$$
Sample of Stock and Firm Valuation Equations
$$P_0 = \frac{D_1}{r-g}$$ $$P_0 = \sum_{t=1}^{n} \frac{D_t}{(1+WACC)^t} + \frac{P_n}{(1+WACC)^n}$$ $$P_0 = \sum_{t=1}^{n} \frac{D_t}{(1+WACC)^t} + \frac{D_{n+1}}{(WACC-g).(1+WACC)^n}$$ $$Firm\ Value = \sum_{t=1}^{n} \frac{FCFF_t}{(1+WACC)^t} + \frac{FCFF_{n+1}}{(WACC-g).(1+WACC)^n}$$
Sample of Asset Pricing Models
$$R_i = R_f + \beta_i \times (R_m - R_f)$$ $$Beta_i = \beta_i = \frac{Covariance_{R_i,R_m}}{Variance_{R_m}}$$ $$E(R_i) - R_f = b_1\left(E(R_M) - R_f\right) + s_i E(SMB) + h_i E(HML)$$

Modigliani Miller Corporate Value and Capital Structure Model

$$V_j = (S_j + D_j) = \frac{\overline{X}_j}{\rho_k}$$

$$i_j = \rho_k + (\rho_k - r)\frac{D_j}{S_j}$$

Black and Scholes Option Pricing Model

$$C = SN(d) - Le^{-rt}N(d - \sigma\sqrt{t})$$

$$d = \frac{\ln\frac{S}{L} + \left(r + \frac{\sigma^2}{2}\right)t}{\sigma\sqrt{t}}$$

Net Present Value & Cash Flow Valuation

$$NPV = \sum_{t=0}^{T}\frac{CF_t}{(1+r)^t} \qquad NPV = CF_0 + \sum_{t=1}^{T}\frac{CF_t}{(1+r)^t}$$

$$\boldsymbol{N}et\ Present\ Value = -II + \sum_{t=1}^{n}\frac{CF_t}{(1+r)^t}$$

See Brealey, Myers, and Allen (2020), Pike, Neale, Akbar, and Linsley (2018), Watson and Head (2016), Williams (1938), Fama and French (1996, 2004, 2015), Gordon (1959), Gordon and Gordon (1997), Gordon and Shapiro (1956), Markowitz, (1952), Modigliani and Miller (1958), Ross (1976), Roll and Ross (1980), Sharpe (1964), Lintner (1965), Merton, (1973), Black and Scholes (1973), Nobel Prize (1997), Koller et al. (2015, 2011), Choudhry (2012, 2018), Damodaran (2012, 2017), Yescombe (2014), Rosenbaum and Pearl (2013), Isaac and O'Leary (2013) and others. See Papazian (2023, 2022) for a detailed discussion of the above, and the absence of space and space impact.

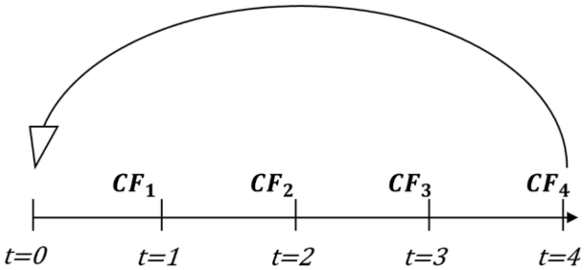
Unfortunately, besides the biases introduced through the value principles of finance, and besides the abstraction of space altogether, and the omission of space impact from our equations, our core value models suffer from yet another bias.

3.3. Discounting the Imaginary, Abstracting the Actual

Built around risk and time, serving the mortal risk-averse return-maximising investor, with inbuilt biases against our evolutionary investments, and an entire dimension of context missing, i.e., space and outer space, our financial value framework and equations do not equip the species with tools through which it can value its own evolutionary investments in space. Our entire framework today misprices our evolutionary investments, like outer space development, exploration, and settlement.

As mentioned above, however, there is more to this story. Our financial mathematics, through our models and equations, reveals yet another key bias. Taking as an example the Net Present Value (NPV) equation, which epitomises a risktime conceptualisation of value in finance, we observe, as in Fig. 7 and Eq. 1, that the mathematical focus is on the non-actual future expected cash flows rather than the actual space impact of investments – which are treated only with a '-' sign to denote an outflow for the investor (Papazian 2023, 2022).[4]

Fig. 7 Discounting Future Expected Cash Flow Timeline[5]
(*Source: Author*)



$$Net\ Present\ Value = -\ II + \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} \quad (1)$$

$n = Time\ Horizon$
$t = Moving\ time$
$r = Discount\ Rate$
$II = Initial\ Investment$
$CF_t = Future\ Expected\ Cash\ Flows$

Actual *Non-Actual*

[4] The Net Present Value equation (NPV) is one of the most commonly used equations. Indeed, Graham and Harvey (2002) reveal that Net Present Value (NPV) is one of the most frequently used capital budgeting techniques by CFOs, along with the internal rate of return (IRR), which is the discount rate that equalizes NPV to zero.

[5] The NPV equation is sometimes written in the below formats, where the first cashflow CF_0 (II) is included in the right-side term as the first cash flow at t=0, or excluded but without the negative sign as the negative sign of the first cash flow CF_0 is assumed:

$$NPV = \sum_{t=0}^{T} \frac{CF_t}{(1+r)^t} \qquad NPV = CF_0 + \sum_{t=1}^{T} \frac{CF_t}{(1+r)^t}$$

The above NPV equation discounts future expected cash flows into the present using a discount rate - a proxy for the risk levels involved in the opportunity - and subtracts the initial investment from the Present Value of the future cash flows. It has two parts, an actual part, the initial investment, and a non-actual part, the future expected cash flows. "Future expected cash flows are non-actual or imaginary because they have not happened yet. They may happen as expected or agreed, or they may not. If these cash flows were guaranteed, there would be no need to discount them into the present to account for their riskiness over time. Naturally, applying a discount rate to the future expected cash flows does not make the cash flows any less non-actual, or more real" (Papazian 2023, 20).

> The omission of space happens when we ascribe an abstract negative sign to the initial investment, disregarding it entirely as a real process with a space impact. Indeed, the assessment of impact can be achieved by digging deeper into the many aspects of the investment and its deployment. In other words, the omission of space and space impact occurs when our treatment of the initial investment is defined and limited to ascribing a negative sign to denote an outflow for the risk-averse investor without further analysis or consideration of its utilisation and impact on the environment, on society, on space. (Papazian 2022, 24)

When the mathematical attention of our models is focused on the future non-actual expected cash flows and their actual space impact is abstracted away, we cannot be surprised with the state of the world. Moreover, we cannot and should not be surprised with the levels of funding allocated to outer space development and exploration – they require massive investments in the present, involve immense risks, promise only very distant cash flows, and much of their value is in their space impact.

It is very hard to see how humanity can invest in outer space and allocate the necessary amounts to achieve a lunar habitat, a Mars habitat, and so on, with a financial value framework and mathematics built in risktime, with principles that discriminate against our evolutionary investments, and equations that are more concerned with the non-actual future expected cash flows than their actual space impact.

IT IS VERY HARD TO SEE HOW HUMANITY CAN INVEST IN OUTER SPACE AND ALLOCATE THE NECESSARY AMOUNTS TO ACHIEVE A LUNAR HABITAT, A MARS HABITAT, AND SO ON, WITH A FINANCIAL VALUE FRAMEWORK AND MATHEMATICS BUILT IN RISKTIME, WITH PRINCIPLES THAT DISCRIMINATE AGAINST OUR EVOLUTIONARY INVESTMENTS, AND EQUATIONS THAT ARE MORE CONCERNED WITH THE NON-ACTUAL FUTURE EXPECTED CASH FLOWS THAN THEIR ACTUAL SPACE IMPACT.

4. Spaceless Monetary Architecture

Given a space-blind financial value framework and mathematics, and all the key structural challenges discussed in the previous section, our discussion must now address our monetary architecture. It is common knowledge that our current monetary system is debt-based, i.e., money in currency, deposit, and central bank reserve form is created through debt transactions and instruments.

4.1. Debt-based Money

McLeay et al. (2014a) describe the debt-based monetary system in an article published in the Bank of England Quarterly Bulletin as follows:

> There are three main types of money: currency, bank deposits and central bank reserves. Each represents an IOU from one sector of the economy to another. Most money in the modern economy is in the form of bank deposits, which are created by commercial banks themselves (McLeay et al. 2014a, 4).

Table 4 gives examples of instruments, portfolios, and transactional engagements used for debt-based money creation within our current system by central and commercial banks. Fig. 8 depicts the debt/loan-based money creation process between central banks, commercial banks, and consumers. Chart 1 depicts the Asset side of the Federal Reserve balance sheet denoting key QE/CE periods of money creation based on debt instrument purchases by the Fed.

