Hardwiring Sustainability into Financial Mathematics
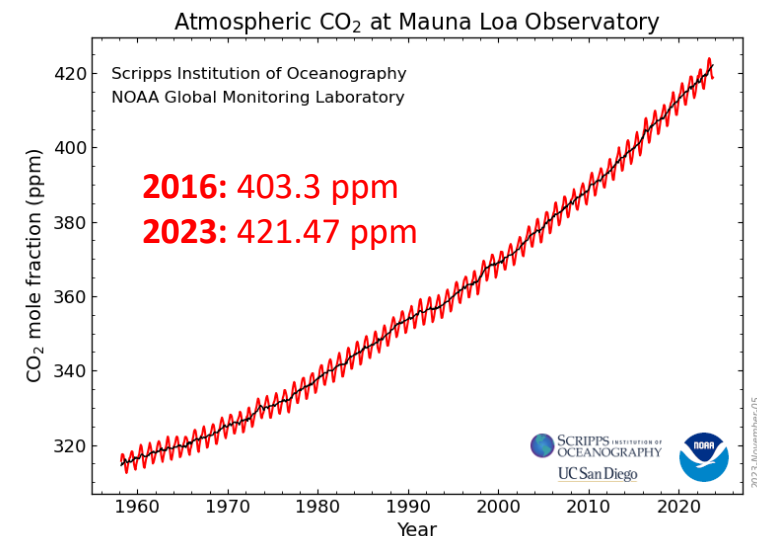Implications for Money Mechanics

**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..."

Atmospheric CO_2 at Mauna Loa Observatory

Scripps Institution of Oceanography
NOAA Global Monitoring Laboratory

2016: 403.3 ppm
2023: 421.47 ppm

SCRIPPS INSTITUTION OF OCEANOGRAPHY
UC San Diego

2023-November-05

Fossil fuel subsidies topped $7 trillion last year
(total fossil fuel subsidies, trillions of USD)

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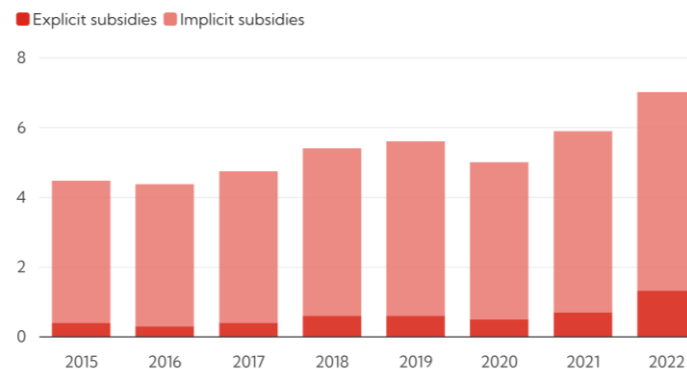
Source: IMF staff calculations.
Note: Figures from 2019 onwards use projections for fuel use. Explicit subsidies: undercharging for supply costs. Implicit subsidies: undercharging for environmental costs and forgone consumption taxes, after accounting for preexisting fuel taxes and carbon pricing.

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

BAU

Current Commitments

-7%

+147%
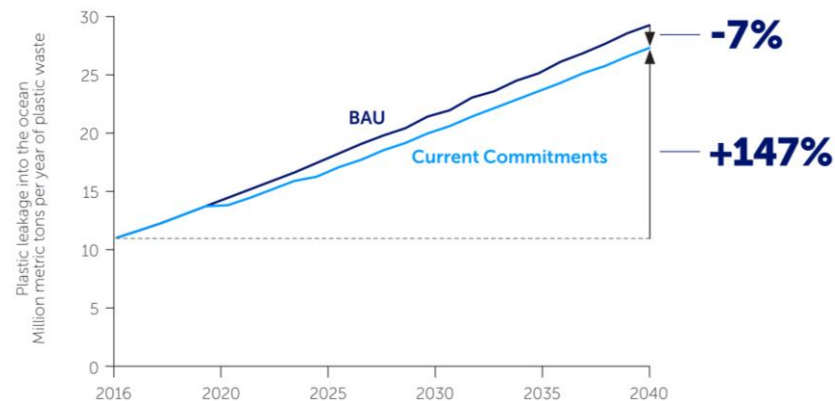
Currently, an estimated 36,500 space debris greater than 10 cm and 130 million space debris from 1 mm to 1 cm are in orbit (ESA)
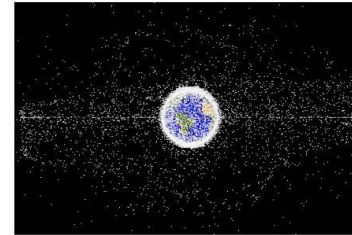
> 9000 metric tonnes (NASA)

2019
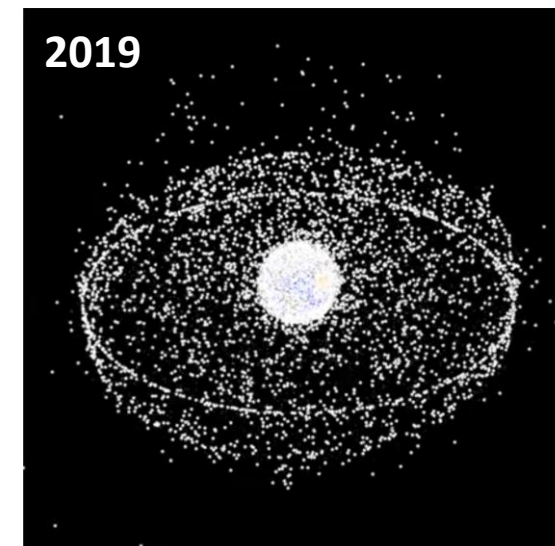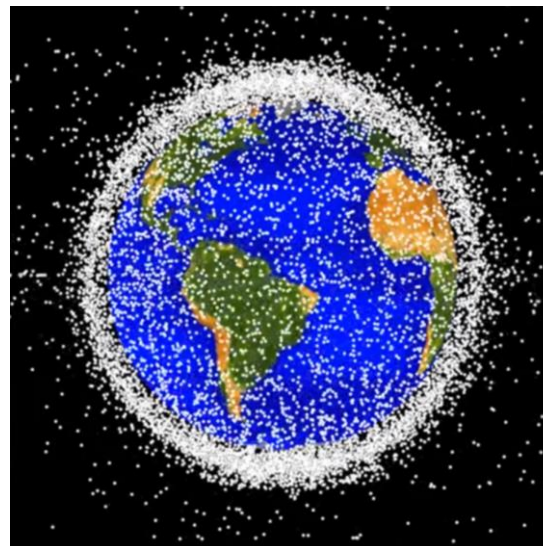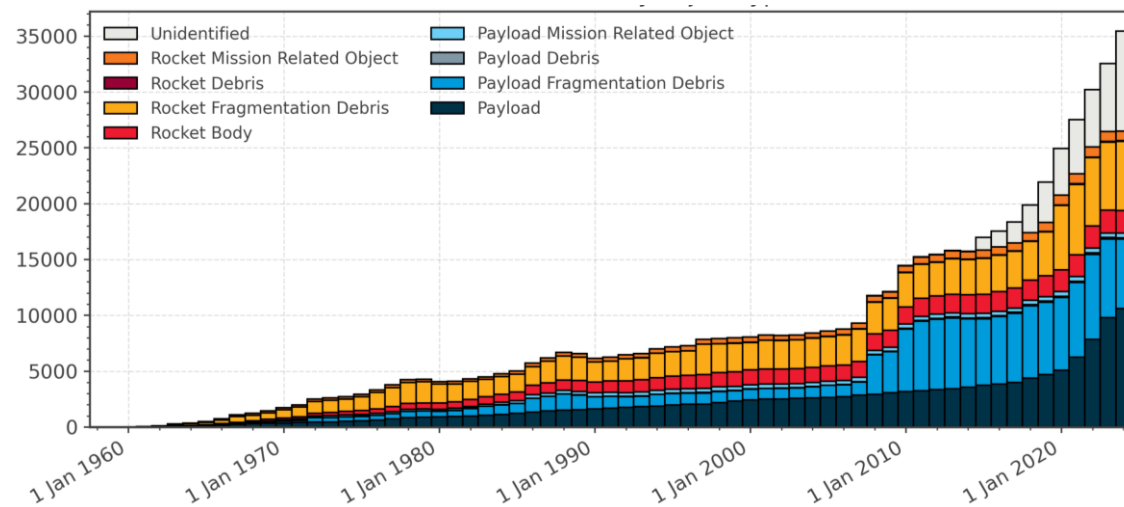
Human productivity is evidently oblivious to and unconcerned with what it leaves behind and how it endangers its very own continuity

