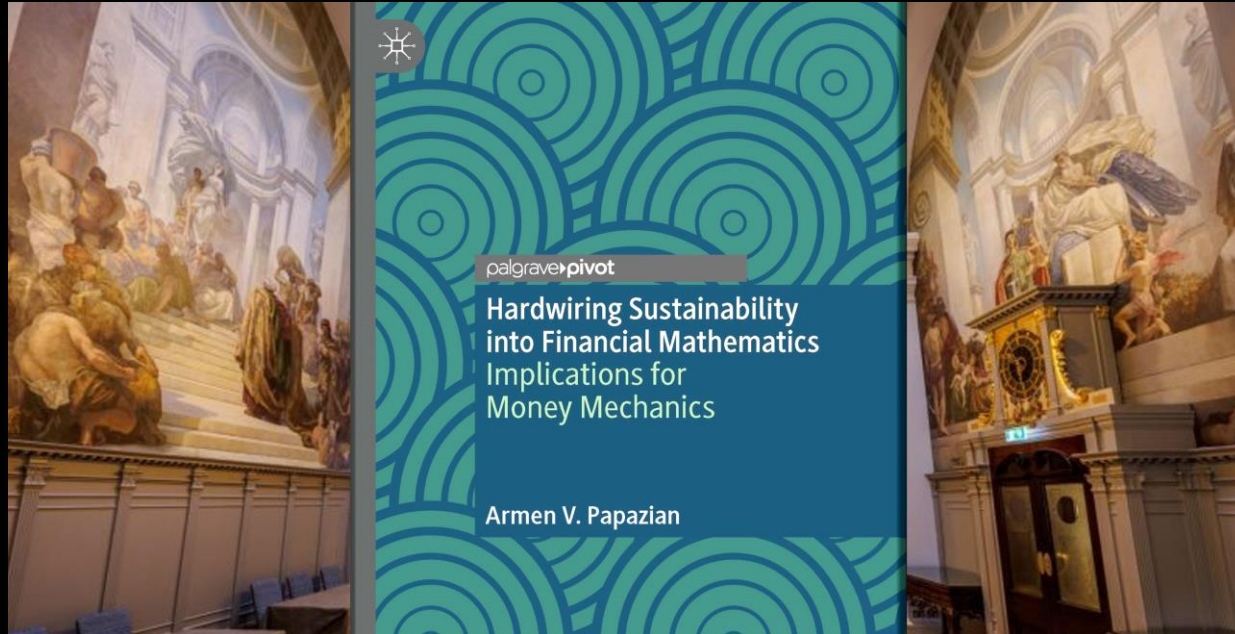


palgrave▶pivot

Hardwiring Sustainability into Financial Mathematics Implications for Money Mechanics

Armen V. Papazian





Hardwiring Sustainability into Financial Mathematics Implications for Money Mechanics

Armen V. Papazian

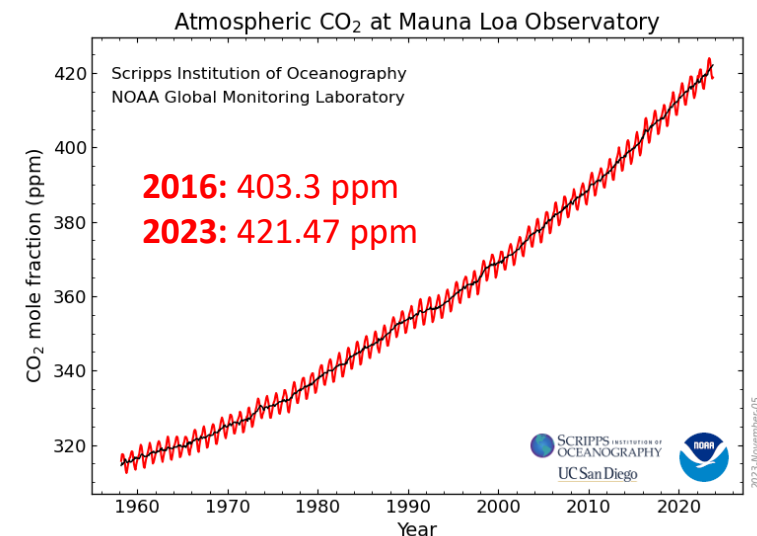
armen@spacevaluefoundation.com





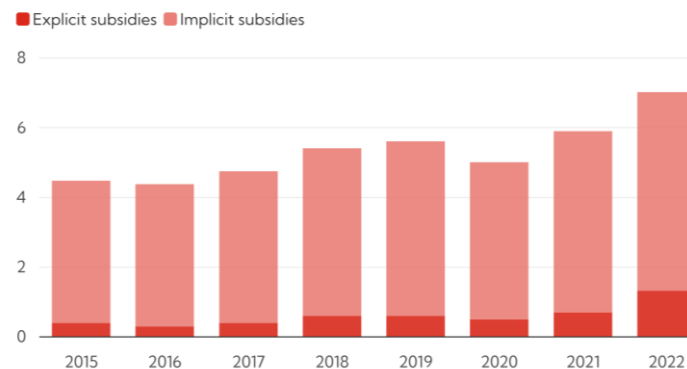
The PARIS Agreement entered into force in November 2016

“Substantially reduce global greenhouse gas emissions to hold global temperature increase to well below 2°C above pre-industrial levels and pursue efforts to limit it to 1.5°C above pre-industrial levels...”



Fossil fuel subsidies topped \$7 trillion last year

(total fossil fuel subsidies, trillions of USD)



Source: IMF staff calculations.
Note: Figures from 2019 onwards use projections for fuel use. Explicit subsidies: undercharging for supply costs. Implicit subsidies: undercharging for environmental costs and forgone consumption taxes, after accounting for preexisting fuel taxes and carbon pricing.

IMF

Hundreds of new North Sea oil and gas licences to boost British energy independence and grow the economy

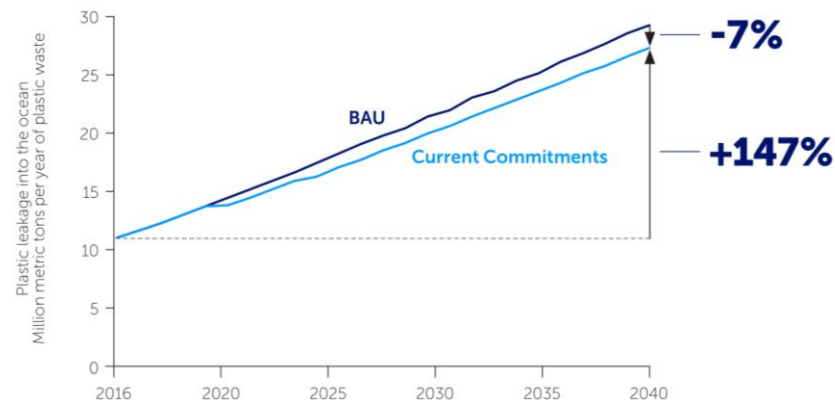


An estimated 50-75 trillion pieces of plastic and microplastics are in our oceans ([IOC-UNESCO](#)).

11 million metric tons of plastic waste enter the ocean every year.

Set to rise to 29 million metric tons per year by 2040
([Pew Charitable Trusts](#))