Table 4 Commercial & Central Bank Sample Debt Instruments, Portfolios, and Transactions (*Source: Papazian, 2023*)

	Commercial Banks	Central Banks
Instruments	Consumer Credit Business Credit Residential Mortgages Commercial Mortgages	Discount Loans (FED) TLTRO Loans (ECB) Subsidiary Loans (BOE)
Portfolios	Loan Portfolios Mortgage Portfolios	Government Bond Portfolios Corporate Bond Portfolios MBS and CDO Portfolios Commercial Paper (FED)
Transactional Engagements	Loan Approvals Mortgage Approvals	Currency Issuance Reserve Issuance - Quantitative Easing - Credit Easing

Fig. 8 Debt-based Money Creation Process
(Source: Adapted from McLeay et al. 2014b)

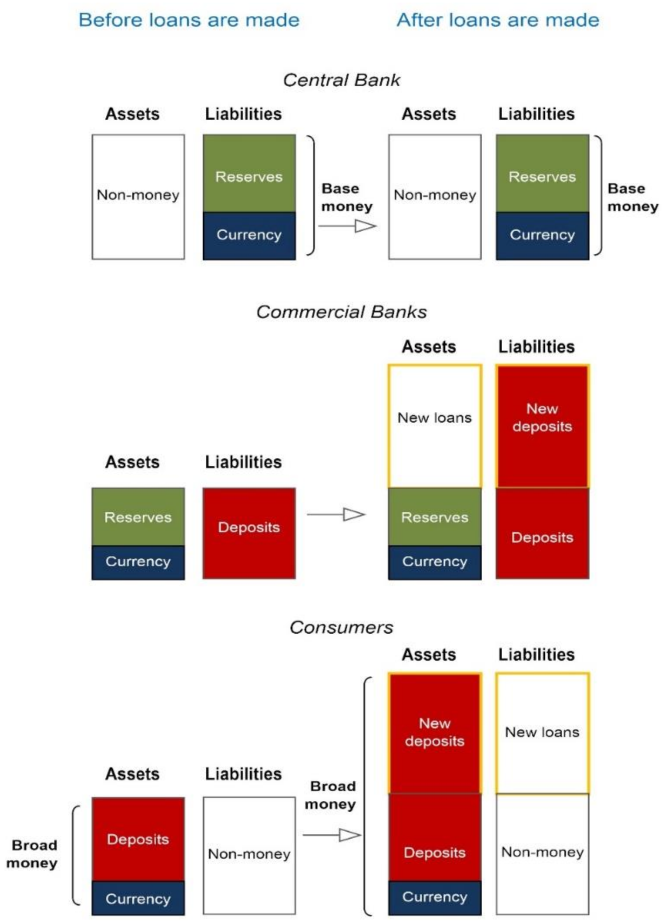
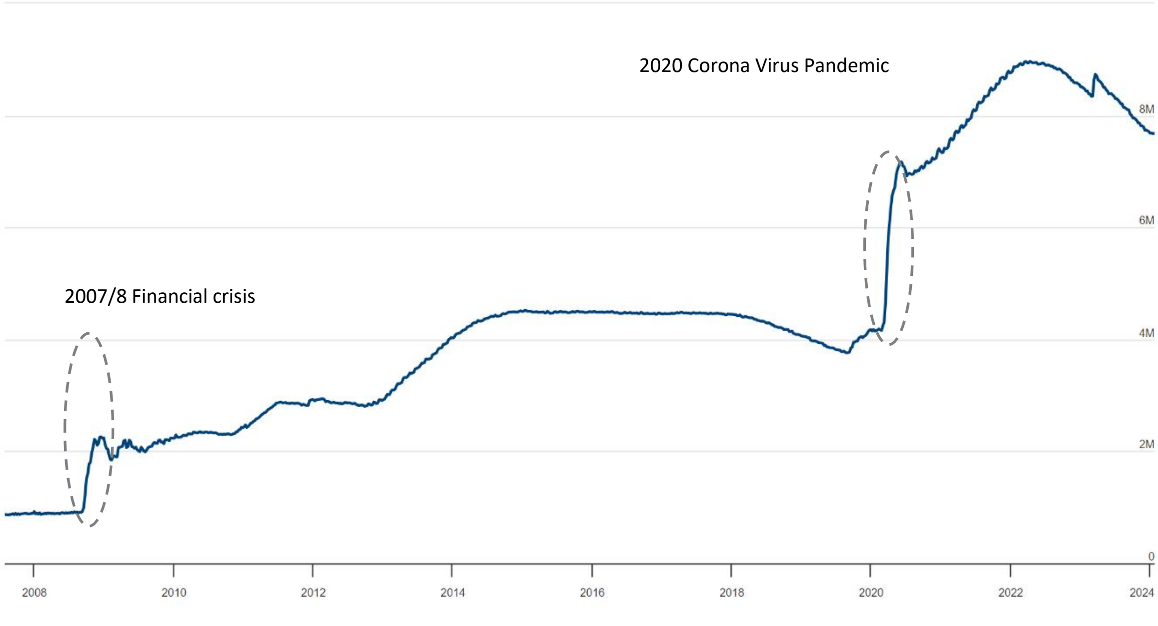


Chart 1 Federal Reserve Balance Sheet, Assets in $ Millions
(*Source: FED 2024*)



4.2. Muzzle, Leash, and Whip in Space

There are a number of fundamental systemic challenges with a spaceless debt-based monetary architecture where money creation is built on instruments designed and valued in a risktime universe without space, without outer space. Specifically, I have addressed three architectural shortcomings that have directly and indirectly defined our impact on space in general, and our inability to invest in outer space specifically. They are:

a) Calendar time
b) Monetary gravity
c) Monetary hunger

I discuss and summarise these challenges next.

4.2.1. Calendar Time: A Muzzle in Space

> Debt, which involves time obligations in terms of scheduled interest and principal repayments, chains everybody involved to calendar time payments. Indeed, whatever the actual shape of the repayment schedule involved, our debt-based money creation methodology chains our entire productive and creative potential to calendar time. (Papazian 2022, 214)

Money creation through instruments based on and linked to calendar time creates serious constraints. A calendar time-based conceptualisation of money creation chains governments, government agencies, municipalities, small businesses, households, individuals, corporations, and even banks to calendar time payments.

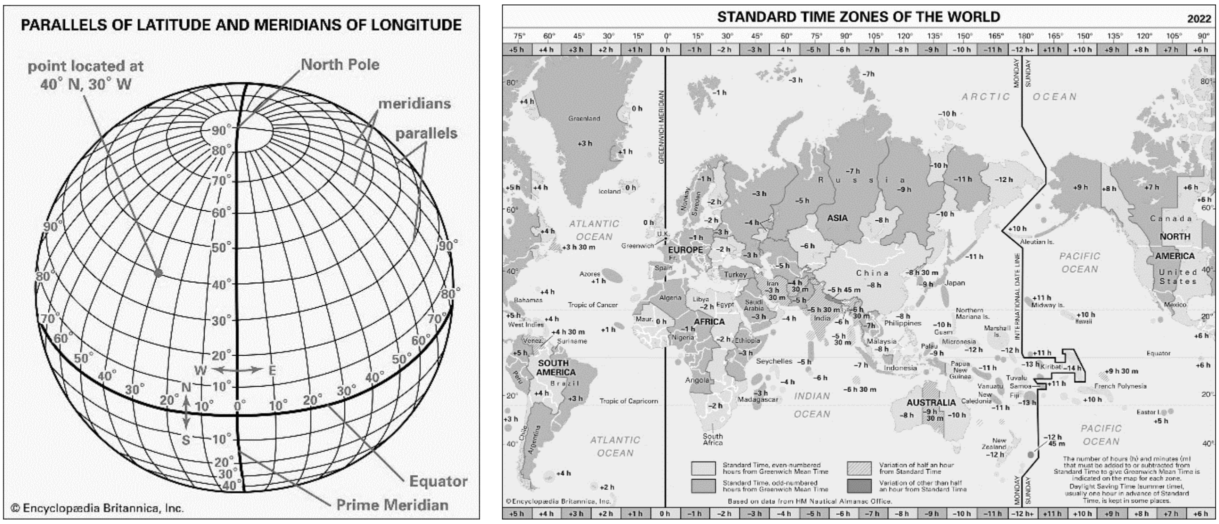
Note that I am using the term 'calendar time', and not time. The nature of time is a debateable subject (Rovelli 2006; Smolin 2006; Greene 2004) and economists have also considered the importance of psychological time to the performance of investments (Blanqué, 2021). What lies at the heart of our monetary system and what is used and applied by banks and central banks in debt transactions is simply calendar time.

Calendar time is a human invention that allows us to structure and navigate our productive life on the planet and it is a central pillar of the world economy. The conceptual mapping of space and time on Earth makes use of the Prime Meridian, at 0° longitude (See Fig. 9).

> The Prime Meridian is the line and the point at which the world's longitude is set at 0°. It does not exist in any strict material sense, yet through maps and clocks, the prime meridian governs the life of every human on Earth. (Withers 2017, 5)

Without negating the structural and civilisational benefits of this imaginary point and line in space, it is critical to observe that linking our entire money creation architecture to calendar time, an artificial social construct, leads to serious impediments due to the fixed paced nature of calendar time.

Fig. 9 Prime Meridian and Standard Time Zones
(*Source: Britannica 2023a, 2023b*)



Put simply, when we link money creation to calendar time, we limit our ability to invest in space timelessly. In other words, the entire grid depicted in Fig. 9, starting from the Prime Meridian, which also defines our time zones and how we are progressing in calendar time, acts like a muzzle. Our entire monetary architecture is linked to Earth's speed and rotation on itself and around the sun.

