TokenSpace: A Conceptual Framework for Cryptographic Asset Taxonomies*

Dr. Wassim Z. Alsindi[0000−0002−6701−0655]

Parallel Industries wassim@pllel.com
www.pllel.com

Abstract This work addresses the ongoing lack of legal clarity and inconsistent pronouncements regarding the regulatory status of cryptographic assets by introducing a novel series of classification approaches employing non-binary scoring systems. Novel taxonomies have been constructed based upon multi-level categorical and numerical discrimination methods following design science of information systems best practices. The aim is to provide greater explanatory insight with respect to the nuanced and complex ensemble of attributes which may be exhibited within this *sui generis* type of objects. The notions of Securityness ($\bar{\mathcal{S}}$), Moneyness ($\overline{\mathcal{M}}$) and Commodityness ($\bar{\mathcal{C}}$) are proposed as candidate meta-characteristics for "TokenSpace": a three-dimensional visual construction of subjective classification approaches towards a coherent and customisable conceptual framework. TokenSpace can be used to make reasoned qualitative and / or quantitative comparisons of asset properties. TokenSpace has more in common with successful prior classification frameworks in other domains and greater development potential using axiomatic, empirical and qualitative approaches than the sorting, clustering, intuitive or naïve categorisation approaches previously employed for cryptographic assets. TokenSpace provides a basis upon which real-time information feeds and predictive analytical tools may be developed in future.

Disclaimer, A Note to the Reader & Contributions The intended purpose of this work is to address a series of unclear and complex issues in the regulatory, compliance and legal domains through the application of a novel conceptual approach to asset classification.
The classification system design choices, scoring outputs and discussion of situational context have been made in an *ad hoc*, *approximate* and *subjective* manner and do not necessarily correlate to an objective representation of reality. *The author is not a lawyer, regulator or legal professional and has no definitive opinion on the regulatory or compliance status or consequences of assets being classified with particular assignations by any territorial or jurisdictional legislature. By reading this document any further you agree that the author accepts no liability or responsibility for the results outlined below or any discussions arising thereof. TS10, TSL7 and TSTDX TokenSpace scores are provided for intellectual purposes and the aforementioned TokenSpaces is an abstract and hypothetical representation based upon the methodologies developed in this work.* If you do not agree to these stipulations, you are not permitted to read this document.

Dear reader, the methodologies and conceptual frameworks included in this manuscript are intended to be useful to legal, regulatory and compliance professionals as well as researchers, investment managers, asset issuers and token engineers in order to compare and contrast the evolving properties of cryptographic networks and assets over time. Though the example taxonomies and TokenSpaces included here are largely based on certain perspectives, the methodology is sufficiently generalisable to be readily repurposable.
Sections 1 and 2 provide introductory background, historical and justification for the development of cryptographic asset classification approaches. Section 3 outlines design choices and considerations for a generalised methodology to build TokenSpaces and the exercise applied to the meta-characteristics identified given the context in sections 1 and 2 to create the *TS10* instantiation of TokenSpace. Section 4 contains the complete *TS10* TokenSpace taxonomies, outputs, analysis and findings alongside miniature *TSL7* and *TSTDX* TokenSpace case studies facilitating comparisons of legacy and cryptographic assets and time-dependence of asset characteristics respectively.

Keywords: Cryptocurrency · Taxonomy · Blockchain · Asset Characterisation

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TokenSpace Primer The instantiation of TokenSpace presented in this work may be considered by analogy with our own spatio-temporal conception of reality, consisting of a three-dimensional space delineated (for convenience and visual clarity) by orthogonal axes $\bar{\mathcal{S}}$, $\overline{\mathcal{M}}$ and $\bar{\mathcal{C}}$ as depicted in Figure A. Assets may possess a score or range on each axis between 0 and 1 inclusive giving rise to an object inhabiting a region of TokenSpace described by the (x, y, z) coordinates ($\bar{\mathcal{C}}$, $\overline{\mathcal{M}}$, $\bar{\mathcal{S}}$). Time-dependence of object properties may also be incorporated to reflect the dynamic nature of cryptocurrency protocol networks and their native assets, tokens issued atop them and network fragmentations such as ledger forks (see §3.3.6).

$\bar{\mathcal{S}}$, $\overline{\mathcal{M}}$ and $\bar{\mathcal{C}}$ correspond to intuitively reasoned assignments of subjective classificatory meta-characteristics Securityness, Moneyness and Commodityness which together form the basis of *TS10* classification methods (see §4). Each asset's location in TokenSpace is intended to be derived from a weighted scoring system based upon taxonomy, typology, intuitive, elicited and / or quantitative methods depending on the choices and assertions of the user - which may or may not be identical to those proposed in this work.

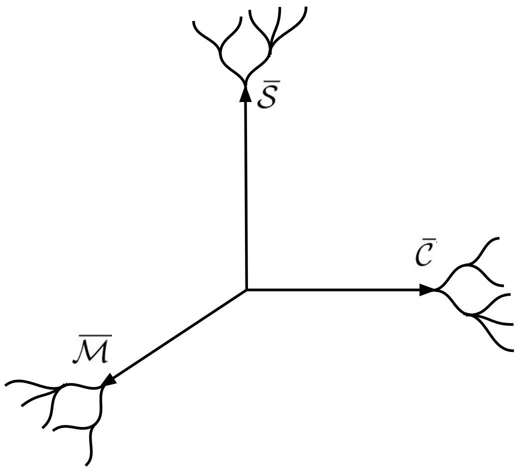

Figure A: TokenSpace visual impression

Definitions of the proposed meta-characteristics:

$\bar{\mathcal{S}}$ - Securityness. The extent to which an item or instrument exhibits characteristics of a securitised asset. For the purposes of clarity this meta-characteristic does not refer to how *secure* (robust / resistant) a particular network or asset is from adversarial or malicious actions.

$\overline{\mathcal{M}}$ - Moneyness. The extent to which an item or instrument exhibits characteristics of a monetary asset.

$\bar{\mathcal{C}}$ - Commodityness. The extent to which an item or instrument exhibits characteristics of a commoditised asset.

Example scores for a range of assets are outlined in Tables A, B and C below with graphical presentation in Figure B. Ideal types are postulated canonical examples of particular asset types and are discussed in §2.2.

It is the aim of this and future research to provide suggestions for classification approaches and some examples on how TokenSpace may be utilised to comparatively characterise assets from the perspective of various ecosystem stakeholders. Time-dependence may also be significant in certain instances and can be incorporated into this framework by evaluating an asset's location in TokenSpace at different points in time and charting asset trajectories.

TokenSpace is expected to be useful to regulators, investors, researchers, token engineers and exchange operators who may construct their own scoring systems based on these concepts. Careful review of territory-specific regulatory guidance and judicious consideration of boundary functions for example delineating "*safe*", "*marginal*" or "*dangerous*" likely compliance of assets with respect to particular regulatory regimes are recommended and an example is presented in Figure C. Parallel Industries has developed hybrid multi-level hybrid categorical / numerical taxonomies for each meta-characteristic alongside time-dependent and probability distribution functions for anisotropic score modelling and is available to develop bespoke TokenSpaces for clients on consulting and contract research bases.

Securityness: example scores as of April 2019

Asset	$\bar{\mathcal{S}}$	Notes
AAPL	1.00	Ideal type for securitised asset*
XRP	0.75	Supply & node operation highly concentrated, no validation reward, missing ledger history
DAO	0.90	Collective investment vehicle, capital risked
BTC	0.09	Leaderless, permissionless
ETH (2015)	0.75	Minimal network functionality
ETH (2019)	0.48	*"sufficiently decentralised"***
GOLD (metal)	0.00	Ideal type for non-securitised asset
SOY (beans)	0.00	Ideal type for non-securitised asset
USD	0.20	Reliance on faith in fiscal prudence of US Government & Federal Reserve

*see Bailey §2.1, **see Hinman summer 2018 comments §1.3.3

Moneyness: example scores as of April 2019

Asset	$\overline{\mathcal{M}}$	Notes
AAPL	0.05	Approaching ideal type of non-monetary asset, limited utility as MoE
XRP	0.10	Used as regulatory arbitrage vehicle and speculative asset with limited utility. Central parties can censor
GOLD (metal)	0.40*	Non-standardised, prone to dilution, necessitates verification of mass and purity
GOLD coins (pre-state minting)	0.50*	Dilution *via* clipping
GOLD coins (state mint)	0.60*	Improved anti-counterfeiting measures
SOY beans	0.05	MoE restricted to barter, consumption or use as underlying for a derivative instrument
CHF	0.80	Approaching ideal type of modern fiat currency
USD	0.70	Inflationary, with supply debasement (Triffin dilemma)
GBP	0.50	Post-reserve currency decline, Brexit uncertainty
BTC	0.41**	Post-bootstrap uncertainty
ETH (2015)	0.03***	
ETH (2019)	0.22***	Not intended to be a monetary asset but has become an MoE and UofA in some circumstances

*Loss of $\overline{\mathcal{M}}$ over time due to digitalisation / simulacrisation of money (see §1.3.1)
*Uncertainty of post-bootstrap phase network security incentives
**Uncertainty of post-bootstrap phase network security incentives
***Uncertain monetary policy, central influence, technical debt & future viability

Commodityness: example scores as of April 2019

Asset	$\bar{\mathcal{C}}$	Notes
AAPL	0.00	Ideal type of a non-commoditised asset
XRP	0.18	Censorability of payments and supply concentration among insiders too great to be freely tradeable
DAO	0.45	Hybrid of security and commodity
BTC	0.68	Ideal type of a digital commoditised asset
ETH (2015)	0.10	Minimal network functionality
ETH (2019)	0.42	Used as a digital utility for token sales and persistent scripts
GOLD (metal)	0.95	Ideal type of a material commoditised non-consumable asset
GOLD (coins)	0.80	Purity assessment and faith in provenance
SOY beans	1.00	Ideal type of a material commoditised consumable asset
USD (pre-1971)	0.55	Proxy for precious metals, state backed
USD	0.25	Loss of gold peg, debasement of supply

*Increase of $\bar{\mathcal{C}}$ over time due to functionality and adoption (see §1.3.2)

Tables A, B and C: Example TokenSpace meta-characteristic scores listed to two decimal places

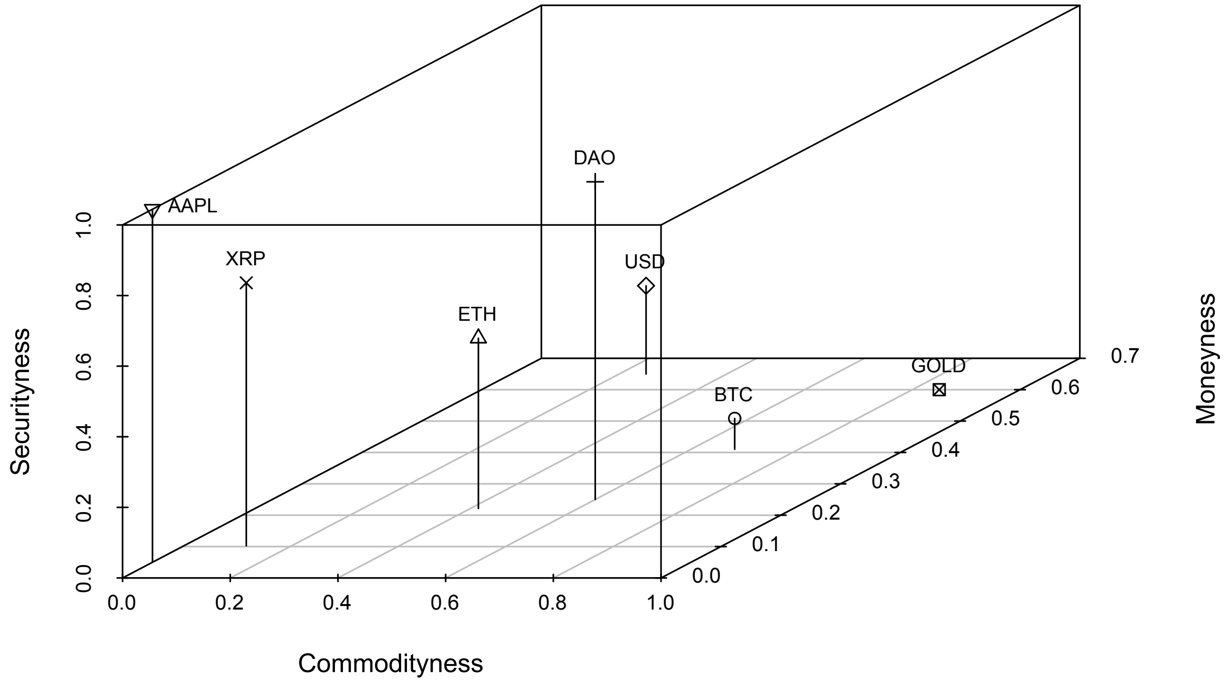

Figure B: Example of objects inhabiting a TokenSpace

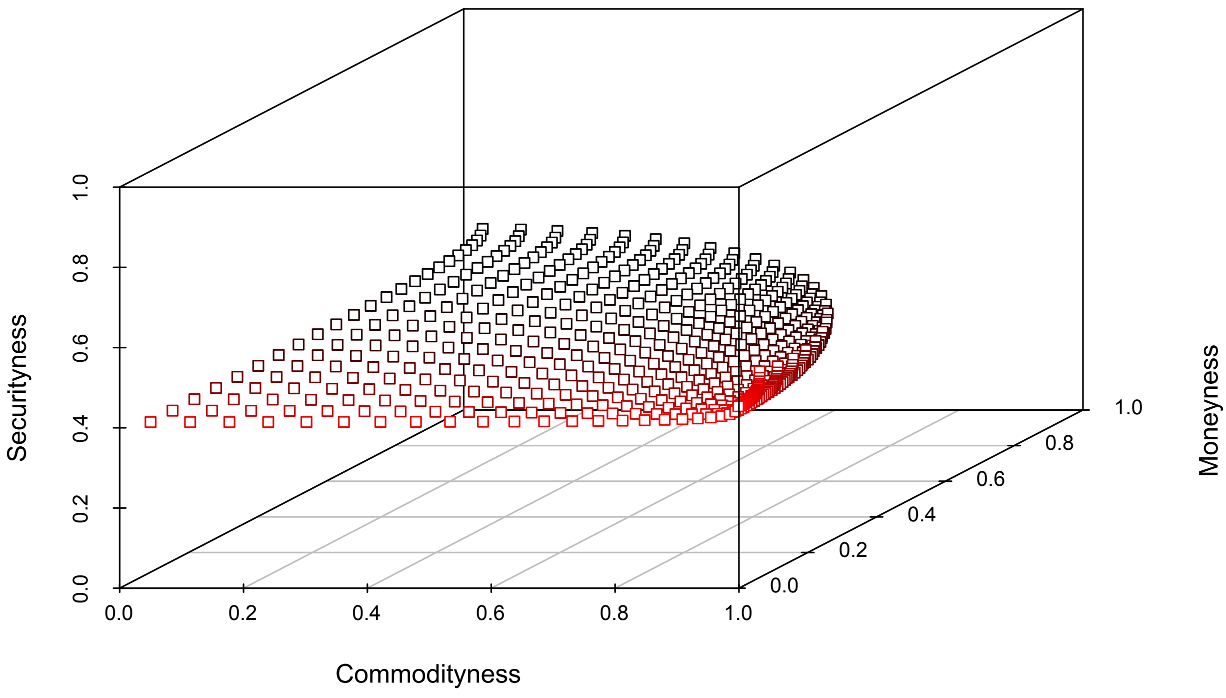

Figure C: Regulatory / compliance boundary visualised in TokenSpace. Arbitrary polynomial for illustrative purposes

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1 Introduction & Historical Review

1.1 Necessity for the Work, Regulatory Opacity & Uncertainty

Open permissionless systems' architecture, functionality and behaviour are radically different to legacy finance structures and there are numerous unanswered questions as to how best to integrate the two, if they are even meaningfully compatible at all. The canonical example of the present day disconnect between traditional finance and *crypto-finance* is without doubt the explosion in disintermediated early-stage venture fundraising through non-equity cryptographic token issuance known popularly as *Initial Coin Offerings* (ICOs). Key drivers for this proliferation are combination of a lack of political, legislative and economic clarity at the nation-state level with respect to cryptographic assets (*cryptoassets*), enabling *regulatory arbitrage* using these nascent "decentralised" technologies [1]. For the purposes of this work cryptoassets are considered to be token-based cryptoeconomic primitives typically issued in trust-minimised distributed environments.

Surrounding these peer-to-peer (P2P) networks and token issuers are a sprawling industry of service providers such as exchanges, public relations advisors, crowdsale consultants, mining operations, crypto-lawyers, wallet hardware and software providers, asset custody services and merchants accepting cryptocurrency which collectively bear resemblance to a wild *distributed boomtown* facilitated by the borderless nature of the technology enabling sophisticated forms of regulatory arbitrage such as *dynamic jurisdiction shopping* as well as other less savoury practices. Regulators and lawmakers have yet to converge upon a coherent legal basis upon which to attempt to regulate cryptographic assets, and due to variations between jurisdictions a global game of regulatory arbitrage *in extremis* has been taking place in numerous locations. Implementing regulation is proving to be far from straightforward, not least because the very act of doing so would likely trigger so-called KYC *factional disintegration events* as is currently in danger of being experienced in the Tezos ecosystem [2].

Since 2008, the scope of capability for financial technology has broadened significantly. Indeed for *value-oriented protocol networks* and associated applications of cryptography the landscape has changed unrecognisably. *Bitcoin* has heralded the instantiation of a new paradigm of open-source, leaderless and permissionless value transfer without rent-seeking intermediaries, giving rise to a realised vision of Friedrich Hayek's *Prize in Economic Sciences in Memory of Alfred Nobel* winning exploratory swathe encapsulated in "*The Denationalisation of Money*" [3]. This optimistic future is resplendent with sunny uplands of individual freedom, monetary sovereignty and empowerment at the expense of figuratively or literally bankrupt legacy finance, wealth management and banking institutions. Bitcoin comprises an effectively dispersed leaderless network, inventively combining a series of technological elements taken from applied cryptography and distributed systems. These are chiefly public-key cryptography to secure wallets and transactions through digital signatures, a thermodynamic solution to the *double-spend distributed consensus problem* incorporating game theoretical elements - *proof-of-work* (PoW) and *Nakamoto Consensus* respectively and strengthening of the *linked list* data architecture. These elements are brought together to create a novel type of pervasive, high-assurance data structure with desirable tamper-resistant characteristics as a basis for the robust implementation of a triple-entry financial ledger possessing formally specified characteristics such as *persistence* (tamper resistance and / or evidence), *liveness* (synchronous messaging requirements placing upper bounds on delivery delay) and *dynamic availability* (nodes can join and leave the network at will). In other words, a so-called "*blockchain*", "*timechain*", "*brickstring*" or "*timecube*" [4].

In the past decade, Bitcoin and related value-oriented protocol networks have proliferated in a manner akin to the *Cambrian Explosion*, with myriad permutations of Bitcoin's characteristic parameters being varied in order to launch independent but similar networks either with a new genesis block - a *codebase fork* - or by continuing the Bitcoin network's ledger history upon divergence at some specified point in time - a *ledger fork* [5]. The same has occurred with cryptocurrency projects built upon novel codebases such as *Ethereum*, leading to the proliferation of ostensible families of genealogically-related codebase and ledger forks. As with the prehistoric Cambrian Explosion, many of these upstart networks and factions do not appear to be created upon sound foundations and as such their longevity may be particularly influenced by the equivalent of an incoming regulatory *Ice Age*. This rapid expansion in complexity and diversity of cryptographic assets poses a series of challenges for protocol developers, token issuers, cryptocurrency researchers, legal professionals and lawmakers attempting to navigate nation-state regulation of these items. Due to the borderless nature of the technology in question and many grey areas in the nature, usage and function of these networks and assets, the aforementioned prospect of regulatory arbitrage with multiple mechanisms is being widely leveraged by token issuers, exchange operators and even nation-states attempting to entice digital enterprise to their territory.

Certain countries have moved quickly to increase their attractiveness to those engaging in what has become a dynamic jurisdictional shopping competition with particular cases of note currently including Malta, Singapore, Hong Kong, Vanuatu, Puerto Rico, Mauritius, Panama, Bermuda, Belarus, Georgia and Britain alongside associated Crown territories such as Gibraltar, Isle of Man and the British Virgin Islands.

Indeed Malta has taken to using the epithet "*Blockchain Island*" to further attract cryptocurrency related industry participants, promising attractive taxation and banking arrangements to many billion-dollar valuation companies which were otherwise itinerantly nation-hopping - with highest profile example being the leading global cryptoasset exchange Binance. The act of facilitating this effective safe harbour for Binance and fellow Asian exchange OKEx had an overnight double-digit impact on the GDP of Malta with the action doubling as a high-visibility signal that Malta was welcoming to businesses struggling with onerous regulatory and compliance requirements in their existing domiciles [6].

1.2 Hybrid Character of Cryptocurrency Networks & Assets, the Complex Provenance & Nature of Decentralisation

With reference to well established classes or types of legacy assets - such as precious metals, stocks, bonds and derivatives - that exhibit fairly clear similarities and differences, cryptoassets appear to be less well-defined by comparison to individual legacy asset classes and may be considered *sui generis*, without close historical counterparts. They frequently but non-exhaustively exhibit hybridised properties being part commoditised bearer asset, part monetary payments medium and network, with the possibility of *commodity-like* intrinsic functionality - in the sense of a so-called *utility token* - or *security-like* on-chain cashflows from more recent alternative extensions to base protocol blueprints such as masternodes or staking.

A complicating factor is that there may be different regulatory agencies within a jurisdiction that cover specific subsets of financial assets - *e.g.* in the United States both the *Securities & Exchange Commission* (SEC) and *Commodities & Futures Trading Commission* (CFTC) agencies claim primacy over cryptocurrencies and related products - therefore a BTC *Futures* contract would be regulated in the US by the CFTC whilst a Bitcoin *Exchange-Traded Fund* (ETF) or an ICO startup might be regulated by the SEC or both SEC and CFTC. This is without even considering overlapping purview with the *Financial Crimes Enforcement Network* (FINCEN) or other US government agencies. This may well lead to a *attention bias* or *Rorschach test* scenario, where regulatory officials with specific remits may be inclined to see specific aspects of cryptoassets as being the leading traits and therefore claim the dominant regulatory purview falls within their domain.