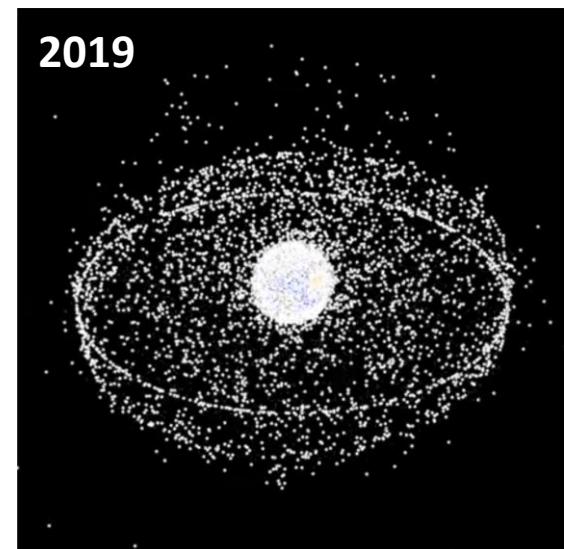
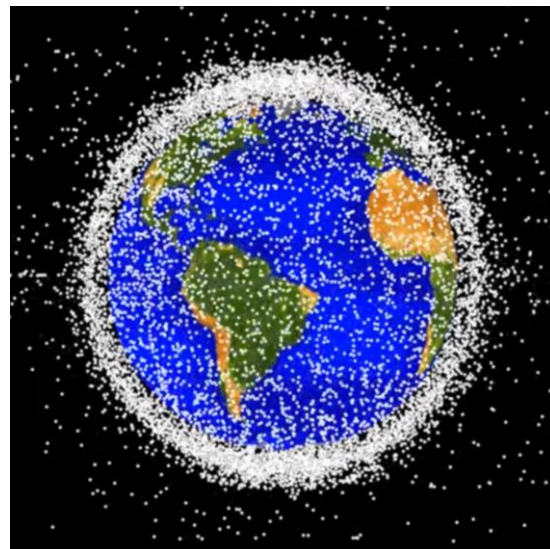
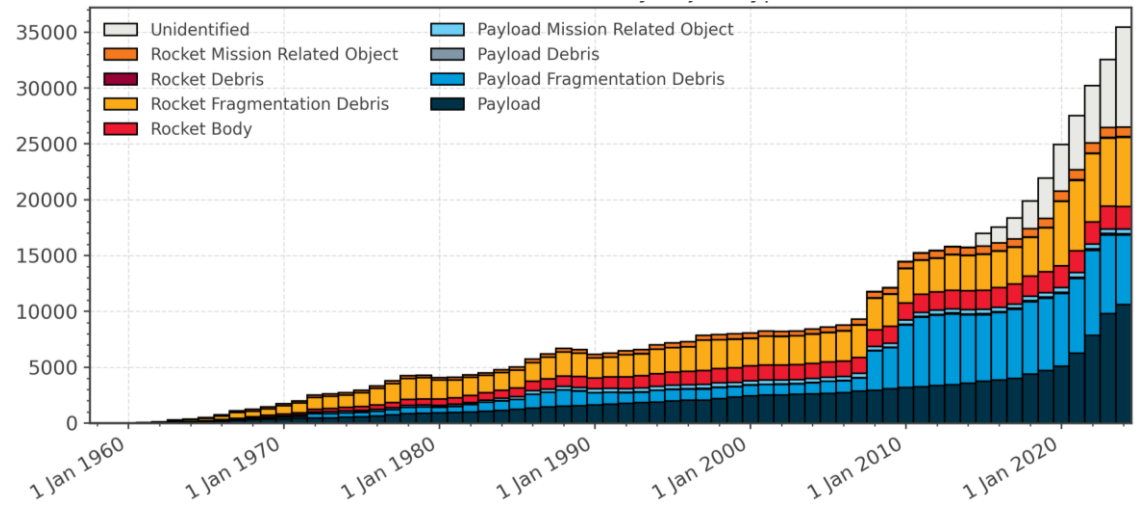
Land-based plastic leakage under the Business-as-Usual and Current Commitments scenarios
Current commitments from industry and government policies achieve only a 7 per cent reduction in plastic leaking into the ocean relative to Business-as-Usual





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](#))

> 9000 metric tonnes ([NASA](#))

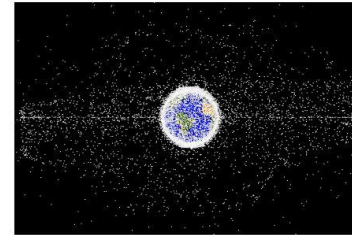




Human productivity is evidently oblivious to and unconcerned with what it leaves behind and how it endangers its very own continuity

Our challenge goes far beyond carbon, emissions, and the climate

We face the necessity to reinvent human productivity





Our Financial Mathematics

Equations of Value and Return

The root cause of our predicament as well as the solutions to our challenges

Sample Bond Valuation Equations

$$\text{Bond Price} = \sum_{i=1}^n \frac{C_i}{(1+r)^i} + \frac{F}{(1+r)^n}$$

$$\text{Bond Price} = C \times \left(\frac{1 - \left(\frac{1}{(1+r)^n} \right)}{r} \right) + \frac{F}{(1+r)^n}$$

$$\text{Bond Price} = \sum_{t=1}^n \frac{CF_t}{(1+r)^t} + \frac{P}{(1+r)^n}$$

$$\text{Bond Price} = \sum_{t=1}^{n \times m} \frac{CF_t}{\left(1 + \left(\frac{r}{m}\right)\right)^t} + \frac{P}{\left(1 + \left(\frac{r}{m}\right)\right)^{n \times m}}$$

$$\text{Bond Price} = \left(\frac{C}{m}\right) \times \left(\frac{1 - \left(\frac{1}{\left(1 + \frac{r}{m}\right)^{n \times m}} \right)}{\left(\frac{r}{m}\right)} \right) + \frac{P}{\left(1 + \frac{r}{m}\right)^{n \times m}}$$

Black and Scholes Option Pricing Model

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

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



Sample of Stock and Firm Valuation Equations

$$P_0 = \frac{D_1}{r - g}$$

$$P_0 = \sum_{t=1}^{\infty} \frac{D_t}{(1+r)^t}$$

$$P_0 = \sum_{t=1}^n \frac{D_t}{(1+WACC)^t} + \frac{P_n}{(1+WACC)^n}$$

$$P_0 = \sum_{t=1}^n \frac{D_t}{(1+WACC)^t} + \frac{D_{n+1}}{(WACC - g) \cdot (1+WACC)^n}$$

$$Firm\ Value = \sum_{t=1}^n \frac{FCFF_t}{(1+WACC)^t} + \frac{FCFF_{n+1}}{(WACC - g) \cdot (1+WACC)^n}$$

Sample of Asset Pricing Models

$$R_i = R_f + \beta_i \times (R_m - R_f)$$

$$Beta_i = \beta_i = \frac{Covariance_{R_i, R_m}}{Variance_{R_m}}$$

$$E(R_i) - R_f = b_1(E(R_M) - R_f) + s_i E(SMB) + h_i E(HML)$$

Risk

Time

Our Financial Mathematics

Equations of Value and Return

Time and Risk proxies to derive the value of cash flows and returns

No context parameters



Our Financial Value Framework

← Time →



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.

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.

Risk



Our evolutionary investments
with high risks and distant cash flows
requiring massive investments in the present



Net Present Value: NPV

Without Context - the impact it would take to achieve or expect the future cash flows are not included



Mortal
Risk-averse
Return-maximising Investor

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

Actual Non-Actual

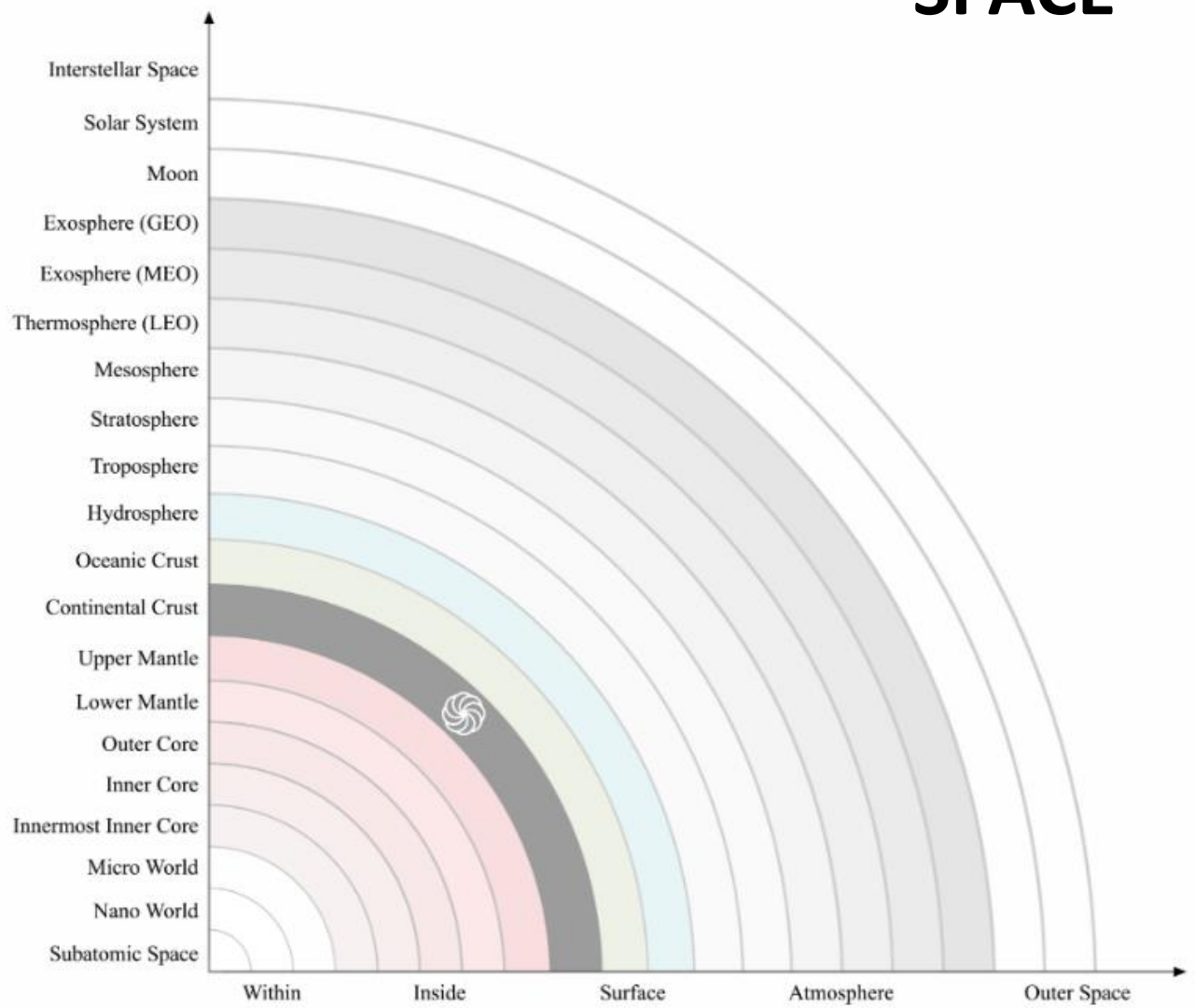
n=Time Horizon
t=Moving time
r=Discount Rate
II=Initial Investment
CFt=Future Expected Cash Flows