The calendar time-based conceptualisation of money chains our productive horizon and limits our reach to the steady turn of the planet on itself.

Our ability to reach far beyond Earth in terms of distance/time and create life and habitats outside of this grid becomes a struggle.

> WHEN WE LINK MONEY CREATION TO CALENDAR TIME, WE SIMPLY LIMIT OUR ABILITY TO INVEST IN SPACE TIMELESSLY.

4.2.2. Monetary Gravity: A Leash in Space

The next challenge with debt-based money is what I call *monetary gravity*. It is directly linked to the use of calendar time as a foundational element of money creation instruments, but it goes one step further. All debt instruments used by central and commercial banks require the repayment of principal and interest to the original source, the creator of money. This obligation to repay is defined by calendar time intervals. In truth, though taken for granted in our current system, this backward loop to the creator of money acts as a unique type of artificially created force that I call monetary gravity (Papazian 2022, 216).

Debt-based money limits the distance in space/outer space an investment can go before it must return to pay back principal and interest to some bank. This is also true when payments are done electronically, as the instrument imposes the necessity to earn/make the payment within the calendar time window. Even when debts can be rolled over, or refinanced, the structural features of debt-based money impose a limit on how far in space a process can go before having to consider its obligation to some bank.

Using the below conceptual equation, and assuming uniform terrestrial conditions for simplicity and the purpose of the argument, we can calculate the limit on distance travelled imposed by a debt instrument requiring a monthly interest payment. Tablet 5 provides the limits on distances given the speed of Usain Bolt, the SSC Tuatara, the Parker Probe (NASA 2018), and light.

DEBT-BASED MONEY LIMITS THE DISTANCE IN SPACE/OUTER SPACE AN INVESTMENT CAN GO BEFORE IT MUST RETURN TO PAY BACK PRINCIPAL AND INTEREST TO SOME BANK.

$$Maximum\ Distance_{Light} = Speed\ in\ \frac{m}{s} \times Time\ Interval\ in\ s$$

Table 5 Distance Travelled in a Month in Meters
(Source: Author, from Papazian, 2022)

	Usain Bolt	SSC Tuatara	Parker Solar Probe	Light
Distance (m)	27,060,480	366,158,880	177,811,397,406.72	777,062,051,136,000

Calculation details: the distance light can travel in one month, also known as a light-month, is the distance that light travels in an absolute vacuum in one full month. The speed of light is equal to 299,792,458 m/s, assuming 30 days in a month, and 86,400 seconds in each, in one month light travels 777,062,051,136,000 metres, which is equivalent to approximately 777 Tm (1 Terameter = 1,000,000,000,000 meters). Usain Bolt, the Jamaican sprinter, set the world record in 2009 in the 100 meter sprint at 9.58 seconds, giving him a speed of 10.44 meters per second, which means the furthest Bolt can run in one month is 27,060,480 meters. The fastest production car, the SSC Tuatara, is reported to have a speed of 316 miles per hour, or 141.265 meters per second, the furthest SSC Tuatara can travel in a month is 366,158,880 meters. The Parker Solar Probe (NASA, 2018) achieved speeds of 153,454 miles per hour or 68,600.076 meter per second, the furthest it can travel within a month is 177,811,397,406.72 meters (Papazian 2023, 121).

These hypothetical limits and examples demonstrate that we and our fastest tools and inventions, and light itself, will experience a limit on distance travelled given an interval of calendar time.

> Debt-based money acts as a leash on our species, chaining us to a self-created calendar, to a self-created system that ultimately chains us to the surface of the planet. Given that calendar time is a human concept, artificially created to manage human activities, linking money creation to an artificially limited concept such as a month or a year, artificially limits the distance we can travel before we need to return to the bank. (Papazian 2022, 218)

DEBT-BASED MONEY ACTS AS A LEASH ON OUR SPECIES, CHAINING US TO A SELF-CREATED CALENDAR, TO A SELF-CREATED SYSTEM THAT ULTIMATELY CHAINS US TO THE SURFACE OF THE PLANET.

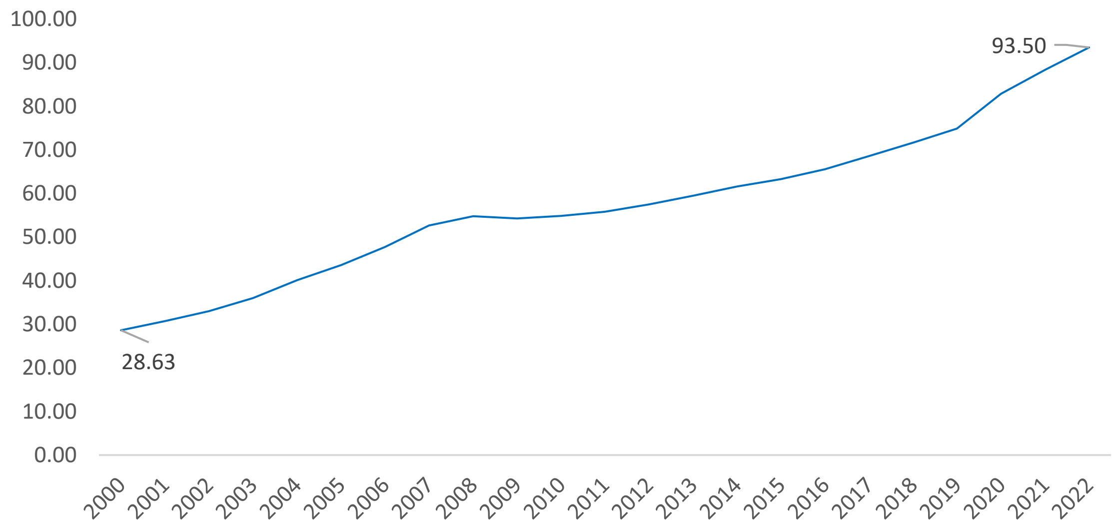
4.2.3. *Monetary Hunger: A Whip in Space*

Last but not least, the third challenge with debt-based money is what I call *monetary hunger*.

> In any debt-based economy, and at any point in time, irrespective of past or current capital accumulation, a large segment of society, including households, municipalities, governments, corporations, and banks, is chasing available cash and deposits to pay calendar time-linked debt obligations. Debt-based money creates this chase, this monetary hunger, in any debt-based economy irrespective of the actual levels of debt to GDP ratios. This is so given that money is continuously created via debt. (Papazian 2023, 122)

As a numerical example, Chart 2 depicts total outstanding public and private debt in the United Stated, between 2000 and 2022, growing from 28.63 to 93.50 trillion US Dollars.

Chart 2 Total Outstanding Public and Private Debt USA, 2000-2022 in trillion U.S. Dollars (*Source: Statista, 2023d*)



Naturally, debt is a fundamental driver of money supply in our current architecture, on commercial and central bank levels, and it is a significant driver of growth, and inflation. However, the monetary hunger it artificially creates in the system also explains personal, business and investment practices. This is so given the fact that the threat of default and loss of ratings and assets are existential threats for governments, corporates, businesses, and households, and avoiding them is naturally a priority.

To put it mildly, given the threat of default and the absence of space and space responsibility from our financial value framework, everyone will serve their debts before the environment or space (outer space included). In fact, this artificially created monetary hunger acts as a whip that triggers and sustains the debt-based system without any consideration for space impact.

Indeed, because our debt-based monetary architecture has been given primacy over our ecosystem, and space in general, including outer space, space agency budgets, which are linked to government debts, cannot break out of the risktime framework, and the private space economy needs to find markets for its inventions, before it can achieve any sustainable long-term breakthrough in actual outer space.

IN ANY DEBT-BASED ECONOMY, AND AT ANY POINT IN TIME, IRRESPECTIVE OF PAST OR CURRENT CAPITAL ACCUMULATION, A LARGE SEGMENT OF SOCIETY, INCLUDING HOUSEHOLDS, MUNICIPALITIES, GOVERNMENTS, CORPORATIONS, AND BANKS, IS CHASING AVAILABLE CASH AND DEPOSITS TO PAY CALENDAR TIME-LINKED DEBT OBLIGATIONS. DEBT-BASED MONEY CREATES THIS CHASE, THIS MONETARY HUNGER

This is why a good proportion of the currently growing private space economy is Earth-bound in terms of the services it provides and sells.

Before presenting and discussing the necessary transformations to enable sustainable outer space development and exploration, it is important to briefly discuss the relatively recent phenomenon of cryptocurrencies, or cryptoassets. This is to clarify that the absence of space is not addressed through crypto, and there is no sustainable potential for outer space development through crypto.

4.3. Cryptocurrencies

We must briefly discuss cryptocurrencies[6] given the popular misconception that they are an alternative to debt-based fiat money. The below discussion aims to show that not only cryptocurrencies are not actual currencies, they have their own set of issues, and their logic of creation does not address the absence of space, and thus outer space.