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

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

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

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

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

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

Black and Scholes Option Pricing Model

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

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

Our Financial Mathematics

Equations of Value and Return

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

No context parameters

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

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

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

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

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

Sample of Asset Pricing Models

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

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

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

Ris

Time

Our Financial Value Framework

← *Time* →

↑
↓
Risk

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.

●

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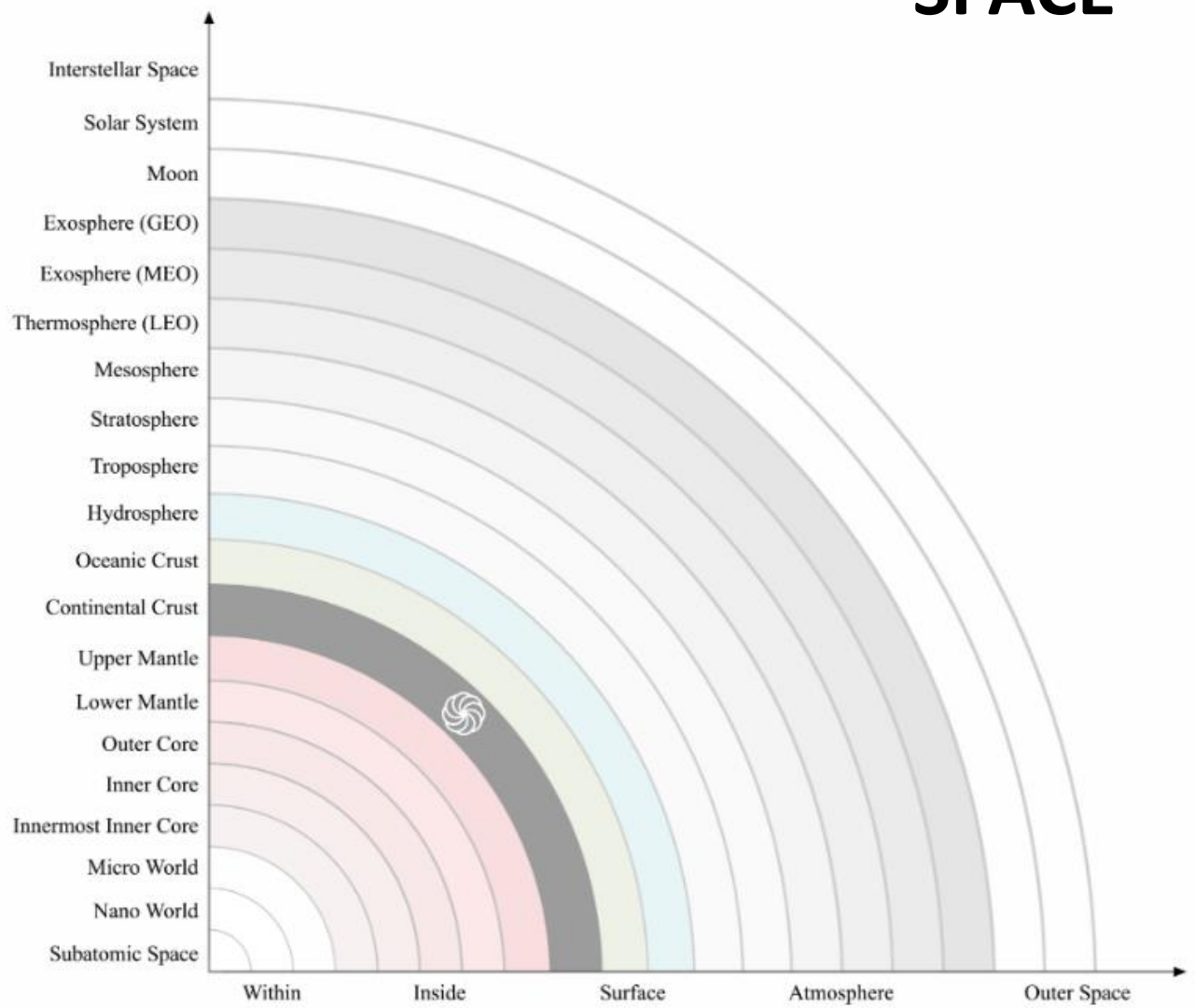t=Moving time
r=Discount Rate
II=Initial Investment
CFt=Future Expected Cash Flows

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.

When our financial value framework and equations omit space, and consequently our responsibility for impact in and on space
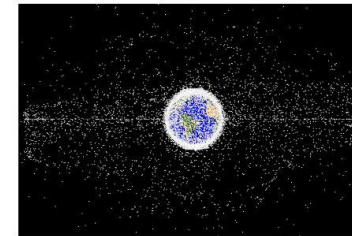
Sustainability in Finance: Frameworks, Standards, and Scores

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

Atmospheric CO_2 at Mauna Loa Observatory

Scripps Institution of Oceanography
NOAA Global Monitoring Laboratory

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

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
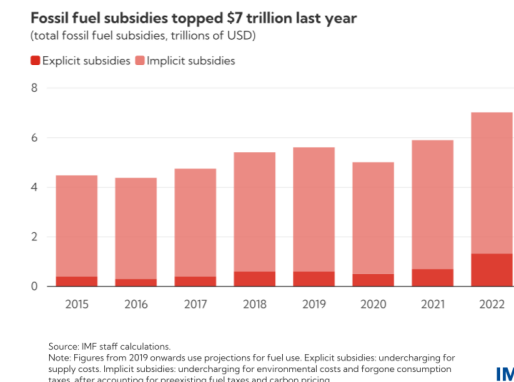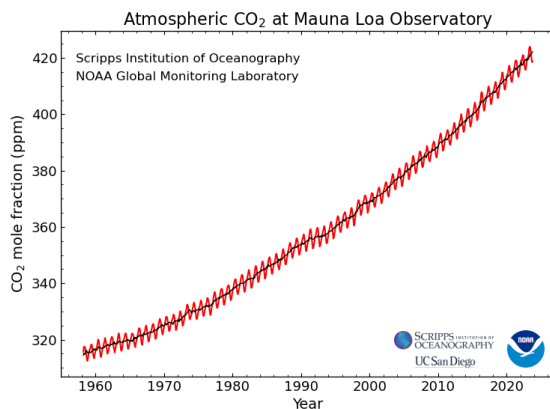
The Missing Dimension