In particular the complex and multi-faceted meaning and provenance of decentralisation is far from trivial to characterise, with its influence and impact on the security-like properties of an asset challenging to elucidate. As a phrase originally coined by de Toqueville as an antonym to the centralisation of state power before and after the French Revolution, a precise definition of the term decentralisation in the technological context would greatly reduce the lack of linguistic precision routinely encountered in the context of tokenised networks and assets [7]. A number of approaches to characterise decentralisation as a meaningful or even quantifiable metric have been made, with varying insights and degrees of success [8, 9]. In the opinion of the author decentralisation is an emergent, non-binary characteristic of P2P distributed networks which is contributed to by an ensemble of factors and is commonly found alongside several other similarly difficult to parametrise characteristics. Examples of these are immutability, defined here as persistence of the canonical transaction set from which the ledger is constructed, permissionlessness which refers to the lack of prevention at the social layer of any network participant from transacting and censorship-resistance, taken here to correspond to the inability of third parties to prevent network participants from transacting using actions at the protocol layer [4].

A helpful framework for the rationalisation of phenomena in cryptocurrency networks is to coarsely consider the entire network and ecosystem as a "stack of layers" as is commonly done with computational networks such as the Open Systems Interconnection model [10]. An example delineation of the cryptocurrency network meta-stack has been proposed by Alsindi & Breen following work by Buterin and this is incorporated in Table 1. [4, 11].

Social / Political	All human decision making and interests arising from the chief stakeholder groups of a network. Typically developers, users, miners, validators and businesses.
Monetary	Transactions, addresses, tokenised incentives and / or monetary issuance (*via* for example proof-of-work), emergent economic characteristics arising from human and autonomous agents employing a P2P monetary network as a value transfer mechanism. (*e.g.* M1, M2, stock-to-flow, price inelasticity of supply).
Protocol	Cryptographic primitives, data structures employed, protocol specifications, nodes implementing the network consensus rules and P2P network messaging behaviour.
Logical / Architectural	Is the data itself stored in a highly redundant and / or replicated manner. Does the network rely overly on centralised backbone infrastructure?

Table 1: Facets of Decentralisation [4, 11]

With this conceptual model in mind, it could be said that immutability is an attribute primarily observed at the protocol layer - upon which the monetary layer depends for persistence - and censorship-resistance is primarily observed at the monetary and social / political layers. Similarly, the word decentralisation could be taken to have different meanings when considering the various layers in question. Protocol decentralisation could refer to distribution of nodes and other incentivised stakeholders such as *miners* and *stakers* that undertake transactions and / or block creation and validation activities. Monetary decentralisation could be described by the distribution of the supply of the asset, which the Gini coefficient attempts to encapsulate [8]. Social decentralisation could be related to the decision-making (or governance) process of a network, and whether some subset of stakeholder constituents are able to exert undue degrees of explicit or implicit influence over a network's outcomes.

1.3 Legal, Economic & Regulatory Characteristics of Cryptographic & Legacy Assets

It is instructive to revisit historical descriptions and characterisations of legacy asset classes - in this case moneys, commodities and securities - to understand how prior classificatory and ontological approaches developed and how these might be integrated into novel subjective conceptual frameworks such as TokenSpace (§3).

1.3.1 Nature of Money Throughout the Ages Scholars in the domains of natural philosophy, law and economics have taken varying approaches to the assessment of properties of monetary assets and objects throughout history. Aristotle may be regarded as the first to seriously attempt an informed characterisation of the attributes which a monetary good may exhibit in the 4th century BC, by listing the most crucial properties as *durability*, *fungibility*, *transportability* and *intrinsic value* [12]. Jevons introduced the notions of three principal functions which a monetary good fulfils in the 19th century AD, characterising them as "*store of value*" (SoV), "*medium of exchange*" (MoE) and "*unit of account*" (UofA) and these definitions are employed often by issuers of cryptographic assets [13]. *United States Federal Reserve* economist Kocherlakota defined "*money as memory*" in 1996 [14], in the sense that money performs a function of providing a structured collective memory which facilitates expedient verification of the canonical state of the record kept in such a system, be they high assurance digital data structures, paper money, commodity money with specie such as gold & silver coins, African glass beads or even giant millstones employed by stone-age Pacific islanders such as the *Rai stones* on Yap island [15].

As much as 20 years ago, economists at the IMF characterised an ostensible trade-off in the attainable control of economic properties of Central Bank Digital Currencies (CDBCs), which may be thought of as digital currencies not necessarily intended to circulate publically but rather utilised to perform wholesale functions such as inter-bank settlement and clearing. Stone *et al.* determined that it would not be possible for a central bank to have control of monetary supply issuance, a free-floating exchange rate against other assets and a centrally-controlled interest rate [16]. Similarly, the *Triffin dilemma* raises the prospect of a perpetual fiscal instability within any nation state that issues a currency which is deemed to the be the global reserve currency of that time and indirectly suggests that the ideal solution would correspond to the *Hayekian* vision of a global reserve money distinct from state-issued currency [3]. By virtue of a currency becoming the *de facto* global reserve, other nations are obliged to hold substantial amounts for international trade and settlement. Therefore an enlarged supply of currency is required to satiate foreign demand and trade deficits are the usual consequence, setting up a dissonance between domestic and international economic priorities.

An interesting instance of the multi-faceted nature of moneys can be seen in the changing nature of fiat currencies as they morphed from being fully redeemable for underlying assets such as precious metals to being primarily instruments reflecting the faith in fiscal management of nation-state governments, monetary issuers and / or central banks. Prior to the 16th century, the British currency (Pounds Sterling) was little more than a UofA, being equivalent - first literally and then *via* redemption - for 454 grams of 92.5% purity silver. As the Crown and later Bank of England loosened this peg, the necessity for the currency to become a SoV itself arose. Indeed since the breaking of this peg, GBP has lost over 99% of its value versus silver, which itself is considered to currently be in the depths of a severe bear market having lost approximately two thirds of its exchange price versus USD since its peak in 2011.

In the months prior to the release of the Bitcoin whitepaper [17], Chung took a novel twin legalistic and post-modern philosophical approach informed by absurdist existential thinker and radical monetary theorist Jean Baudrillard with respect to the nature of money [18]. Chung asserts that Baudrillard's notion of a *simulacrum* - a simulation or *abstracted representation of the real* - is useful in understanding the development of what societies adopt and consider as money, given the increasing pace of technological advancements over time [19]. The progression from direct use of commodity moneys of varying quality such as locally rare seashells, glass beads or precious metals to minted coins and gold-backed paper money issued either as proxy for the underlying or as a faith-based instrument backed by governments demonstrated this *simulacrisation.* The recent development of naïvely digitised paper fiat instruments such as internet banking and payment intermediaries such as *PayPal* and finally natively digital programmable trust-minimised P2P monetary networks such as Bitcoin lend credence to the notion that as digital technology increasingly pervades all aspects of modern human society, the monetary goods which such a society will accept and use for the exchange of goods and services will also follow a similar trend. It is reasonable to suggest that Bitcoin - and similar cryptocurrency networks - instantiate the most *hyperreal monetary simulacrum* to date. In Baudrillard's parlance, the realness of Bitcoin may even surpass that of original commodity money bearer assets such as gold and silver.

Related to the above concepts are those of the *hardness* or *goodness* of money [20]. In essence, a good or hard money is one which retains its value and usefulness over time, chiefly due to judicious choice of monetary material in question. This may be rationalised in terms of the characteristic of *price elasticity of supply* [21] which may be thought of as a measure of the marketplace's supply-side response to the increased price of a good. Failed local currencies such as glass beads, fiat currencies and naïvely digitised government moneys differ widely from scare assets such gold and bitcoin in this respect. Glass beads were used in many parts of Africa as a monetary asset as they were locally rare, however European explorers making early expeditions throughout the continent quickly realised the inter-continental opportunities available for exploitation and rapidly inflated the local supply of the beads, acquiring much of the local wealth, engendering human slavery and causing rampant inflation of goods prices as accounted for in the local monetary asset - the so-called *Cantillon Effect* [22]. Unbacked "fractional reserve" fiat money also exhibits shortcomings here, in that it is trivial for a central issuer to inflate currency supply with or without this necessarily becoming apparent to holders of the currency until inflation arises throughout the wider economy.

Gold has some price elasticity of supply insofar as extractive mining necessitates significant capital resources, environmental distress and capital to realise highly purified metal, however should the price of gold double overnight it is reasonable to suppose that the associated motivations and incentives will facilitate a greater degree of exploration and extraction of the metal, thereby increasing its supply. Bitcoin is ostensibly the most *supply-inelastic* monetary good observed to date on account of its algorithmically determined disinflationary supply issuance schedule fixed at the genesis of the network with very little prospect for change. Every 144000 blocks (*ca.* 4 years) the subsidy awarded to a mining participant who solves a cryptographic puzzle halves in amount, having started at 50 bitcoin (BTC) per block and currently comprising 12.5 BTC per block. The issuance schedule is completely independent of any crossrate valuation of BTC in some other unit of account, and therefore the supply is completely inelastic with reference to internal network parameters (block height and number of BTC issued).

There have been numerous discussions that due to the long window of mining difficulty readjustment - which recalibrates the likelihood of a miner finding a valid block to satisfy Bitcoin's consensus rules every 2016 blocks (approximately twice a month) - an advancing BTC-fiat crossrate may incentivise the deployment of further fiat-sequestered computational resource onto the network thereby decreasing the average inter-block issuance times and by extension increasing the effective supply as measured by calendar time rather than internal network time (block height). The long-term average of inter-block time in Bitcoin is approximately 9.5 minutes over 10 years to date, consistent with this notion as the vast majority of difficulty adjustments are increases, reflecting the general trend of increasing computational resource directed to the network. Creator of Bitcoin progenitor *Bit Gold* Nick Szabo encapsulated this desirable nature of good money as "*unforgeable costliness*" [23] as regards the asymmetry between the difficulty of asset replication, dilution, reverse-engineering and so on versus facile verification of authenticity. Indeed this takes the notion of price inelasticity of supply to its logical conclusion, especially with reference to natively digital assets for which solving the issues around double-spending are non-trivial.

More recently, work by Gogerty and Johnson has explored *Network Capital* valuation approaches. By considering all monetary systems as protocols, the notion of potential future transaction networks known as *transactomes* is proposed as a powerful concept [24]. As such, the transaction graph of a monetary protocol network moves from an objectively known and understood status in the past, to an intersubjective transient state in the present and perceived subjective status in the future. This model may offer an improved perspective of network effects as a monetary protocol expands in scale as compared to Metcalfe's Law [25], proposing that the rate of change of network utility (dN/dt) is a higher quality heuristic than network utility itself (N). Table 2 briefly outlines relevant aspects of this model.

$$\mathrm{P} = \mathrm{Max}[\mathrm{R}, (\mathrm{N}+\mathrm{S})]$$

where P = Price, R = Redemption utility, N = Network utility, S = Speculative utility

An important consideration when discussing money is the breadth of the protocol in question. As cryptographic assets are digital bearer objects, there is little discussion or development of instruments of debt, credit, re-hypothecation and so on atop cryptoassets to date in comparison to traditional assets, though the Ethereum-oriented "DeFi" movemement is currently addressing this. This makes them objectively narrow moneys or currencies. Bearing this in mind is helpful when considering the current monetary characteristics of Bitcoin in

Price	Price is only known at the completion of a transaction, therefore the equation aims to address this uncertainly through the use of the additional terms.
Redemption utility	Redeeming asset-backed currency for the underlying collateral, consuming / transforming goods such as oil or ether, eating fish or corn.
Network utility	The expected value to be realised from transaction with a network of economic actors who would willingly accept that asset as money. The transactome network corresponds to the expected set of agents willing to accept an asset as money in a transaction at some point in the future within the time domain in question.
Speculative utility	As the "true" value of a good is not known until the moment of transaction, this term allows for sentiment and supply / demand considerations to affect the market-determined price over time.

Table 2: Aspects of Gogerty & Johnson's *Network Capital* valuation approach [24]

comparison to legacy moneys such as gold and US Dollars. At present, there is little "financial engineering" occurring using the base currency as collateral, which in tandem with no underlying and therefore no redemption utility, limited but improving network utility and high speculative utility the case can readily be made that BTC is currently a reasonable currency but somewhat of a poor money with the potential to become a better one in the future.

1.3.2 What Makes a Good Become Commoditised? In a general sense, a commodity is a commercial good that becomes standardised and possesses a sufficiently developed market that it may be considered largely interchangeable with another like good - in other terms, highly fungible. In a value transfer sense, fungibility and liquidity are key drivers of commoditisation and a healthy future prospect to remain so. It is instructive to distinguish between time-sensitive (consumables / perishables) and ambient / transformable commodities which are time-insensitive as to their usefulness or delivery value. In the cryptoasset domain, the concept of usefulness or utility maps - at least coarsely - onto the generalised notion of a commodity. How useful a token is depends on the demand to hold or use it, and how necessary it is to engage in a worthwhile activity such as private transaction or access to a decentralised service built atop a blockchain-architected protocol network. Burniske and Tatar's nomenclature of *cryptocommodities* does seem to be apt and it is reasonable to presume significant levels of utility for BTC, Ether (ETH) and some other PoW-based protocol tokens such as Ethereum Classic (ETC), Decred (DCR) and Monero (XMR) [26]. Analogies have historically been drawn between BTC and *digital gold* with respect to rarity, durability and mining. Likewise, ETH is often thought of as *digital oil* as it is used as *gas* to pay for computation in the *Ethereum Virtual Machine* (EVM) which executes the network's persistent scripts commonly known as "*smart contracts*".

A handful of countries remain that still use something resembling commodity money, even in an abstract sense with indirect central bank backing. Mongolia has a significant level of precious metals backing implied by the ongoing extractive resource mining boom, whilst Lebanon has surprisingly high reserves given its level of paper debt. It has been remarked that globalist economic policies as leveraged by transnational financial organisations such as the *International Monetary Fund* (IMF) and the *World Bank* are leading contributors to the decline of nation-state gold reserves, as "rescue packages" given to countries with large current account deficits often involve "liberation" of sequestered commodity reserves. [27]. In the context of a digital monetary network, extent of intrinsic utility or *commodityness* is also related to unforgeable costliness as the supply of newly mined bitcoin is strictly algorithmically controlled with ever-decreasing supply inflation with mining subsidy attenuating stepwise as the 21 million BTC supply limit is approached. Commodity money was pervasive and long-lived in human society because it held its value well against reference items, as an effective store of value due to limited supply increases. Since the collapse of the *Bretton-Woods* agreement in 1971 and the subsequent abandonment of an explicit USD gold standard, fiat money has been diverging from its commodity backed roots and losing utility as backing becomes primarily based on faith in the financial management of a territory's ruling regime [28].

In some ways the disinflationary hard cap supply maximum concept does seem to echo the difficulty of prospecting for rare physical minerals and materials, versus an uncapped supply philosophy which intends to maintain transactional utility and lack of friction typically with a constant or declining inflation rate. Some privacy-oriented cryptocurrency networks have *shielded token pools* within their networks for which the supply is not knowable without breaking the entire cryptographic scheme of the network protocol. Therefore the not uncommon "inflation bugs" which appear even in mature and well-tested codebases such as the *Bitcoin Core* client and *Zcash* which were notoriously used to counterfeit large amounts of coins on *Bytecoin* (a progenitor of *Monero*) and *Bitcoin Private* (a derivative of Zcash) may be abused to debase monetary supply without wide knowledge of clandestine currency issuance [29, 30, 31].

1.3.3 Regulating Securitised Asset Issuance in a Post-Howey Paradigm *What do orange groves and golf courses have to do with BTC, ETH, and TheDAO tokens?*

A detailed history of securities laws and regulation in the USA, UK and other relevant jurisdictions is beyond the scope of this text and therefore the reader is invited to peruse the referenced works on these matters [32, 33, 34, 35], whilst a brief overview primarily based on American precedent and events will follow. The nominal definition of a *security* or a *securitised asset* is a fungible, tradeable product which constitutes an agreement between issuer and purchaser. A security such as an *equity* - for example a *share* or *stock* - or a debt-based instrument such as a *bond* may further formalise the right to claim future proceeds, cashflows or other outcomes arising from partial ownership of an underlying, *securitised* asset [36]. The act of issuing a security agreement based upon an underlying asset is known as *securitisation.*

Three landmark rulings in the United States established a great deal of precedence which is still employed in the present day to legislate and regulate securities issuance and offerings using the *Securities Exchange Acts* of 1933 & 1934. Given that (for the time being) the US commands a dominant position in global politics and finance, these are often cited as worldwide benchmarks for financial conduct. The case of *The SEC against WJ Howey (1946)* related to a collective investment contract which offered claims on future cash flows arising from the proceeds of orange groves in California [37]. Whereas the trees and oranges are clearly not securities themselves, the investment contract was found to be consistent with that of a security agreement as the contract established several key aspects within the relationship between contract issuer and investment participant: claims on future proceeds and / or expectation of profit, fractional ownership of the underlying asset, a person or team who are relied upon to maximise shareholder returns and voting control / influence over the outcome of outputs from the underlying. The case involving *Silver Hills Golf Club (1961)* is also an oft-cited precedent as the fractional ownership offered by collective investment into a golf course constituted the allocation of *risk capital* with the expectation of capital growth of the principal in addition to any cashflows realised [38]. In the case of *Reves versus Ernst & Young (1990)*, The US *Supreme Court* adopted a "*family resemblance*" test to determine whether a particular financial agreement type known as a *note* is a security or not by comparison with existing assignments of security status of an asset. Key attributes were found to be motivations of seller and buyer, the plan of distribution of the instrument, reasonable expectations of investors and the presence of alternative regulatory regime which would lead to a lowering of investment risk [39].

The *Financial Conduct Authority* (FCA) in the UK and the SEC in the US have both made pronouncements in 2017 and 2018 that they deem the Bitcoin network, and bitcoin tokens themselves to definitively not be security-like and therefore not subject to securities regulation. The leaderless, permissionless and decentralised operation of the network through thermodynamic means to assign block creation privileges and selection of the canonical ledger history *via* Nakamoto Consensus is typically cited in rationalisations of these governmental decisions [40, 41]. The meaningfulness of statements justified using these characteristics do suffer from imprecision of definitions (for example not specifying network layers or specific stakeholder constituencies), lack of comprehension of detailed function of a permissionless network, lack of familiarity with open-source software (OSS) development workflows and an ostensible mischaracterisation of the techniques of obfuscation of implicit *extra-protocol* power structures and diversionary nature of what has become known as *decentralisation theatre* [43]. This finding is in keeping with the SEC's existing *Howey / Silver Hills* regulatory paradigm as Bitcoin offers none of the characteristics of leadership, control, cashflows, collectively risked capital or expectation of profit specifically when considering the native token as its own unit of account. Framing this another way, despite the volatile fluctuations of the price of BTC in another unit of account one bitcoin is always still equal to one bitcoin, as with other bearer assets such as the dollar or an ounce of gold - not accounting for *demurrage.* Considering the functionality of the Bitcoin network, the current value of one bitcoin may be understood implicitly as the value of 75 seconds of the computational resource directed at defending the network from thermodynamic attacks and providing a high probability of assurance that the integrity of the canonical ledger will continue to be maintained.

Comments made in summer 2018 by SEC official William Hinman gave heavy implication that he deemed the Ethereum network to have become "*sufficiently decentralised*" for its native token ether to not be considered a security, although the token crowdfunding event in 2014 most likely was a securities offering [44]. These comments ostensibly necessitate two features for a *robust present-day classification paradigm*: a non-binary framework of how *security-like* an asset is; and a *time-dependent* component to allow for changes as the network and / or asset matures. This may be justified as follows: the evolving characteristics of proliferating tokenised P2P networks appear to have a significant bearing on the opinions of senior regulators with respect to the security status of particular assets, and no objective boundary (or *"securityness threshold"*) to separate objects on either side of exists *a priori.* The discussion regarding security status of bitcoin had previously also been effectively decided on the poorly defined *pseudo-metric* of decentralisation which leaves substantial uncertainty over the perceived bounds at which US securities regulators would be prompted to act and make legal pronouncements. By implication in a plurality of SEC officials' public statements (official or personal in nature) was that most other subsequent token offerings were very likely unregistered securities with particular reference to "*TheDAO*" (DAO), a *quasi-securitised* leaderless "*Decentralised Autonomous Organisation*" which suffered a catastrophic failure in 2016 following an exploitation of flawed smart contract code [45]. Hinman made further comments in November 2018 suggesting that any token which has its value predicated on the expectation of returns would also likely be considered a security which has potentially wide-reaching implications for a large number of assets, particularly tokens issued by exchanges for the purposes of profit-sharing and / or fee reduction such as *Binance Coin* (BNB) [46]. Further guidance was issued in early 2019 which made some clarifications as to the SEC's current views but provided little in the way of concrete and actionable advice [47].

The UK's FCA reported findings from its "Cryptoasset Taskforce" which largely mirrored US policy but with a somewhat softer tone, focussing on the need to maintain financial stability and consumer protection with regard to cryptographic asset issuance, trading and offerings [48]. There is still a lack of clarity over policy specifics and indeed more general government sentiment in the major Asian trading locations Korea, China and Japan [49, 50]. A current view of the worldwide regulatory status of cryptoassets can be found in the 2019 Edition of Cambridge University Centre for Alternative Finance's *Regulatory Landscape Study* [51].

Beginning in 2013 - with early examples such as *Mastercoin*, *Ethereum* and *MaidSafe* - and proliferating enormously in the midst of the 2017 bull market in cryptoasset markets, Initial Coin Offerings have become synonymous with unsavoury practices and behaviours. ICOs promised the disintermediation and democratisation of early-stage venture investing, widening participation beyond the typical retinue of Venture Capital, Angels, Hedge Funds, Family Offices, Trusts and wealthy individuals (collectively referred to as accredited investors) to technically savvy retail investors who were early adopters of cryptocurrency technology. The nomenclature bears uneasy and striking resemblance to the long-established securitisation mechanism of conducting an *Initial Public Offering* (IPO) whereby a privately held company would become listed on a public stock exchange thus facilitating a wider distribution of prospective share ownership. Naturally such a mechanism would be subject to well-established securities laws in the relevant jurisdiction, with sufficient *prior case, tort or written law precedent* to guarantee stiff penalties (monetary and / or incarceratory) to disincentivise any potential foul play or unfair practices such as *insider trading* or *unauthorised issuance of securities.* A superficially different but semantically equivalent term to describe the issuance of a cryptographic token - usually atop an existing blockchain-architected network platform - is *Token Generation Event* (TGE), with critics of the phenomena stating that this is simply a last-gasp attempt by regulatory arbitrage participants to engage in *security theatre* so as to avoid nation-state law enforcement, allowing more time to make their exit from projects or territories coming to realise the complexities of the regulatory situation at hand [52].