As of the 3rd of February 2024, there were 8843 cryptocurrencies listed on coinmarketcap.com (CoinMarketCap 2024). Bitcoin is the first on the list and I use it as an example. Before addressing some of the salient issues, it is important to refer to their labelling as currency. The Bank of England refers to them as cryptoassets:

> Put it this way, you wouldn't use cryptocurrency to pay for your food shop. In the UK, no major high street shop accepts cryptocurrency as payment. It's generally slower and more expensive to pay with cryptocurrency than a recognised currency like sterling. Development is underway to make cryptocurrency easier to use, but for now it isn't very 'money-like'. This is why central banks now refer to them as "cryptoassets" instead of "cryptocurrencies". Today cryptocurrencies are generally held as investments by people who expect their value to rise (Bank of England 2020).

Another main challenge with crypto is what Prasad (2021) addresses referring to the 'greater fool' theory. He writes: "The valuations of meme currencies seem to be based entirely on the "greater fool" theory—all you need to do to profit from your investment is to find an even greater fool willing to pay a higher price than you paid for the digital coins." A parallel

[6] Cryptocurrencies should not be confused with Central Bank Digital Currencies (CBDC) which are now being considered by the Bank of England and other central banks (Bank of England, 2023a).

approach is that the attractiveness of Bitcoin and other cryptocurrencies is in their lack of transparency, as 'dark money' (Economist 2022).

In parallel, besides the e-waste of Bitcoin, estimated at 30.7 metric kilotons per annum as of May 2021 (De Vries and Stoll 2021), the Cambridge Bitcoin Energy Consumption Index (CBECI) estimates that the yearly average annualised electricity consumption of the Bitcoin Network is around 118.3 TWh per year, higher than the yearly consumption of the Netherlands at 113.3 TWh per year (CCAF 2023).[7]

While the above are important points to consider, the main issue lies in the very logic of their creation. Bitcoins are created after a mining process through powerful computers performing specific mining operations which consist in solving complex mathematical puzzles.

> Anybody can become a Bitcoin miner by running software with specialized hardware. Mining software listens for transactions broadcast through the peer-to-peer network and performs appropriate tasks to process and confirm these transactions. Bitcoin miners perform this work because they can earn transaction fees paid by users for faster transaction processing, and newly created bitcoins issued into existence according to a fixed formula.
>
> For new transactions to be confirmed, they need to be included in a block along with a mathematical proof of work. **Such proofs are very hard to generate because there is no way to create them other than by trying billions of calculations per second**. This requires miners to perform these calculations before their blocks are accepted by the network and before they are rewarded. As more people start to mine, the difficulty of finding valid blocks is automatically increased by the network to ensure that the average time to find a block remains equal to 10 minutes. As a result, mining is a very competitive business where no individual miner can control what is included in the block chain (Bitcoin 2023a,b).[8]

In other words, while fiat money, i.e., central bank and commercial bank money, is created via debt instruments and transactions, Bitcoins are created/awarded through a process that involves and is dependent on '*trying billions of calculations per second*'.

To put it mildly, moving from a debt logic to mathematical guesswork is hardly the type of transformation we need to support our expansion into outer space.

[7] For a relative understanding of the numbers, note that the two highest consuming countries, China and USA, use respectively 7,805.66 TWh and 3,979.28 TWh per year (CCAF, 2023).
[8] Emphasis added.

5. Introducing Space

5.1. Introducing Space into Finance

The previous sections revealed that space, and thus outer space, have been entirely absent from our financial value framework and the resulting debt-based monetary architecture. Our financial mathematics is missing the dimension of space, and our money creation methodology is designed in and serves a risktime universe with severe consequences on our ability to invest in our evolutionary challenges, irrespective of risk and time.

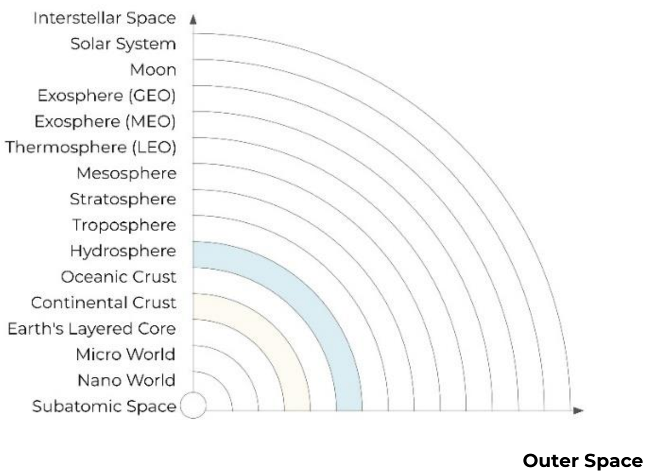
This section introduces the dimension of space into finance, and then goes on to introduce the missing principle of value, *the space value of money*, which allows and facilitates a space-adjusted financial mathematics. Naturally, this is only a high-level summary of the concepts and equations, and a detailed analysis can be found in Papazian (2023, 2022).

In fact, any civilisation or species in space that uses money and monetary incentives to drive and guide its own creativity and productivity needs to integrate the dimension of space, a commensurate principle, and ensuing equations into its financial value framework and monetary architecture to be able to respect, value, and explore space and its many layers.

5.1.1. Space

As defined at the beginning of this paper, space is our physical context of matter that stretches from subatomic to interstellar space and every layer in between and beyond. Fig. 10 is identical to Fig.1 and depicts a layered conceptualisation of our physical context.

Fig. 10 Space Layers and Outer Space
(Source: Adapted from Papazian 2023, 2022)



SPACE IS DEFINED AS OUR PHYSICAL CONTEXT OF MATTER STRETCHING FROM SUBATOMIC TO INTERSTELLAR SPACE AND EVERY LAYER IN BETWEEN AND BEYOND, WHERE 'OUTER SPACE' IS BUT A SEGMENT.

Once we conceptualise the analytical dimension of space, of our physical context, introducing it into our financial value framework requires a new principle, the 'Space Value of Money', which defines our relationship with space, just like the 'Risk and Return' and 'Time Value of Money' principles define our relationship with risk and time.

5.1.2. The Space Value of Money

I have proposed the introduction of a third principle into core finance theory and practice, the space value of money.

> The space value of money principle complements time value of money and risk and return. It establishes our spatial responsibility and requires that a dollar ($1) invested in space has at the very least a dollar's ($1) worth of positive impact on space. (Papazian 2022, 104)

The space value of money is a necessary first step to trigger the necessary transformations in our value framework. The core function of the principle is to establish and entrench our responsibility for space impact, and to establish the bottom threshold of investment acceptability.

By requiring that a dollar invested in space has at the very least a dollar's worth of positive impact on space, taking into account all layers of space including outer space, the principle introduces respect for space into our monetary and financial system. By doing so it achieves not just sustainability in our productive capacity, as it conditions capital allocation and money creation by a positive space impact principle, but also provides the foundations upon which space impact is valued and integrated into our models.

This allows the consideration of space impact and value in an otherwise risk and time dominated framework, where our principles discriminate against our evolutionary investments with distant cash flows and very high risks.

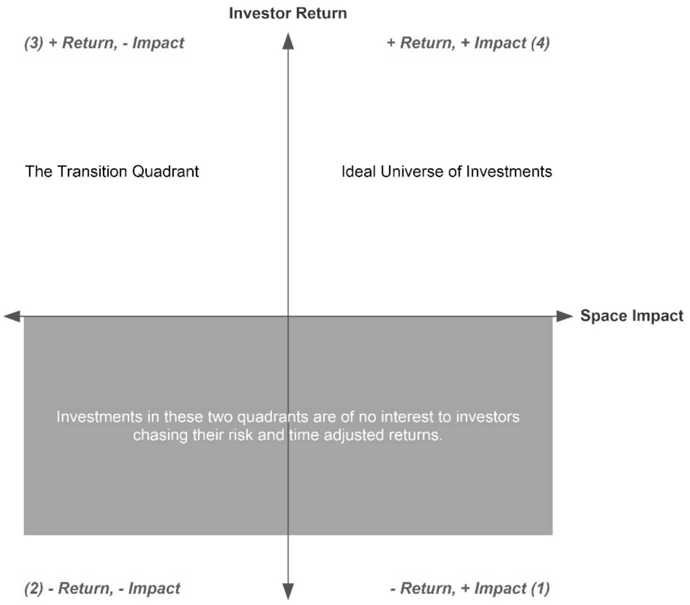
The principle, as depicted in Fig. 11 and Fig. 12 - The TRIM, the Transition Return Impact Map, allows the reallocation of capital to investments that have a positive space impact, while allowing the integration of such impact into the value equations of finance.

This is necessary because our current value framework and equations in finance do not prevent investors from investing in opportunities that have a negative space impact, in the top left quadrant in Fig. 11 (Quadrant 3), where returns are positive, but impact is negative. Given our current framework and equations in finance, the bottom two quadrants in Fig. 11 (Quadrants 1 and 2) are unattractive because expected returns are negative.[9]

> SPACE VALUE OF MONEY: A DOLLAR ($1) INVESTED IN SPACE MUST AT THE VERY LEAST HAVE A DOLLAR'S ($1) WORTH OF POSITIVE IMPACT ON SPACE.