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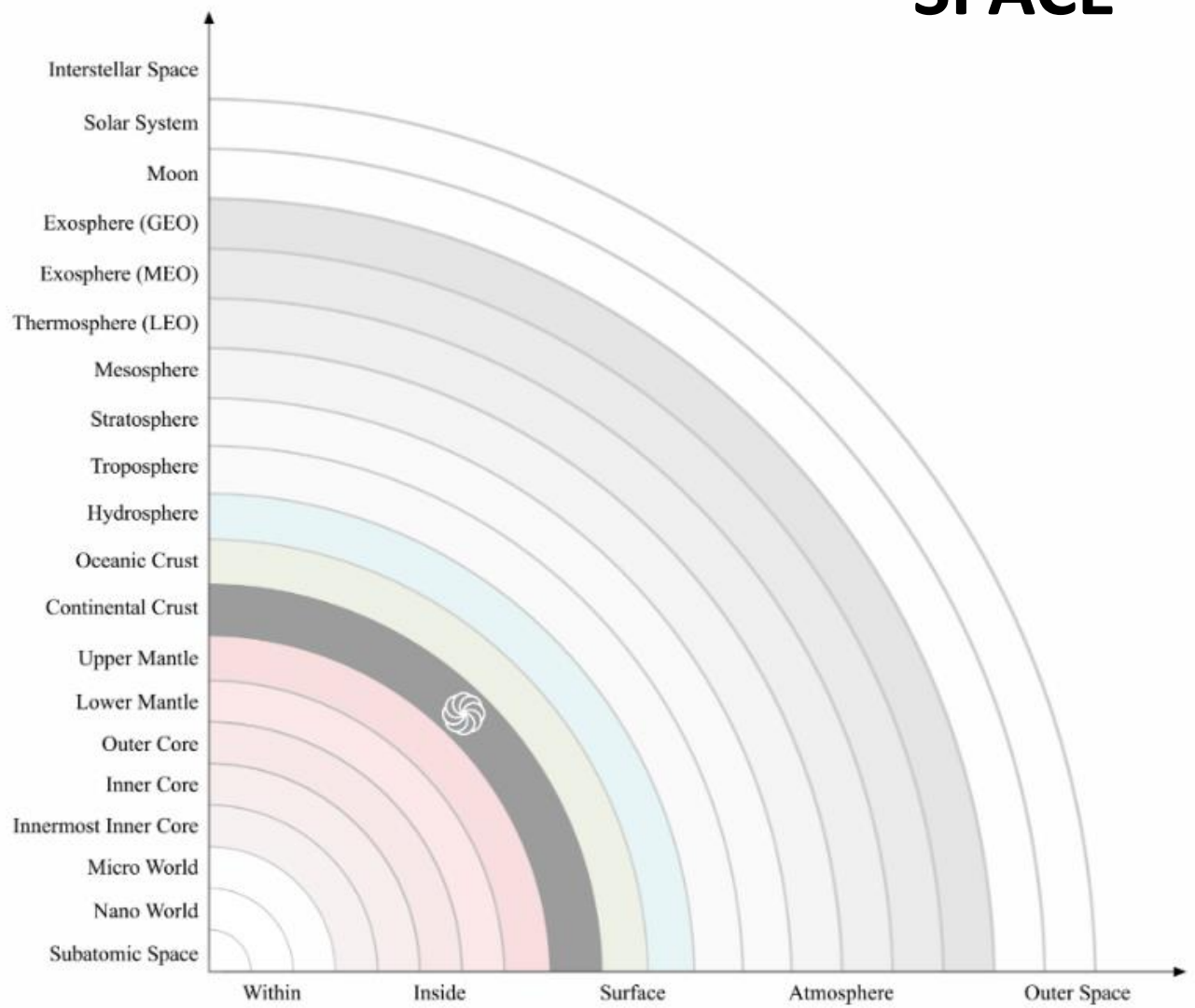
Why a layered analysis of space is key

$$\sum_{s=1}^{S}$$
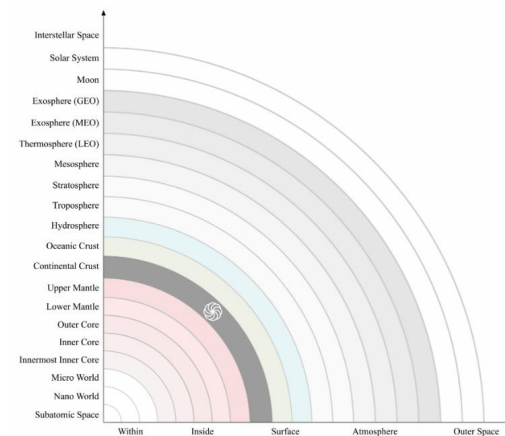
1- Value Chain: Because the value chains of investments affect different layers of space.

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

Investor Return

(3) + Return, - Impact   + Return, + Impact (4)

Investments Excluded
Through
Space Value of Money
Principle

Ideal Universe of Investments

Space Impact

Investments in these two quadrants are of no interest to investors
chasing their risk and time adjusted returns.

(2) - Return, - Impact   - Return, + Impact (1)
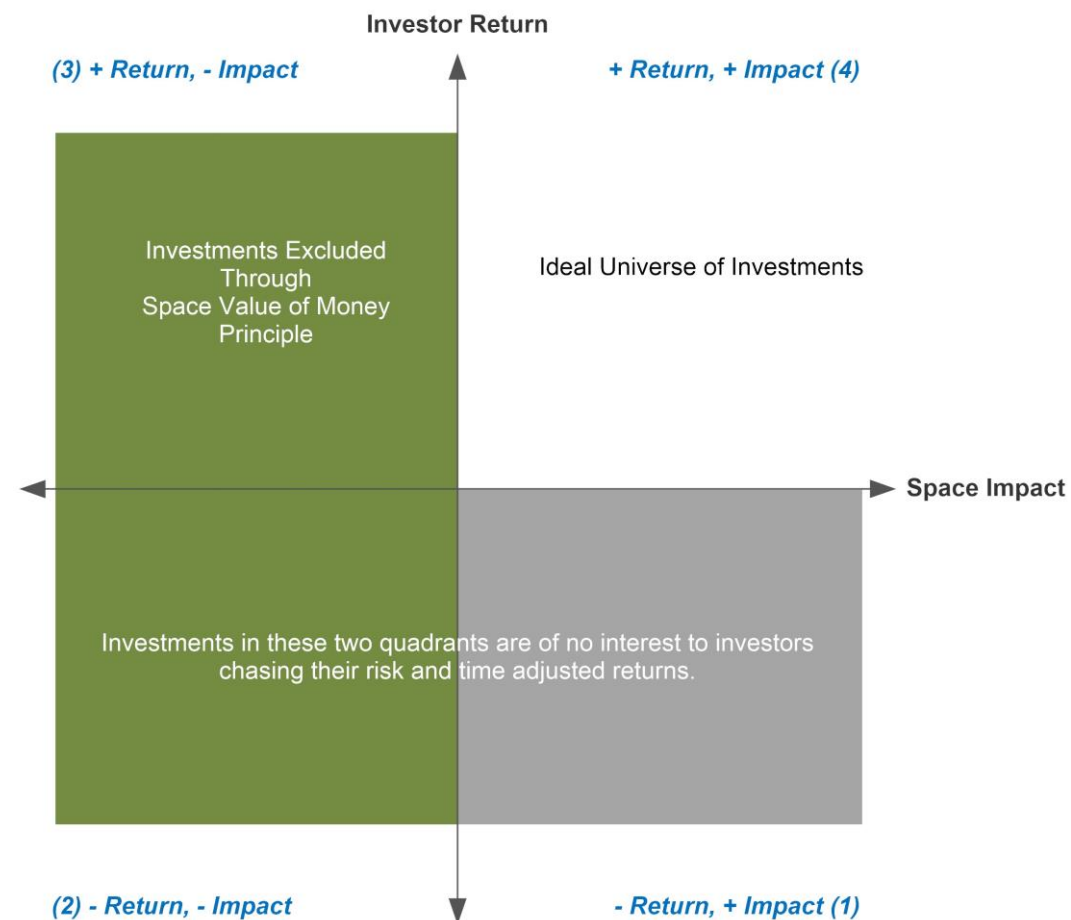
The New Stakeholders of Financial Mathematics