In the interests of brevity, a full treatment of observed phenomena and discussion of root causes of the rise to prominence of ICOs / TGEs is beyond the scope of this text. The reader is directed to referenced literature for further information [53]. The key issue to date with this movement has been the cavalier attitudes exhibited by the founders and insiders of such projects. Most token sales to date have suffered from incentive architecture misalignment *in extremis*: founders collect unconfiscatable fungible assets at the outset (typically BTC or ETH) with essentially no conditions or stipulations on project performance or milestones. Shadow marketing houses and mercenary smart-contract developers pump out misleading promotional materials and unaudited code predictably leading to an extremely high percentage of outright failure or chronic under-delivery of project outcomes [54]. Even the attempt by industry participants to self-regulate and create the *Simple Agreements for Future Tokens* (SAFT) Framework has not been viewed particularly positively by legal commentators as being definitively legally compliant in the US [55].

With this tilt of incentives towards short-termism it is no surprise that the ICO space has become a magnet for a morally dubious *get rich quick* ethos, with heavy promotion of unrealistic or even magical claims and a lack of critical counterpoint or technical rebuttal. There has been a wide practice of what the author terms *blockchain first, ask questions later* whereby the perceived advantages of temporally-sequenced data structures are proffered uncritically and without discussion of the trade-offs necessary to achieve the dubiously optimistic characteristics proffered in marketing material. A combination of magical claims, greed, absent technical acumen and lack of previous entrepreneurial success constituted the typical unregulated ICO in 2017 and 2018, and from comments made in December 2017 by SEC Commissioner Jay Clayton, at that time zero ICO projects had registered their tokens with US regulators as security offerings [56], though this has recently changed [57]. It is common to observe token sales taking place with the exclusion of US investor participation, no doubt due to the United States' Federal Government policy of *extraterritorial jurisdiction.* A selection of ICO enforcement actions undertaken by the the SEC can be found at the referenced materials, with court proceedings increasing in incidence in early 2019 [58].

There were numerous high-profile examples of the circumvention of typical investor protections by ICO fundraises in 2017 and 2018. Responsible for nominally raising tens of billion dollars collectively, the token sales took place in a situation of *network pre-functionality* - insofar as the native networks intended to house the tokens were not active or even close to ready - and token-holders were given no rights or claims in the terms of agreements between issuer and purchasers. Frequently companies responsible for creating the network software went to great lengths to explicitly state the lack of rights participants would have on tokens in the future network, or any functionality that those tokens may or may not have in future. These examples are typical of the attempted circumvention of responsibilities as asset issuers in order to engage in both jurisdictional and securities arbitrage, as some opted for a binary company-foundation model while others took their operations to opaque offshore jurisdictions [59, 60].

More recently it has become clear that researchers, lawmakers and / or regulators believe a second type of regulatory arbitrage to have taken place, which can be thought of as *psuedo-desecuritisation* or *decentralisation theatre* [43]. By carefully attempting to manufacture asset characteristics so as not to resemble those typically encountered in the traditionally employed definitions of financial product types such as securities, many cryptoasset project founders have intended to steer a course around legislation intended to function as consumer protections for the average investor.

Comment should also be made regarding so-called *utility tokens* which are typically non-native tokens issued atop blockchain networks such as Ethereum and are designed to be required for the use of a protocol, thereby giving their asset a "unique utility" which is hoped to reduce its resemblance to a security. However this utility token layering model does not appear to have convinced many regulators who seem increasingly suspicious about the claims of intrinsic usefulness when a more straightforward and lower-friction *crypto-economic* model would be to simply use the base network's native token *e.g.* ETH. Consideration should also be made to the stability of any asset issued atop an existing network, as network characteristics and performance may vary widely over time and economic or vulnerability exploit attacks are an ever-present prospect. This is especially true in less established networks, which are typically undergoing protocol development with no guarantee of successful outcomes. *Stablecoins* are another interesting subset of utility tokens which are designed or intended to have reduced volatility versus fiat currencies than typical cryptoassets, and are usually engineered to achieve this by either *fully / over-collateralising* a two-way peg, algorithmic management or by a *seigniorage shares* model where adjustments are made in response to market dynamics by adjusting the circulating supply dynamically. Basis is an example of a stablecoin which was under development following highly successful fundraising which has returned capital to investors and ceased work on the project citing regulatory and compliance issues [61]. It is possible that certain stablecoin issuance and / or price stability mechanisms may make the asset in question significantly more security-like.

Security Tokens are another relatively novel subset of utility token, though these are explicitly declaring themselves to be security-like. By following regulatory and compliance procedures in relevant jurisdictions, security tokens may therefore may give direct rights to part ownership in an enterprise, on-chain cashflows, voting / governance rights or other securitised agreements for future claims. *Iconomi* is an example of an existing ERC20 utility token that is being reissued as a security token [62]. There are questions over the viability of existing security token models due to the onerous compliance requirements for both issuers and holders [63].

1.3.4 Legacy Assets Exhibiting Hybrid Characteristics Brief mention should be made of legacy assets that may not fit cleanly into one of the above pure asset classes. Gold coins are an example of commodity-moneys, albeit their monetary role has diminished over time. Short-dated securitised government debt such as 3-month US Treasury bills may function as reasonable proxies for money and arguably exhibit commodity-like characteristics as well. To the best of the author's knowledge few other assets exist which exhibit characteristics of both commodities and securities exist unless derivatives such as gold futures, mining company stocks and ETFs are considered to have qualities of the underlying.

2 Classification Approaches & Design Science of Information Systems

2.1 Definitions of Terms Within Paradigms of Classification

Without downplaying the enormous contributions of biology, botany, zoology, entomology and related life sciences fields to the development of classification systems derived from the Linnean *binomial paradigm*, emphasis will be directed in this work on broader and more recent approaches into the categorisation of objects and concepts into classes, categories or other types of divisions. It should be noted for clarity that *classification* is a general term which may appropriately describe any of a number of approaches to the organisation of domain-specific knowledge. Within classification, there are several subsets which shall be briefly defined and discussed for precision moving forwards.

Classification was defined by Bowker & Star, and Bailey:

> "The ordering of entities into groups or classes on the basis of their similarity." [64]
> "A spatial, temporal, or spatio-temporal segmentation of the world." [65]

Such a classification may be approached conceptually, axiomatically, empirically or intuitively. Discrimination between objects is often univariate (*e.g.* number of legs an organism possesses to determine a biological specimen's *phylum, class, order* and so on) but may also be multivariate where two or more attributes are employed to differentiate between objects. One potential criticism of classification methods in general is that naïve categorisation may be inadequate to appropriately encapsulate the variety or heterogeneity observed in a set of objects, with issues arising at boundaries of continuous variables or with edge cases.

A *classification system* was described by Bowker & Star and later developed by Nickerson *et al.* to comprise the following:

> "A set of boxes (metaphorical or literal) into which things can be put to then do some kind of work - bureaucratic or knowledge production." [64]
> "The abstract groupings or categories into which we can put objects" with the term classification used "for the concrete result of putting objects into groupings or categories." [66]

Framework was characterised by Nickerson building upon work by Schwarz *et al.* as follows:

> "a set of assumptions, concepts, values and practices that constitutes a way of understanding the research within a body of knowledge." [67]

The term *typology* is applied correctly to a series of conceptually-derived groupings, often multivariate - thereby being more discriminatory than simple classification systems - and are predominantly qualitative in nature. [65, 68]

Taxonomy is the most widely used term to describe classificatory approaches, though from a recent literature survey it does also appear to be a term which is often used with a lack of precision [66]. A *taxonomic system* can be understood as a subset of classification systems as defined above, and a taxonomy itself can be generated and derived from a taxonomic system. Most literature adopts the term taxonomy for empirically-derived classification systems in contrast to conceptually-derived typological systems. However it is clear from classification literature that taxonomy may refer to both empirically and conceptually derived classifications and this broader, modern usage of the term is employed by this work. A subset of taxonomies employing quantitative classifications are termed *phenetic* approaches, which are typically empirically-derived groupings of attribute similarity and are largely arrived at using statistical and data analytical approaches such as correlation mapping, data clustering or principal component analysis. Similarly *cladistic* approaches are akin to historical, deductive, evolutionary or genealogical inter-relationships of sets of objects. Relevant examples include the fragmentation and proliferation of Linux codebase / kernel / distribution descendants, upstart networks employing the CryptoNote protocol codebase and ledger forks of cryptocurrency networks such as Bitcoin [5]. Taxonomy helps researchers study relationships between objects and concepts [69], and such approaches may further help researchers find voids in parameter space which may be a result of anomalous emergent characteristics or mismatch between ensembles of attributes [66].

2.2 Philosophy of Design Science & Classification Approaches

Following Weber [70], Bailey characterised the notions of *ideal types* and *constructed types* with reference to typology and taxonomy development respectively [65]. For the most part typologies conceptually derive an ideal type (category) which exemplifies the apex (or maximum) of a proposed characteristic whereas taxonomies develop a constructed type with reference to empirically observed cases which may not necessarily be idealised

Term	Definitions & Notes
Classification	Spatial, temporal or spatio-temporal segmentation of the world
	Ordering on the basis of similarity
Classif. System	A set of boxes (metaphorical or literal) into which things can be put to then do some kind of work
	A construction for the abstract groupings into which objects can be put
Framework	A set of assumptions, concepts, values and practices that constitutes a way of understanding the research within a body of knowledge
Typology	A series of conceptually-derived groupings, can be multivariate and predominantly qualitative in nature
Taxonomy	Empirically or conceptually derived classifications for the elucidation of relationships between artifacts
Taxon. System	A method or process from which a taxonomy may be derived
Cladistic Taxon.	Historical, deductive or evolutionary relationships charting the genealogical inter-relationships of sets of objects
Phenetic Taxon.	Empirically derived groupings of attribute similarity, arrived at using statistical methods

Table 3: Classification terminology [64, 65, 66, 67, 68, 69]

but can be employed as canonical (or most typical) examples. Such a constructed type may subsequently be used to examine exceptions to the type. Bailey exemplifies this distinction by equating an ideal type to the optimum or most extreme value in a collection of data, whereas the constructed type may be taken from the mean or median of a population. In developing a typological system through conceptual or theoretical foundations, the structure of a typology may be elucidated through deduction or intuition. This approach may be employed to build multi-layered systems using conceptual, empirical and combinations of elements thereof - termed *indicator / operational levels*. Such a method can be used to transition in either direction between conceptual and empirical bases for the classification system as classification is iteratively developed. Nickerson *et al.* summarise Bailey's approach:

> "A researcher may conceive of a single type and then add dimensions until a satisfactory typology is reached, in a process known as *substruction*. Alternatively the researcher could conceptualise an extensive typology and then eliminate certain dimensions in a process of *reduction*." [65, 66]

In contrast to Kuhn's paradigmatic assessment of the evolution of concepts, Popper's *Three Worlds* provides some philosophical bedrock from which to develop generalised and systematic ontological and / or epistemological approaches. The first world corresponds to material and corporeal nature, the second to consciousness and cognitive states and the third to emergent products and phenomena arising from human social action [71, 72]. Niiniluoto applied this simple classification to the development of classifications themselves and commented:

> "Most design science research in engineering adopts a realistic / materialistic ontology whereas action research accepts more nominalistic, idealistic and constructivistic ontology." [73]

Materialism attaches primacy to Popper's first world, idealism to the second and anti-positivistic action research to the third. Design science and action research do not necessarily have to share ontological and epistemological bases. Three potential roles for application within information systems were identified: means-end oriented, interpretive and critical approaches. In terms of design science ethics Niiniluoto comments on taxonomy as a descriptivistic endeavour:

> "Design science research itself implies an ethical change from describing and explaining the state of the existing world to shaping and changing it." [73]

Ivari considered the philosophy of design science research itself:

> "Regarding epistemology of design science, artifacts of taxonomies without underlying axioms or theories do not have an intrinsic truth value. It could however be argued that design science is concerned with pragmatism as a philosophical orientation attempting to bridge science and practical action." [74]

Methodology of design science rigour is derived from the effective use of prior research (*i.e.* existing knowledge). Major sources of ideas originate from practical problems, existing artifacts, analogy, metaphor and theory [75].

Following on from Plato and Aristotle's notion of *essentialism* - a characteristic essence of every entity, concept and material [76] - the epistemology of design science as evinced by taxonomy development until the Industrial Revolution was at least partially informed by a naïve and pre-Darwinian essentialist sensibility. There is a lack of agreement as to the extent that early classifiers such as Linneaus and Haeckel were complete essentialists that *fully* believed that the biosphere was composed of static, time-independent ensembles of living things. Ivari makes a post-essentialistic statement as follows, highlighting the value of abstract or conceptual approaches as possible intermediaries in the ontological quest:

> "Conceptual knowledge does not have an intrinsic truth value, but is a relevant input for the development of theories representing forms of descriptive knowledge, which may have a truth value." [74]

Figure 1: Linnean binomial classification example [77]

2.3 Selected Examples of Taxonomy & Typology Approaches

The scholarly pastime of classifying objects systematically is usually traced back to Carl Linneaus the Swedish botanist, physician, and zoologist who was active in the 17th century and prepared a number of thorough approaches to classifying living things including the formalised binomial nomenclature which is still in use for the naming of species [77, 78]. Prior to this, Aristotle's *Predicamenta* laid the conceptual foundations for the activity of categorising concepts and objects [79]. These were simple inductive approaches which began with conceptual or empirical inquiry and led in some successful cases to axiomatic reasoning, however given the paucity of reliable and objective information available at that time, it is entirely understandable that thorough and concise frameworks did not develop immediately. Oil and coal products trees in the 19th century as shown in Figure 2 were inspired by this [80, 81]. As the *Industrial Revolution* was carbon driven, complex organic materials comprised of myriad constituents principally derived from coal and oil were purified, refined and processed into a new generation of high performance products. Fortunes were made and lost on classification accuracy with fractionation and purification of carbon feedstocks yielding a plethora of fuels, dyes, lubricants and other organic compounds previously undiscovered or unobtainable by chemical synthesis. These classification approaches were still informed by the natural sciences' categorical branching hierarchy paradigm and would be thought of as cladistic taxonomies as the interrelation of objects is directly associated with their incidence, derivation and provenance.

Hertzprung and Russell employed empirical data from astronomical surveys in the early 20th century and found that stars could be grouped into families based on their surface temperature and luminosity, affording insight into their probable future fates. By studying the evolution of thermodynamic, nucleosynthetic and photo-physical characteristics of stellar objects through these clusters, the Hertzsprung-Russell phenetic taxonomy has

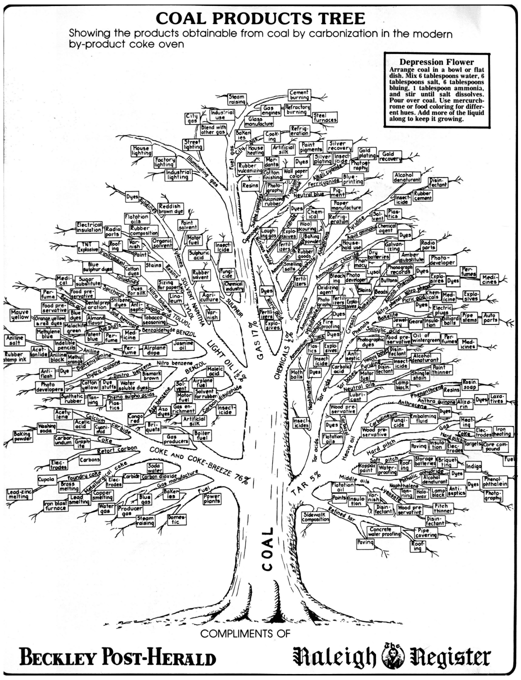

Figure 2: Example of a coal products tree [82]

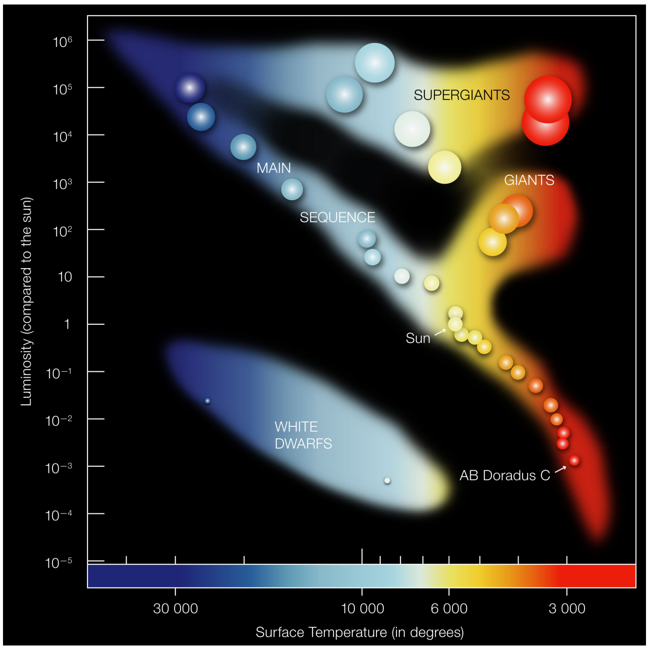

Figure 3: Example of a Hertzsprung-Russell diagram [84]

over time been refined, simplified and developed further into a highly successful visual classification mechanism with an example shown in Figure 3 [83, 84].

The so-called *periodic table of the chemical elements* that exists in the present day is an evolution of taxonomic approaches initially developed phenomenologically then refined with increasingly meaningful heuristics as scientific knowledge developed from the 17th century to the present. Newton studied elemental properties under the auspices of alchemy when, as Master of the British Royal Mint he ostensibly attempted to systematise approaches to reverse-engineer gold, at that time the most unforgeably scarce material known [85]. Geoffroy later developed symbolic matrices empirically studying affinities between materials [86]. Lavoisier and Priestley are credited for the discovery of elemental oxygen and its role in combustion, invalidating incumbent phlogiston theory and the long-lived mythic notion of an element of fire [87, 88]. Döbereiner attempted to group materials based on *elemental mass triads* in the 1820s, after Dalton's work lent credence to Democritus' atomic theory as depicted in Figure 4 [89]. In the mid-19th century theories developed to bridge the gap between empirical pattern-finding and axiomatic classification of elements on the basis of atomic mass and number, with varying approaches developed in isolation by de Chancourtois, Newlands, Meyer and Mosey [90, 91, 92, 93].

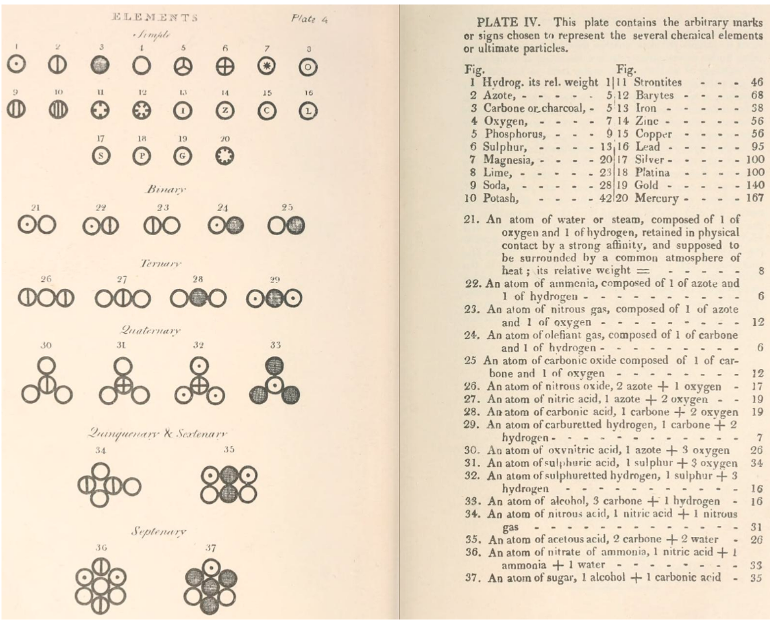

Figure 4: Dalton's *Notes from Chemical Philosophy*, 1808 [94]

Elemental taxonomy progress is well documented and disseminated widely as each physical instantiation of the periodic table constitutes a snapshot in time given that heavy elements continue to be discovered and advances in scientific theory further the progress from empirical to axiomatic bases for this taxonomy approach. As with Kekulé's elucidation of the aromatic cyclical structure of the benzene molecular, Mendeleev was thought to have made the necessary deductive leaps in an *ouroborosian* dreamtime reverie, perceiving a rotary concept to be the key inventive step towards a unified chemical ontology [95, 96].

In the late 19th and early 20th century linear (Figure 5) and cyclical (Figure 6) schemas both developed as classification discriminant improved from ranking of elemental oxides to atomic number and outer shell electron configuration as determined by permutations of quantum numbers. Circular designs such as Soddy's have a greater conceptual and explanatory power than linear ones by dispensing with the need to choose a position for the empty-shelled noble gases [97]. Moving across the table, outer electron orbital shells are populated according to thermodynamic principles with quantum mechanical orbital theory providing the geometries and energetic characteristics of *s*, *p*, *d* and *f-type* orbital *probability density functions* (PDFs) [98].

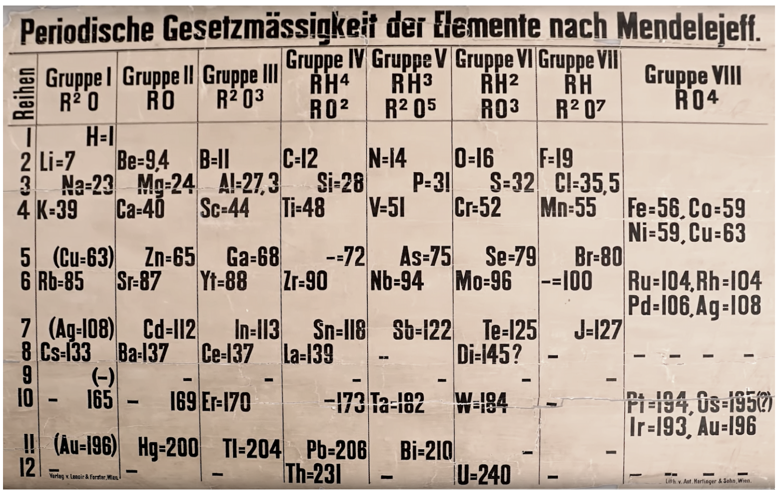

Figure 5: Example of a rare periodic table found at the University of St. Andrew's, dated approximately to 1885 [99]

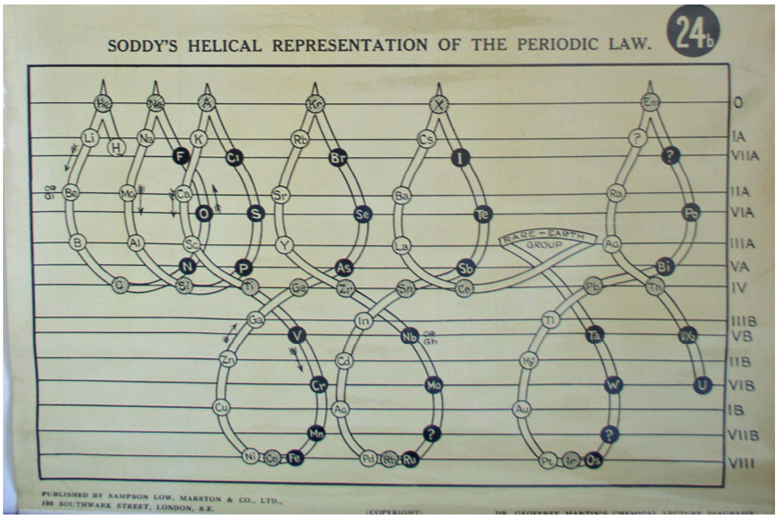

Figure 6: Soddy's circular model of elemental classification [99]

In the present day, elemental discoveries continue and systematised classification frameworks exist to explain, predict, observe and categorise. Periodic tables constitute mature taxonomy approaches predominantly employing axiomatic reasoning and empirical validation. Indeed this taxonomy format has itself become a *memetic simulacrum*, representing and signalling the triumph of scientific traditions, though critical debate as to its absolute veracity continues [100, 101, 102]. The symbolic meaning of form may surpass that of contents as "periodic tables" of unrelated objects proliferate, with perhaps the most egregious misuse of this term and of taxonomy itself to date discussed below in §2.4. As with all information systems, the principle of GIGO (Garbage In, Garbage Out) applies [103].