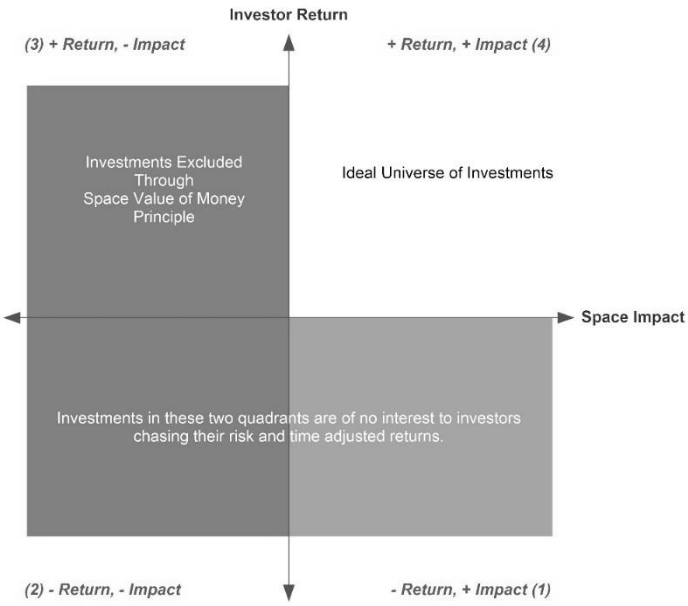
[9] Note that actual returns could be negative post investment, and this is referring to expected and required returns. Also, some public investors may initiate investments in the bottom two quadrants for a variety of reasons, amongst them is the provision of public goods, paid through tax revenue.

Fig. 11 The TRIM: Transition Return Impact Map
(Source: Papazian 2023)



The space value of money principle allows us to prevent new investments that have a negative impact on space. In other words, it integrates respect for space into our financial and monetary framework.

Fig. 12 The TRIM with Space Value of Money
(Source: Papazian 2023)



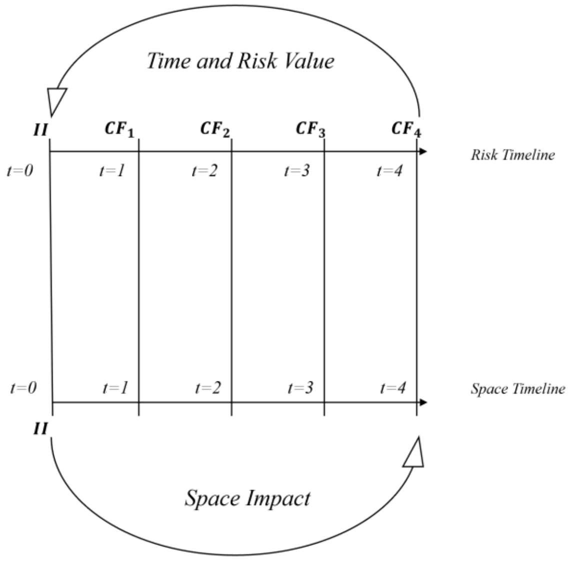
Simultaneously, through the integration of the dimension of space and space impact into our core equations, the principle allows a change in the way we value investments. Risk and Time are no longer the only pillars, and we can correct the mispricing of our evolutionary challenges.

5.1.3. Space-adjusted Financial Mathematics

Once space, as analytical dimension, and our physical context, is introduced into our financial value framework, and our responsibility for space impact is established through the space value of money principle, we can begin to design the space-adjusted mathematics where our equations of value and return reflect the space impact of cash flows and investments.

The below described space value framework requires respect for space, integrates the value of space, and empowers the exploration of space, including outer space.

Fig. 13 The Double Timeline
(Source: Papazian 2023)



I have introduced the double timeline as a conceptual tool to help design and measure the space impact of cash flows in parallel to their time and risk value. At the most abstract level, this allows us to measure and compound the space impact of cash flows across all affected space layers.

The minimum space value condition, given the space value of money principle, is that a dollar invested in space has, at the very least, a dollar's worth of positive impact on space. I have introduced the concepts and equations of Gross Space Value and Net Space Value to measure the aggregate space impact of cash flows (Papazian 2023, 2022).

$$Gross\ Space\ Value_{T,S} = \mathrm{NSV} + II$$
$$NSV + II = GSV \mid NSV = 0 = Space\ Neutral \qquad (2)$$
$$\boldsymbol{GSV = II}$$

The Net Space Value is defined as the Planetary, Human, and Economic impact of the investment or cashflows:

$$\boldsymbol{NSV_{T\&S} = Net\ Space\ Value\ of\ Investment}$$
$$\boldsymbol{NSV_{T\&S} = \{Planetary,\ Human,\ and\ Economic\ Impact\}_{All\ S\ Layers\ \&\ T\ Periods}}$$

$$T = Total\ Number\ of\ Years\ of\ Investment\ being\ Considered$$

$$S = All\ Space\ layers\ Involved\ in\ the\ Investment$$

$$NSV_{T\&S} = \sum_{t=1}^{T}\sum_{s=1}^{S} Pollution\ \&\ Biodiversity\ Impact + \sum_{t=1}^{T}\sum_{s=1}^{S} Human\ Capital\ \&\ R\ and\ D\ Impact + \sum_{t=1}^{T}\sum_{s=1}^{S} New\ Asset\ \&\ New\ Money\ Impact \qquad (3)$$

Each of the above elements, i.e., planetary, human, and economic, are further defined as the pollution, biodiversity, human capital, R & D, new money and new asset impacts of the investment (See Table 6). I do not discuss the derivation and logic of each of the component equations in this paper, but you can find further details in Papazian (2023, 2022). However, a few important points are necessary to clarify the relevance of the Space Value framework.

Table 6 The Equations of Impact
(*Source: Papazian, 2022*)

Impact Aspect	*Net Space Value*	$\boldsymbol{g \times (PI_{T,S,P} + BI_{T,S,B} + HCI_{T,S} + RDI_{T,S,N} + NAI_{D,S,A} + NMI_T)}$	(4)
PLANETARY	*Pollution Impact*	$PI_{T,S,P} = \sum_{t=1}^{T}\sum_{s=1}^{S}\sum_{p=1}^{P} Q_{pst} \times C_{pst}$	(5)
	Biodiversity Impact	$BI_{T,S,B} = \sum_{t=1}^{T}\sum_{s=1}^{S}\sum_{b=1}^{B} A_{bst} \times R_{bst}$	(6)
HUMAN	*Human Capital Impact*	$HCI_{T,S} = f \times \sum_{t=1}^{T}\sum_{s=1}^{S} E_{st} + T_{st} + H_{st} + I_{st} + C_{st} + S_{st}$	(7)
	R and D Impact	$RDI_{T,S,N} = \sum_{t=1}^{T}\sum_{s=1}^{S}\sum_{n=1}^{N} h_n \times RD_{tsn}$	
ECONOMIC	*New Asset Impact*	$NAI_{D,S,A} = \sum_{s=1}^{S}\sum_{a=1}^{A} k_a \times BVA_{asD}$	(8)
	New Money Impact	$NMI_T = (II \times DR \times BLR) + mm \times (II + X_T - M_T)$	(9)
			(10)
Coefficients	*Fairness* *Health* *Transition* *Governance*	f h k g	

> The Space Value framework introduces the necessity and tools to assess the impact of cash flows across *all the layers of space* that the considered cashflows may be affecting. (Papazian 2022, 85)

This is a unique contribution of the framework and allows a detailed mapping of the space impact of cash flows depending on the value chains involved. The space value framework is not just about quantifying the space impact of cash flows, it is also about integrating them into our models and equations of value and return.

Once we have mapped and quantified the multilayered space impact of investments, we can then make sure that negative impacts are prevented and avoided. To do so, negative impacts must be made to affect the value of the cash flows and/or investment. Eq. 11 is one example of such an integration using the Net Present Value formula. The equation uses the absolute value of the negative space impacts and adds the negative external to the total for theoretical clarity.[10]

$$Negative\ Impact\ Adjusted\ NPV = -\left|NNSV_{T,S}\right| - II + \sum_{t=1}^{T} \frac{CF_t}{(1+r)^t} \tag{11}$$

$$NNSV_{T,S} = The\ Sum\ of\ Negative\ Impacts\ Across\ All\ Years\ and\ Space\ Layers$$

Similarly, when negative impacts are avoided, the value of the investment can be complemented with the Space Value of the cash flows, as in Equation 12, using the example of the firm value equation using free cash flow to firm over time.

$$Positive\ Impact\ Adjusted\ Firm\ Value\ = \frac{NSV_1}{WACC - J_p} + \sum_{t=1}^{T} \frac{FCFF_t}{(1+WACC)^t} + \frac{FCFF_{T+1}}{(WACC - g).(1+WACC)^T} \tag{12}$$

Naturally, these are high level examples to demonstrate that through the space value framework, we can do both, eliminate negative impacts and optimise positive impacts across all space layers affected. This brings us to the next conceptual contribution of the space value framework, the Space Growth Rate (SPR).