The Missing Dimension

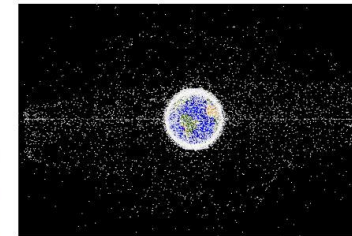
Our Physical context of matter – a multi layered reality that stretches from subatomic to interstellar space, and every layer in between and beyond.

SPACE





**When our financial value framework
and equations omit space, and
consequently our responsibility
for impact in and on space**

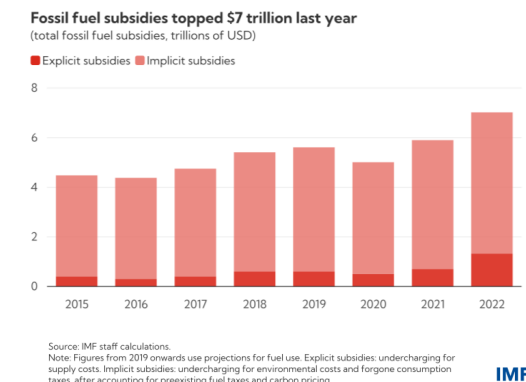
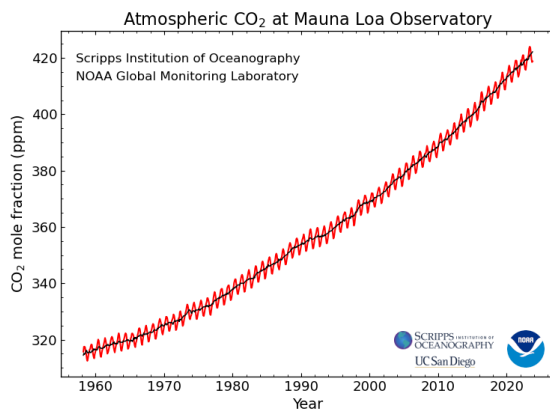




Sustainability in Finance: Frameworks, Standards, and Scores

Our spaceless value framework and equations remain intact

	TCFD (2017)	IFRS (2023a) (S1)	IFRS (2023b) (S2)
Risk	438	167	144
Time	55	29	24
Space	0	0	0



No change in trajectory yet

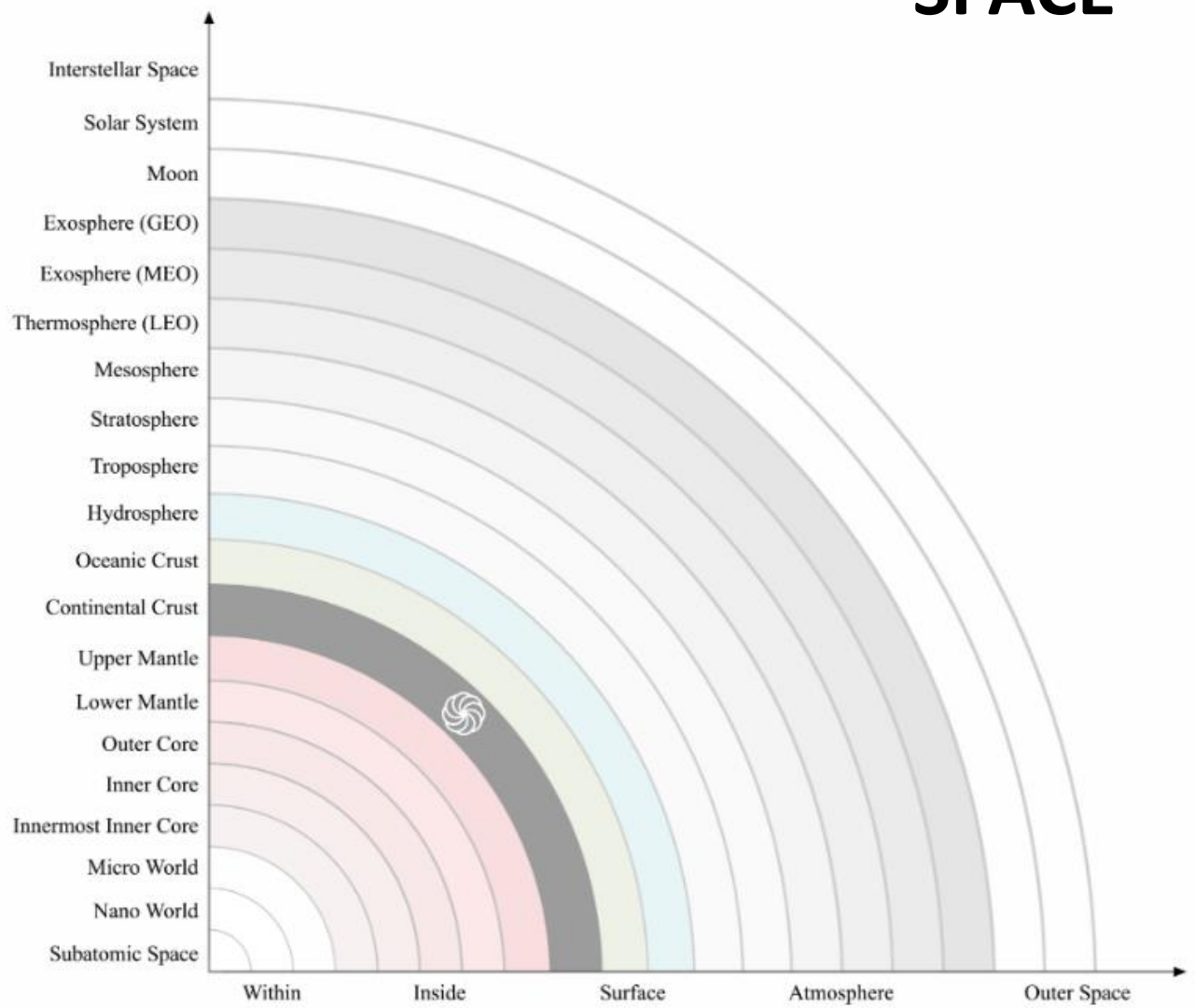
- 1) Voluntary frameworks and standards (x-ESRS)
- 2) Focused on the reporting not the interpretation and application by investors
- 3) ESG Ratings do not measure impact and are opinion points rather than data points
- 4) No analytical framework to evaluate marginal new piece of information in between rating updates
- 5) ESG Integration is tantamount to adjusting variables in our existing models
- 6) Do not transform the analytical content of core finance theory and equations



The Missing Dimension

Our Physical context of matter – a multi layered reality that stretches from subatomic to interstellar space, and every layer in between and beyond.

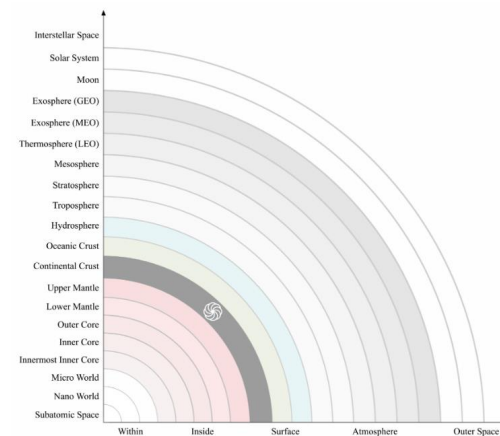
SPACE





Why a layered analysis of space is key

$$\sum_{s=1}^S$$



1- Value Chain: Because the value chains of investments affect different layers of space.

2- Impact Intensity: Because the intensity of impact differs across space layers.

3- Clean-up Technology: Because cleaning the same pollutant in different space layers involves different technologies.

4- Costs: Given all of the above, the costs of impact differ across different layers of space, even for the same pollutant or type of waste.