Mortal Risk-averse Return-maximising Investor

Planet and Humanity

The Space Value Framework

The Double Timeline

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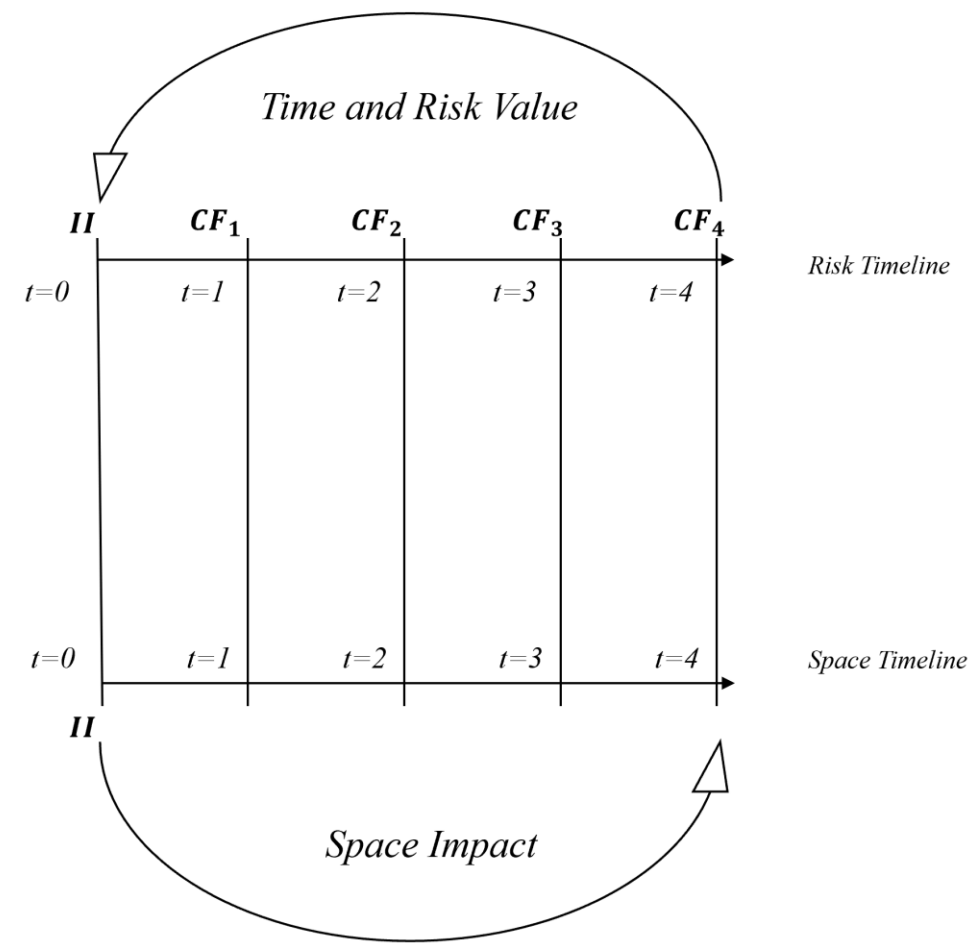
$$NSV_{T\&S} = \textbf{Net Space Value of Investment}$$

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

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

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

$$NSV_{T\&S} = \sum_{t=1}^{T}\sum_{s=1}^{S} Pollution\ \&\ Biodiversity\ Impact$$

$$+ \sum_{t=1}^{T}\sum_{s=1}^{S} Human\ Capital\ \&\ R\ and\ D\ Impact$$

$$+ \sum_{t=1}^{T}\sum_{s=1}^{S} New\ Asset\ \&\ New\ Money\ Impact$$

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

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

$$GSV = II$$

The Space Value Framework

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

The Space Value Framework

$$\textbf{\textit{Planetary Impact Intensity}}_t = \textit{PI and BI per Expected Cash Flow}_t$$

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

$$\textbf{\textit{Human Impact Intensity}}_t = \textit{HCI and RDI per Expected Cash Flow}_t$$

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

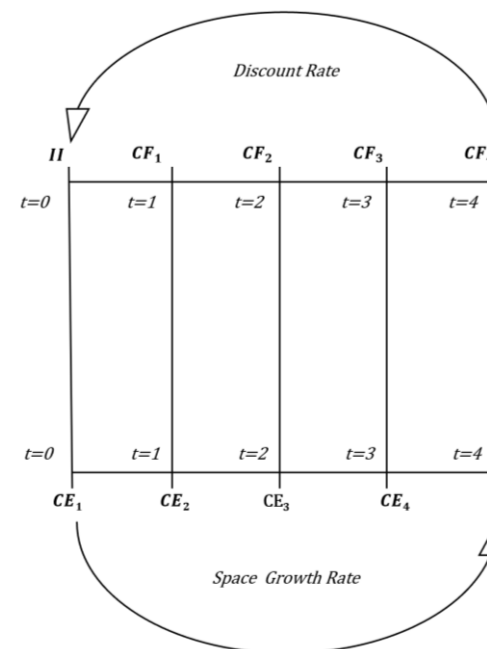$$\textbf{\textit{Economic Impact Intensity}}_t = \textit{NAI and NMI per Expected Cash Flow}_t$$