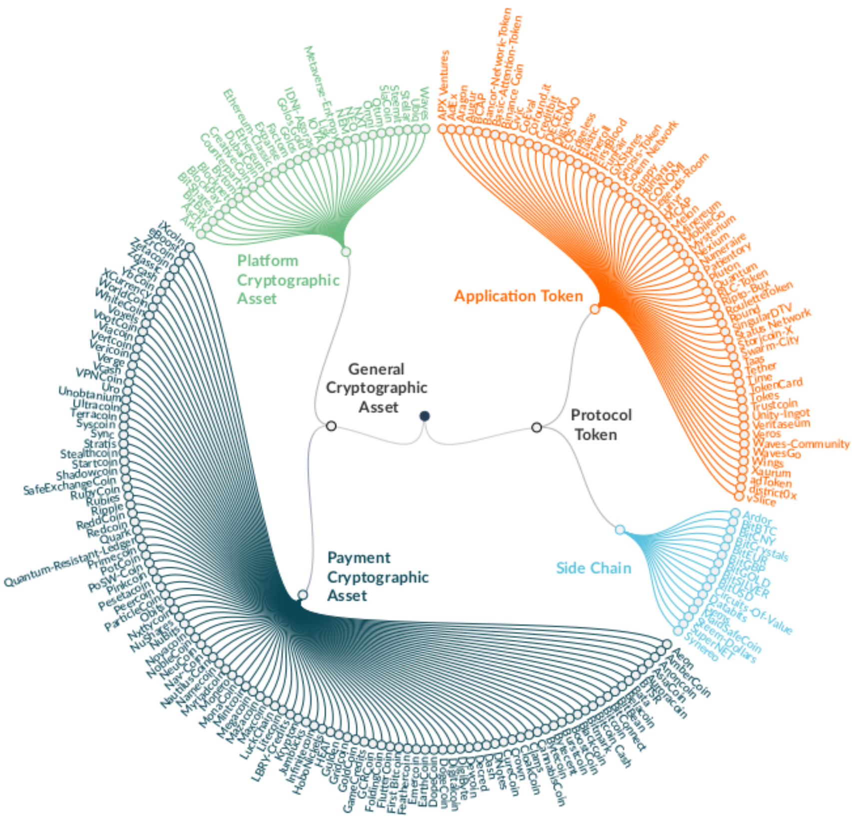

Figure 7: Brave New Coin visual classification excerpt [104]

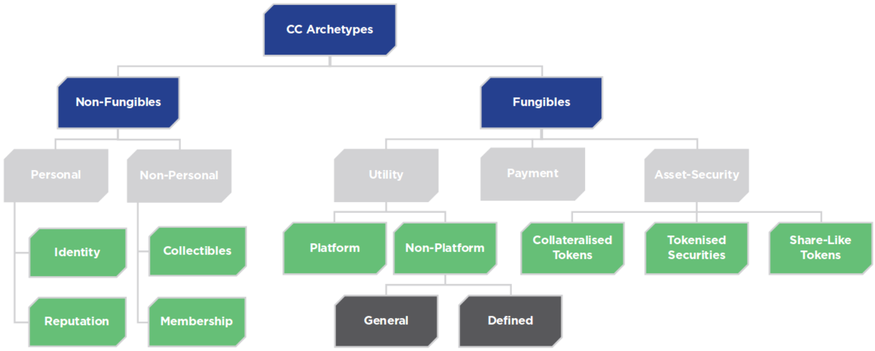

Figure 8: CryptoCompare visual classification excerpt [105]

2.4 Recent Approaches to Classifying Monetary & Cryptographic Assets

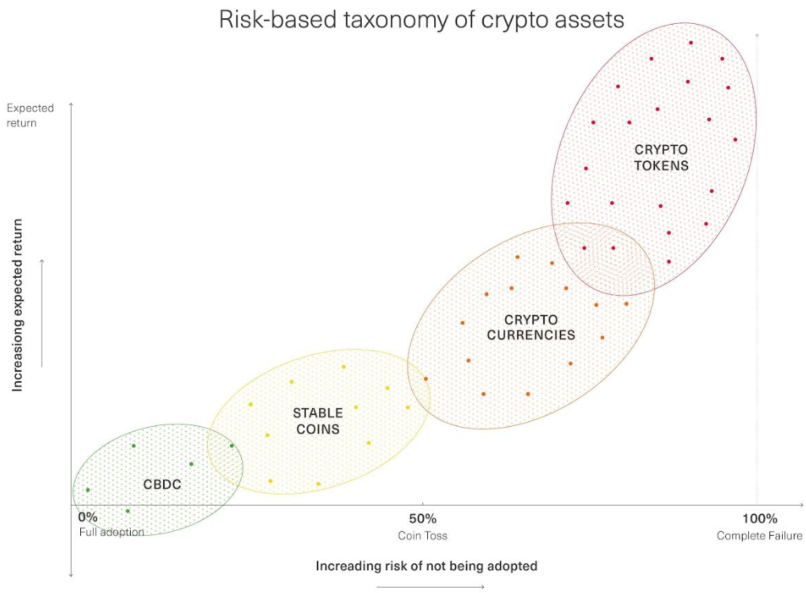

Figure 9: The least useful self-proclaimed "taxonomy" of cryptographic assets to date, by Kirilenko [106]

In contrast to the above historical successes of taxonomy, classification approaches to legacy and cryptographic assets have been rather limited in scope and depth to date. Both transnational banking institutions such as the *Bank for International Settlements* (BIS), *International Monetary Fund* (IMF) and credible commentators are largely yet to progress beyond somewhat naïve classification methods, which provide little explanatory power or exhaustiveness of classification [107, 108]. In the current era of regulatory inconsistency and opacity, a more logical and robust conceptual framework using more considered classification approaches would allow existing taxonomic, scoring or rating philosophies to be integrated into a more versatile conceptual framework.

Brave New Coin and *CryptoCompare* are the sources of the most thorough characterisations of cryptographic assets to date, building upon some of the categorisations and nomenclature employed by Greer, Burniske and Tatar [26, 110] with illustrations in Figures 7 and 8. In the Burniske / Tatar approach, cryptoassets are considered to be classified sufficiently by two sets of binomial categorisation: 1) "value-protocol use or not" and 2) "direct value or not", "functional value or monetary". Some unique characteristics of the various attributes were identified but ultimately this framework approach largely fails to withstand scrutiny of the Nickerson *et al.* requirements of a valid taxonomy regarding the lack of exhaustiveness, possessing multiple overlapping attributes and being descriptive rather than explanatory (see §2.1, §2.2 and §3.2) [66]. Some of the classification approaches contained within both studies would map reasonably well onto the Nickerson *et al.* construction of a taxonomy

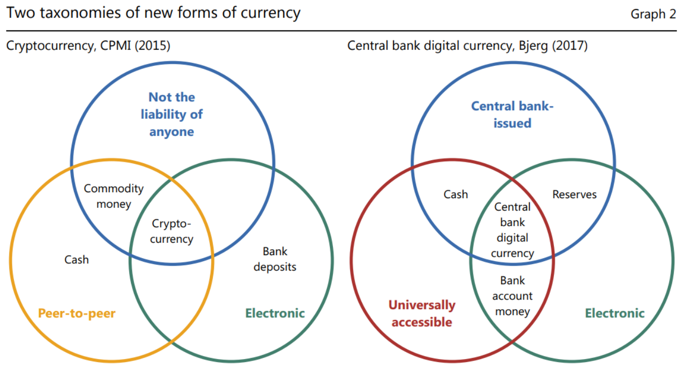

Figure 10: BIS money flower (adapted from Bech and Garratt) [108, 109]

problem statement and canonical requirements (see §3.1), though they would be better described as databases or information repositories of relevant metrics and attributes. Other self-proclaimed cryptoasset classification attempts fare less well when judged by these criteria. Of particular note is the "taxonomy" produced under the auspices of a "periodic table of cryptocurrencies" which rather resembles an arbitrary scatterplot with a polynomial fitting line "connecting" the axes of risk and reward (Figure 9). Such a simple intuitive "clustering" of cryptographic asset types - if indeed the "data" presented is genuine and has been legitimately been examined using *pseudo-taxonomic* approaches - appears to be absolutely devoid of explanatory power [106]. A number of largely trivial Venn type sorting approaches have been attempted by Bech & Garratt and others for both public and private legacy moneys. For example the so-called BIS *Money flower* [108, 109] fails as a useful taxonomy in the Nickerson *et al.* sense - being inexhaustive, possessing multiple overlapping attributes, and being primarily descriptive rather than explanatory.

	Dimension	Characteristics			
Token	Token implementation level	native (9)	on-chain (42)	sidechain (1)	
	Token purpose/type	usage token (31)	work token (3)	funding token (9)	staking token
	Token supply growth	fixed supply (38)	fixed inflation rate (5)	adaptive inflation rate	
	Token supply cap	uncapped (11)	capped (41)		
	Token burning	no (42)	yes (10)		
	Token distribution deferral	no (22)	yes (30)		
	Token holder voting rights	no (38)	yes (14)		
Issuer	Issuing legal structure	limited liability (42)	foundation (10)		
	Team token share	minority stake (45)	half (3)	majority stake (4)	
	Team vesting period	none (16)	single period (15)	multiple periods (21)	
Sales Terms	Pre-sale before ICO	none (26)	private pre-sale (21)	public pre-sale (5)	
	Pre-sale discount	no (27)	yes (25)		
	Planned occurrence	single round (38)	multiple rounds (12)	not specified (2)	
	Registration needed	no (23)	yes (29)		
	Eligibility restriction	none (28)	geographic (17)	accreditation (3)	multiple (4)
	Purchase amount limit	none (43)	minimum (6)	maximum (2)	both (1)
	Auction mechanism	none (49)	Dutch auction (3)		
	Sales price	fixed (42)	floating (10)		
	Price fixing currency	fiat currency (17)	crypto currency (35)		
	Funding currency	crypto currency (43)	crypto and fiat currency (9)		
	Funding cap	uncapped (9)	soft cap (2)	hard cap (27)	multiple (14)
	Time horizon	fixed ending date (41)	fixed ending block time (10)	open-end (1)	
	Time-based discount	none (26)	single rate (5)	multiple rates (21)	

Table 3. Final taxonomy of ICOs

Figure 11: Classification results of Fridgen *et al.* [112]

Linear, hierarchical and uni / bivariate sorting approaches including lists, scoring systems and typologies have been employed with examples such as the *SpacesuitX* ICO scoring system and Swiss regulator FINMA with its one-dimensional "utility, payment, asset, hybrid" delineation [111]. CryptoCompare commented in October 2018 that by FINMA's rationale, over 50% of major cryptographic assets would be classified as securities by Swiss law [105]. In addition to many informal self-proclaimed taxonomies, the word does seem to be used loosely enough to be applied to simple lists of phenomena or objects or even a polynomial fitting function overlaid upon ostensibly arbitrarily placed data with some creative license [106].

	Cluster 1 (40%)	Cluster 2 (13%)	Cluster 3 (13%)	Cluster 4 (33%)
Token implementation level	on-chain	on-chain	native	on-chain
Token purpose/type	usage token	staking token	usage token	usage token
Token supply growth	fixed supply	fixed supply	fixed inflation	fixed supply
Token supply cap	capped	capped	uncapped	capped
Token burning	no	no	no	no
Token distribution deferral	yes	yes	yes	yes
Token holder voting rights	no	yes	no	no
Issuing legal structure	Limited	Limited	Foundation	Limited
Team token share	minority stake	minority stake	minority stake	minority stake
Team vesting period	multiple periods	multiple periods	no	no
Pre-sale before ICO	private presale	no	no	no
Pre-sale discount	yes	no	no	no
Planned occurrence	single round	single round	multiple round	single round
Registration needed	yes	yes	no	no
Eligibility restriction	geographic	geographic	none	none
Purchase amount limit	none	none	none	none
Auction mechanism	none	none	none	none
Sales price	fixed	fixed	fixed	fixed
Price fixing currency	cryptocurrency	fiat currency	cryptocurrency	cryptocurrency
Funding currency	cryptocurrency	cryptocurrency	cryptocurrency	cryptocurrency
Funding cap	hard cap	multiple	uncapped	hard cap
Time horizon	fixed ending date	fixed ending date	fixed ending date	fixed ending date
Time-based discount	none	multiple rates	multiple rates	none

Table 4. Results of the cluster analysis

Figure 12: Clusters in parameter space as observed by Fridgen *et al.* [112]

The most complete example to date of a strictly valid cryptographic asset taxonomy is from a recent conference proceedings article by Fridgen *et al.* entitled *Don't Slip on the ICO* and this study employed Nickerson methodology to arrive at a reasonably useful taxonomy with cluster analysis performed on their desktop research and expert judgement derived dataset. Figures 11 and 12 contain key findings from this publication [112]. This work was presented at an *EJIS* conference in 2018, suggesting that the information systems research domain is leading the way with robust application of taxonomy design in the domain of cryptographic assets, rather than attempts arising from within the nascent cryptocurrency research community itself. Worthy mentions also go to Glaser *et al.* and Tasca *et al.* for producing meaningful classificatory work in the related areas of decentralised consensus mechanisms and blockchain technologies respectively [113, 114].

3 Designing TokenSpace: A Conceptual Framework for Cryptographic Asset Taxonomies

3.1 Introduction & Problem Statement of Taxonomy Development

Much of the taxonomy development methodology developed here is based on the work of Nickerson *et al.* [66, 115] which developed generalised frameworks for the creation of classifications, taxonomies and typologies in the domain of design science for information systems. As the purpose of a taxonomy development is to structure and / or order knowledge or objects within a specific domain, this allows researchers to understand how concepts are interrelated and whether there are anisotropies in the relative incidence of ensembles of characteristics within the group of objects to be classified, if voids or dearths of combinations of characteristics exist within the possibility space and so on.

Using the methodology of Nickerson *et al.* with terminology as outlined in §2.1, we can recall the use of the generalised term taxonomy to refer to conceptual, axiomatic, intuitive, elicited, empirical or hybrid approaches to classification. Phenetics - numerical taxonomy - may be employed to score or weight branches of a taxonomy based on quantitative metrics - such as the number or proportion of fully validating nodes in a network - or to arrive at some initial phenomenological groupings of objects using clustering or other statistical grouping techniques. It is instructive to state explicitly that though classifications may be a step towards ontology as evinced by the periodic table of chemical elements in §2.3, the exercise of developing taxonomies themselves is often conducted with a large degree of intuitive reasoning or *ad hoc* decision making as the process of developing component *taxa* - and the taxonomies they are constructed from - is typically iterative. Using this approach, Nickerson and coworkers have made a valuable contribution to the systematisation the act of systematising domain information - in a sense, *meta-taxonomy* [66, 115].

In the binomial classification paradigm of Linneaus - as applied to biology, botany and zoology - there exists a hierarchy of categories that the user of the taxonomy must follow in order to classify a living thing as a member of a *taxonomic rank*: *kingdom*, *phylum*, *class*, *order*, *family*, *genus* or *species* [116]. Such approaches may be considered as cladistic as well (§2.1), in that they are based on geneaology, provenance or ancestry. *Codebase forkonomies* - fragmentation maps of OSS codebases, kernels and distributions - are a more modern example of simple cladistic taxonomies [5].

3.2 Construction of the TokenSpace Framework: Components & Methodology

3.2.1 Building Robust Taxonomies based on Information Systems Best Practices Nickerson and co-authors describe what can be considered a *taxonomy with flat dimensions*, arrived at by following the process outlined in Figure 13 and approach details in Table 4:

A taxonomy T is a set of n Dimensions D_i ($i = 1, ..., n$) each consisting of k_i ($k_i > 1$) mutually exclusive and collectively exhaustive Characteristics C_{ij} ($j = 1, ..., k_i$) such that each object under consideration has one and only one C_{ij} for each D_i.

$$T = \{D_i,\ i = 1, ..., n\ |D_i = \{C_{ij},\ j = 1, ..., k_i;\ k_i > 1\}\}$$

Prat *et al.* later extended this formal definition to allow hierarchical dimensions, so that *characteristics* may be grouped into *categories*, which may themselves be nested in a higher-level category - Nickerson's *dimensions* - as many times as necessary until the highest *(root)* category is reached which corresponds to the meta-characteristic in Nickerson's lexicon [117].

Method sufficiently describes the objects in domain of interest
Considers alternative approaches to tax. dev.: empirical, conceptual, intuitive, elicited, mixed
Reduces possibility of including arbitrary or *ad hoc* attributes
Can be completed in a reasonable period of time (ending conditions)
Straightforward to apply & "useful"

Table 4: Taxonomy methodology development [115]

Meta-characteristics and characteristics: taxonomy development requires the determination *meta-characteristics*, to serve as the basis of choice of characteristics within the taxonomy. Choice of meta-chararacteristic should be based on the purpose of the taxonomy, and purpose should be based on use. The choice of meta-characteristic in a taxonomy may be arrived at iteratively, as "themes" of the object characteristics being analysed become

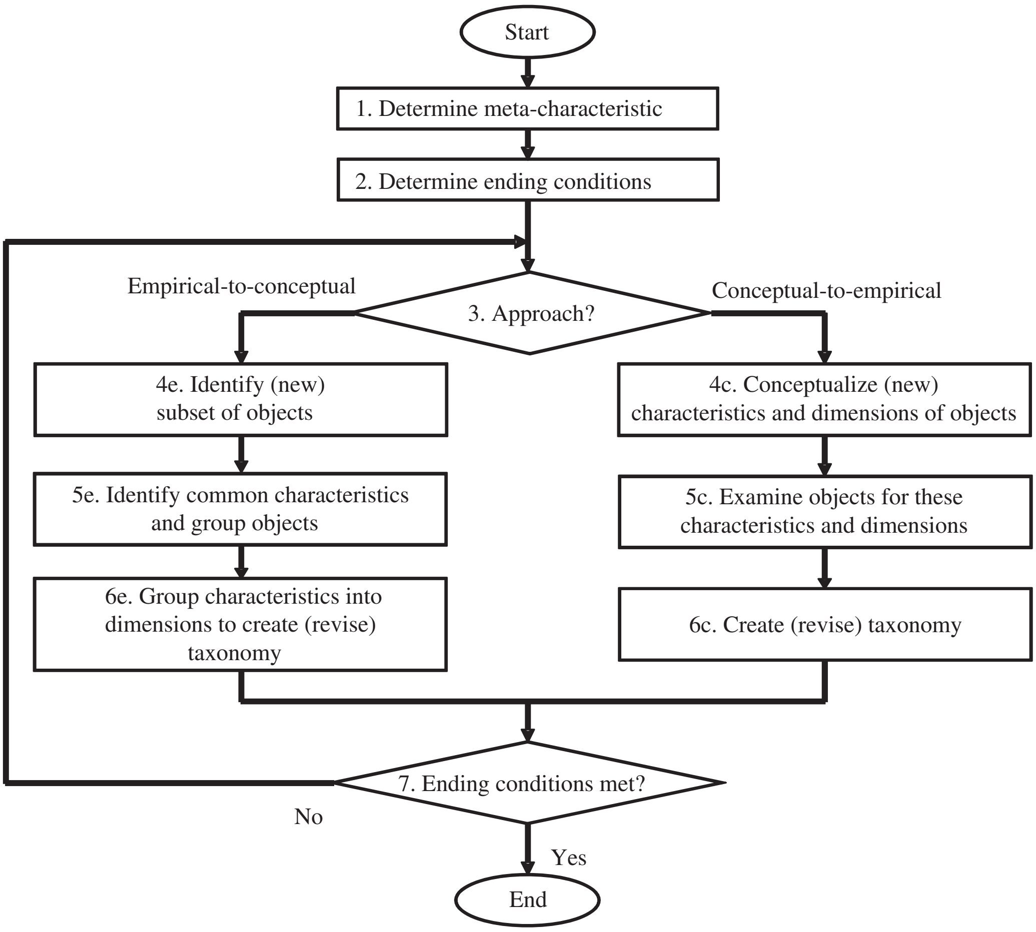

Figure 13: Methodology for taxonomy development by Nickerson *et al.* [115]

apparent or alternatively may be determined *via* empirical investigation with statistical analysis, intuition or by pre-existing conceptual design. After the meta-characteristic has been selected, the researcher can proceed with either conceptual or empirical approaches to reach the first iteration of their *proto-taxonomy*. The meta-characteristic should be the most comprehensive characteristic which the taxonomy should differentiate on the basis of. Characteristics should be logical consequences of the meta-characteristic. Each characteristic that objects exhibit should follow from the meta-characteristic but also discriminate among the objects.

Dimensions: groupings of characteristics which branch recursively from the meta-characteristics. Approaching *conceptually-to-empirically*, dimensions are first conceived intuitively or inductively with meta-characteristic in mind, with characteristics which then follow from the meta-characteristic and are also *mutually exclusive* and *collectively exhaustive* amongst themselves. In an approach of *empirical-to-conceptual* type, dimensions may be conceived *a priori* and later subjected to methodological scrutiny as to their validity. The optimal approach depends on domain knowledge of researcher and the quality and quantity of empirical data available. Flexibility in the approach adopted is valuable as further empirical data and / or domain objects to classify may become available over time.