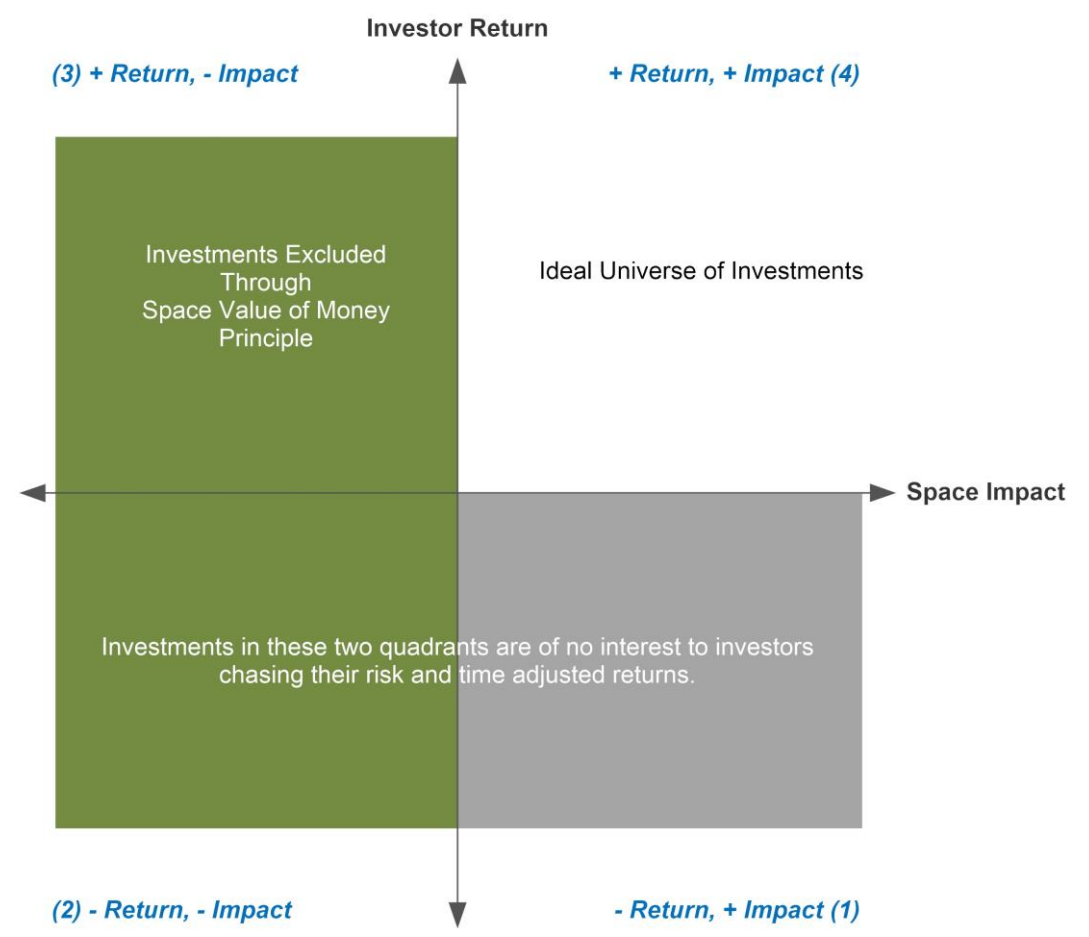


The Missing Principle

The 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

TRIM: Transition Return Impact Map





The New Stakeholders of Financial Mathematics

Mortal Risk-averse Return-maximising Investor



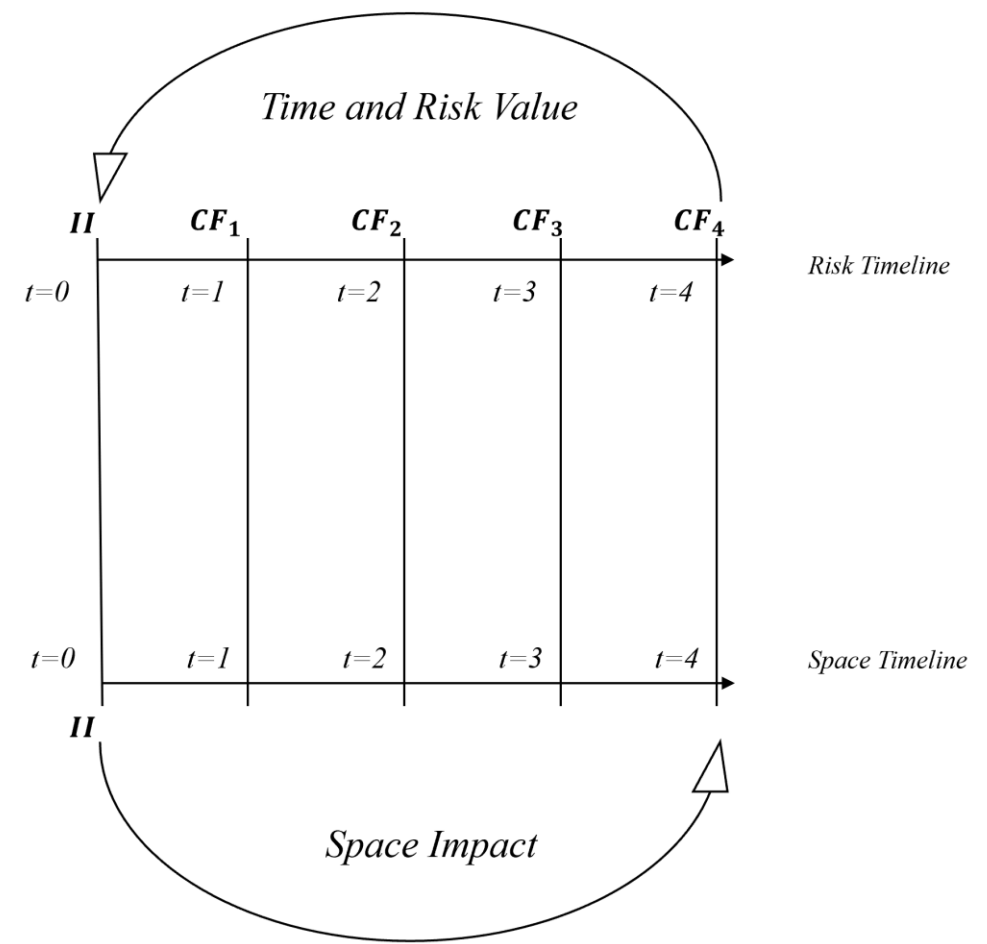
Planet and Humanity





The Space Value Framework

The Double Timeline





The Net & Gross Space Value of Investment

$NSV_{T\&S}$ = Net Space Value of Investment

$NSV_{T\&S} = \{\text{Planetary, Human, and Economic Impact}\}_{T\&S}$

T = Total Number of Years of Investment being Considered

S = All Space layers Involved in the Investment

The Space Value Framework

$$\begin{aligned} NSV_{T\&S} &= \sum_{t=1}^T \sum_{s=1}^S \text{Pollution \& Biodiversity Impact} \\ &+ \sum_{t=1}^T \sum_{s=1}^S \text{Human Capital \& R and D Impact} \\ &+ \sum_{t=1}^T \sum_{s=1}^S \text{New Asset \& New Money Impact} \end{aligned}$$

$$\text{Gross Space Value}_{T,S} = NSV + II$$

$$NSV + II = GSV \mid NSV = 0$$

$$GSV = II$$



The Space Value Framework

Impact Aspect Net Space Value $g \times (PI_{T,S,P} + BI_{T,S,B} + HCI_{T,S} + RDI_{T,S,N} + NAI_{D,S,A} + NMI_T)$

PLANETARY

Pollution Impact

$$PI_{T,S,P} = \sum_{t=1}^T \sum_{s=1}^S \sum_{p=1}^P Q_{pst} \times C_{pst}$$

Biodiversity Impact

$$BI_{T,S,B} = \sum_{t=1}^T \sum_{s=1}^S \sum_{b=1}^B A_{bst} \times R_{bst}$$

HUMAN

Human Capital Impact

$$HCI_{T,S} = f \times \sum_{t=1}^T \sum_{s=1}^S E_{st} + T_{st} + H_{st} + I_{st} + C_{st} + S_{st}$$