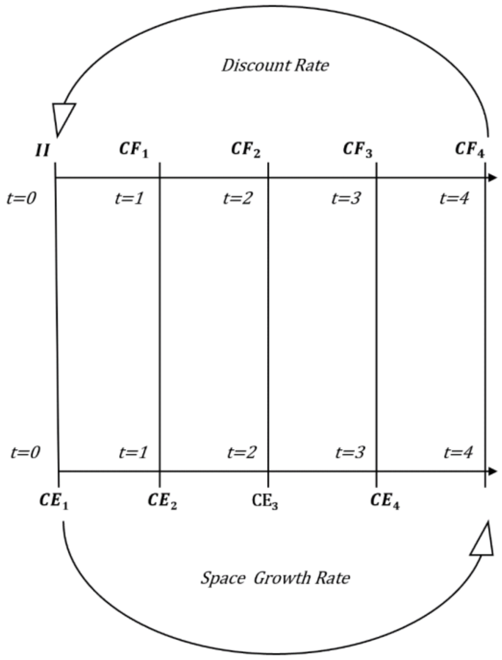
The Space Growth Rate measures the implied periodic rate of growth using the Initial Investment (II) and the aggregate Net Space Value of the investment across the T periods and S layers of the investment.

The Space Growth Rate is a summary rate that can be used similarly to how the discount rate is used in our current models. With the space value of money principle, investors can continue to pursue their risk and time adjusted returns, but their impact must be accounted for and compounded into the future when relevant.

Fig. 14 and Equations 13 and 14 reveal the relationship between the space growth rate and the Net Space Value of an investment, where the investment is considered as a series of cash expenditures, and the SPR is used to compound them into the future (Papazian 2022, 100-101).

[10] See Papazian (2022) for additional examples and a more extensive discussion.

Fig. 14 The Double Timeline and the Space Growth Rate
(Source: Papazian 2022)



$$\boldsymbol{SPR} = \sqrt[T]{\frac{\boldsymbol{NSV_{T,S}}}{\boldsymbol{II}}} - \boldsymbol{1} \qquad (13)$$

$$Net\ Space\ Value = NSV_{T,S}$$

$$SPR = The\ Space\ Growth\ Rate\ per\ period$$

$$II = Initial\ Investment$$

$$T = All\ Time\ Periods\ involved\ in\ the\ Investment$$

$$S = All\ Space\ Layers\ Involved\ in\ the\ Investment$$

$$II = \sum_{t=0}^{T} CE_t = Initial\ Investment$$

$$\boldsymbol{NSV_{T,S}} = \sum_{\boldsymbol{t=0}}^{\boldsymbol{T}} \boldsymbol{CE_t(1 + SPR)^{T-t}} \qquad (14)$$

The Space Growth Rate is a summary tool that can be used to set the minimum required space growth rate for public and private investments. Just like benchmark discount rates are used to measure the risk and time value of cash flows and investment opportunities, we could set benchmark space growth rates >0 that would set the minimum positive space impact required for public and private investments (Papazian 2023, 2022).

This is an important, and yet missing, tool in our current financial framework and mathematics. Our focus on risk and time excludes the space impact of cash flows as a relevant component of value, and thus, as discussed in earlier sections, discriminates against our evolutionary investments which tend to have very high risks, distant cash flows, and abundant space impact.

The introduction of the analytical dimension of space, the space value of money principle, and ensuing equations will allow us to correct the current imbalance in finance theory and practice. Risk and time may be of concern to the mortal risk-averse return-maximising investor, but from a species perspective, our evolutionary continuity in space takes priority. Thus, our financial value models must be able to properly price our evolutionary investments and include the necessary tools that could result in a positive valuation for massive investments in the present with incredibly high risks, very distant returns, and high positive impact on space.

Once we have transformed and reformed our financial value framework and liberated our investment flows from the claws of time and risk, the proper evaluation of outer space development programs and investments becomes possible.

ONCE WE HAVE TRANSFORMED AND REFORMED OUR FINANCIAL VALUE FRAMEWORK AND LIBERATED OUR INVESTMENT FLOWS FROM THE CLAWS OF TIME AND RISK, THE PROPER EVALUATION OF OUTER SPACE DEVELOPMENT PROGRAMS AND INVESTMENTS BECOMES POSSIBLE.

While the above is a necessary transformation, it is not sufficient for us to be able to truly explore the universe. We must also transform our monetary architecture built upon a transformed value framework and mathematics.

5.2. Money Mechanics with Space Value Creation

Section 4 explored the key challenges of debt-based money and the key systemic bottlenecks it creates for a species in space that has outer space ambitions. In this section, I propose a solution by way of a new money creation channel based on space value creation.

The alternative logic of money creation proposed here is built upon the introduction of a new instrument for the purpose. While some may seek or argue for a more radical transformation, I am convinced that we *must* improve the monetary system we have.

To start off, to remove any doubts from the reader's mind, it is possible and necessary to improve and fine-tune our money creation methodology. It is my personal opinion that we will not be able to address the many evolutionary challenges we have created for ourselves without such a transformation. The below quote and Table 7 reveal as to why we should and must consider this avenue as an opportunity for innovation and improvement in money mechanics.

> [I]f the Bank of England can create and back banknotes by a deposit in the banking department of the Bank of England, if the Bank of England can create new money by loaning to its own wholly owned subsidiary, if the Federal Reserve can create new money by buying toxic Collateralised Debt Obligations and Mortgage-Backed Securities or by buying commercial paper, there is no reason why they cannot back or create new money through an alternative equity-like instrument that shares risks, shares the ownership of the assets created through the instrument, has a tangible and inspiring positive space impact, and helps resolve our evolutionary challenges. (Papazian 2022, 223)

The balance sheet of the issue department of the Bank of England reveals that much of the British Pounds in circulation are backed by an internal deposit at the banking department of the Bank of England. During the 2007/8 financial crisis and the 2020 Corona virus pandemic, the Bank of England injected hundreds of billions of new money into the financial system through loans to its own wholly owned subsidiaries.

> When the APF is used for monetary policy purposes, purchases of assets are financed by the creation of central bank reserves…. The APF transactions are undertaken by a subsidiary company of the Bank of England – the Bank of England Asset Purchase Facility Fund Limited (BEAPFF). The transactions are funded by a loan from the Bank…. (Bank of England 2021, 117).

Table 7 BOE Balance Sheet, Issue Department, in (£mn), As of Feb 2023
(Source: *Bank of England 2023b)*

	2023 £mn	**2022** £mn
Assets		
Securities of, or guaranteed by, the British Government	1,536	1,698
*Other securities and assets including those acquired under reverse repurchase agreements	84,371	84,742
Total Assets	**85,907**	**86,440**
Liabilities		
Note Issued		
In Circulation	85,907	86,440
Total Liabilities	**85,907**	**86,440**
*		
Other securities and assets including those acquired under reverse repurchase agreements		
Deposit with Banking Department	84,261	82,387
Reverse repurchase agreements	110	2,355
	84,371	**84,742**

What is proposed in this white paper and in Papazian (2023, 2022) is a systemic change that amounts to the introduction of a new financial instrument within our existing monetary architecture. I propose the introduction of a new instrument of money creation, Public Capitalisation Notes (PCNs), which have a different logic and different locus of injection. As such, they differ from previously used debt instruments by the Federal Reserve, Bank of England and the European Central Bank (Bernanke 2009). Echoing the commonly used policies, quantitative and/or credit easing (QE/CE), I describe this new instrument and its use as Value Easing.