Ending conditions: using an iterative method there must be specified conditions for the taxonomy development process to terminate / complete, as seen in Table 5. When the classification system fits the definition of a functioning taxonomy that iteration of the taxonomy is complete, for example: characteristics mutually exclusive and collectively exhaustive, sufficient specificity and dimensionality to adequately characterise and differentiate domain objects of interest. That is to say, the taxonomic process can be considered to have completed satisfactorily when no spurious dimensions or characteristics remain, new objects may be classified without need for amendment, each object is satisfactorily classified and the activity of classification furthers understanding of the properties of the class of objects, rather than simply describing them.

Concise - no spurious / non-discriminatory dimensions or characteristics
Robust - can withstand new information and objects
Comprehensive - each object should be classified
Extendible - can integrate new objects, dimensions and characteristics
Explanatory not descriptive

Table 5: Ending conditions for useful taxonomies [115, 118]

3.2.2 Three Conceptual-to-Empirical Approaches to Short-Listing Taxonomy Dimensions & Characteristics Selected dimensions and characteristics for this instantiation of a TokenSpace based on the legacy asset classes discussed in §1.3 follow. Individual taxonomies have been iteratively constructed using a conceptual-to-empirical approach for each meta-characteristic. Taxonomy examples, scores and visual representations are detailed in §4.

Securityness The extent to which an asset or instrument exhibits characteristics of a security.

Proposed contributing factors to an asset's Securityness score which are candidate attributes for taxonomy dimensions and characteristics are listed in Table 6.

A	*Explicit profit-sharing or cost reductions:* dividend payouts, token supply destruction
A	*Rights to on-chain cashflows:* masternodes, passive income such as staking
B	*Intentions or assertions of network creators / asset issuers:* marketing claims and promises, pre-functional trading, explicit / implicit
B, C, G	*Network functionality and / or asset utility:* at $t = 0$ and $t = \mathrm{T}$, network's native asset or secondary layer
C, D, E, G	*Developers:* competence / influence, open-source codebase, originality, commit numbers / concentration, repository control, soft power
D, E, G	*Nodes / users / economic participants:* validation incentives, number and distribution, pooling / aggregation, soft power (*e.g.* UASF)
C, D, E, G	*Miners / validators:* number and distribution, pooling / aggregation, soft power (S2X, hash battles)
D, E, G	*Hardware manufacturers:* clandestine action, influence, incentive alignment with network health
C, D, E, G	*Conspicuous leaders and personalities:* CEOs, thought leaders, deified figures, social media influencers, captured regulators and politicians
C, D, E, G	*Foundations / insiders:* resource control from token sale or self-allocation, seigniorage rights, influence & supply concentration
D, E, G	*Other stakeholders, influencers, institutional stakeholders and shadow plutocrats:* influence & supply concentration
C, D, E, G	*Governance:* decision-making & treasury control concentration, asymmetry between issuer and investor, primacy of human or algorithmic rule, interventionist / non-interventionist.
E, G	*Infrastructure incentives:* nodes, miners / validators, hardware manufacture, supply chain
E, G	*Seigniorage rights:* fair, premine / arbitrary mint, superblocks, masternodes, permissioned
E, G	*Network topology:* centrality, coordinated / permissioned, node aggloremation by number and geography
B, D	*Initial issuance mechanism:* PoW, costless PoX , costly PoX (*e.g.* Proof-of-Burn) / arbitrary mint, premine , snapshot ledger fork, airdrop
B, D	*Ongoing issuance mechanism:* PoW (permissionless entry) / PoX / arbitrary mint
B, G	*Utility:* lack of consumability / intrinsic usefulness / high friction so-called utility tokens

A: Claims on future proceeds — B: Expectation of profit — C: Fractional ownership / Common Enterprise
D: Stakeholders / entities relied upon — E: Voting Control & Influence — F: Risk Capital
G: Post-Howey "Sufficient Decentralisation"

Table 6: Candidate attributes for Securityness

Moneyness The extent to which an asset or instrument exhibits characteristics of a monetary good.

Proposed contributing factors to an asset's Moneyness score which are candidate attributes for taxonomy dimensions and characteristics are listed in Table 7.

A	*Durability:* resistance to change, degradation, reverse-engineering or retrosynthesis
A	*Portability / Payment Friction:* specie retards transportation as narrow money / currency but protocol layers may be built atop (such as gold IOUs, credit facilities)
A	*Divisibility / Fungibility / Privacy:* in-protocol or extra-protocol (UTXO mixing, transaction origin obfuscation, forward secrecy, amounts hiding, bullion franking, coin milling and reeding
A	*Intrinsic Value:* global *versus* local scarcity, price inelasticity of supply, unforgeable costliness, asymmetry of replication / verification
A, B, D, E	*Store of Value:* scarcity, costliness of replication, durability and change-resistance
A, B, F	*Medium of Exchange:* acceptability as payment method, pervasiveness of protocol, transactomes versus Metcalfe
B, F	*Unit of Account:* pervasiveness & legitimacy of the protocol unit. USD worldwide at retail and wholesale level. Gold worldwide but less common. Exchange base pair status.
C, D	*Realness:* simulacrisation / memeticism / Schelling point
D, E	*Hardness:* asymmetry of forgery or simulation vs verification, price elasticity of supply, stock-to-flow ratio
D, E, F	*Supply dynamics:* provable scarcity, global / locally rare, inflation-seigniorage rate, central / treasury reserve
D, E, F	*Demand dynamics:* Lindy, Veblen, Giffen
F	*Resilience:* network security guarantees, stakeholder incentive alignment, honesty assumptions, adversary mitigation, change / tamper resistance, permissionlessness, issuance mechanism, native or non-native
F	*Protocol Breadth:* evolution from narrow to broad money, credit as L2, transactomes as leading indicator of monetary potential, adoption / acceptance as present / lagging indicator

A: After Aristotle — B: After Jevons — C: After Baudrillard — D: After Szabo — E: After Hayek
F: Network Utility & Value

Table 7: Candidate attributes for Moneyness

Commodityness The extent to which an asset or instrument exhibits characteristics of a commodity good.

Proposed contributing factors to an asset's Commodityness score which are candidate attributes for taxonomy dimensions and characteristics are listed in Table 8.

Durability: in- and extra-protocol persistence resistance to change or retrosynthesis, Lindy-type time-dependent effects.
Resilience: network security & honesty assumptions, key entity and technology risk, stakeholder alignment, native / non-native asset.
Universality: portability / transaction friction, realness / materiality, protocol breadth, network maturity, network legitimacy, fungibility in- and extra-protocol
Intrinsic Value: network consensus model, supply and demand dynamics
Usefulness: reason for holding asset, liquidity depth, asset utility (consumability / transformability), crypto-economic friction
Explicit Incentives: profit / surplus sharing or cost reduction, rights to on-chain cash flows

Table 8: Candidate attributes for Commodityness

3.3 Design Choices & Justifications for TokenSpace

3.3.1 TokenSpace as a Conceptual Representation of Spatio-Temporal Reality The instantiation of a TokenSpace presented in §4 is best thought of as an idealised three-dimensional space within which assets are placed according to taxonomy-derived "scores". Each axis maps to a particular meta-characteristic as outlined in §3.2, "Securityness", "Moneyness" and "Commodityness". The TokenSpace presented here may be considered by analogy with our own spatio-temporal conception of reality, consisting of a three-dimensional space delineated (for convenience and visual clarity) by orthogonal axes $\bar{\mathcal{S}}$, $\overline{\mathcal{M}}$ and $\bar{\mathcal{C}}$ with a fourth temporal dimension able to be incorporated through the "movement" of assets through the space as characteristics evolve over time.

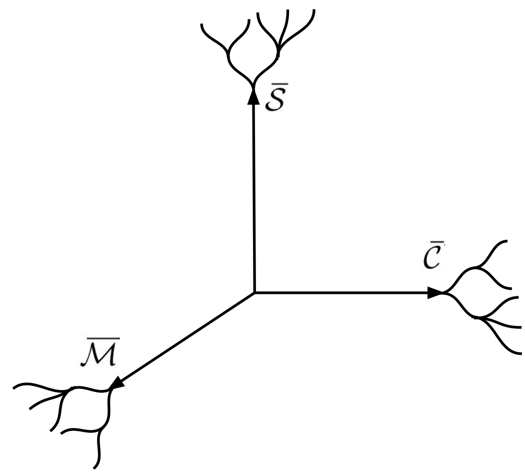

Figure 14: TokenSpace visual impression

Other constructions with different meta-characteristics, boundaries, scoring methods or dimensionality are possible. TokenSpace is intended to be a flexible conceptual framework designed to output visually comparable results. Assets may possess a score or range on each axis between 0 and 1 inclusive giving rise to an object inhabiting a region of TokenSpace described by the (x, y, z) coordinates which in this case map to the meta-characteristics ($\bar{\mathcal{C}}$, $\overline{\mathcal{M}}$, $\bar{\mathcal{S}}$). Each asset's location in TokenSpace is intended to be derived from a weighted scoring system based upon combinations of taxonomy, typology, intuitive, elicited and / or quantitative methods depending on the choices and assertions of the user - which may or may not be identical to those proposed in this work.

3.3.2 Defining Boundaries For the purposes of facile comprehension, each axis is bounded between the values of zero and one. An asset that is determined - using whichever scoring method is chosen by the researcher - to exhibit *none* of the properties that are taken to constitute the meta-characteristic would possess a score of zero. Conversely an asset constituting an *ideal* or canonical example in the context of Bailey's definitions (see §2.1) of the meta-characteristic in question would possess a score of one. Assets may possess any value between zero and one, although this somewhat coarse approach does not distinguish between "good" or "bad" assets - for example a 2017 ICO may constitute a very poor investment analogue of a security, and at present TokenSpace does not distinguish between this asset's Securityness from a *bona fide* security such as a legitimately issued stock or bond. TokenSpace could be extended to occupy a space between negative one and positive one to reflect the difference in quality of assets in the future.

3.3.3 Dimensionality & Clarity The choice of three meta-characteristics and hence spatial dimensions in the example instantiation of a TokenSpace constructed in §4 is partially justified by the analysis of traditional asset classes in §1.3.3 and the apparent link between securities, commodities and moneys with characteristics of various cryptographic assets. Depending on the needs of the user, a custom TokenSpace could be created with any number of dimensions but beyond 3 or 4 the visual clarity afforded by the framework diminishes. Conversely fewer dimensions could be used, or a bespoke TokenSpace could be constructed by iteratively adding dimensions with scores derived from the usual menu of options with judgement applied as to the dimensionality which provides the greatest explanatory power. Alternative graphical approaches such as a "radar" diagram may be helpful in visually comparing higher dimension TokenSpaces, as seen in Figure 15, though awareness of the so-called *Curse of Dimensionality* and in particular implications to statistical analysis of populations in sparsely populated high-dimensional Euclidean space [119]. In particular analytical techniques such as k-means clustering may produce unreliable results in such scenarios.

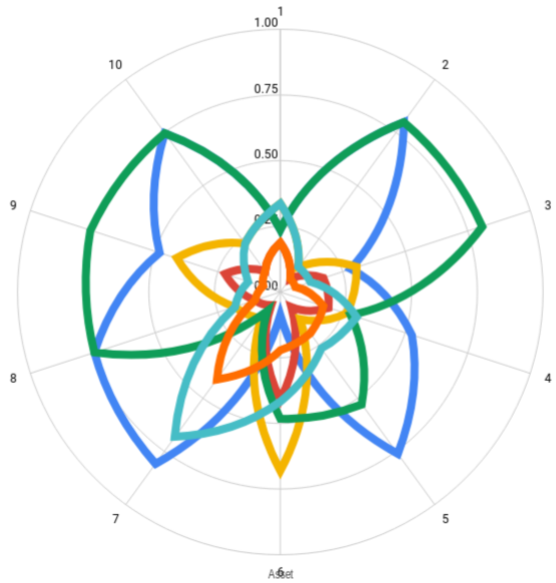

Figure 15: A radar graphical approach for a hypothetical TokenSpace

Some discussion of the true "orthogonality" of the meta-characteristics employed here is worthwhile. It is not the belief of the author that these overarching attributes are completely independent from one another, instead the utilisation of orthogonal axes is a conceptual simplification considered acceptable in order to produce output which can be easily visually discerned by humans. This is in accordance with the aims of producing a useful classification framework for the subjective comparison of cryptographic asset properties. For instance Commodityness could be seen as an analogue of *utilityness*, but so-called utility tokens also frequently exhibit security-like characteristics. Likewise, commodity-like assets such as Bitcoin and Ethereum are also partially usable as *pseudo-monetary* goods. The taxonomies displayed in Tables 10 and 11 show a great deal of commonality in the dimensions between Moneyness and Commodityness, with significant differences in the weightings of scores.

3.3.4 Categorical & Numerical Characteristics For an ideal instantiation of TokenSpace with maximum explanatory power, a balance should be struck between thorough utilisation of discriminatory attributes whilst not encumbering the researcher with a classification which is overly burdensome to apply. For the instantiation of TokenSpace in §4 the optimal balance was found with hybrids of categorical and phenetic taxonomy types. This design choice - preferring hybrid *supra-taxonomies* to simpler categorical taxonomies - is justified by the desired outcome of numerical scores as the output of the classification execution in order to populate asset locations in the Euclidean 3D space that TokenSpace creates. A particularly useful tool, made use of widely in the taxonomy examples in §4 is the *indexed dimension*. Taking the notion of a range-bound score - determined in any manner deemed acceptable as part of the experiment design process - as a proxy for one or more categorical discriminants allows significant simplification of the application of taxonomic systems to objects. A pertinent example of this in the *TS10* TokenSpace example illustrated in §4 is the consolidation of seven multi-layered dimensions addressing the balance of power and influence between network stakeholders into a single "alignment index".

It is important to consider Goodhart's Law when developing quantitative metrics, as the decentralisation theatre discussed in §1.3.3 or susceptibility of metrics to Sybil nodes or automated agents mean that many quantitative metrics cannot be relied upon in an absolute sense. That which can be measured, becomes an optimisation target and as a result is susceptible to manipulation [120]. Comparative analytical approaches may be still be valuable, and judgement should be exercised by the researcher with respect to this. Taking this one step further, the researcher should keep in mind that their classification approach may require constant appraisal and optimisation. Due to strong incentives for ecosystem participants to portray some assets favourably with respect to others for a variety of motivations, the very act of publishing a classification approach renders it vulnerable to perversion through relatively facile means of manipulation. In this respect, though making use of indexed dimensions increases the relative subjectivity of a classification system it also somewhat mitigates the effects of Goodhart's Law providing the researcher is sufficiently cautious in the development of their taxonomic system and its application to populations of objects.

3.3.5 Score Modifiers & Weightings for Taxonomy Characteristics & Dimensions The purpose of assigning weightings to each dimension and/or characteristic in a meta-characteristic's taxonomy is to provide a rational basis from which to derive a quantitative but subjective score for each axis that a TokenSpace is constructed from. In the instantiation of TokenSpace presented in §4, with three meta-characteristics and indexed or categorical discrimination the weightings attached to dimensions may be conceived intuitively or by employing optimisation approaches. So for a dimension with three (mutually-exclusive) characteristics, characteristic A may increase the overall score by 0.05, characteristic B may increase it by 0.025 and characteristic C leads to no change. In the instantiation of TokenSpace presented in §4, weightings have been applied in an *ad hoc* manner for each meta-characteristic's taxonomy. In doing so, even when different taxonomies contain significant overlap of dimensions, categories and characteristics their weightings and overall scores may vary depending on how important those factors are judged to be in contributing to the meta-characteristic.

Approximate "target" scores for a selection of assets were intuitively reasoned and score modifiers for characteristics adjusted to facilitate loose convergence of conceptual and empirical methods. This approach could be refined by using statistical and operational research techniques such as cluster analysis of results, algorithmic optimisation or methods such as Delphi elicited judgement [121].

The approach employed in §4 with *TS10* was to assign weightings to the dimensions themselves, so that the characteristic scores are themselves scored for importance in their overall contribution to each meta-characteristic score.

The definition of one or more category would be the selection of the dimensions: $\{a_i,\ i = 1, ..., n\}$,

which together would constitute the taxonomy for a particular meta-characteristic, and the relative weighting of these attributes: $\{w_i,\ i = 1, \ldots, n, \sum_i w_i = 1\}$.

3.3.6 Time-Dependence Time-dependence of asset characteristics and hence their location in TokenSpace may be significant in certain instances due to temporal phenomena such as the putative *Lindy effect*, increased functionality of a network and hence a token that is required to access its services, and more generally the dynamic nature of cryptocurrency protocol networks and their native assets, tokens issued atop them and network fragmentations such as ledger forks. Time-dependent phenomena can be coarsely incorporated into this framework by evaluating an asset's location in TokenSpace at different points in time and charting asset trajectories. A more advanced approach (currently in development) could be to calculate a coordinate at time t based upon functions mapping expected or judged variation. Care should be taken to distinguish between temporal interpolation between past and present, and extrapolation beyond the present as future characteristics of an asset may not necessarily be easily predicted with a high degree of confidence.

A pertinent example of time-dependence of the Securityness meta-characteristic is the ostensible judgement of senior SEC official William Hinman to heavily imply in public comments made in summer 2018 that he deemed the Ethereum network to have become "*sufficiently decentralised*" for its native token ETH to not be considered a security, although the token crowdfunding event in 2014 most likely was a securities offering (see §1.3.3). These comments give rise to the necessity of a *time-dependent* scoring aspect to allow for changes as the network and / or asset matures. This may be justified as follows: the evolving characteristics of proliferating tokenised P2P networks appear to have a significant bearing on the opinions of senior regulators with respect to the security status of particular assets, and no objective boundary (or *"Securityness threshold"*) to separate objects on either side of exists *a priori*. Another consideration is the prospect of a "grace period" for distributed networks bearing cryptographic assets and tokens, as invariably these will commence operation as much more concentrated / centralised systems than the would eventually be envisaged to become.

Whilst these types of comments are indicative of an open-minded approach from legislative officials, some open questions remain. If future claims of ether on the as-yet-unfunctional Ethereum Frontier mainnet were a security at time of the crowdfunding, but ETH no longer carries that designation due to an "increase in decentralisation" then - making the assumption that regulators are rational and logical actors - we can propose that some *regulatory boundary surface / zone* in TokenSpace has been advanced through, from *is security* to *is not security* and the primarily underlying reason for this according to Hinman is "*sufficient decentralisation*" without making clear what the justification for this opinion was, or indeed decentralistion at which layer of the network meta-stack and ecosystem (§1.2).

A more general regulatory policy question arises, which has significant implications for assets which were issued in a state of *high Securityness* with properties such as pre-network functionality and / or tightly held supply by insiders. Indeed the long-running cryptoasset exchange *Poloniex* announced in late 2018 that it was delisting three assets *Gnosis* (GNO), *Expanse* (EXP) and *Synereo* (AMP) without reasons proffered. However these assets share to some extent both of the above Securityness increasing properties, lending credence to the notion that the new owner of the business - Goldman Sachs-backed *Circle* - intends to follow a *compliance-first* strategy and are assessing the possible declaration of particular cryptoassets as securities by the SEC at some point in the future [46].

3.3.7 Boundary Functions Following on from the complexities raised in §3.3.6 regarding the time-dependence of the location of assets inhabiting TokenSpace, the notion of a regulatory boundary function has been developed to delineate the change in ETH's status from *is security* to *is not security* based upon Hinman's summer 2018 comments (see §1.3.3). Naturally this is a subjective assignment and may be affected by factors both endogenous and exogenous to the networks and assets in question. An example of such a regulatory boundary visualised in TokenSpace is presented in Figure 16.

This binary approach may be extended to account for edge cases and regulatory grey zones by instead making a "*safe*", "*marginal*" or "*dangerous*" distinction with regard to the likely compliance of assets with respect to particular regulatory regimes. Careful review of territory-specific regulatory guidance and judicious consideration of boundary functions is a necessity for this approach to have utility beyond the hypothetical.

3.3.8 Non-point & Anisotropic Asset Locations When there is uncertainty or disagreement regarding the optimal weighting of a taxonomy characteristic or the categorical assignment of an asset, it may be helpful to employ a range, error bars or probability density functions (PDFs) to represent the likelihood of the meta-characteristic instead of precise *loci* [122]. The space-filling representations of quantum mechanical electron orbitals displayed in Figure 17 provide a set of well-understood and characterised functions from which to develop such an extension to TokenSpace and this is the subject of ongoing research.