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

$$NAI_{D,S,A} = \sum_{s=1}^S \sum_{a=1}^A k_a \times BVA_{asD}$$

New Money Impact

$$NMI_T = (II \times DR \times BLR) + mm \times (II + X_T - M_T)$$

Coefficients

- Fairness f
- Health h
- Transition k
- Governance g



Multiple Impact Intensities

The Space Value Framework

Planetary Impact Intensity_t = *PI and BI per Expected Cash Flow_t*

$$PLANETII_t = \frac{PI_{t,S,P} + BI_{t,S,B}}{\text{Expected Cash Flow}_t}$$

Human Impact Intensity_t = *HCI and RDI per Expected Cash Flow_t*

$$HUMANII_t = \frac{HCI_{t,S} + RDI_{t,S,N}}{\text{Expected Cash Flow}_t}$$

Economic Impact Intensity_t = *NAI and NMI per Expected Cash Flow_t*

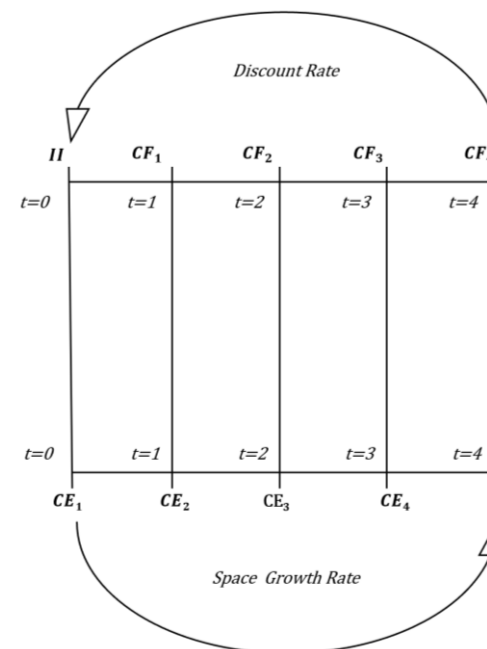
$$ECONOMICII_t = \frac{NAI_{d,S,A} + NMI_t}{\text{Expected Cash Flow}_t}$$



The Space Value Framework

The Space Growth Rate

$$SPR = \sqrt[T]{\frac{NSV_{T,S}}{II}} - 1$$



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

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



Space Adjusted Value and Return Equations

$$NIA\ NPV = -|NNSV_{T,S}| - II + \sum_{t=1}^T \frac{CF_t}{(1+r)^t}$$

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

The Space Value Framework

$$NSV_{T,S,i} \geq 0$$

$$SPR_i \geq 0$$

$$R_i = R_{min} + MSP_i$$

R_i = Return on Investment or Security i

$R_{min} = R_{minimum}$ = Return on Investment with minimum tolerated space impact

MSP_i = Market Space Premium on Security i

$$MSP_i = \theta_i \cdot (R_{HIP} - R_{min})$$

R_{HIP} = Expected Return on High Impact Portfolio

θ_i = Theta = Space Impact Sensitivity of Security i

$$\theta_i = \frac{\text{Covariance}_{R_i, NSV_i}}{\text{Variance}_{NSV_i}}$$



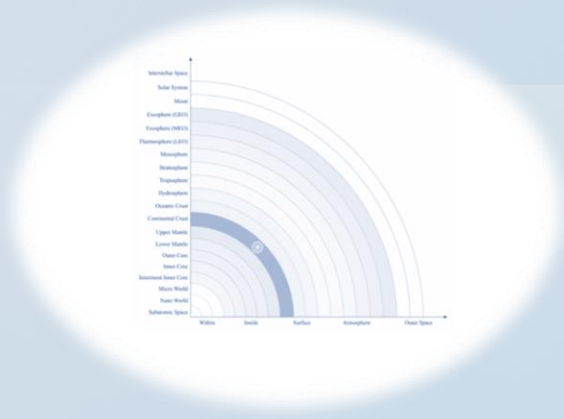
Implications for Money Mechanics



The frameworks, standards, and scores of sustainability in finance treat money creation/mechanics as immaterial to the sustainability challenge and opportunity



If investors must adopt the Space Value of Money principle and ensuing equations, then money creators, commercial and central banks, must also follow suit



Technical implications on the assets, portfolios and transactions used by central and commercial Banks when creating new reserves, currency, and deposits.

	<i>Commercial banks</i>	<i>Central banks</i>
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

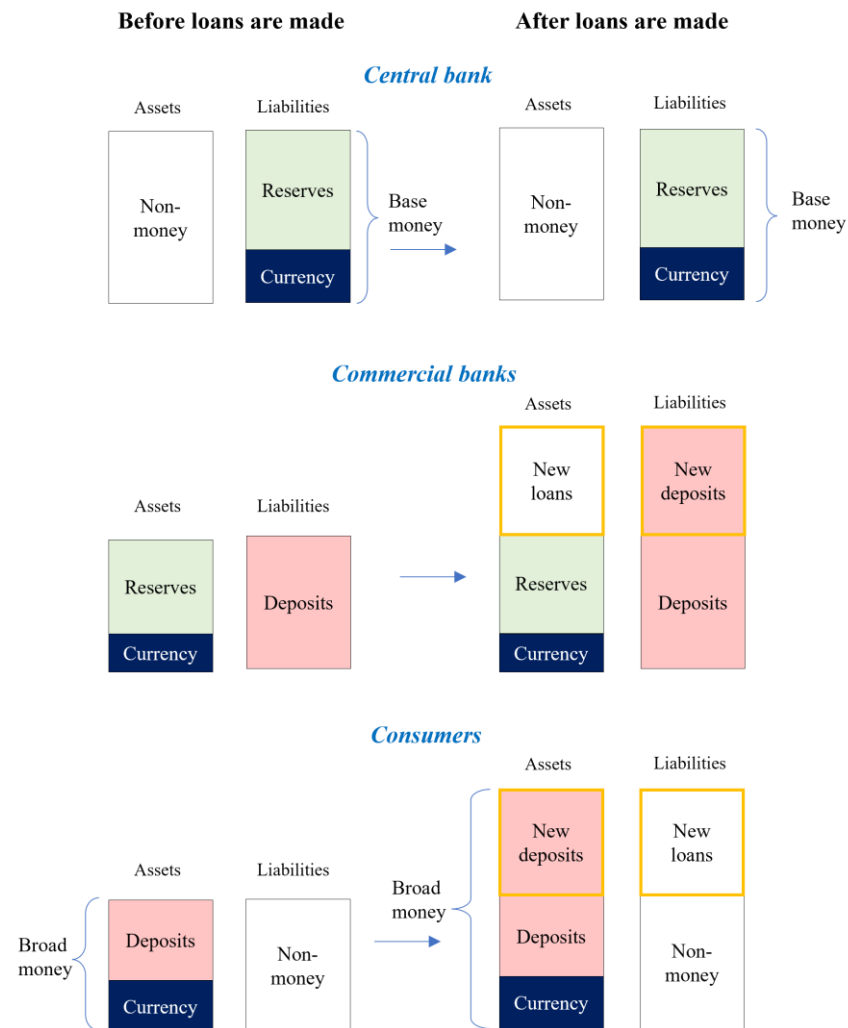
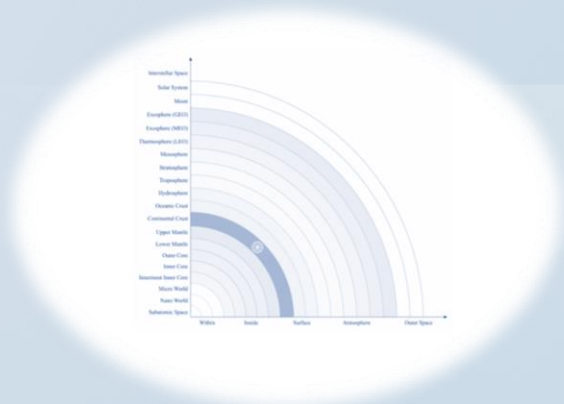
Source Author

Three systemic implications given our debt-based monetary architecture



The three types of money: Currency, bank deposits, and central bank reserves

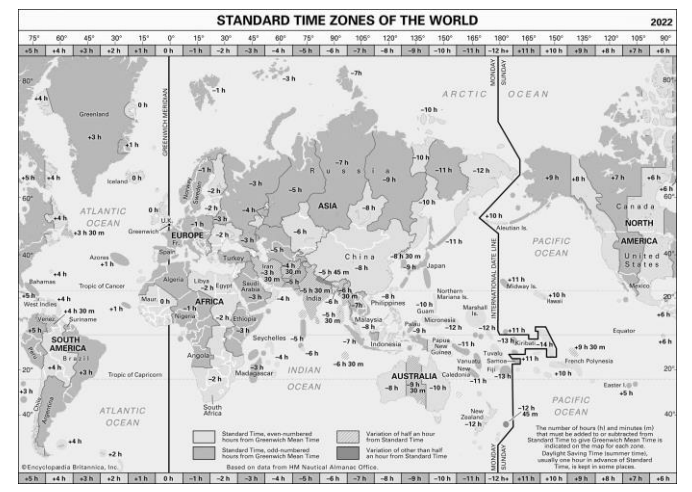
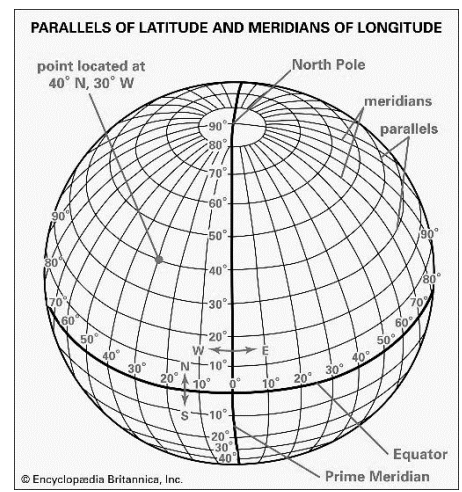
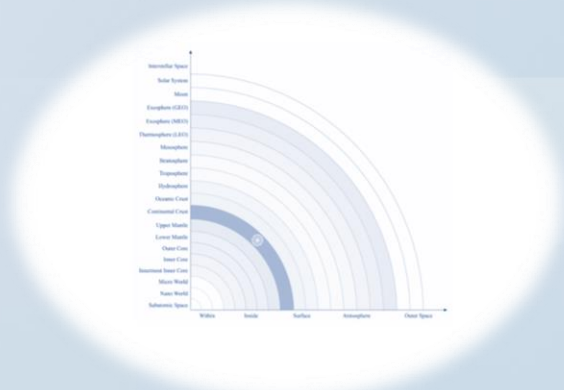
They all represent an IOU, revealing a debt-based monetary architecture



