Crypto Asset Valuation Series

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Part I: Principles of Value

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Abstract. Valuation theory and methodologies for traditional assets are widely accepted and understood but are relatively nascent in crypto assets. In part, the novel characteristics and diversity of crypto assets and lack of empirical data makes valuation methodology construction and ex-post valuation analyses challenging. Our motivation for this series is to propose valuation frameworks that academics and practitioners may utilize. In this paper, we explore and compare traditional valuation theories, including discounted cash flows, relative, utility, and contingent claim valuations. We review how leading valuation methodologies for traditional asset classes are utilized in contemporary valuation theory.

1 Introduction

Valuation theory and practices for traditional financial assets have become widely accepted through decades of research and empirical analysis by both academics and practitioners. In contrast, valuation theory and methodologies for crypto assets remain in their nascent stages much like the broader crypto asset market. The lack of consensus regarding accepted valuation theory and methodology stems from the novel nature and variety of characteristics that crypto assets exhibit, which do not fit neatly into traditional asset valuation methodologies. Furthermore, the lack of robust data makes the evaluation of emerging valuation theory with empirical analysis difficult.

As interest in crypto assets as both utilities and financial instruments continue to grow, the need for robust and empirically supported valuation methodologies is imperative. Our motivation is to formulate valuation frameworks that academics and practitioners may utilize for research and to make informed investment decisions.

This paper is structured as follows. Section 2 provides a background on the principles of valuation and provides a brief overview of past literature. Section 3 reviews existing leading valuation methodologies for traditional asset classes. Section 4 concludes the paper.

2 Background

Asset valuation lies at the foundation of finance and capital markets, spanning capital formation, markets, and asset management. Modern academics and practitioners enjoy decades of empirical evidence and work supporting modern valuation theory across a diverse set of assets and financial instruments. Given the sheer span and comprehensive nature of existing literature devoted to valuation, we will only provide a high-level overview of existing valuation theories and practices as context for this series. Prior literature reviews provide a useful starting point to examine leading work and valuation methodologies. (Damodaran, 2006b)

In a general sense, there are four broad approaches to valuation in traditional asset classes: discounted cash flow valuation, relative valuation, utility valuation, and contingent claim valuation.

2.1 Discounted Cash Flow

In discounted cash flow valuation models, the value of an asset is the present value of the expected cash flows on the asset, discounted back to the present at a rate (or rates) that reflect the potential variability of these cashflows. The value of an asset is determined by the cash value the asset can generate, not what others perceive its worth to be.

Central to the discounted cash flow theory is the concept of a discount rate dependent on 1) the time value of money (investors would rather have cash immediately than having to wait and must therefore be compensated by paying for the delay) and 2) risk premium (reflects the extra return investors demand because they want to be compensated for the risk that the cash flow might not materialize). The concept of discounting and interest rates are well established; early evidence from Mesopotamian interest rate tables to Italian commerce in the 1300s and railway valuations in the 1800s suggest that such economic constructs were understood. (Neugebauer, 1969; Parker, 1968; Wellington, 1914) The discounted cash flow formula is derived from the future value formula for calculating the time value of money and compounding returns. (Marshall, 1920) Concretely, a discounted cash flow valuation can be described as:

$$DCF = \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \cdots + \frac{CF_n}{(1+r)^n}$$

$$FV = DCF * (1+r)^n$$

$$DPV = \frac{FV}{(1+r)^n}$$

where FV is the nominal value of a cash flow amount in a future period, CF is the normal value of a cash flow amount associated for a point in time, r is the interest rate or discount rate, which reflects the cost of tying up capital and may also allow for the risk that the payment may not be received in full, n is the time in years before the future cash flow occurs, and DPV is the discounted present value of the future cash flow FV.

When multiple cash flows in multiple time periods are being discounted, it is necessary to sum them:

$$DPV = \sum_{i=1}^{n} \frac{FV_t}{(1+r)^t}$$

for each future cash flow FV at any time period t in years from the present time, summed over all time periods. The sum can then be used as a net present value figure. If the amount to be paid at time 0 for all the future cash flows is known, then that amount can be substituted for DPV and the equation can be solved for r, or the internal rate of return.