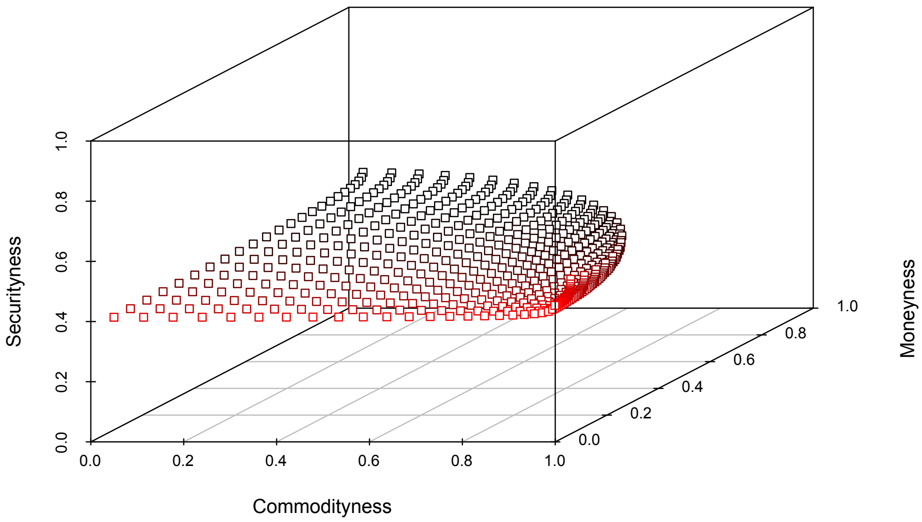

Figure 16: Regulatory / compliance boundary visualised in TokenSpace. Arbitrary polynomial for illustrative purposes

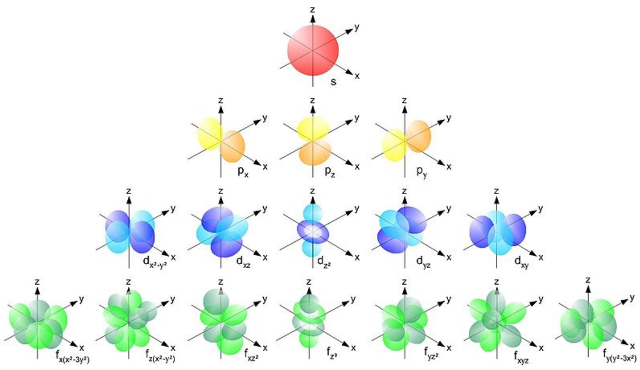

Figure 17: Single electron orbital probability density functions represented in 3D space [122]

Dimension	Category	Characteristics						
Explicit Incentives								
(1)	Profit-sharing / cost-reduction	Dividends, token buybacks or burns A (0.4)	Issuer-sanctioned airdrops B (0.3)	Service discounts C (0.3)	Combinations / other D (0 to 1)	None E (0)		
(2)	Rights to CFs	Masternodes A (0.6)	Staking rewards B (0.4)	Combinations / other C (0 to 1)	None D (0)			
Implicit Incentives								
(3)	Marketing claims / investor expectations			Quantitative variable: Expectations index (0 to 1)				
(4)	Network functionality at time t			Quantitative variable: Network functionality index (Inverse) (0 to 1)				
(5)	Asset utility at time t			Quantitative variable: Asset utility index (Inverse) (0 to 1)				
(6)	Initial issuance mechanism	PoW A (0)	Costly PoX e.g Proof-of-Burn B (0.2)	Snapshot / Fork / Airdrop C (0.4)	Costless PoX D (0.55)	Arbitrary Mint / Premine / Instamine E (0.7)	ICO F (0.85)	SAFT/Deferred Distribution G (1)
(7)	Ongoing issuance mechanism	PoW A (0)	PoX B (0.25)	Arbitrary Mint (algorithmic / autonomous) C (0.5)	Arbitrary Mint (centrally controlled) D (0.75)	None E (1)		
Stakeholder Alignment								
(8)	Balance between network participants			Quantitative variable: Alignment index (Inverse) (0 to 1)				
Network Governance								
(9)	Governance Type	Masternode A (0.6)	Token/ticket B (0.3)	Reputation C (0.2)	Combination / other D (0 to 1)	None / off-chain E (0)		
(10)	Token-Holder voting rights	Upgrade & treasury A (1)	Upgrade B (0.5)	Treasury C (0.5)	Indirect (implicit) D (0.2)	None (explicit) E (0)		
(11)	Treasury / foundation supply control			Quantitative variable: Insider supply control index (0 to 1)				
(12)	Power asymmetry between issuer and investors			Quantitative variable: Asymmetry index (0 to 1)				
(13)	Human primacy over codebase / assets			Quantitative variable: Mutability index (0 to 1)				
Network Topology / Software Properties								
(14)	Network centrality / distribution			Quantitative variable: Centrality index (0 to 1)				
(15)	Permissioned / proprietary elements			Quantitative variable: Openness index (Inverse) (0 to 1)				
(16)	Ease of node operation / software compatibility			Quantitative variable: Network compatibility index (Inverse) (0 to 1)				

Table 9: Securityness taxonomy (3rd iteration)

Dimension	Category	Characteristics						
Longevity								
	DURABILITY							
(1)	In/extra-protocol persistence	Quantitative variable: Technical / social antifragility index (0 to 1)						
(2)	Lindy type time-dependent effects	Quantitative variable in the time domain (0 to 1)						
	RESILIENCE							
(3)	Network & protocol robustness	Quantitative variable: Robustness index (0 to 1)						
(4)	Key entity risk / Layer N risk / Smart Contract risk / Cryptography risk	Quantitative variable: Externality index (Inverse) (0 to 1)						
(5)	Balance between network participants	Quantitative variable: Alignment index (Inverse) (0 to 1)						
Portability								
(6)	Transactional friction	Quantitative variable: Friction index (Inverse) (0 to 1)						
Pervasiveness								
(7)	Realness / Materiality Memeticism / Simulacrisation	Quantitative variable: Materiality index (0 to 1)						
(8)	Protocol breadth at time t	Quantitative variable: Protocol breadth index (0 to 1)						
(9)	Network maturity at time t	Quantitative variable: Maturity index (0 to 1)						
(10)	Network legitimacy at time t	Quantitative variable: Legitimacy index (0 to 1)						
Fungibility / Privacy								
(11)	In protocol	Full transparency A (0)	Opt-in privacy B (0.3)	Private with selective audit C (0.65)	Fully private D (1)			
(12)	Extra protocol	Coin mixing A (0.25)	Sender obfuscation B (0.25)	Node level C (0.25)	L2 / Sidechain D (0.25)	Combinations thereof E (0 to 1)	None F (0)	
Supply Dynamics								
(13)	Initial issuance mechanism	PoW A (1)	Costly PoX e.g Proof-of-Burn B (0.8)	Snapshot / Fork / Airdrop C (0.6)	Costless PoX D (0.45)	Arbitrary Mint / Premine / Instamine E (0.3)	ICO F (0.15)	SAFT/Deferred Distribution G (0)
(14)	Ongoing issuance mechanism	PoW A (1)	PoX B (0.75)	Arbitrary Mint (algorithmic / autonomous) C (0.5)	Arbitrary Mint (centrally controlled) D (0.25)	None E (0)		
(15)	Price elasticity of supply	Quantitative variable: Price Elasticity of Supply / unforgeable costliness (0 to 1)						
(16)	Inflation	None A (1)	Fixed/known B (0.5)	Adaptive/variable C (0)				
(17)	Scarcity	Hard cap (algorithmically enforced) A (1)	Cap (social consensus / implied) B (0.65)	No cap (promised) C (0.3)	No cap (no promise) D (0)			
(18)	Asset supply concentration	Quantitative variable: Proportion of supply controlled by insiders/foundation (Inverse) (0 to 1)						
Demand Dynamics								
(19)	Acceptability as payment method	Quantitative variable: Acceptability index (0 to 1)						
(20)	Settlement and value flows	Quantitative variable: Settlement index (0 to 1)						
(21)	Liquidity depth	Quantitative variable: Liquidity index (0 to 1)						
(22)	Volatility in price	Quantitative variable: Volatility index (Inverse) (0 to 1)						

Table 10: Moneyness taxonomy (3rd iteration)

Dimension	Category	Characteristics							
Longevity									
	DURABILITY								
(1)	In/extra-protocol persistence	Quantitative variable: Technical / social antifragility index (0 to 1)							
(2)	Lindy type time-dependent effects	Quantitative variable in the time domain (0 to 1)							
	RESILIENCE								
(3)	Network & protocol robustness	Quantitative variable: Robustness index (0 to 1)							
(4)	Key entity risk / Layer N risk / Smart Contract risk / Cryptography risk	Quantitative variable: Externality index (Inverse) (0 to 1)							
(5)	Balance between network participants	Quantitative variable: Alignment index (Inverse) (0 to 1)							
Portability									
(6)	Transactional friction	Quantitative variable: Friction index (Inverse) (0 to 1)							
Pervasiveness									
(7)	Realness / Materiality Memeticism / Simulacrisation	Quantitative variable: Materiality index (0 to 1)							
(8)	Protocol breadth at time t	Quantitative variable: Protocol breadth index (0 to 1)							
(9)	Liquidity depth	Quantitative variable: Liquidity index (0 to 1)							
(10)	Network maturity at time t	Quantitative variable: Maturity index (0 to 1)							
(11)	Network legitimacy at time t	Quantitative variable: Legitimacy index (0 to 1)							
Fungibility / Privacy									
(12)	In protocol	Full transparency A (0)	Opt-in privacy B (0.3)	Private with selective audit C (0.65)	Fully private D (1)				
(13)	Extra protocol	Coin mixing A (0.25)	Sender obfuscation B (0.25)	Node level C (0.25)	L2 / Sidechain D (0.25)	Combinations thereof E (0 to 1)	None F (0)		
Supply Dynamics									
(14)	Initial issuance mechanism	PoW A (1)	Costly PoX e.g Proof-of-Burn B (0.8)	Snapshot / Fork / Airdrop C (0.6)	Costless PoX D (0.45)	Arbitrary Mint / Premine / Instamine E (0.3)	ICO F (0.15)	SAFT/Deferred Distribution G (0)	
(15)	Ongoing issuance mechanism	PoW A (1)	PoX B (0.75)	Arbitrary Mint (algorithmic / autonomous) C (0.5)	Arbitrary Mint (centrally controlled) D (0.25)	None E (0)			
(16)	Price elasticity of supply	Quantitative variable: Price Elasticity of Supply / unforgeable costliness (0 to 1)							
(17)	Inflation	None A (1)	Fixed/known B (0.5)	Adaptive/variable C (0)					
(18)	Scarcity	Hard cap (algorithmically enforced) A (1)	Cap (social consensus / implied) B (0.65)	No cap (promised) C (0.3)	No cap (no promise) D (0)				
(19)	Asset supply concentration	Quantitative variable: Proportion of supply controlled by insiders/foundation (Inverse) (0 to 1)							
Demand Dynamics / Usefulness									
(20)	Asset purpose	Access to service A (0.15)	Rights to CFs B (0.15)	Reward potential / spec. C (0.15)	Volatility hedge D (0.15)	SoV E (0.15)	Issuer-mandated airdrops F (0.15)	Payment / MoE G (0.15)	Combination / none H (0 to 1)
(21)	Asset utility at time t	Quantitative variable: Utility index (0 to 1)							
(22)	Settlement and value flows	Quantitative variable: Settlement index (0 to 1)							

Table 11: Commodityness taxonomy (3rd iteration)

	wt /	BTC	ETH	XRP	EOS	LTC	BCH	USDT	XLM	TRX	BNB
1 Profit share / cost red	0.025	0	0	0	0.3	0	0	0	0.3	0.3	0.3
2 Rights to CFs	0.025	0	0	0	0.4	0	0	0	0	0.4	0
3 Marketing Claims / Investor Expectations	0.05	0	0.7	0.85	1	0.2	0.3	0.3	0.7	1	0.8
4 Network Function	0.15	0.1	0.5	0.8	0.9	0.3	0.15	0.2	0.8	0.6	0.8
5 Asset Utility	0.1	0.3	0.45	0.8	0.9	0.4	0.5	0.2	0.7	0.85	0.85
6 Initial Issuance Mech	0.1	0	0.85	0.7	0.85	0	0.4	0.2	0.7	0.85	0.85
7 Ongoing Issuance Mech	0.05	0	0	1	0.55	0	0	0.75	1	0.25	1
8 Stakeholder Balance	0.1	0.2	0.65	0.9	0.8	0.5	0.6	0.7	0.9	1	1
9 Governance Type	0.025	0	0.2	0.2	0.6	0	0.2	0.2	0.2	0.6	0.3
10 Token-Holder Vote Rights	0.025	0	0	0	0.5	0	0	0	0	0.5	0.2
11 Treasury Supply Control	0.05	0	0.4	0.85	0.5	0.2	0	1	0.9	0.9	0.9
12 Power Asymm	0.1	0.2	0.6	0.9	1	0.3	0.4	0.8	0.9	0.9	0.9
13 Primacy Algo/Human Code & Assets	0.1	0	0.75	0.9	1	0.3	0.3	1	0.9	0.9	0.9
14 Network Centrality / Distn	0.05	0	0.2	0.7	0.8	0.4	0.3	1	0.9	0.9	0.9
15 Permissioned/Propietary Elements	0.025	0	0	0.6	0	0	0	1	0.6	0	0.6
16 Ease of Node Operation / Compatability	0.025	0.1	0.3	0.6	0.9	0.1	0.2	1	0.6	0.9	1
TS10 SCORE		0.09	0.48	0.75	0.80	0.24	0.28	0.53	0.75	0.76	0.81

Table 12: Securityness category assignments and scores as of April 2019

	wt /	BTC	ETH	XRP	EOS	LTC	BCH	USDT	XLM	TRX	BNB
1 In/extra-protocol persistence	0.025	0.6	0.1	0.05	0.1	0.25	0.2	0.3	0.05	0.05	0.05
2 Lindy type time-dependent effects	0.025	0.3	0.15	0.05	0	0.2	0.05	0.1	0.05	0	0
3 Network robustness	0.05	0.4	0.2	0	0	0.15	0.05	0.05	0	0	0
4 Externality risk	0.05	0.3	0.1	0.05	0.025	0.15	0.05	0	0.05	0	0
5 Stakeholder alignment	0.05	0.65	0.8	0.1	0.1	0.3	0.1	0	0.05	0.025	0.025
6 Transactional friction	0.025	0.3	0.3	0.05	0.05	0.2	0.2	0.2	0.1	0.1	0.025
7 Realness / materiality	0.05	0.75	0.15	0.05	0.05	0.025	0.05	0.1	0.05	0.05	0
8 Protocol breadth	0.1	0.2	0.1	0.05	0.025	0.075	0.05	0.1	0.05	0.025	0
9 Network maturity	0.05	0.3	0.1	0.1	0.025	0.15	0.05	0.1	0.1	0.05	0.025
10 Network legit	0.025	0.6	0.4	0.1	0.2	0.05	0.1	0.1	0.1	0.05	0.025
11 Fung/priv in-prot	0.1	0	0	0	0	0	0	0	0	0	0
12 Fung/priv extra-prot	0.025	0.6	0.2	0	0	0.2	0.2	0	0	0	0
13 Initial issuance	0.025	1	1	0.3	0.15	1	1	0.8	0.3	0.15	0.15
14 Ongoing issuance	0.025	1	1	0	0.75	1	1	0.25	0	0.75	0.75
15 Price inelasticity	0.025	0.8	0.5	0.1	0.1	0.35	0.8	1	0.1	0.1	0.1
16 Inflation	0.025	0.5	0	1	0	0.5	0.5	0	1	0.5	0.5
17 Scarcity	0.025	1	0.3	1	0	1	1	0	1	0.3	0.3
18 Asset supply conc	0.05	0.5	0.3	0.1	0.15	0.2	0.2	0.2	0.05	0.05	0.05
19 Acceptability paym	0.1	0.3	0.15	0.05	0.05	0.1	0.1	0.1	0.05	0.025	0.025
20 Settlement/valflows	0.05	0.4	0.1	0.05	0.025	0.01	0.05	0.15	0.05	0.025	0.025
21 Liquidity depth	0.05	0.25	0.1	0.025	0.01	0.01	0.025	0.5	0.025	0.025	0.025
22 Volatility	0.05	0.3	0.1	0.05	0.05	0.05	0.05	1	0.05	0.05	0.05
TS10 SCORE		0.41	0.22	0.10	0.06	0.19	0.17	0.19	0.10	0.07	0.06

Table 13: Moneyness category assignments and scores as of April 2019

	wt /	BTC	ETH	XRP	EOS	LTC	BCH	USDT	XLM	TRX	BNB
1 In/extra-protocol persistence	0.025	0.6	0.1	0.05	0.1	0.25	0.2	0.3	0.05	0.05	0.05
2 Lindy type time-dependent effects	0.025	0.3	0.15	0.05	0	0.2	0.05	0.1	0.05	0	0
3 Network robustness	0.025	0.4	0.2	0	0	0.15	0.05	0.05	0	0	0
4 Externality risk	0.025	0.3	0.1	0.05	0.025	0.15	0.05	0	0.05	0	0
5 Stakeholder alignment	0.025	0.8	0.25	0.1	0.1	0.3	0.1	0	0.05	0.025	0.025
6 Transactional friction	0.025	0.3	0.3	0.05	0.05	0.2	0.2	0.2	0.1	0.1	0.025
7 Realness / materiality	0.05	0.75	0.15	0.05	0.05	0.025	0.05	0.1	0.05	0.05	0
8 Protocol breadth	0.025	0.2	0.1	0.05	0.025	0.075	0.05	0.1	0.05	0.025	0
9 Liquidity depth	0.025	0.25	0.1	0.025	0.01	0.01	0.025	0.5	0.025	0.025	0.025
10 Network maturity	0.025	0.3	0.1	0.1	0.025	0.15	0.05	0.1	0.1	0.05	0.025
11 Network legit	0.025	0.6	0.4	0.1	0.2	0.05	0.1	0.1	0.1	0.05	0.025
12 Fung/priv in-prot	0.025	0	0	0	0	0	0	0	0	0	0
13 Fung/priv extra-prot	0.025	0.6	0.2	0	0	0.2	0.2	0	0	0	0
14 Initial issuance	0.025	1	1	0.3	0.15	1	1	0.8	0.3	0.15	0.15
15 Ongoing issuance	0.025	1	1	0	0.75	1	1	0.25	0	0.75	0.75
16 Price inelasticity	0.05	0.8	0.5	0.1	0.1	0.35	0.8	1	0.1	0.1	0.1
17 Inflation	0.025	0.5	0	1	0	0.5	0.5	0	1	0.5	0.5
18 Scarcity	0.025	1	0.3	1	0	1	1	0	1	0.3	0.3
19 Asset supply conc	0.025	0.5	0.3	0.1	0.15	0.2	0.2	0.2	0.05	0.05	0.05
20 Asset purpose	0.05	0.6	0.75	0.45	0.6	0.6	0.6	0.45	0.6	0.6	0.6
21 Asset utility	0.375	0.9	0.6	0.2	0.1	0.4	0.3	0.3	0.3	0.1	0.1
22 Settlement/val flows	0.05	0.4	0.1	0.05	0.025	0.01	0.05	0.15	0.05	0.025	0.025
TS10 SCORE		0.68	0.42	0.18	0.12	0.34	0.31	0.27	0.23	0.13	0.12

Table 14: Commodityness category assignments and scores as of April 2019

4 Creating a TokenSpace: *TS10*

4.1 Iterative Construction of Taxonomies, Indices & Score Modifiers

Based on the asset characteristics discussed in §1.3 and the methodologies employed by Bailey, Nickerson and Prat in §2 and §3, the author has constructed a TokenSpace named *TS10* and three hybrid categorical and quantitative taxonomies with weighted scores based on the meta-characteristics, dimensions and characteristics discussed in §3.2 paying heed to the design considerations outlined in §3.3. These taxonomies are shown in Tables 9, 10 and 11. In applying the Nickerson methodology (§3.2.1) some judgement was used to reduce the complexity of the putative taxonomies by consolidating a number of similar and / or overlapping categories into "indexed" ranged score modifiers as discussed in §3.3.4. Care was taken to ensure the correct "polarity" of outputted scores - for example a network perceived to have poor stakeholder balance would lead to an increase in Securityness but a decrease in Moneyness. This is consistent with the design goals of being useful, straightforward to apply and minimising arbitrary elements. It is a potential goal for extensions of this work to more thoroughly delineate the impact of each of these elements in finer granularity and assign appropriate score modifiers and / or branch weightings to them.

TS10 Taxonomy Development Iterations:
1) Progression from intuitively reasoned shortlists in §3.3 to categorical & indexed dimensions.
2) Assigned unstandardised characteristic score modifiers (weightings incorporated), reduced number of dimensions, some categorical dimensions consolidated into index form.
3) Standardised characteristic score modifiers to separately apply weightings, further reduction of dimensions, collapsing some categoricals further into indices for ease of application - at possible expense of increased subjectivity.

4.2 Placing Assets in *TS10*

Having produced these *proto-taxonomies*, the Nickerson method was applied and selected major cryptographic assets were "classified" with meta-characteristic scores for Securityness ($\bar{\mathcal{S}}$), Moneyness ($\overline{\mathcal{M}}$) and Commodityness ($\bar{\mathcal{C}}$) in order to populate this *TS10* instantiation of TokenSpace. Assets were selected by their perceived importance *via* the admittedly coarse heuristic of market capitalisation at time of writing. Assets included: Bitcoin (BTC), Ethereum (ETH), Ripple (XRP), EOS (EOS), Litecoin (LTC), Bitcoin ABC (BCH), Tether (USDT), Stellar (XLM), Tron (TRX) and Binance Coin (BNB). *TS10* full breakdowns of scores and weightings for each meta-characteristic's taxonomy are presented in Tables 12, 13 and 14. Overall score values are presented in Table 15 and definitions of dimensions in Table 16. Statistical analytical results are visually represented in Figures 18 & 19, and the *TS10* TokenSpace is visually represented in Figure 20.

DISCLAIMER: A reminder that the decisions of category selection, dimension weighting and / or index values have been made in an *ad hoc*, *approximate* and *subjective* manner and do not necessarily correlate to an objective representation of reality. *The author is not a lawyer, regulator or legal professional and has no definitive opinion on the regulatory or compliance status or consequences of assets being classified with particular assignations by any territorial or jurisdictional legislature. By reading this document you agree that the author accepts no liability or responsibility for the results outlined below or any discussions arising thereof. TS10, TSL7 and TSTDX TokenSpace scores are provided for intellectual purposes and the aforementioned TokenSpaces are an abstract and hypothetical representation based upon the methodologies developed in this work.*

Asset	($\bar{\mathcal{S}}$)	($\overline{\mathcal{M}}$)	($\bar{\mathcal{C}}$)	Notes
BTC	0.09	0.41	0.68	
ETH	0.48	0.22	0.42	
XRP	0.75	0.10	0.18	
EOS	0.80	0.06	0.12	
LTC	0.24	0.19	0.34	
BCH	0.28	0.17	0.31	
USDT	0.53	0.19	0.27	
XLM	0.75	0.10	0.23	
TRX	0.76	0.07	0.13	
BNB	0.81	0.06	0.12	
Mean	0.55	0.16	0.28	
Std. Dev.	0.27	0.11	0.17	

Table 15: *TS10* scores listed to two decimal places

SMC *Balance between network participants:** The extent of egality and balance of influence among the various network stakeholders.
SMC *Initial issuance mechanism:* The token distribution method employed by asset issuers at first.
SMC *Ongoing issuance mechanism:* The token distribution method employed by asset issuers after genesis.
SC *Asset utility at time t:** How functional the asset is at a point in time.
MC *In / extra-protocol persistence:** The extent to which the social and protocol layers of the network resist influence to change the transaction record.
MC *Lindy type time-dependent effects:** A variable in the time domain to reflect the gradual increase in desirability of an asset with reference to the putative Lindy effect.
MC *Network & protocol robustness:** Security and honesty assumptions / requirements for optimal network function.
MC *Key entity risk / Layer N risk / Smart Contract risk / Cryptography risk:** Long-tail risks and systemic frailties.
MC *Transactional friction:** How facile transacting with the asset is, on base or secondary layers.
MC *Realness / Materiality / Memeticism / Simulacrisation:** The "realness" or "mimetic stickiness" of an asset.
MC *Protocol breadth at time t:** How widely the network and protocol are distributed at a point in time.
MC *Network maturity at time t:** How mature the network is at a point in time.
MC *Network legitimacy at time t:** How legitimate the network is considered to be in terms of functionality at a point in time.
MC *Privacy In-protocol:* Privacy of transactions and participants using the network in a naive manner.
MC *Privacy Extra protocol:* Privacy of transactions and participants using additional tools or techniques.
MC *Price elasticity of supply:** The extent to which additional supply of an asset can be brought to production / market in response to an increase in demand.
MC *Inflation:* The inflationary properties of the asset supply.
MC *Scarcity:* Whether the asset has fixed or implied supply limits.
MC *Asset supply concentration:** How widely distributed is the asset. As Gini-type measurements are highly gameable an indexed approach of researcher perceptions based on publically available information has instead been employed.
MC *Liquidity depth:** The extent to which the asset's market can absorb suppply and demand changes.
MC *Settlement and value flows:** The extent to which the asset is used for payments and settlement.
S *Profit-sharing / cost-reduction:* Whether network / asset profits are shared with token-holder, or if holding the asset gives rights to preferential treatment.
S *Rights to CFs:* Does holding the asset confer rights to on-chain cashflows such as masternodes or staking rewards?
S *Marketing claims / investor expectations:** The extent to which network / asset proponents engaged in marketing with speculative or profit-oriented themes.
S *Network functionality at time t:** How functional the network is at a point in time.
S *Governance Type:* What governance mechanism (if any) doe the network utilise?
S *Token-Holder voting rights:* Do the token-holders have "voting rights" in network governance and how is this exercised?
S *Treasury / foundation supply control:** The extent of the asset supply under control by a central treasury or foundation.
S *Power asymmetry between issuer and investors:** The extent to which the network / asset creators are advantaged over token-holders in terms of implicit and / or explicit influence.
S *Human primacy over codebase / assets:** The extent to which the network / asset creators can make changes to the network function, codebase, asset distribution or transactions.
S *Network centrality / distribution:** How widely dispersed the network nodes are. As node number and distribution are highly gameable an indexed dimension of the author's perceptions based on publically available information has instead been employed.
S *Permissioned / proprietary elements:** Are there permissioned, closed-source or patented elements in the network?
S *Ease of node operation / software compatibility:** How straightforward it is to run a validating node in the network.
M *Acceptability as payment method:** How widely the asset is accepted in return for goods and services.
M *Volatility in price:** The extent of variation in the market pricing of the asset (relative to USD).
C *Asset purpose:* What is the intended purpose for holding and / or using the asset?