McLeay, M., A. Radia, and R. Thomas. 2014b. Money Creation in the Modern Economy. Bank of England. Quarterly Bulletin. <https://www.bankofengland.co.uk/-/media/boe/files/quarterly-bulletin/2014/money-creation-in-the-modern-economy>.



Calendar Time

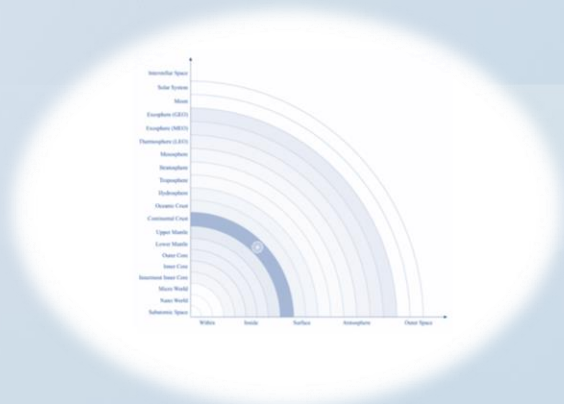


“The Prime Meridian is the line and the point at which the world’s longitude is set at 0°. It does not exist in any strict material sense, yet through maps and clocks, the prime meridian governs the life of every human on Earth.” (Withers 2017, 5)

Given the fixed pace of the artificially projected construct, i.e., calendar time, a money mechanics based on instruments linked to calendar time obligations acts as a muzzle limiting our ability to invest in space timelessly.

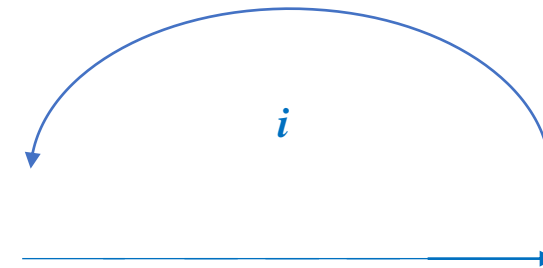


Monetary Gravity



Any Process Funded Through Debt

Backward loop to money creator



Even when paying interest and principal electronically

Given the backward loop to the money creator, calendar time linked debt-based money imposes a limit on the distance a process/investment can go in space before it must return to pay interest to some bank, acting as an unnecessary leash in space.



Monetary Hunger

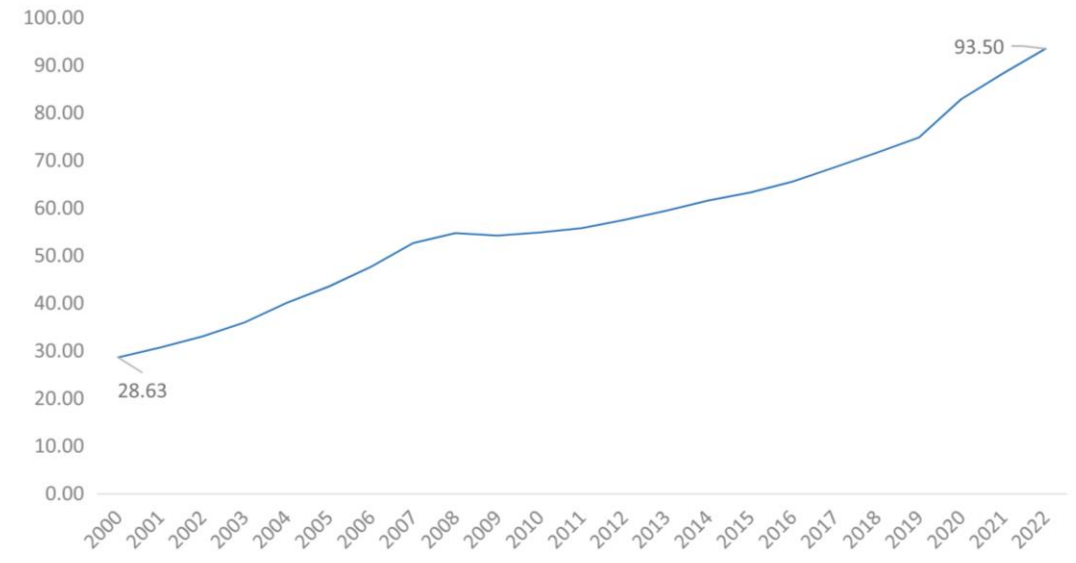
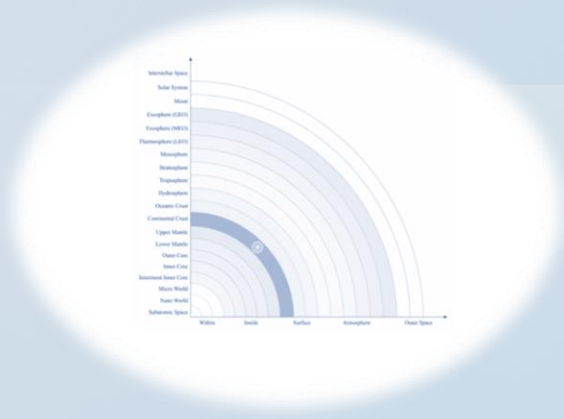


Chart 5.2 Total outstanding public and private debt USA, 2000–2022 in trillion US dollars (*Source* Statista [2022])

Given that money is continuously created through debt, irrespective of capital accumulation, debt-based money creates monetary hunger in any economy, and given the actual threat of default, it acts as a whip and triggers unsustainable practices as borrowers choose to serve their debts before the environment.



Cryptocurrencies/Cryptoassets

Unsustainable alternative



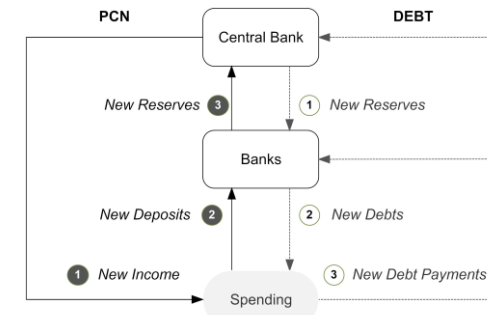
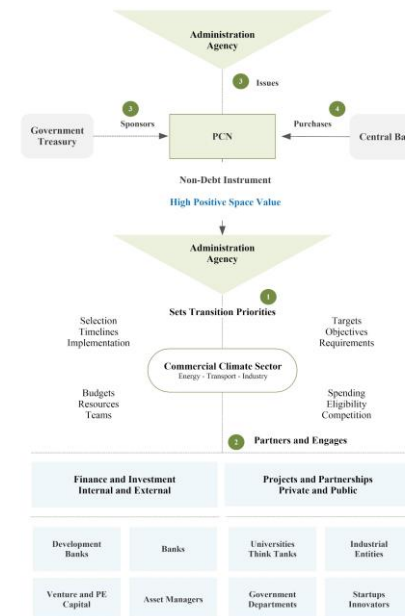
- Volatility
- Limited Quantity
- Greater Fool
- Dark Money
- Electronic Waste Footprint
- Carbon Footprint

- Logic of Creation
 - **Mathematical Guesswork**



We are in dire need of a money mechanics that has and creates positive space value and addresses the limitations of debt-based money

Value Easing is the transactional process undertaken by a central bank that consists in purchasing non-debt / no-maturity / equity-like / high positive space value instruments issued by qualified government agencies or PPPs, sponsored by the Treasury, using the bank's balance sheet and injecting liquidity outside the banking system/reserves.