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

The Space Value Framework

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

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

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

The Space Value Framework

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

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

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

$$SPR_i \geq 0$$

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

$$R_i = Return\ on\ Investment\ or\ Security\ i$$
$$R_{min} = R_{minimum} =\ Return\ on\ Investment\ with\ minimum\ tolerted\ space\ impact$$
$$MSP_i = Market\ Space\ Premium\ on\ Security\ i$$

$$MSP_i = \theta_i.\,(R_{HIP} - R_{min})$$
$$R_{HIP} = Expected\ Return\ on\ High\ Impact\ Portfolio$$
$$\theta_i = Theta = Space\ Impact\ Sensitivity\ of\ Security\ i$$

$$\theta_i = \frac{Covariance_{R_i,NSV_i}}{Variance_{NSV_i}}$$

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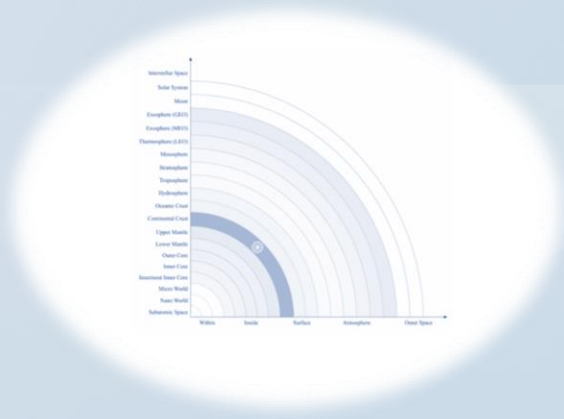
Technical implications on the assets, portfolios and transactions used by central and commercial Banks when creating new reserves, currency, and deposits.

	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

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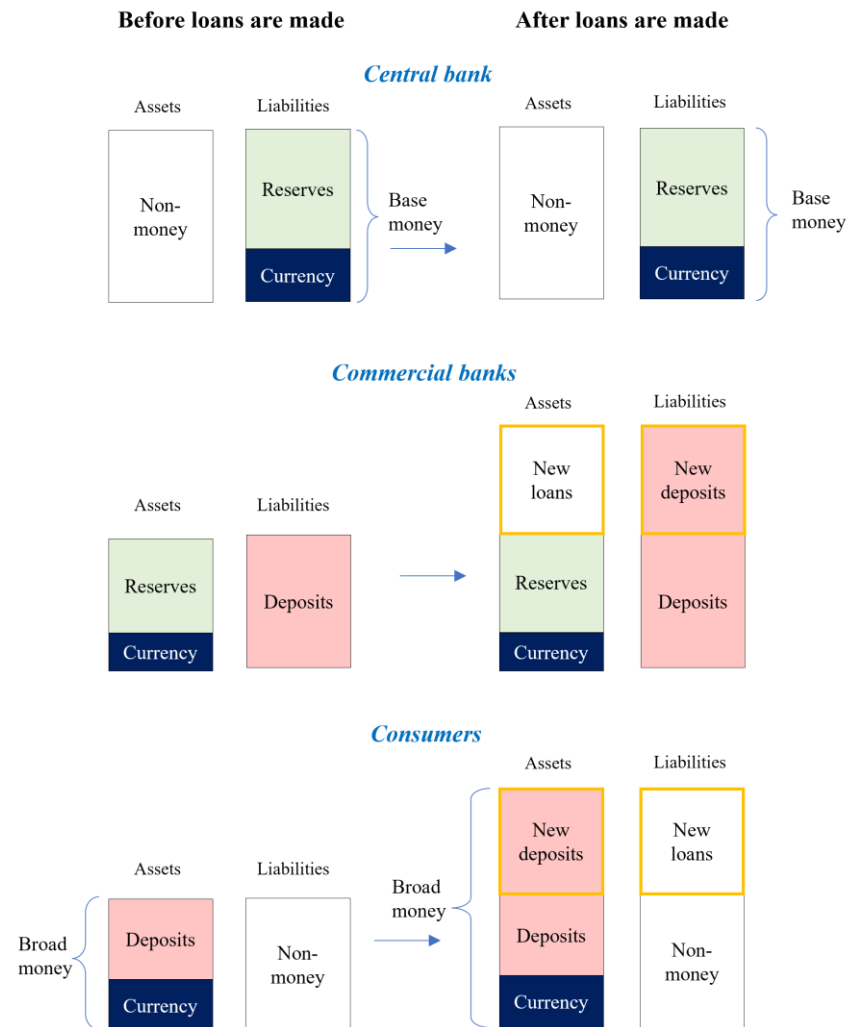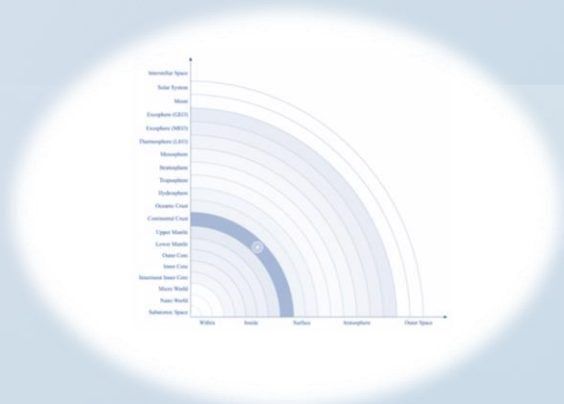
McLeay, M., A. Radia, and R. Thomas. 2014b. Money Creation in the Modern Economy. Bank of England. Quarterly Bulletin. https://www.bankofengland.co.uk/-/media/boe/files/quarterly-bulletin/2014/money-creation-in-themodern-economy.

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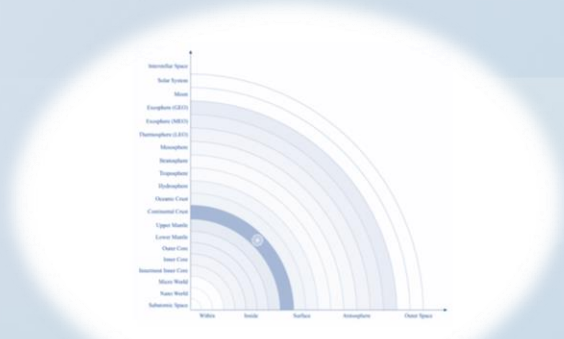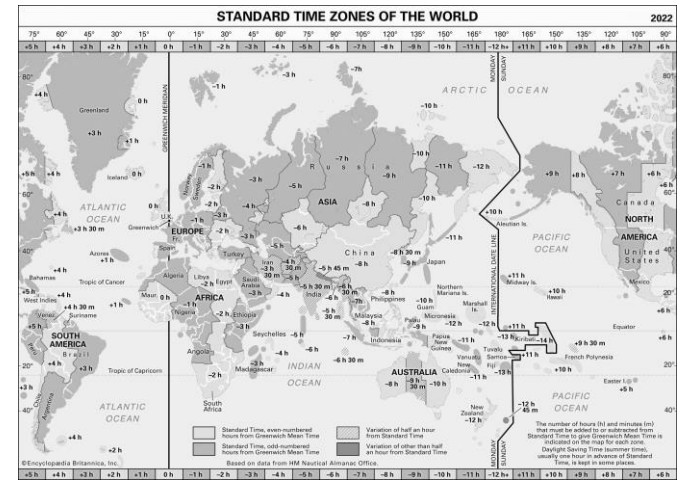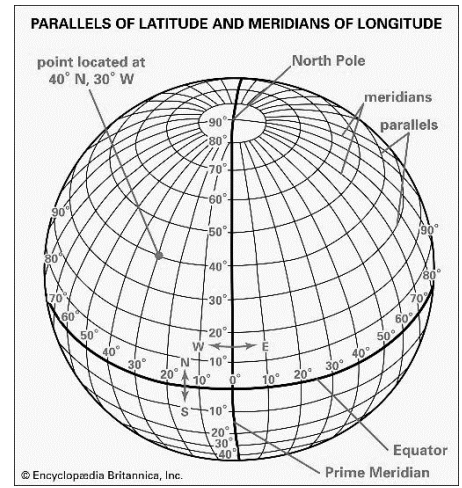
"The Prime Meridian is the line and the point at which the world's longitude is set at 0°. It does not exist in any strict material sense, yet through maps and clocks, the prime meridian governs the life of every human on Earth." (Withers 2017, 5)

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 <u>muzzle</u> limiting our ability to invest in space timelessly.