5.2.1. *Public Capitalisation Notes (PCNs)*

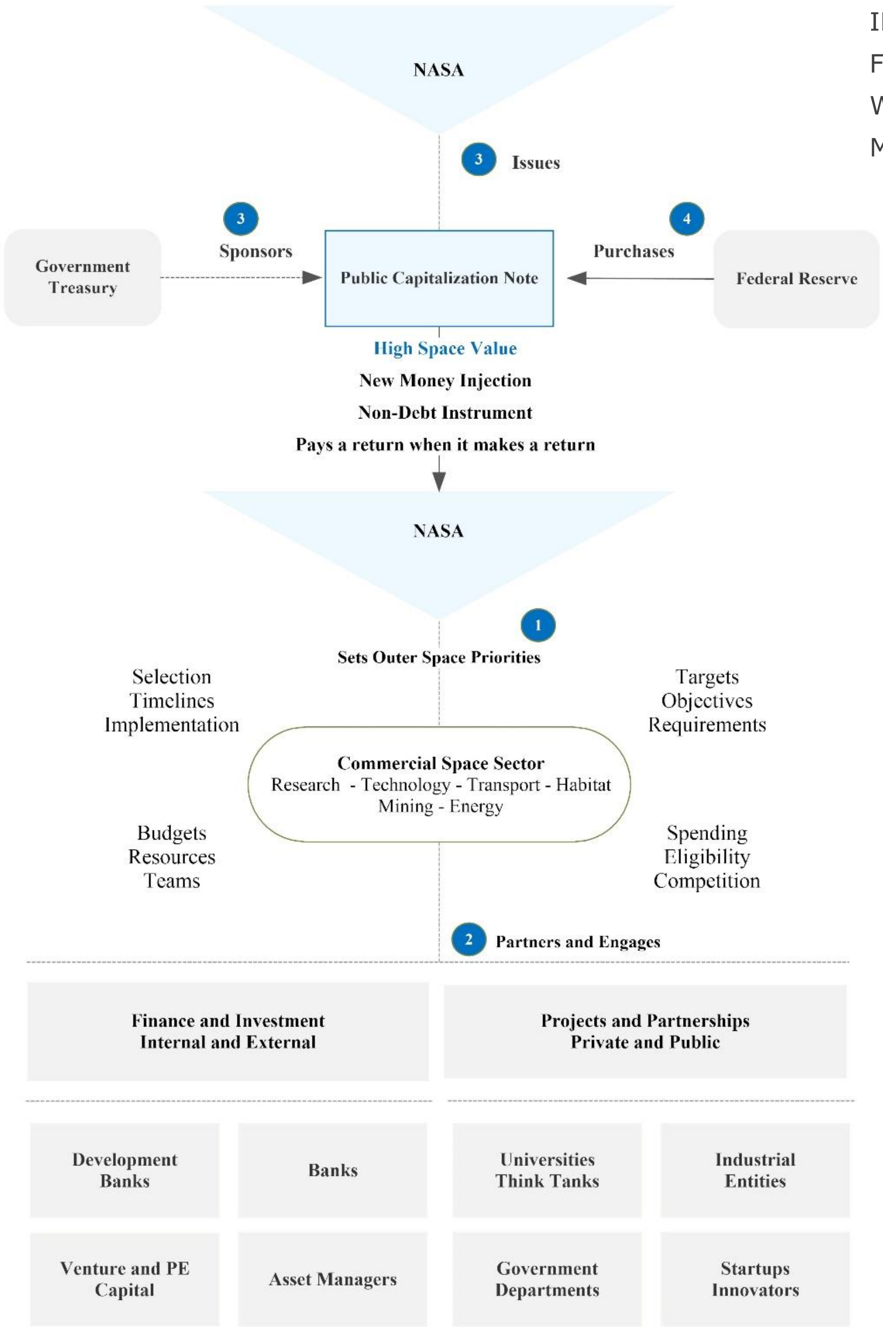
The logic and purpose of Public Capitalisation Notes are designed to help us transcend the three systemic bottlenecks created by debt-based money (Section 4).

PCNs are conceived as instruments that can be used by any central bank. They are not debt instruments and introduce a new logic of money creation founded on space value creation. In other words, if with debt instruments used for money creation the trigger is the agreement to repay, with PCNs, this is changed to a commitment to create necessary positive space value and share the returns when and if they occur.

Fig. 15 describes a possible NASA PCN that could be used by the US Treasury and Federal Reserve to jump start a massive investment drive in public and private outer space development and exploration through NASA. Naturally, NASA is given as an example, and other alternative viable institutions can also be used. Similarly, PCNs can facilitate the injection of liquidity into a megafund structure dedicated for the purpose (Kessler et al. 2015).

Fig. 15 NASA PCN
(Source: Adapted from Papazian 2023, 2022)

WHAT IS PROPOSED IS A SYSTEMIC CHANGE THAT AMOUNTS TO THE INTRODUCTION OF A NEW FINANCIAL INSTRUMENT WITHIN OUR EXISTING MONETARY ARCHITECTURE.



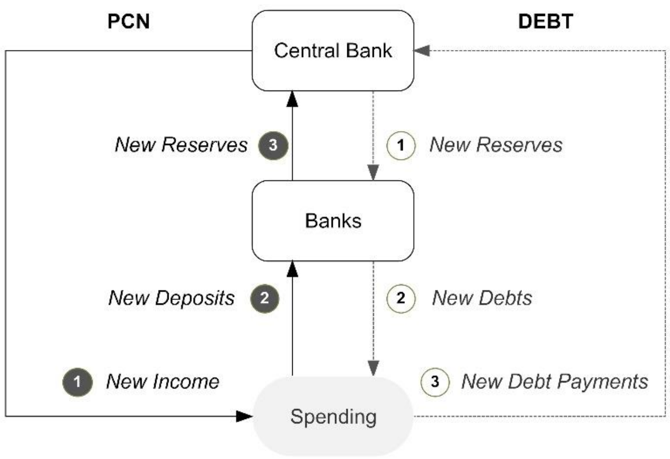
The key features of PCNs:

Non-debt (addresses monetary hunger), no-maturity (addresses monetary gravity), equity-like (shares risks & assets and returns when due), high space value/impact (addresses challenges like outer space exploration and settlement), issued by qualified government agencies (as administrative HQ), in collaboration with private sector (Public Private Partnerships), with Treasury sponsorship (shares risk & assets and returns when due), increase the central bank's balance sheet (like QE and CE), inject new liquidity outside the banking system/reserves (unlike QE and CE). (Papazian 2023, 2022)

Fig. 16 describes the change of locus of the injection. Given that PCNs allocate the newly created money outside bank reserves, they do not condition the space impact of the created new money by new or further lending by banks. When new money creation is done through a PCN, the injected liquidity is outside the banking system/reserves and is spending before it becomes bank reserves.

In the case of QE and CE, the initial point of injection is bank reserves. As such, the eventual impact of the new liquidity is dependent on further bank lending, which, as discussed in section 3, is guided by and built upon a risk and time focused value framework. PCNs, because of their design and structural features, allow the funding of our many evolutionary challenges and necessary economy wide investment programs without any additional debt.

Fig. 16 PCN vs Debt Money Injection
(Source: Papazian 2023)



The transformations proposed here introduce a new logic of money creation and a new locus of injection that allow us to address the challenges of debt-based money. I call this new approach of monetisation Value Easing (VE).

5.2.2. *Value Easing*

> Value Easing: The transactional process undertaken by a central bank that consists in purchasing non-debt no-maturity equity-like high space impact value creating instruments from qualified government agencies and/or public private partnerships (PPP) with relevant Treasury sponsorship that increases the central bank's balance sheet and injects new liquidity outside the banking system/reserves. (Papazian 2023, 129)

Value Easing is less inflationary than Quantitative Easing and Credit Easing, and it allows the injection of new liquidity to be directed where it is most necessary and needed, instead of being left to the lending priorities and preferences of the banks. This is necessary given the risk and time-based analytical framework within which banks create and manage their assets and liabilities.

Value Easing can be directed to address evolutionary challenges, like outer space exploration and settlement, where risk levels and return timelines are outside the normal parameters of a risk and time framework.

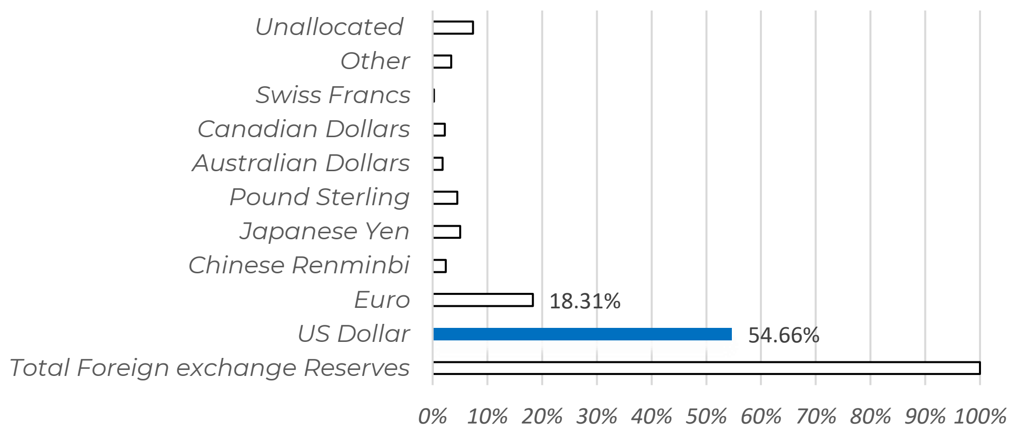
Furthermore, following the discussion in section 4, where we identified the systemic challenges posed by a debt-based architecture, imposing limits on human productivity and acting as a muzzle, leash, and whip in space, the above proposed instrument and solutions grant us the opportunity to transcend those systemic bottlenecks.

5.2.3. *From US Debt Ceiling to Wealth Floor*

Once we have achieved the above-described transformations, i.e., we have introduced the analytical dimension of space into finance, adjusted our equations to integrate space impact, and created the commensurate instruments of money creation, we can begin the funding of evolutionary investments/challenges.

A parallel architectural benefit of Value Easing is that it will also help us address the issue of the US national debt, a serious bottleneck for the United States as well as the world financial system. Despite the ambitions of many to compete and/or replace the US dollar, the dollar remains the most commonly used global reserve currency (IMF 2023b) (Chart 3).

Chart 3 Global Currency Reserves Percentages
(Source: IMF 2023b)



In the first half of 2023, the US Treasury reached its debt limit of $31.4 trillion (Edelberg and Sheiner 2023) and the ceiling was raised on the 31st of May 2023.

The debt limit or ceiling has been a central institutional bottleneck and the subject of intense debate in the US (Austin 2015). The US Department of the Treasury describes the debt limit or ceiling as follows:

> The debt limit is the total amount of money that the United States government is authorized to borrow to meet its existing legal obligations, including Social Security and Medicare benefits, military salaries, interest on the national debt, tax refunds, and other payments (US Treasury 2023).