**Indicates indexed dimension, others are categorical.*

S, M, C indicate which meta-characteristic taxonomies the dimension is included in.

Table 16: Definitions and rationale for categorical and indexed dimensions for *TS10*

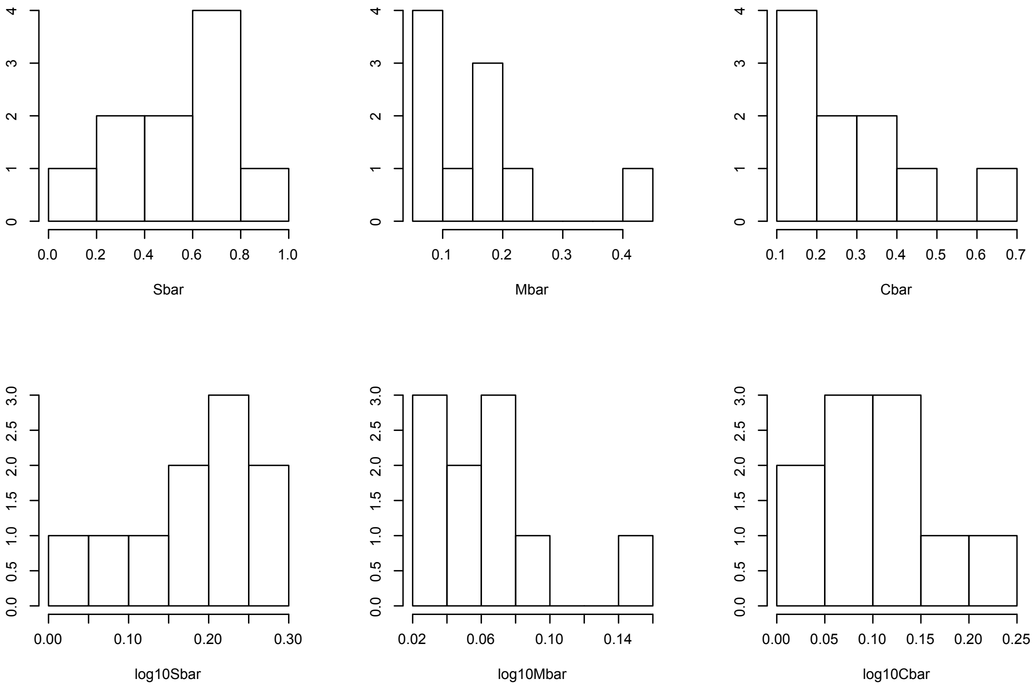

Figure 18: *TS10* meta-characteristic score histograms

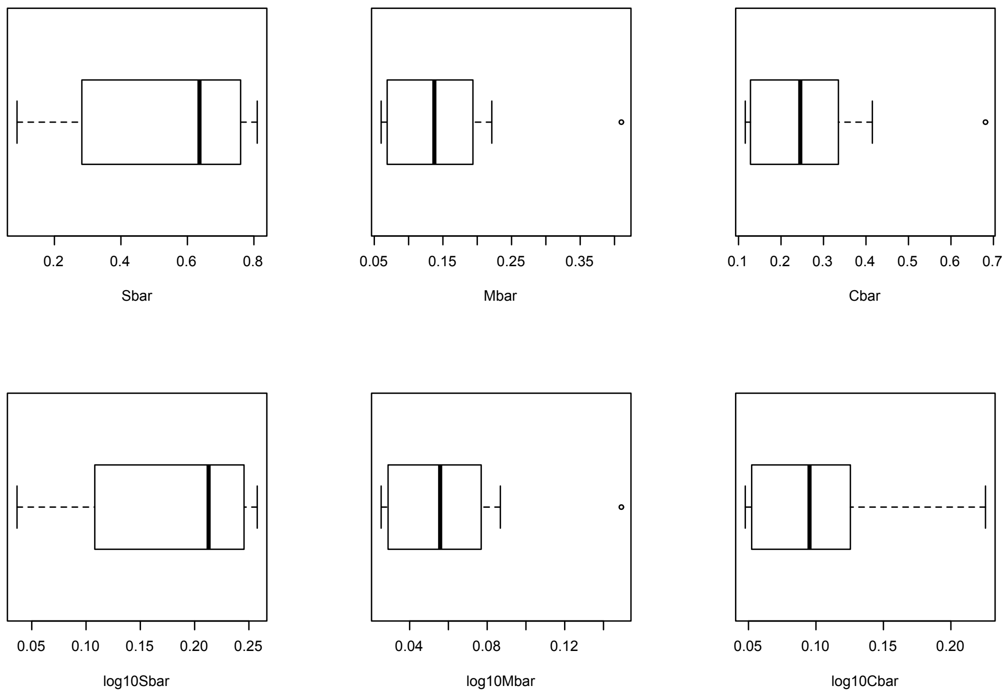

Figure 19: *TS10* meta-characteristic score boxplots

Considering first the scores realised by the *TS10* TokenSpace in Table 15, it is clear that there is significant variation between the values obtained for $\bar{\mathcal{S}}$, $\overline{\mathcal{M}}$ and $\bar{\mathcal{C}}$ meta-characteristics across the 10 cryptoassets with the highest nominal market capitalisations.

Securityness in *TS10* exhibits a minimum of 0.088 for BTC, a maximum of 0.81 for BNB, a mean of 0.55 and standard deviation of 0.27. The range of values is wide at 0.72, as some cryptoassets possess very high values whilst others possess low or moderate values. There is also considerable skew in the distribution of these values, as the maximum value is 0.96 standard deviations from the mean whilst the minimum value is 1.7 standard deviations away.

Moneyness in *TS10* exhibits a minimum of 0.06 for BNB, a maximum of 0.41 for BTC, a mean of 0.16 and standard deviation of 0.11. The range of values is comparatively compact at 0.35, a consequence of all cryptoassets possessing modest or low scores. Significant skew is also present in the distribution of these values, as the maximum value is 2.3 standard deviations from the mean whilst the minimum value is 0.91 standard deviations away.

Commodityness in *TS10* exhibits a minimum of 0.12 for EOS and BNB, a maximum of 0.68 for BTC, a mean of 0.28 and standard deviation of 0.17. The range of values is significant at 0.56. There is also considerable skew in the distribution of these values, as the maximum value is 2.35 standard deviations from the mean whilst the minimum value is 0.94 standard deviations away.

Figures 18 and 19 depict histograms and boxplots for each of the three meta-characteristics in linear and logarithmic scales to visually display the distibution of scores. Interestingly the statistical computing software employed here (R) initially treated the $\overline{\mathcal{M}}$ and $\bar{\mathcal{C}}$ values of BTC as outliers due to their significant difference to the other cryptoassets considered. In the author's opinion this is a reflection of Bitcoin's unique status as a leaderless and permissionless *pseudo-monetary commodified* good with a paucity of attributes in common with other cryptoassets. In other words, Bitcoin is *sui generis* among other cryptoassets, which themselves are *sui generis* to lesser and varying degrees in comparison to legacy assets.

Figure 20 contains a three-dimensional view of the *TS10* TokenSpace with included assets occupying the coordinates arising from their scores. As intended in the design of the TokenSpace methodology, this affords ready visual comparison of asset locations. From this visual representation, it becomes more readily apparent that there are several sub-populations of cryptoassets within *TS10*. BTC occupies a domain of its own, as do ETH and USDT to a lesser extent. This is unsurprising as these three cryptoassets are significantly differentiated: Bitcoin as a highly decentralised P2P commodity money, Ethereum as a scripting platform and Tether as a collateralised stablecoin. Ethereum's Securityness largely arises from its initial issuance mechanism - its token crowdfunding was the largest "ICO" at time of launch - and the presence of a powerful foundation and leadership class who largely influence and fund the course of action of the network [123]. BCH and LTC occupy locations close to each other, as minor analogues of Bitcoin they exhibit some similarities to BTC but have much weaker value propositions as monetary or commodity goods due to inferior network security and the presence of single points of failure such as prominent leadership. However like Bitcoin they did not issue assets *via* a token sale and solely rely on proof-of-work, keeping their Securityness fairly low. XRP and XLM appear close together which is unsurprising as they share many of the same characteristics, with XLM originating as a codebase fork of XRP by the same progenitor (Jed McCaleb), with both networks having a heavy concentration of asset supply residing with insiders and / or foundations. Network nodes of both XRP and XLM are challenging to run permissionlessly with high concentrations of validating nodes in the respective federations being controlled by Ripple Labs and IBM / Stellar Foundation respectively [124, 125]. XRP transactions have been prevented from occurring due to disputes between network controllers and estranged insiders, and a major historical covert supply inflation event was recently uncovered in XLM which allowed an attacker to create several billion tokens [126]. For these reasons and others, XRP and XLM are poor monetary or commodity assets but do display a fairly high degree of Securityness.

EOS, TRX and BNB are the final subset of cryptoassets in *TS10*. All three were intially issued *via* ICOs, and exhibit a high degree of centralisation in monetary, network, architecture and / or stakeholder influence with limited asset and / or network utility at time of analysis in early 2019. These cryptoasets exhibit high Securityness, low Moneyness and low Commodityness, making them possible targets for regulators looking for high profile cases to investigate. It is somewhat apparent from the operations of these projects that this has been considered to be a risk, with EOS creator Block.One locating themselves in the British Virgin Islands and offering non-functional tokens in their ICO with no promise to launch a network. Binance Coin is issued by the sprawling exchange group Binance, which is commencing exchange operations in new jurisdictions faster than regulators can react having nominally relocated to Malta last year. The token burning and exchange fee discounts for token-holders give BNB a very high degree of likeness to a classical securitised asset. Tron is a project which seems to be mostly focused on marketing with a constant stream of giveaways and partnership announcements, a rather consistent record of questionable veracity of claims, initially uncredited re-use of code (*EthereumJ*), whitepaper (*IPFS / Filecoin)*, dubious claims and explicit promotion of the speculative potential of the asset [127].

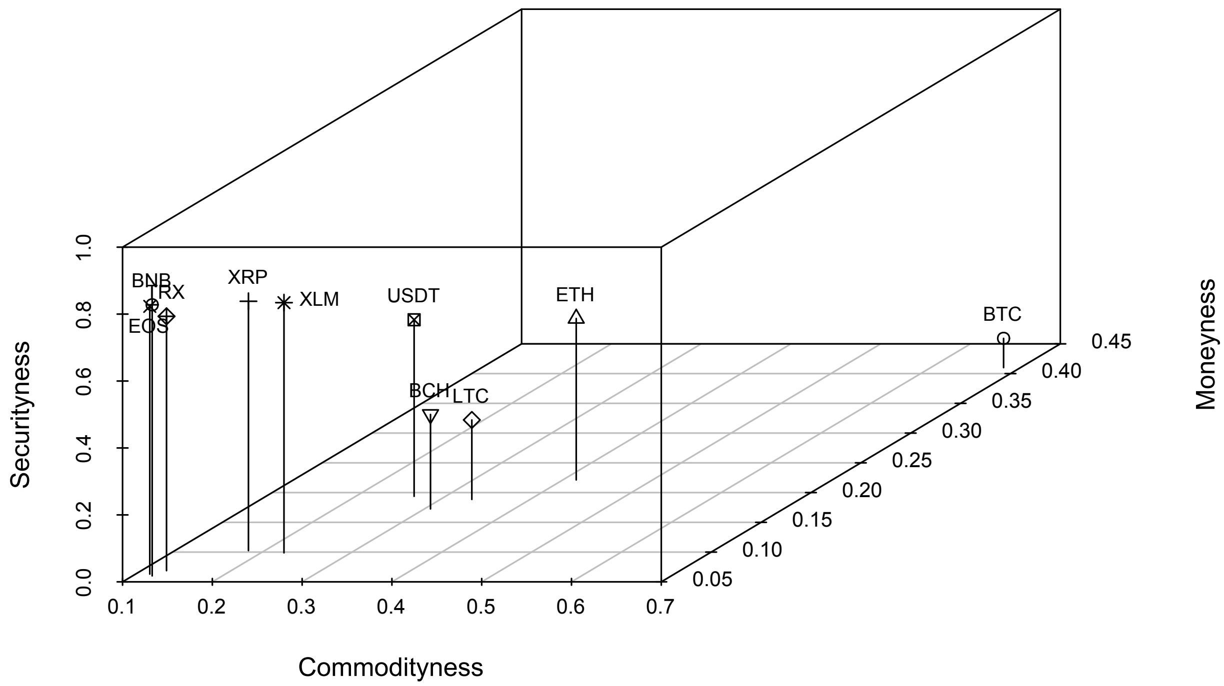

Figure 20: Assets placed in *TS10* TokenSpace

4.3 Cluster Analysis & Correlations

Two statistical analysis methods were employed to further understand the anisotropy of the asset locations in *TS10*, k-means and agglomerative hierarchical clustering [128, 129]. Each approaches the dataset in different ways to reach a set of ending conditions, in a manner not unlike taxonomies themselves. The k-means algorithm creates k number of cluster centroids (with k being adjustable or optimisable) before iteratively assigning values to the closest centroid and adjusting the updated position of the centroid until no further changes take places between iterations. One key assumption made by the algorithm is that data is isotropic (or spherical), which may render it ineffective for advanced TokenSpace studies employing higher dimensionalities and / or anisotropic PDFs as discussed in §3.3.8.

Agglomerative hierarchical clustering in contrast incrementally builds clusters, producting a *dendrogram*. The algorithm first assigns each sample to its own cluster, with each step incorporating a merge of the two most similar clusters until all have been merged. When perceived in reverse, the dendrogram resembles a stepwise sorting machine, sub-dividing the population of objects on the basis of similarity. No centroid parameter is required.

For k-means clustering of *TS10*, it was found that values of k of 3 or above produced acceptable levels of extrinsic variation between the clusters *versus* intrinsic variation within the sum of squares of clusters (Figure 21). To correlate with the visually-derived groupings above, 6 clusters were judged to be optimal but the analysis could also be conducted using 4 or 5. Results from k-means clustering with values of k = 3, 4, 5 and 6 are displayed in Figure 22.

Hierarchical complete-link clustering was conducted with the dendrogram produced exhibited in Figure 23. Complete-link refers to the clustering method, whereby in each iteration, merging occurs between two clusters which possess the smallest maximum pairwise distance. In contrast single-link clustering merges the two clusters with the smallest minimum pairwise distance. In this case, both techniques were employed and the complete-link approach resulted in the greater similarity between clusters as measured by agglomerative coefficient, with 0.84 versus 0.77 for single-link [130]. As discussed above, when the clustering process is considered in reverse, it takes on some of the properties of a "sorting machine", allowing the degrees of similarities and differences between assets to be readily parsed. Largely corroborating previous results, the process found BTC to be unique among the *TS10* basket of cryptoassets, with further clusters ETH and USDT, LTC and BCH, XRP and XLM and

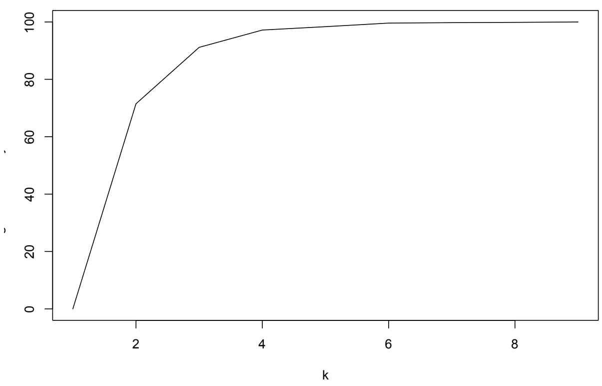

Figure 21: Choosing k for k-means clustering of *TS10*

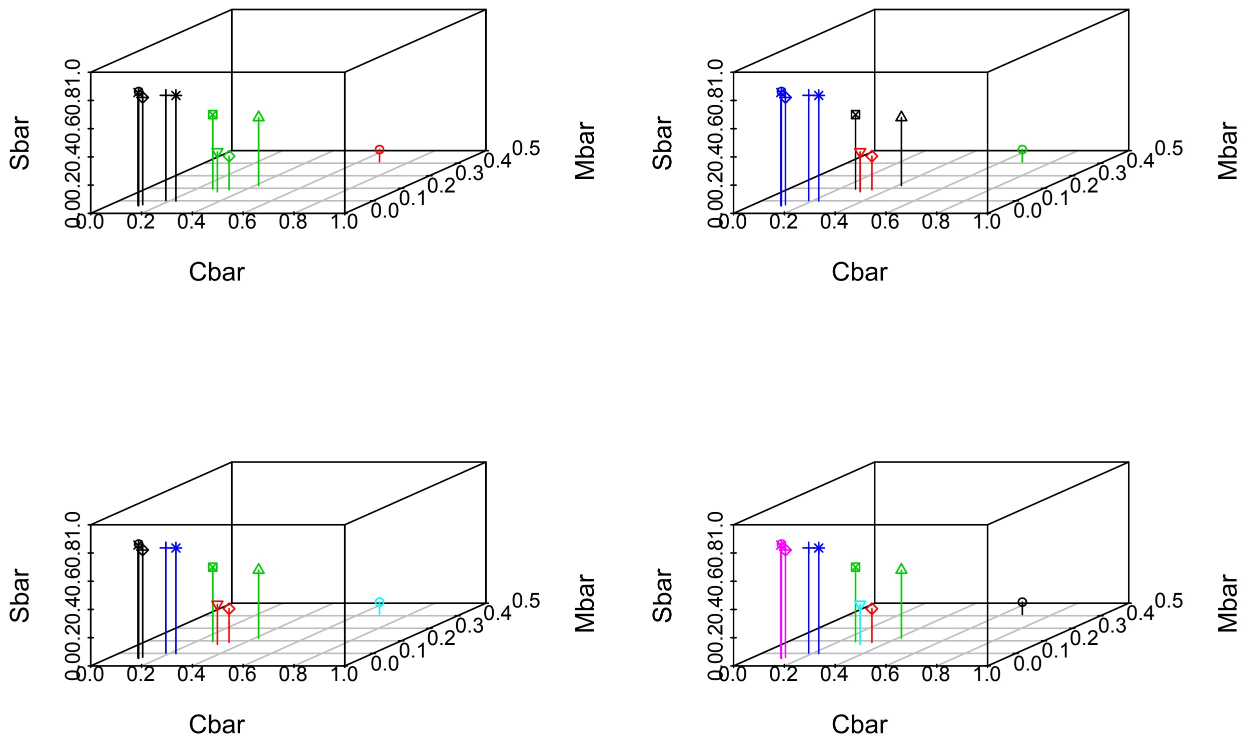

Figure 22: *TS10* k-means clustering with k = 3,4,5,6

EOS, BNB and TRX. The principal difference in results between this approach and the 6 cluster k-means is that ETH and USDT are not differentiated here, making it more similar to the 5 cluster k-means results.