Monetary Gravity
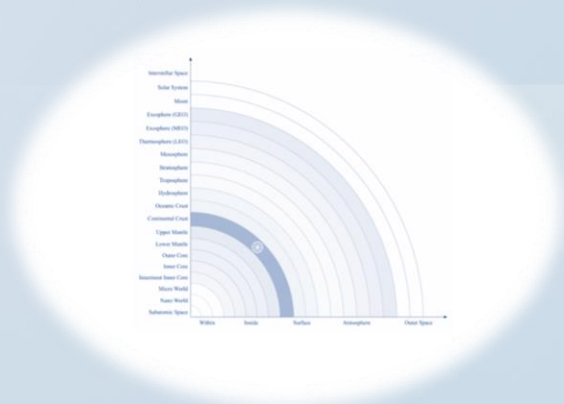
Any Process Funded Through Debt

Backward loop to money creator

i
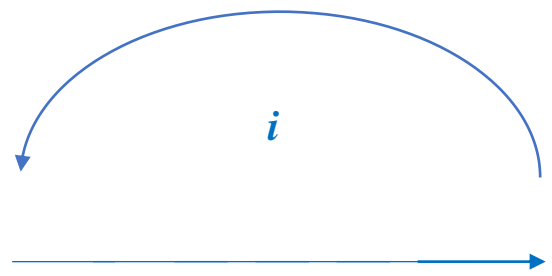
Even when paying interest and principal electronically

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 <u>leash</u> in space.

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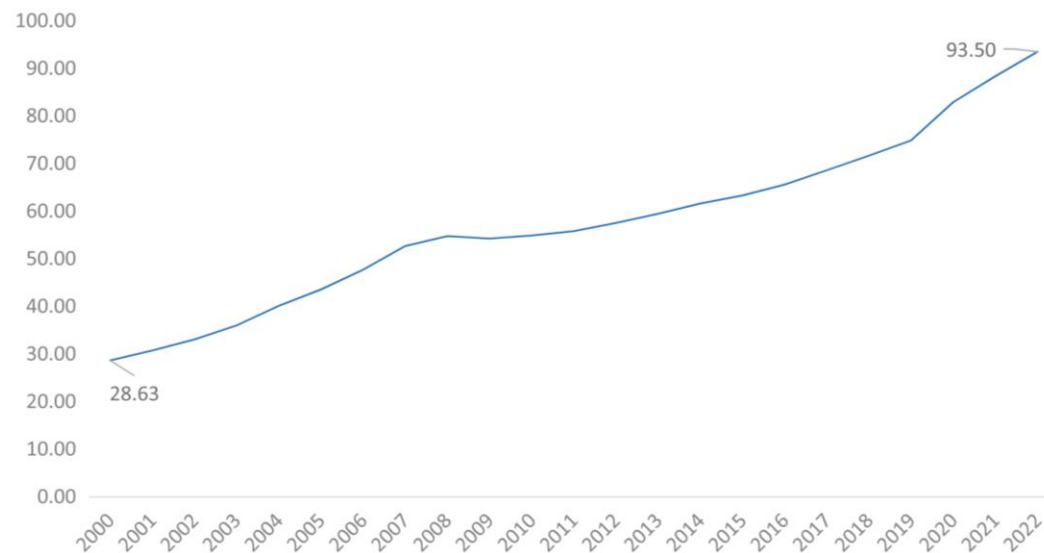
Chart 5.2 Total outstanding public and private debt USA, 2000–2022 in trillion US dollars (*Source* Statista [2022])

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 <u>whip</u> 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**

Value Easing is the transactional process undertaken by a central bank that consists in purchasing <u>non-debt</u> / <u>no-maturity</u> / <u>equity-like</u> / <u>high positive space value</u> 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.

We are in dire need of a money mechanics that has and creates positive space value and addresses the limitations of debt-based money
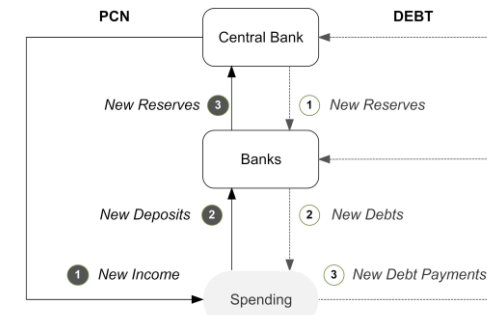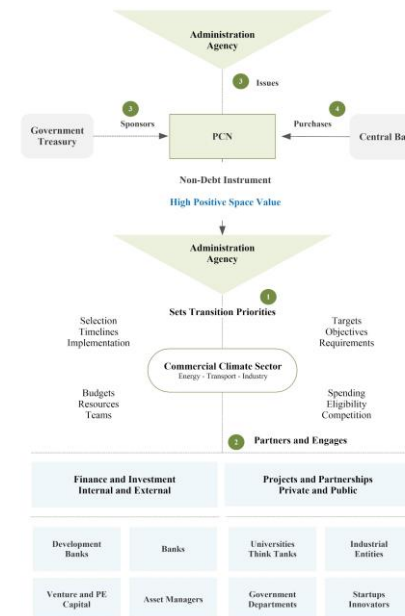
Climate PCN to fund the transition to a Net Zero sustainable world economy