Climate PCN to fund the transition to a Net Zero sustainable world economy



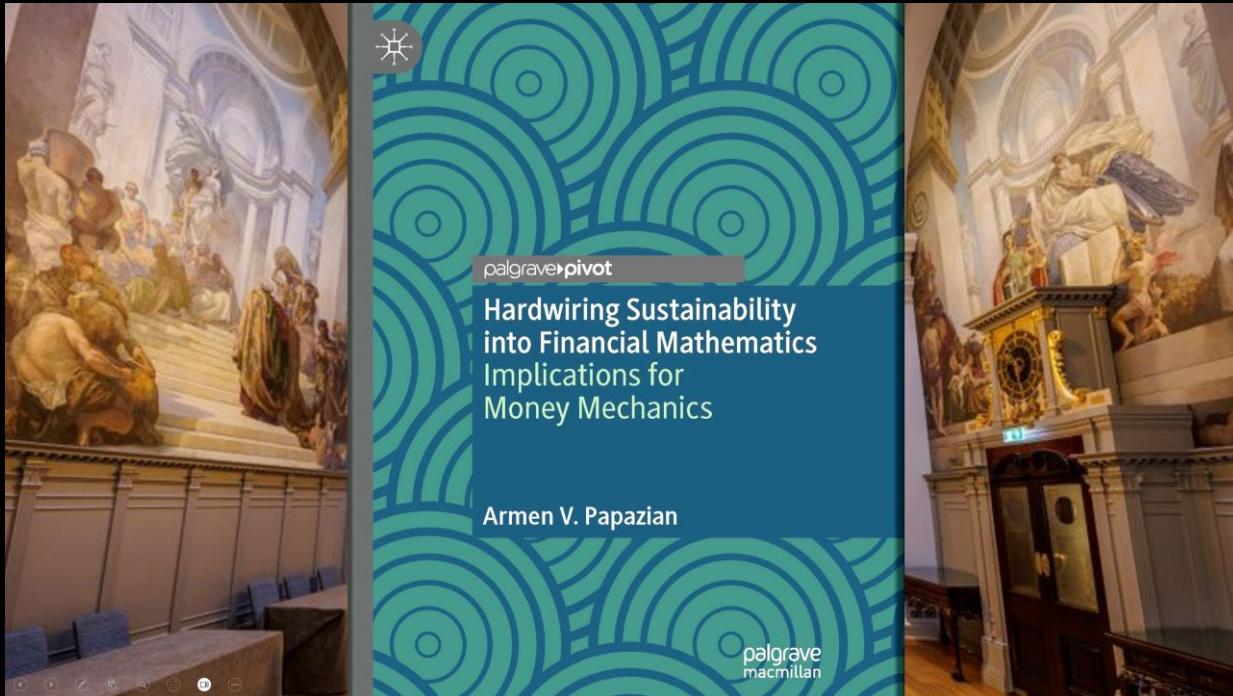
To secure the sustainability as well as future expansion of human productivity across time and space

THE SPACE VALUE OF MONEY

Rethinking Finance
Beyond Risk & Time

Armen V. Papazian





THANK YOU!



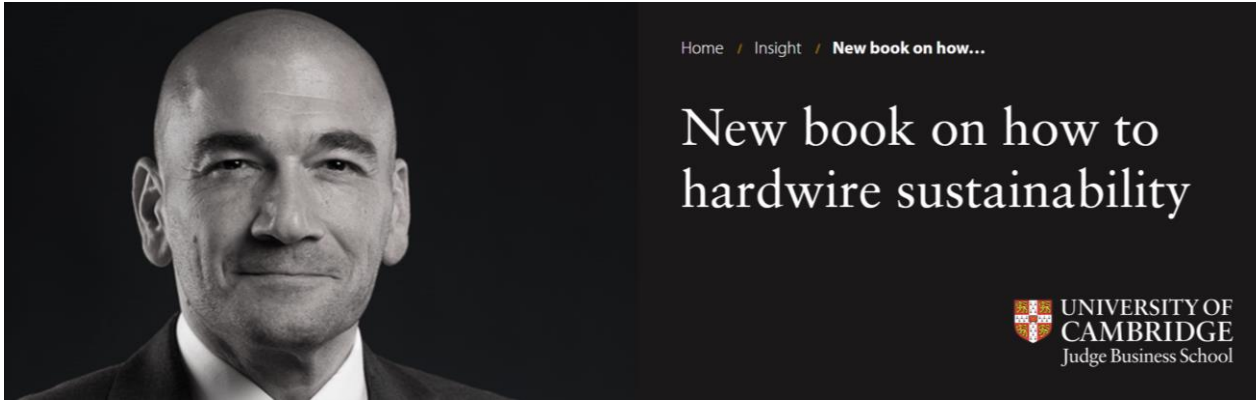


Dr. Armen V. Papazian
Founder & Director
Space Value Foundation

Armen is a financial economist, board director, consultant, and innovator with a track record in global finance. He has more than 20 years' experience in sustainable finance, capital markets, and analytics. A Doctor of Financial Economics from Cambridge University, Armen combines extensive industry experience with financial institutions and markets, with in-depth research into both the theoretical and practical aspects of sustainable finance. He is the author of 'The Space Value of Money' and 'Hardwiring Sustainability into Financial Mathematics' and a founder of the Space Value Foundation. He is an active contributor to the public debate on sustainability in finance.

armen@spacevaluefoundation.com





Hardwiring Sustainability into Financial Mathematics

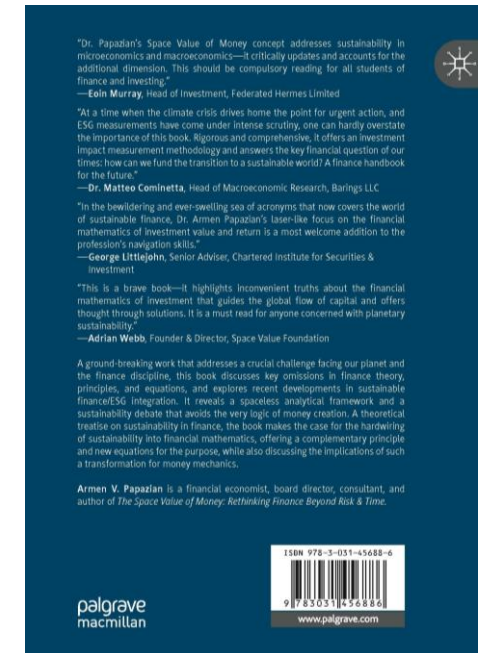
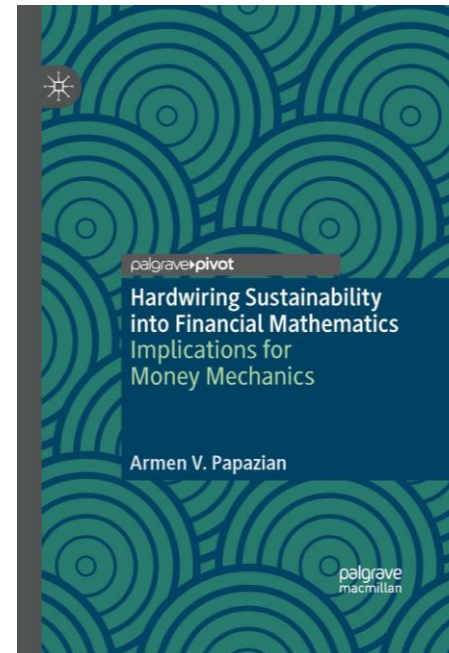
Implications for Money Mechanics

Auditorium, Chartered Accountants Hall, 1 Moorgate Place, London, EC2R 6EA

7th of December 2023 @ 17:30 GMT

Running Order

- 18:00 – Address by the 695th Lord Mayor of the City of London, Alderman Professor Michael Mainelli
- 18:08 – Federated Hermes Limited, Head of Investment, Eoin Murray
- 18:16 – Cambridge Judge Business School, Head of Alumni & External Engagement, Mary Priddey
- 18:24 – Chartered Institute for Securities & Investment, Senior Advisor, George Littlejohn
- 18:32 – Author Address and Q&A, Dr. Armen V. Papazian
- 19:00 – Book Signing, Drinks Reception, and Informal Discussion
- 21:00 – Close





THE SPACE VALUE OF MONEY

RETHINKING FINANCE BEYOND RISK AND TIME

Armen V. Papazian

A fresh and innovative perspective on sustainability and finance, the book proposes a change in the logic of the value of money to account for risk, time, and space parameters, and offers an approach through which we can meet the challenges of the Net Zero transition and facilitate long-term transformations in human productivity.