On the 3rd of May 2023, in a blog that reads as a warning, the White House wrote:

> New analyses by both the Congressional Budget Office and the U.S. Department of the Treasury suggest the United States is rapidly approaching the date at which the government can no longer pay its bills, also known as the "X-date." History is clear that even getting close to a breach of the U.S. debt ceiling could cause significant disruptions to financial markets that would damage the economic conditions faced by households and businesses. Real time data, shown below, indicate that markets are already pricing in political brinkmanship related to Federal government default through higher risk premia. (White House 2023)

The x-date, which is when the Treasury runs out of funds, is a hypothetical date that will hypothetically be avoided *ad infinitum*. However, it further illustrates the limitations of the debt-based monetary architecture we are bound by. All the systemic challenges discussed in section 4 are further emphasised by the very existence of the x-date.

Value Easing using PCNs provides us the tools and opportunity to transform the debt ceiling into a *wealth floor*. Naturally, this will have to be a gradual transition for systemic stability reasons, but the rehabilitation of a debt-based monetary architecture and public expenditure structure can begin.

6. Conclusion

Outer space development, exploration, and settlement is an evolutionary challenge for humanity, and it is directly affected by a spaceless financial value framework and monetary architecture that bind us to risk and calendar time, thwarting the timeless and hazardous investments we must initiate to break through.

The mortal risk-averse return-maximising investor and her/his/their preferences will only serve us to the extent of her/his/their risk adjusted returns, further undermined by a risk and time focused value framework and monetary architecture within which she/he/they must survive.

To be able to invest and build that which we need to build to become an interplanetary species, or multi habitat species, we must change and reform our financial value framework and reinvent the very principles that define the value of money and its creation. Anything short of such a fundamental change may lead to momentary breakthroughs, may even lead to a growing Earth-bound outer space industry, but will fall short of providing us the monetary and financial foundations necessary for our expansion and settlement into outer space.

This white paper, based on Papazian (2023, 2022), proposed the introduction of the analytical dimension of space into finance, along with the space value of money principle and ensuing equations, to rectify the structural imbalance of our risk and time focused framework, currently crippling our ability to invest in and address our many evolutionary challenges, which include, along with outer space exploration, the transition to a Net Zero global economy, and numerous socioeconomic crises..

We must be able to integrate the space and outer space impact of cash flows into the valuation of cash flows to be able to balance their risk and time value. The discounting of future expected cashflows must be accompanied by the compounding of their space impact into the future, if our monetary and financial system is to support our ambitions. Our footprint must create its value in outer space, without linking it to the concerns of individual mortal beings on Earth, i.e., risk and time, and without conditioning it by the planet's rotation on itself and around the sun. This is necessary if the outer space industry is to grow beyond Earth-bound services.

To secure the sustainability as well as future expansion of human productivity, we must be able to respect, value and explore space and its many layers. To achieve such a civilisational leap from where we are today, we must reinvent our financial value framework, mathematics, and monetary architecture. The space value framework provides the theoretical and mathematical foundations through which we can engineer the new products and instruments that can be used to transform a debt-based monetary system and allow us to invest in our evolutionary challenges. Outer space development, exploration, and settlement is one such challenge and opportunity, the transition to a Net Zero economy is another.

The space value of money principle, the financial mathematics that ensues, and the monetary transformations it can lead to entrench the respectful treatment of space into our models, allow the integration of our footprint, and empower us to create value where we stand, and wherever we may go, irrespective of calendar time and the risks involved.

7. Executive Summary

i. Total global government expenditure on outer space development programs and agencies reached a record $117 billion in 2023, slightly surpassing the total revenues of the global toilet paper industry at $107.38 billion. Meanwhile, the private space economy revenues reached $427.6 billion in Q2 of 2023, expected to reach $1 trillion in 2030/2040 depending on sources. Today, the private space economy is much smaller than the total revenues of the global advertising industry at $874.47 billion in 2023. A species whose public spending on outer space development barely surpasses what it spends on toilet paper, and whose private outer space economy is smaller than what it spends on trying to sell goods and services to itself, cannot go very far in outer space. Humanity must be able to fund massive investments in outer space education, R&D, and manufacturing if it is going to be able to sustain lunar habitats and other exploration missions beyond LEO, MEO, and GEO.

ii. The paper focuses on the monetary and financial factors that have created such a contradiction for a species in space. The main arguments presented in this paper are derived and based on Papazian (2023, 2022), and space is defined as our physical context of matter stretching from subatomic to interstellar space and every layer in between and beyond, where outer space is but a segment, a layer. Indeed, space, as analytical dimension, and our physical context, is missing from our financial value framework and the corpus of equations used across finance theory and practice.

iii. Our entire analytical framework in finance is built around risk and time, based on two principles of value, Risk and Return and Time Value of Money, which discriminate against our evolutionary investments due to their biases against highly risky and very distant cash flows. The omission of space as an analytical dimension in finance has led to the abstraction of our responsibility for space impact, and thus the abstraction of space impact from our models. This is particularly relevant to evolutionary investments, such as outer space development and exploration, given that the risk and time features of such investments are at odds with our principles and equations of value in finance. Space impact is critical to balancing our time and risk focused financial value framework and equations, and necessary to allow the positive valuations of opportunities that are highly risky, have distant cash flows, and imply significant space impact.

iv. As a direct consequence of our financial value framework and mathematics, space is also absent from our monetary architecture where money is created through debt instruments, designed in and valued through a risktime framework without space and outer space. Three key architectural challenges created by our debt-based monetary architecture impose serious systemic limitations on our ability to invest and explore space and outer space.

v. *Calendar time*: using calendar time as a foundational pillar of money creating instruments chains everyone to calendar time, and acts as a *muzzle* on our ability to invest in space timelessly. *Monetary Gravity*: using debt instruments linked to calendar time acts as a *leash* on or species, due to the feedback loop included in the structure of the instruments, limiting the distance we can travel before having to return to the bank, ultimately chaining us to the surface of the planet. *Monetary Hunger*: using debt instruments for money creation, whatever the level of capital accumulation, creates an artificial chase for cash and deposits, a monetary hunger which coupled with the threat of default acts as *whip* in space. Given our current financial value framework and monetary architecture, our entire monetary potential and thus productive capacity is chained to risk and time, to the surface of this planet, triggered to consume it at all costs to serve a debt based monetary architecture that has primacy over our ecosystem, over space and outer space.

vi. To enable and empower our outer space ambitions and address our evolutionary challenges, we must introduce the analytical dimension of space and the associated principle of value, the space value of money, into finance theory and practice. The space value of money states that a dollar invested in space must, at the very least, have a dollar's worth of positive impact on space. The space value of money allows the relevant and necessary transformations in our financial mathematics, where space-adjusted equations can facilitate both the sustainability of our activities on Earth as well as the funding and expansion of our footprint in outer space. The space value of money and equations proposed allow us to respect, value, and explore space by quantifying impact and integrating it into our equations of value and return, ushering in a new period where our investments with very high risks and very distant cash flows, like outer space exploration projects, can still have a positive value beyond risk and time, beyond Earth-bound services and calendar time.

vii. Following the introduction of the principle and equations of the space value framework, the next necessary step is to transform money creation based on the principle and equations that provide the blueprint of a new form of monetisation, *Value Easing*, using a non-debt, no-maturity, equity like instrument called Public Capitalisation Notes, which allow us to transcend the limitations imposed by debt-based money. Once such an alternative channel of money creation is introduced, the transformation will also allow us to transcend the *US debt limit* and transform it into a *wealth floor*. Any species that drives and guides its own creativity and productivity through money and monetary incentives must integrate space, our physical context, into its equations of value and return, if it is to enable long horizon high risk evolutionary investments into its economic, monetary, and financial fabric.

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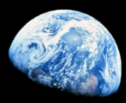
Is the fulfilment of these ideas a visionary hope? Have they insufficient roots in the motives which govern the evolution of political society? Are the interests which they will thwart stronger and more obvious than those which they will serve?

… At the present moment people are unusually expectant of a more fundamental diagnosis; more particularly ready to receive it; eager to try it out, if it should be even plausible. But apart from this contemporary mood, the ideas of economists and political philosophers, both when they are right and when they are wrong, are more powerful than is commonly understood. Indeed the world is ruled by little else. Practical men, who believe themselves to be quite exempt from any intellectual influences, are usually the slaves of some defunct economist. Madmen in authority, who hear voices in the air, are distilling their frenzy from some academic scribbler of a few years back. I am sure that the power of vested interests is vastly exaggerated compared with the gradual encroachment of ideas. Not, indeed, immediately, but after a certain interval; for in the field of economic and political philosophy there are not many who are influenced by new theories after they are twenty-five or thirty years of age, so that the ideas which civil servants and politicians and even agitators apply to current events are not likely to be the newest. But, soon or late, it is ideas, not vested interests, which are dangerous for good or evil.

John Maynard Keynes
The General Theory of Employment, Interest and Money, 1936, 383-384



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