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
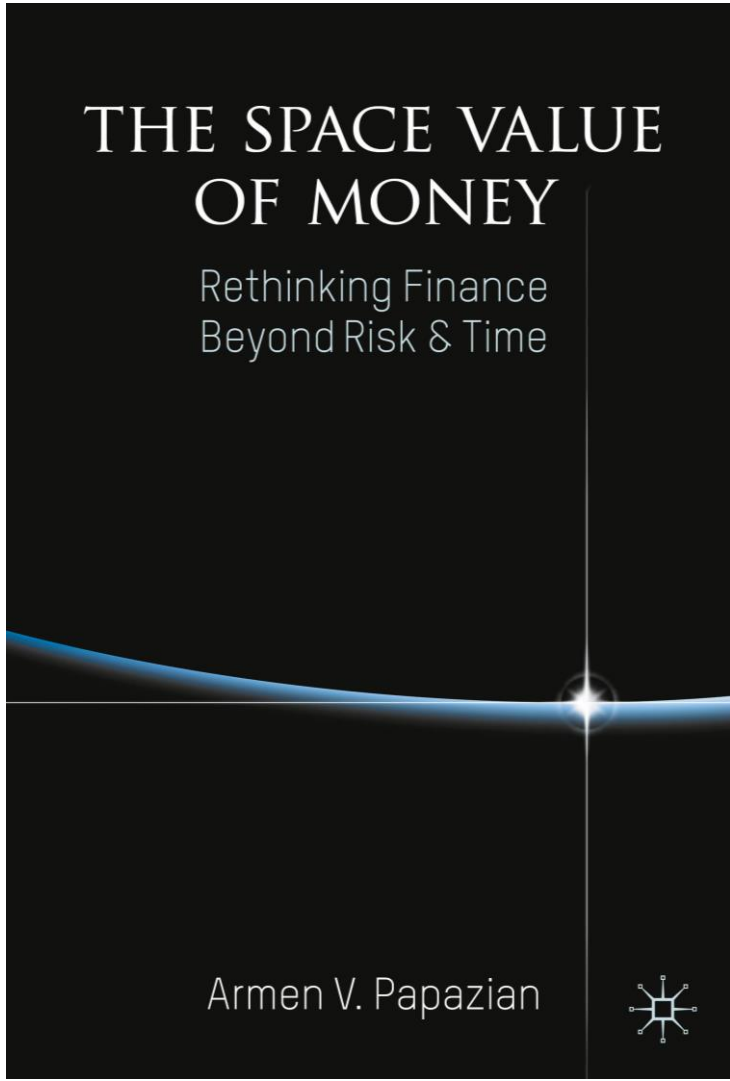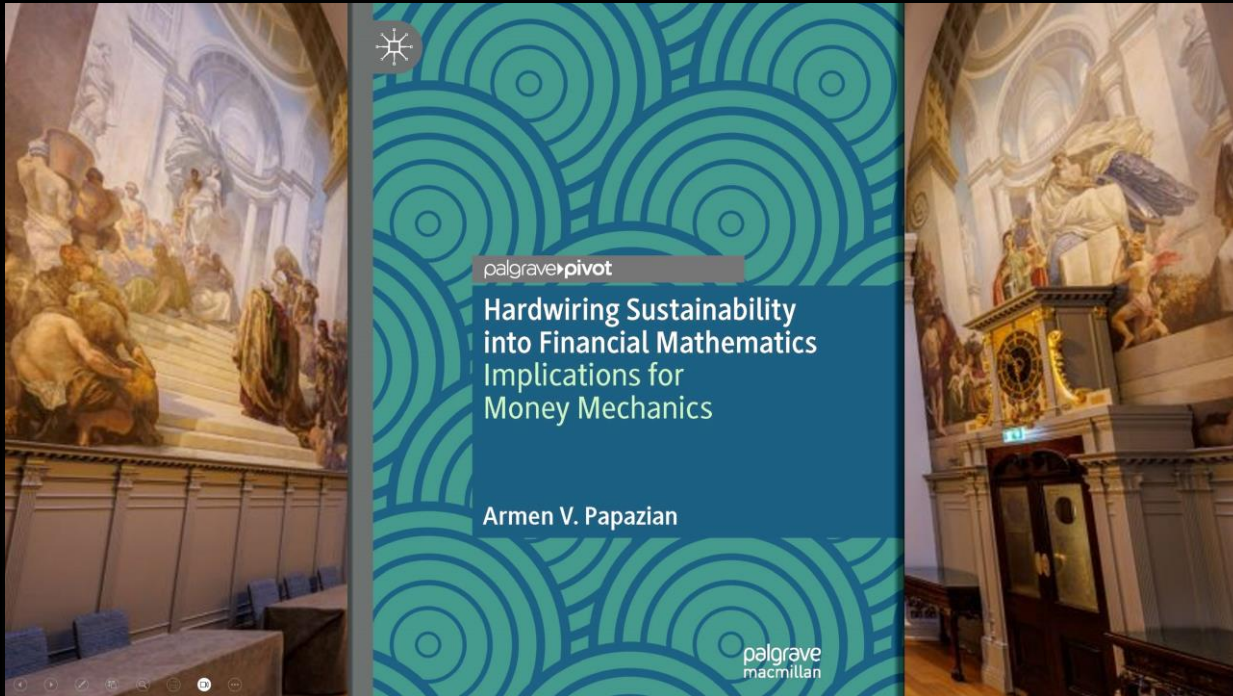
Armen V. Papazian

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
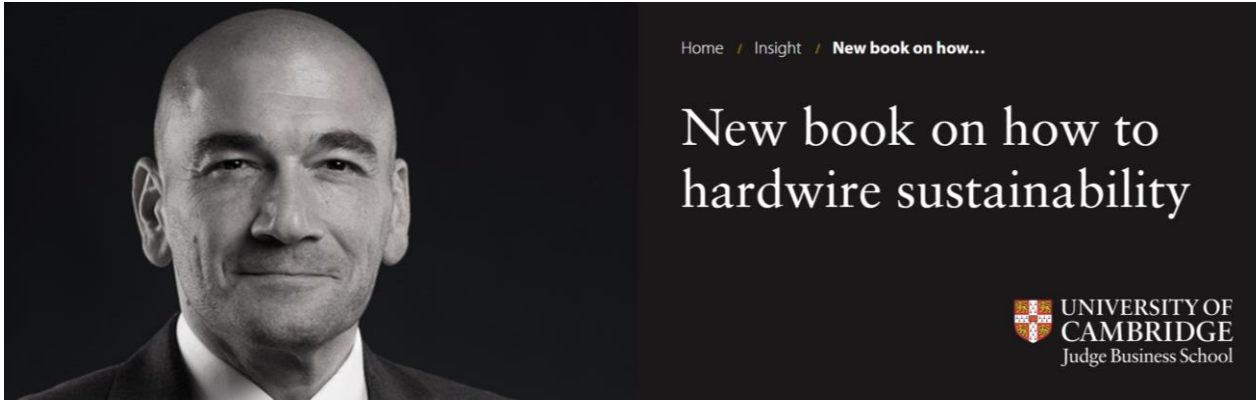
New book on how to hardwire sustainability

UNIVERSITY OF CAMBRIDGE — Judge Business School

Home / Insight / New book on how…

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

CITY OF LONDON · Federated Hermes Limited · UNIVERSITY OF CAMBRIDGE Judge Business School · CISI CHARTERED INSTITUTE FOR SECURITIES & INVESTMENT · KING'S COLLEGE CAMBRIDGE · palgrave macmillan · SPACE VALUE FOUNDATION

CISI — CHARTERED INSTITUTE FOR SECURITIES & INVESTMENT

palgrave pivot

Hardwiring Sustainability into Financial Mathematics
Implications for Money Mechanics

Armen V. Papazian

palgrave macmillan

"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

A ground-breaking work that addresses a crucial challenge facing our planet and the finance discipline, this book discusses key omissions in finance theory, principles, and equations, and explores recent developments in sustainable finance/ESG integration. It reveals a spaceless analytical framework and a sustainability debate that avoids the very logic of money creation. A theoretical treatise on sustainability in finance, the book makes the case for the hardwiring of sustainability into financial mathematics, offering a complementary principle and new equations for the purpose, while also discussing the implications of such a transformation for money mechanics.

Armen V. Papazian is a financial economist, board director, consultant, and author of *The Space Value of Money: Rethinking Finance Beyond Risk & Time*.