THE SPACE VALUE OF MONEY

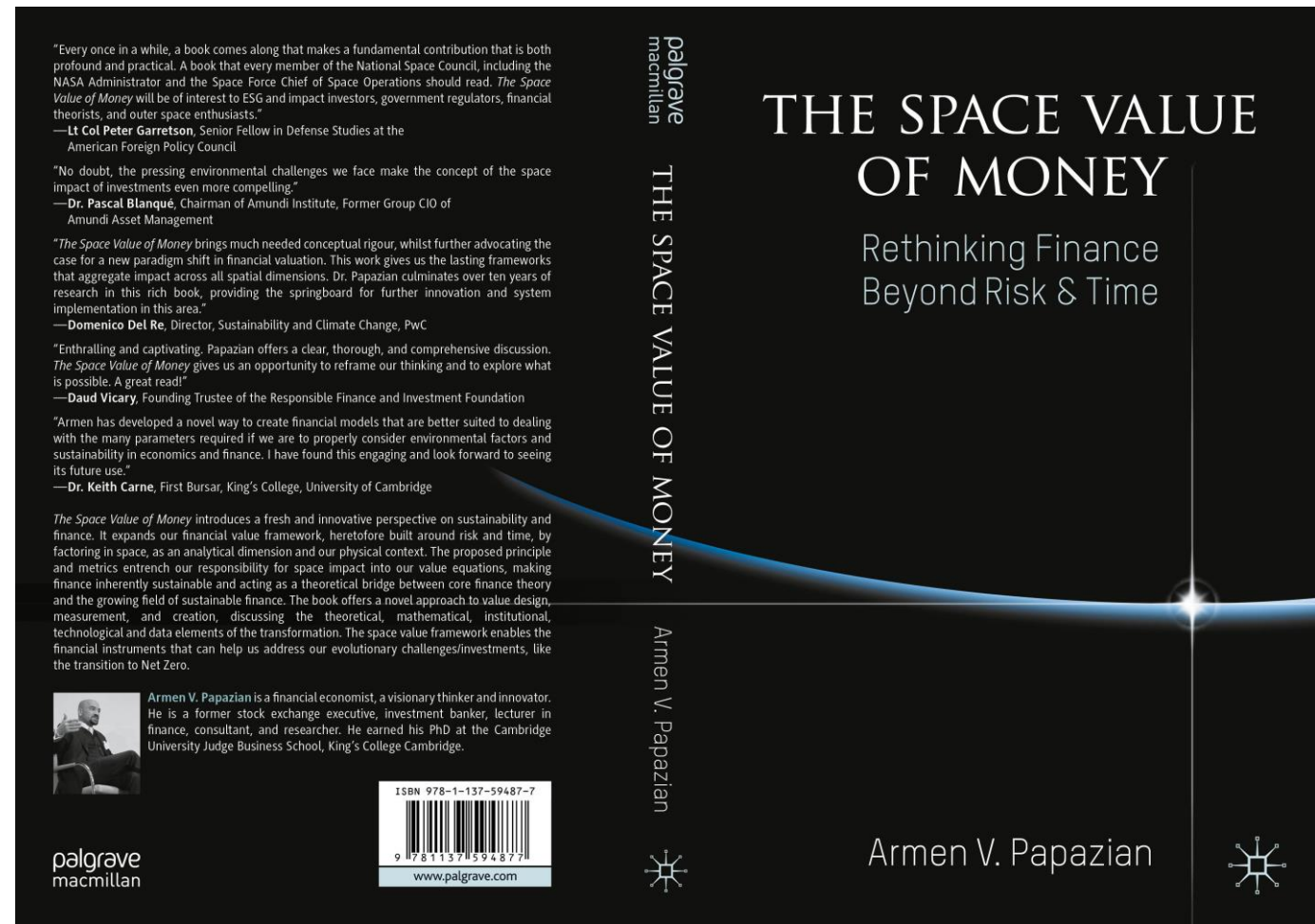
Rethinking Finance Beyond Risk & Time

Keynes' Lecture Theatre, King's College Cambridge

2nd November 2022

Running Order

16:00 – Judge Business School Welcome	16:45 – Book signings
16:08 – Space Value Foundation Welcome	– Drinks & Canapés reception
16:15 - Author Address	– Informal networking & discussion
16:35 – Questions	18:30 – Close



"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."
—Lt Col Peter Garretson, Senior Fellow in Defense Studies at the American Foreign Policy Council

"No doubt, the pressing environmental challenges we face make the concept of the space impact of investments even more compelling."
—Dr. Pascal Blanqué, Chairman of Amundi Institute, Former Group CIO of Amundi Asset Management

"*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."
—Domenico Del Re, Director, Sustainability and Climate Change, PwC

"Enthralling and captivating. Papazian offers a clear, thorough, and comprehensive discussion. *The Space Value of Money* gives us an opportunity to reframe our thinking and to explore what is possible. A great read!"
—Daud Vicary, Founding Trustee of the Responsible Finance and Investment Foundation

"Armen has developed a novel way to create financial models that are better suited to dealing with the many parameters required if we are to properly consider environmental factors and sustainability in economics and finance. I have found this engaging and look forward to seeing its future use."
—Dr. Keith Carne, First Bursar, King's College, University of Cambridge

The Space Value of Money introduces a fresh and innovative perspective on sustainability and finance. It expands our financial value framework, heretofore built around risk and time, by factoring in space, as an analytical dimension and our physical context. The proposed principle and metrics entrench our responsibility for space impact into our value equations, making finance inherently sustainable and acting as a theoretical bridge between core finance theory and the growing field of sustainable finance. The book offers a novel approach to value design, measurement, and creation, discussing the theoretical, mathematical, institutional, technological and data elements of the transformation. The space value framework enables the financial instruments that can help us address our evolutionary challenges/investments, like the transition to Net Zero.



Armen V. Papazian is a financial economist, a visionary thinker and innovator. He is a former stock exchange executive, investment banker, lecturer in finance, consultant, and researcher. He earned his PhD at the Cambridge University Judge Business School, King's College Cambridge.



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THE SPACE VALUE OF MONEY

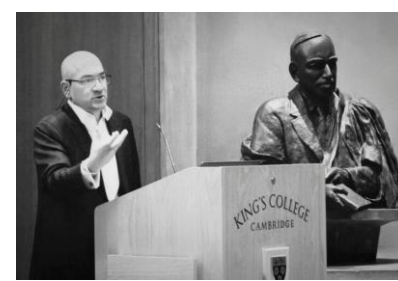
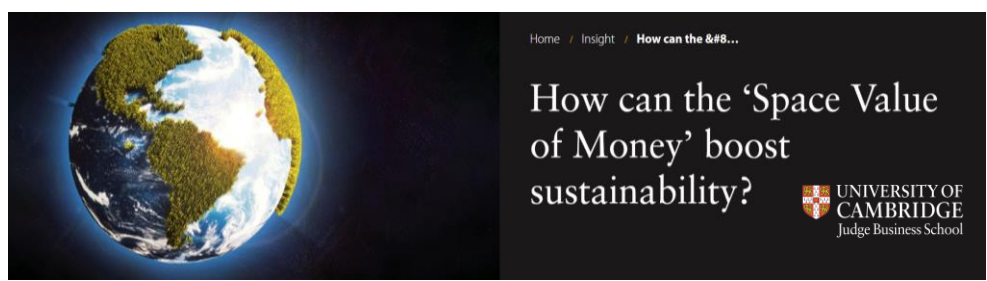
Armen V. Papazian



THE SPACE VALUE OF MONEY

Rethinking Finance Beyond Risk & Time

Armen V. Papazian



Interstellar Space

Solar System

Moon

Exosphere (MEO & GEO)

Thermosphere (LEO)

Mesosphere

Stratosphere

Troposphere

Hydrosphere

Oceanic Crust

Continental Crust

Upper Mantle

Lower Mantle

Outer Core

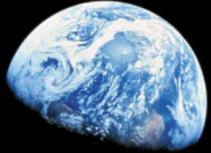
Inner Core

Innermost Inner Core

Micro World

Nano World

Subatomic Space



A new financial
mathematics of
sustainability

More About the Space Value Foundation

Space Value Foundation is a not-for-profit organisation registered as a company limited by guarantee (Companies House No.14071917). We are not a charity; we have no shareholders and we do not distribute profits.

We invest all revenues in pursuit of the mission: to hardwire sustainability and responsibility into financial mathematics by transforming our current financial value framework, by introducing the dimension of space and our responsibility for space impact into our equations of value and return, by rethinking the models that define the value of money, its logic, its allocation, and deployment.

Please consider joining us and our other partners by assisting our work to address some of the fundamental barriers to a sustainable future.

All monetary support we receive is treated as a membership contribution. All revenue is continuously invested and reinvested in our mission and programs. You can support our work either with a one-off contribution or by becoming a regular supporter.



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Reg No. 14071917

The Space Value Foundation is a not-for-profit organisation registered as a company limited by guarantee. It does not distribute profits and invests all its revenue into the mission – to transform our equations of monetary value and return, to advocate for a new financial mathematics of sustainability built upon our responsibility of space impact.