For continuous cash flows, the summation in the above formula is replaced by an integration:

$$\int_0^T FV(t)e^{-\lambda t}\,dt = \int_0^T \frac{FV_t}{(1+r)^t}$$

where FV_t is now the rate of cash flow, and $\lambda = \log(1+r)$

Discounted cash flows laid the foundations for fixed income valuation and financial statement and cash flow modeling as the basis for equity valuation.

2.2 Relative Valuation

In relative valuation, assets are valued based upon how similar assets in the market are priced. For example, a house buyer may compare the price of a prospective home by looking at the prices paid for similar homes in the neighborhood, while a stock investor may look at what the market is pricing similar stocks. There are marked differences between discounted cash flow and relative valuation. In discounted cash flow valuations, the intrinsic value of an asset based upon its ability to generate cash flows whereas in relative valuations, assets are worth what the market is paying for comparable assets. In an efficient market, on average, discounted cash flow and relative valuations should converge. If the market systematically over or under prices a group of assets, discounted cash flow valuations may diverge from relative valuations. This valuation method generally requires 1) finding comparable assets that are priced by the market, 2) scaling the market prices to a common variable to generate standardized prices that are comparable, and 3) adjusting for differences across assets when comparing their standardized values. (Damodaran, 2006b)

Relative valuation methodologies are commonly used across asset classes: prior research suggests 90% of equity research valuations and 50% of acquisition valuations use some combination of multiples and comparable companies. (Damodaran, 2002) In some instances, relative valuation can be accomplished using a multiple of revenue, earnings that asset generates, or book value, particularly in comparable equity valuation. Examples include P/E ratios and EV/EBITDA multiples.

2.3 Utility Valuation

The classical school of utility value, such as Smith and Ricardo (Ricardo, 1817; Smith, 1776) sought to explain pricing primarily on the basis of cost of production. If commodity A cost twice as much to produce as commodity B, then the price of A should be twice the level as that of B. Otherwise, the greater profitability of investing in the commodity that is relatively underpriced would cause its production to increase and drive down the price, while the production of the other commodity would decline, thus raising its price, until both commodities reached a pricing equilibrium. This analysis considered only part of the problem: since the cost of a commodity in part depends on the quantity produced (such as through economies of scale), the pricing analysis must consider the ultimate demand for the commodity. Modern value theory considers prices to be simultaneously determined by the cost and demand for such goods and recognizes the interactions between the demands and supplies of various commodities affecting one another. (Marshall, 1920)

Goods have ascribed value ultimately because of supply limitations and resource scarcity. If goods were available in unlimited supply, they would be effectively free. Non-zero prices serve as a rationing mechanism whereby consumption is limited to the available supply. Resources may be scarce in absolute and relative terms: there may be absolute scarcity of a commodity, but the consumption of that commodity for a purpose creates a relative scarcity of that commodity for substitutable uses. The usage of a commodity in one manufacturing process causes it to become scarcer in other uses. In an efficient market economy, the price of a good and the quantity supplied depends on the cost of production and the cost of not using it for substitutable uses.

Within economics, the concept of utility is used to model value, though its usage has evolved significantly over time since its introduction. The term was initially introduced as a measure of satisfaction within the theory of utilitarianism proposed by philosophers such as John Stuart Mill, though over time has been adapted within neoclassical economics, which dominates current modern economic theory. (Mill, 1863) Modern utility valuation construction revolves around modeling demand for the asset, driven by aggregate preferences and utility functions, and the supply for the asset, given production and supply constraints.

2.3.1 Utility & Indifference Curves

In neoclassical economics, utility is described as a utility function that represents one's preference ordering over a choice set. A utility function represents preferences if it is possible to assign a real number to each alternative. An alternative *a* is assigned a real number greater than alternative *b*, if and only if, the individual prefers alternative *a* to alternative *b*. An individual that selects the most preferred alternative available is necessarily also selecting the alternative that maximizes the associated utility function.