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www.palgrave.com

THE SPACE VALUE OF MONEY

RETHINKING FINANCE BEYOND RISK AND TIME

Armen V. Papazian

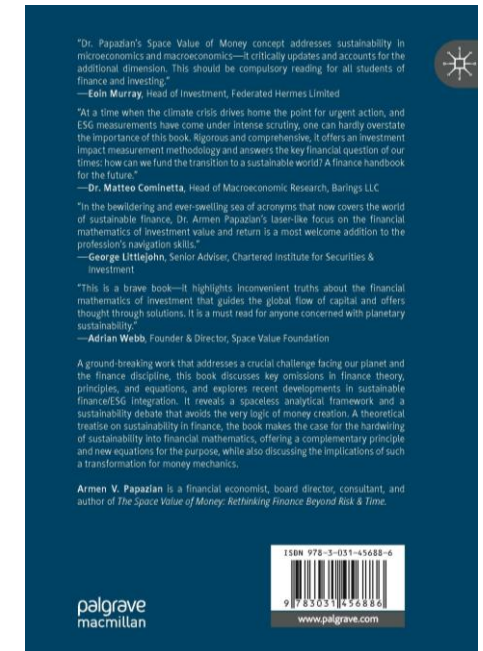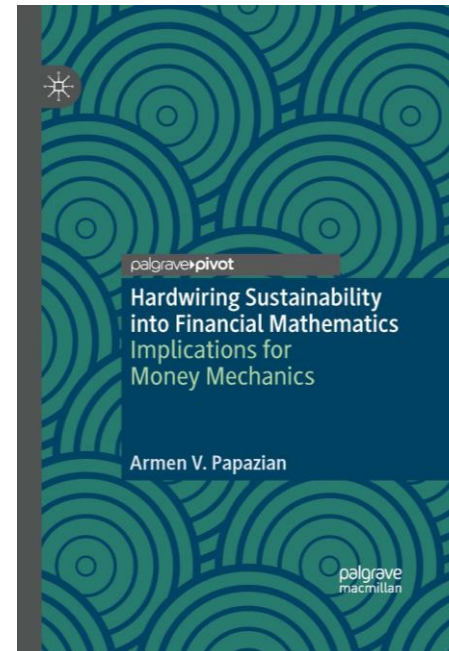A fresh and innovative perspective on sustainability and finance, the book proposes a change in the logic of the value of money to account for risk, time, and space parameters, and offers an approach through which we can meet the challenges of the Net Zero transition and facilitate long-term transformations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

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## 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

16:08 – Space Value Foundation Welcome

16:15 - Author Address

16:35 – Questions

16:45 – Book signings

– Drinks & Canapés reception

– Informal networking & discussion

18:30 – Close

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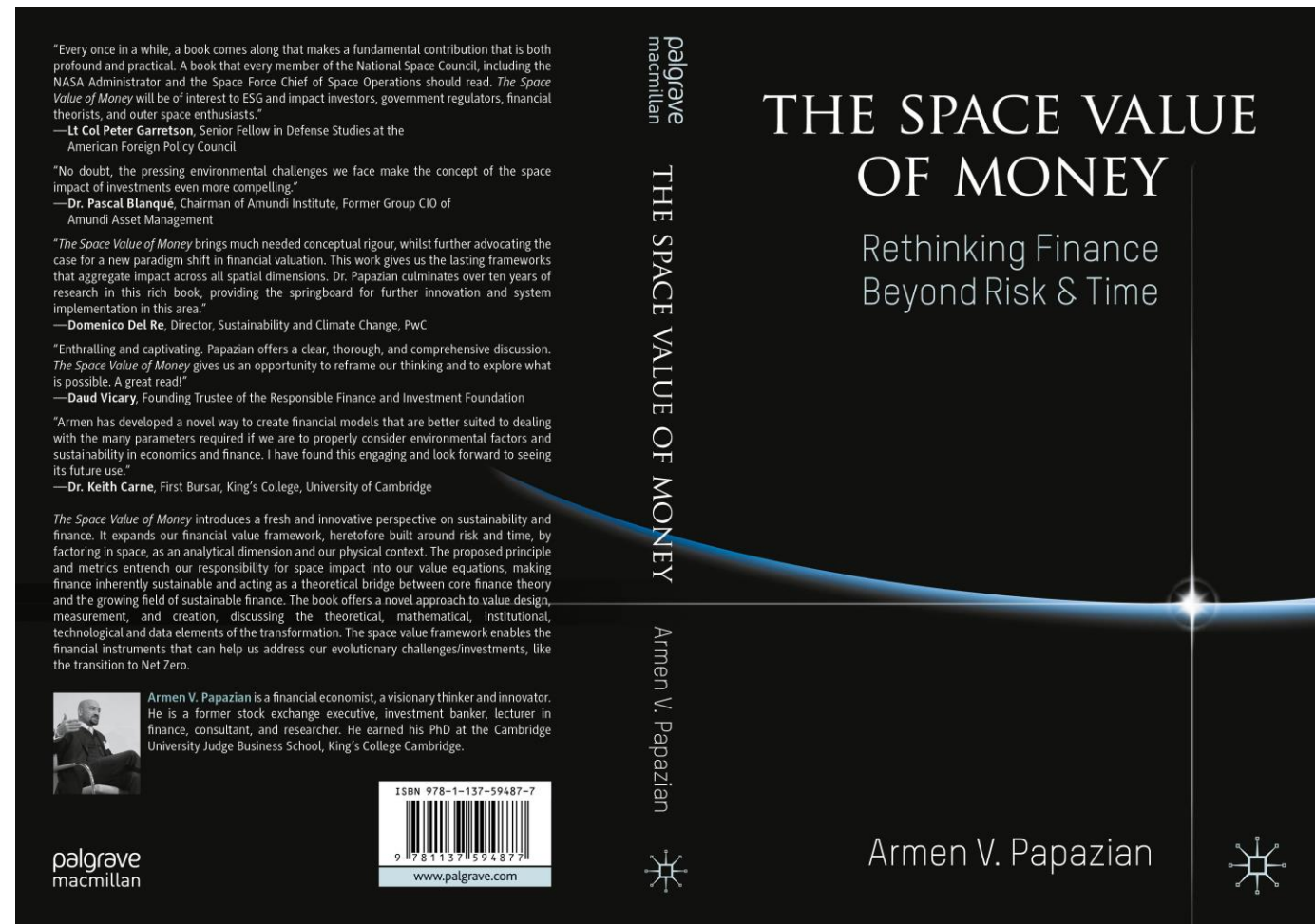
"Every once in a while, a book comes along that makes a fundamental contribution that is both profound and practical. A book that every member of the National Space Council, including the NASA Administrator and the Space Force Chief of Space Operations should read. *The Space Value of Money* will be of interest to ESG and impact investors, government regulators, financial theorists, and outer space enthusiasts."
—**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

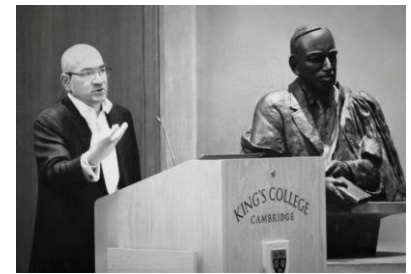Armen V. Papazian

THE SPACE VALUE OF MONEY

Rethinking Finance Beyond Risk & Time

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How can the 'Space Value of Money' boost sustainability?

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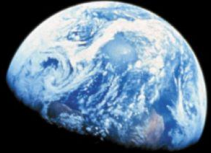
More About the Space Value Foundation

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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