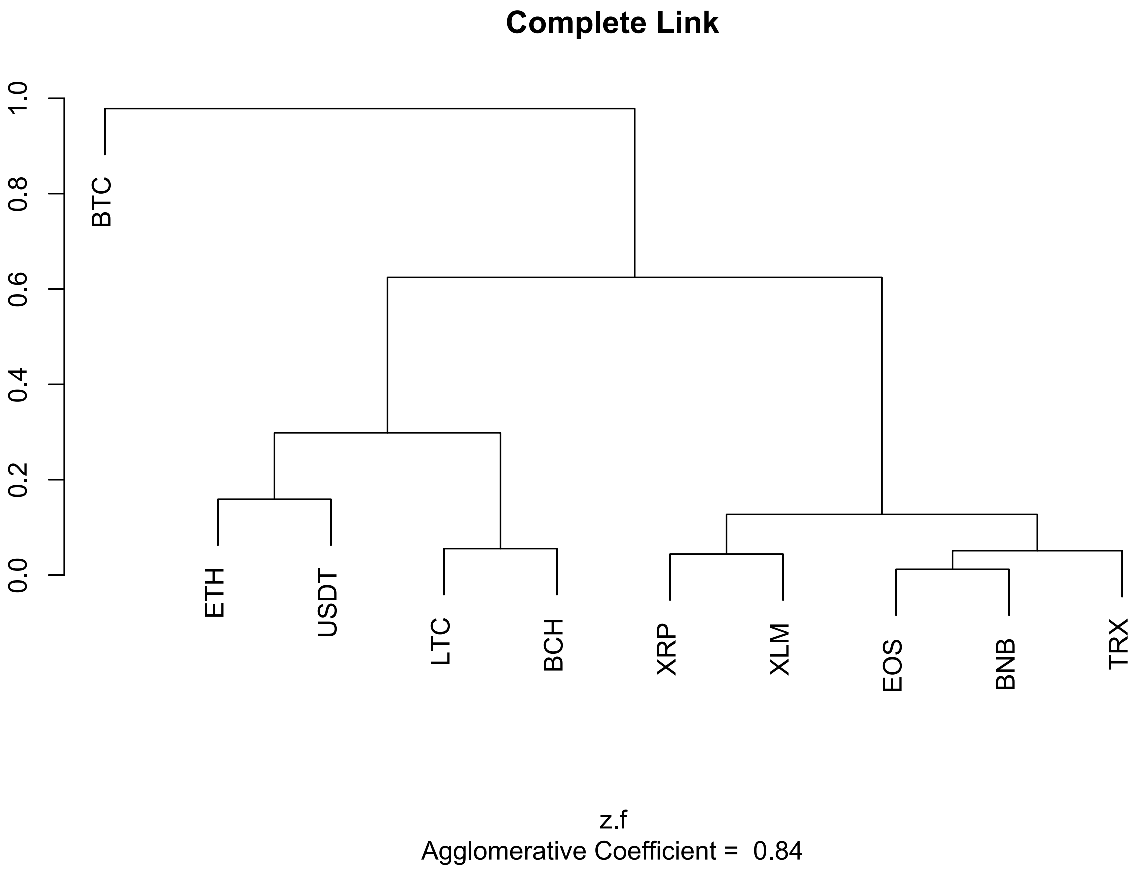

Figure 23: *TS10* Hierarchical sorting process (complete-link)

Correlations between the three meta-characteristics were also explored pairwise and are listed in Table 17. *Pearson's correlation coefficient (Rho)* can take values between positive one and negative one, representing perfect positive and negative correlation of two datasets respectively. As would be expected from the prior findings, in *TS10* there is a high degree of positive correlation between Moneyness and Commodityness with a Pearson's Rho of 0.99, indicating that indeed Moneyness and Commodityness are highly related attributes - base dupon the empirical data and subjective inputs to *TS10* at least. Correlation of Securityness to Moneyness and Commodityness are similar and strongly negative with values of -0.88 and -0.87 which is to be expected for meta-characteristics which required dimensions to be inverted when used across taxonomies.

Meta-char	$\bar{\mathcal{S}}$	$\overline{\mathcal{M}}$	$\bar{\mathcal{C}}$
$\bar{\mathcal{S}}$	1	-0.878	-0.872
$\overline{\mathcal{M}}$	-0.878	1	0.985
$\bar{\mathcal{C}}$	-0.872	0.985	1

Table 17: *TS10* meta-characteristic correlations

4.4 *TSL7*: Using TokenSpace to Compare Cryptographic & Legacy Assets

A separate TokenSpace construction to *TS10* will now be presented: *TSL7*, with the goal of exemplifying the ability of TokenSpace to compare and contrast legacy assets alongside cryptoassets. No taxonomies have been developed for this TokenSpace, instead relying on the *TS10* data for cryptoassets and intuitively reasoned scores for legacy assets. Tables for overall scores and each meta-characteristic are shown in Tables 18, 19, 20 and 21 with visual representation in Figure 24.

Apple stock (AAPL) represents an ideal type of a securitised asset with negligible monetary or commodity attributes, with soy beans (SOY) and gold metal (GOLD) being canonical examples of consumable and non-consumable commodities respectively. The US Dollar (USD) still possesses a strong Moneyness being the *de facto* world reserve currency, though as is seen in §4.5 its Moneyness and Commodityness have been falling due to governmental and central bank policy choices. One interesting observation is the near-equivalence in *TSL7* of the Moneyness of gold metal and Bitcoin (BTC). There appears to be a reversal of the perceived premier commodity monetary good as human society continues to engage in technological and particularly digital advances.

The "Lindy type time-dependence" indexed dimension values were considered to be universally low for *all* cryptographic assets due to the lack of ecosystem maturity, with a "Lindy index" of 1 for gold, which has been considered valuable by humans for no less than several thousand years [131].

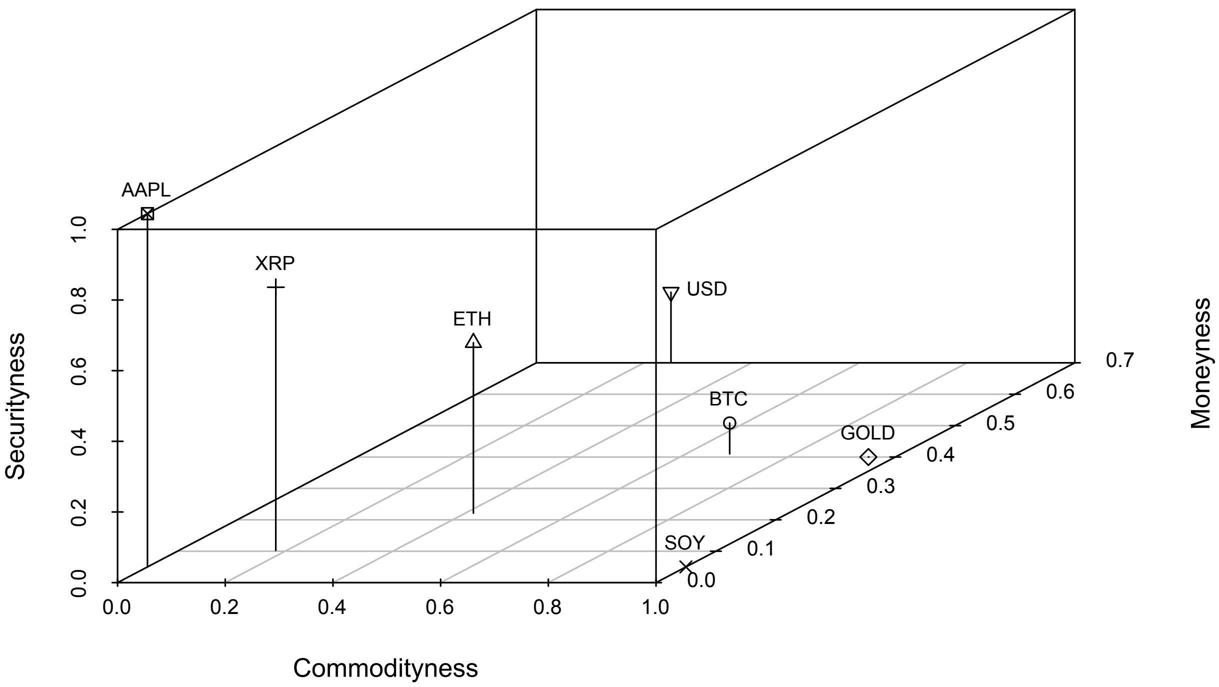

Figure 24: Example of legacy assets and cryptoassets inhabiting *TSL7* TokenSpace

Asset	($\bar{\mathcal{S}}$)	($\overline{\mathcal{M}}$)	($\bar{\mathcal{C}}$)	Notes
BTC	0.09	0.41	0.68	
ETH	0.48	0.22	0.42	
XRP	0.75	0.10	0.18	
SOY (beans)	0.00	0.05	1.00	
GOLD (metal)	0.00	0.40	0.95	
USD	0.20	0.70	0.25	
AAPL	1.00	0.05	0.00	

Table 18: *TSL7* scores listed to two decimal places

Securityness

Asset	$\bar{\mathcal{S}}$	Notes
BTC	0.09	Leaderless, permissionless
ETH*	0.48	*"sufficiently decentralised"*
XRP	0.75	Supply concentration & nodes insider-skewed, no validation reward, missing ledger history
SOY (beans)**	0.00	Ideal type for non-securitised asset
GOLD (metal)**	0.00	Ideal type for non-securitised asset
USD	0.20	Reliance on faith in fiscal prudence of US Government & Federal Reserve
AAPL**	1.00	Ideal type for securitised asset

*see Hinman §1.3.3, **see Bailey §2.1

Table 19: Securityness scores for *TSL7* listed to two decimal places

Moneyness

Asset	$\bar{\mathcal{M}}$	Notes
BTC	0.41*	Post-bootstrap uncertainty
ETH	0.22**	Not intended to be a monetary asset but has become an MoE and UofA in some circumstances
XRP	0.10	Used as regulatory arbitrage vehicle and speculative asset with limited utility. Central parties can censor
SOY (beans)	0.05	MoE restricted to barter, consumption or use as underlying for a derivative instrument.
GOLD (metal)	0.40	Non-standardised, prone to dilution, necessitates verification of mass and purity
USD	0.70	Inflationary, with supply debasement (Triffin dilemma).
AAPL	0.05	Approaching ideal type of non-monetary asset, limited utility as MoE

*Uncertainty of post-bootstrap phase network security incentives
**Uncertain monetary policy, central influence, technical debt & future uncertainty

Table 20: Moneyness scores for *TSL7* listed to two decimal places

Commodityness

Asset	$\bar{\mathcal{C}}$	Notes
BTC*	0.68	Ideal type of a digital commoditised asset
ETH	0.42	Used as a digital utility for token sales and persistent scripts
XRP	0.18	Censorability of payments and supply concentration among insiders too great to be freely tradeable
SOY (beans)*	1.00	Ideal type of a material commoditised consumable asset
GOLD (metal)*	0.95	Ideal type of a material commoditised non-consumable asset
USD	0.25	Loss of gold peg, debasement of supply
AAPL*	0.00	Ideal type of a non-commoditised asset

*see Bailey §2.1

Table 21: Commodityness scores for *TSL7* listed to two decimal places

4.5 *TSTDX*: Time-Dependence of Selected Assets

A third TokenSpace construction will now be presented. *TSTDX* has been constructed with the goal of exemplifying the ability of TokenSpace to map time-dependence of asset attributes. As with *TSL7* no taxonomies have been developed for this TokenSpace, instead relying on the *TS10* data for cryptoassets in 2019 and intuitively reasoned scores for present day scores of legacy assets and all historical values. Tabulation of overall meta-characteristic scores are shown in Table 22 with visual representation in Figure 25. Intuitive judgement was applied to give an *indicative depiction* of how a time-dependence TokenSpace such as *TSTDX* may be more rigorously constructed in future.

A number of interesting observations can be made in *TSTDX*. It is apparent that monetary metals such as gold (GOLD) and silver (SILVER) are decreasing in Moneyness with time as Bitcoin's (BTC) increases - ostensibly as the digitalisation of human society corresponds to favouring similarly digital ("simulacrised") money such as Bitcoin over specie.

The loss of gold and silver backing on moneys such as the British Pound (GBP) and the US Dollar (USD) leading to loss of Commodityness, Moneyness and an increase in Securityness may also be rationalised as *derealisation* - a loss of mimetic gravitas in addition to simulacrum-related societal sentiment. Related is the loss of Moneyness of gold and silver over time, as these two metals have long been on a path to *demonetisation*. In this respect, silver is some way ahead of gold, being largely a commodity rather than a commodity-money in the present day.

The time-dependence of cryptographic assets generally shows a trend of decreasing Securityness as the networks mature and assets become more adopted, distributed, widely held, useful and used. In concert Moneyness and Commodityness also tend to increase as more reasons to use, hold and transact with the assets emerge. Ethereum (ETH) is particularly remarkable as - in tandem with Hinman's summer 2018 sentiments as discussed in §1.3.3 - what started as a securities offering of a centralised asset reliant on the efforts of a team of others for speculative gain has become (to some extent) more widely used, useful, held and distributed hence leading to a decrease in Securityness and increases in Moneyness and Commodityness. It could perhaps be said that Ethereum in particular is well on the path to *desecuritisation*, or indeed may have arrived at that destination depending on where boundaries are perceived to lie in TokenSpace. The US Dollar (USD) still possesses a strong Moneyness being the *de facto* world reserve currency, though as is seen in §4.5 its Moneyness and Commodityness have been declining since the abandonment of gold-backing and the rise of the petrodollar system.

Asset	($\bar{S}$)	($\overline{\mathcal{M}}$)	($\bar{C}$)	**Notes**
BTC (2019)	0.09	0.41	0.68	
BTC (2017)	0.13	0.33	0.60	
BTC (2015)	0.19	0.25	0.50	
BTC (2012)	0.24	0.15	0.35	
BTC (2009)	0.30	0.07	0.20	
ETH (2019)	0.48	0.22	0.42	
ETH (2018)	0.55	0.20	0.32	
ETH (2017)	0.62	0.18	0.23	
ETH (2016)	0.70	0.13	0.15	
ETH (2015)	0.75	0.03	0.10	
XRP (2019)	0.75	0.10	0.18	
XRP (2017)	0.77	0.08	0.15	
XRP (2015)	0.79	0.07	0.12	
XRP (2014)	0.81	0.06	0.11	
XRP (2013)	0.85	0.05	0.10	
LTC (2019)	0.24	0.19	0.34	
LTC (2017)	0.29	0.17	0.30	
LTC (2015)	0.35	0.14	0.25	
LTC (2013)	0.40	0.11	0.17	
LTC (2011)	0.45	0.08	0.10	
GOLD (2019)	0.00	0.40	0.95	
GOLD (1920)	0.00	0.50	0.92	
GOLD (1820)	0.00	0.60	0.88	
GOLD (1720)	0.00	0.70	0.85	
GOLD (1620)	0.00	0.80	0.82	
SILVER (2019)	0.00	0.20	0.75	
SILVER (1920)	0.00	0.25	0.70	
SILVER (1820)	0.00	0.35	0.65	
SILVER (1720)	0.00	0.45	0.60	
SILVER (1620)	0.00	0.60	0.55	
USD (2019)	0.20	0.70	0.25	
USD (1970)	0.15	0.75	0.33	
USD (1920)	0.00	0.80	0.41	
USD (1870)	0.00	0.43	0.44	
USD (1792)	0.00	0.10	0.20	
GBP (2019)	0.20	0.50	0.15	
GBP (1900)	0.05	0.70	0.35	
GBP (1800)	0.00	0.75	0.45	
GBP (1700)	0.00	0.70	0.48	
GBP (1600)	0.00	0.75	0.55	

Table 22: *TSTDX* Time-dependent meta-characteristic scores, listed to two decimal places

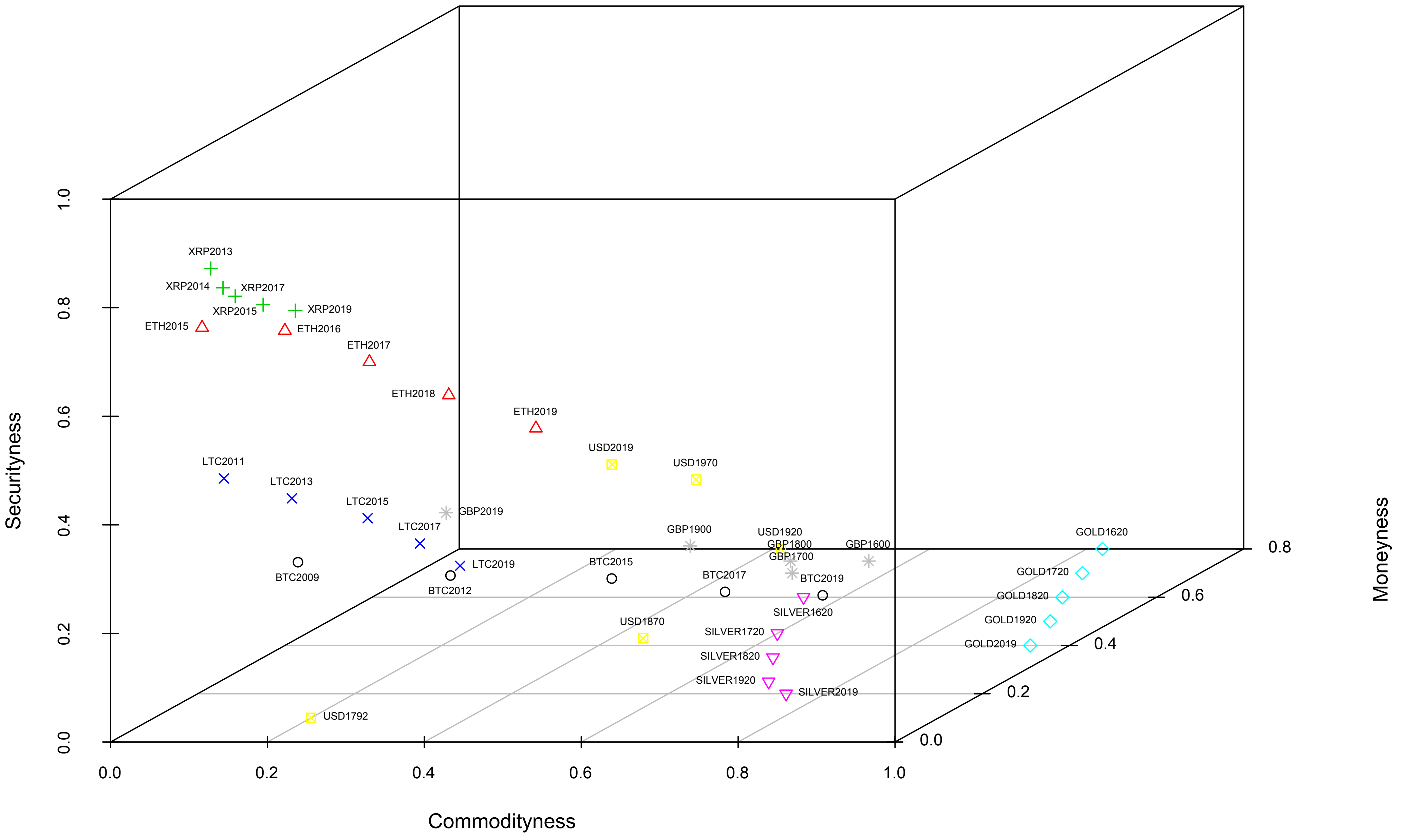

Figure 25: Graphical representation of *TSTDX* TokenSpace

5 Discussion & Considerations Informing Further Development of TokenSpace

It is non-trivial to arrive at a robust classification framework employing categorical discrimination in tandem with judiciously chosen and carefully optimised formulae for quantitative characteristics and this will be a focus of future work, as will time-dependent scoring mechanisms and scoring ranges where there may be significant disagreement or uncertainty over the optimal location of an asset in TokenSpace. Often token issuers engineer their assets to have a perceived value proposition by apportioning future cash flows to the holders, *via* mechanisms such as token burns, staking or masternodes which are coarsely analogous to share buybacks but with critical and significant differences to the downside [132, 133]. Likewise masternodes, staking rewards or issuer-sanctioned airdrops map coarsely to *dividends* in legacy finance. However, if a token is deemed to be too security-like then exchanges may be reluctant to list for fear of future liability or compliance issues.

It is important to explicitly discuss the limitations of TokenSpace. For the purposes of a subjective classification system such as TokenSpace, as many attributes of cryptographic networks and assets are continuous, exhibit subtle variations and / or edge cases, a mixture of categorical and numerical discrimination is most likely the optimal approach. Therefore, the instantiations of TokenSpace which will demonstrate the most explanatory power will be hybrids of traditional and phenetic taxonomy types. This design choice is justified by the desired outcome of numerical scores as the output of the classification execution in order to populate asset locations in the Euclidean 3D space that TokenSpace creates. Conversely in the interests of pragmatism, a great deal of insight may still be derived from a primarily categorical classification approach with some range-bound indices and if this meets the needs of the user then it is an acceptable and valid design choice. Further it minimises over-reliance on measurable attributes which may be subject to manipulation for motivations related to decentralisation theatre.

As with all information systems, the principle of GIGO (Garbage In, Garbage Out) applies. A number of potential pitfalls are as follows, and the author does not exclude oneself from susceptibility to any or all of these. The use of misinformed judgement, lack of methodological rigour in taxonomy construction, over-estimation of the researcher's knowledge of the field or competence in applying taxonomic methodology, latent biases, poor quality / misleading data sources or judgements and a lack of appreciation of edge cases or category overlap may severely limit the usefulness of the TokenSpace produced and therefore its explanatory power.

It must be re-iterated yet again that TokenSpace affords a subjective conceptual framework for the comparative analysis of assets. The meta-characteristic definitions and choices, dimensions, categories and characteristics employed, score modifiers and / or weightings are all subjective and depend on the choices of the researcher which derive from intended purpose. It is entirely realistic that an asset issuer may tailor their taxonomies, score modifiers, regulatory boundary functions or a combination of the above to present a favourable assessment with respect to their biases or motivations. Additionally, considering the changing nature of regulatory and compliance landscape may have a large bearing on what can be considered to be acceptable asset characteristics in compliance terms and may necessitate a re-evaluation of weightings and / or score modifiers [51].

As discussed in §3.3.2 with particular reference to the 2017 vintage of regulatory arbitrage mechanism of token sales for so-called utility tokens, some distinction between "good" and "bad" securities, moneys or commodities in an area of particular interest. Extending TokenSpace to occupy a region between -1 and +1 could provide a coarse mechanism to do this, though the way that dimension scores and weightings are determined would have to be adjusted and naive methods such as taking moduli do not sufficiently discriminate as to the quality of an asset.

Future planned developments include the construction of TokenSpaces with higher dimensionality as discussed in §3.3.3, and alternative taxonomies for different meta-characteristics with intended purposes other than increasing regulatory clarification. The scoring mechanisms as discussed in §3.3.4 and §3.3.5 including categorical and indexed dimensions, score modifiers and weightings may also be further refined and extended. Other approaches to generating asset coordinates for TokenSpaces will also be explored, with plans in place to form "digital round tables" with broad subsets of stakeholders to arrive at asset scores or ranges.

Work is underway with collaborators to extend TokenSpace into *DAOSpace* in order to characterise similarities and differences of "Decentralised Autonomous Organisations" as opposed to assets. One interesting nexus of DAOSpace and TokenSpace is attempting to disentangle the design choices and properties of decentralised organisations (and their native assets) with respect to Securityness in particular. As discussed in §1.3.3, the SEC has already made it clear that TheDAO tokens (DAO) would be classified as securities and therefore profit-oriented tokenised DAOs must be designed carefully with this in mind should they intend to be compliant with existing regulations. Interestingly Malta has passed laws giving DAOs legal personality, meaning that another cycle of jurisdictional arbitrage may be underway, this time with organisations as well as or instead of assets (§1.1.1).

Likewise stablecoins with certain properties especially related to asset issuance may also be problematic from a compliance perspective (§1.3.3) so a potential extension of this work towards a *StablecoinSpace* classification framework for pegged assets is an avenue being explored currently.

A future goal of TokenSpace is the development of an environment which may be updated in real-time from various information feeds from market, semantic / linguistic and / or network data in order to provide dynamic information as to evolving asset characteristics as well as historical trends at varying points in time. This may facilitate the goal of descriptive, explanatory and even predictive techniques for understanding, rationalising or foreseeing trends, issues and opportunities relating to assets and networks before they become readily apparent from naïve analysis.

6 Acknowledgements

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