Utility is commonly applied in constructs such as indifference curves, which plot the combination of commodities that an individual would accept to maintain a given level of satisfaction. Indifference curves are generally visualized as follows in Figure 1:

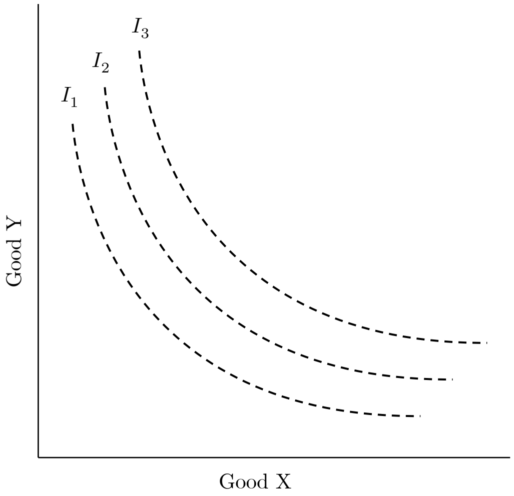

Fig. 1: Indifference curves I_1, I_2, and I_3, with different levels of utility U.

Concretely, an individual's utility can be expressed as a function of the quantities of commodities X and Y consumed:

$$U = U(X, Y)$$

where U is the level of utility and the function $U(X, Y)$ states the level of utility depends in some fashion on the levels of commodities X and Y consumed by the individual.

We note several important features of the utility function. Increases in the levels of X and Y always lead to increases in U. In other words, the partial derivatives of the utility function with respect to X and Y are positive:

$$\frac{\partial U}{\partial X} = \frac{\partial U(X, Y)}{\partial X} > 0 \quad \textit{and} \quad \frac{\partial U}{\partial Y} = \frac{\partial U(X, Y)}{\partial Y} > 0$$

Another feature of the function $U(X, Y)$ is the principle of diminishing marginal utility, or the principle that the marginal utility of X declines as the quantity of X increases and the marginal utility of Y decreases as the quantity of Y increases. The slope of an indifference curve is the negative of the ratio of the marginal utility of X over the marginal utility of Y.

$$\frac{dY}{dX} = -\frac{\partial U/\partial X}{\partial U/\partial Y}$$

where dY/dX is the slope of the indifference curve, otherwise known as the marginal rate of substitution.

2.3.2 Observable Utility Value

In financial economics, utility is applied to generate a price for an asset known as an indifference price. There has been some controversy whether the utility of a commodity can be measured or not. Utility functions are treated as either cardinal or ordinal, depending on whether the function is interpreted as providing more information than simply the rank ordering of preferences. The cardinal school of thought assumes that an individual is able to exactly measure the level of utility provided by the commodity, and that the cardinal utility function is a utility index that preserves preference orderings uniquely up to positive affine transformations. (Ellsberg, 1954) In modern economics, cardinal utility is considered somewhat outdated except for a few specific contexts. In contrast, ordinal theory claims that it is only meaningful to ask which option is better than the other, but not useful to inquire the magnitude of utility or differences between choices. (Pareto, 1906) Most modern theories of individual decision-making under conditions of certainty are typically expressed in terms of ordinal utility. As an example, an individual may state

"I prefer A to B and B to C." The individual's preferences may be described as (where u is the level of utility):

$$u(A) = 13 \mid u(B) = 6 \mid u(C) = 2$$

Under ordinal theory, the preference magnitudes do not matter and only the order $u(A) > u(B) > u(C)$ is relevant; the preference order could just as easily be represented as by the function v:

$$v(A) = 3 \mid v(B) = 2 \mid v(C) = 1$$

Both preference ranks are ordinally equivalent, but not cardinally equivalent as the latter assumes that the differences between preferences are also important.

Many, however, argue that utility is not observable in the real world. Cambridge economist Robinson argued that "utility is a metaphysical concept of impregnable circularity; utility is the quality in commodities that makes individuals want to buy them, and the fact that individuals want to buy commodities shows that they have utility." (Robinson, 1962) Robinson argued that preferences have fixed utility is not a testable assumption, since we cannot know to what extent the change in an individual's behavior is due to changes in price/budget constraints, or how much was due to an actual change in preferences. Similarly, later work argued that if there are no conclusions regarding the tangible structure and stability of preferences, then demand and supply curves cannot be demonstrated empirically and are ontological in nature. (Albert, Arnold, & Maier-Rigaud, 2012)

2.3.3 Indirect Utility

As opposed to direct utility functions, which focus on an individual's derived benefit for a commodity, indirect utility functions reflect individual preferences and market conditions and hold that individuals think about their preferences in terms of what they consume rather than absolute prices. Indirect utility functions give the optimal attainable value of a given utility function depending on the prices of the goods and the income level of an individual. An indirect utility function $v(p, w)$ gives an individual's maximum utility when faced with a vector p of goods prices and a given level of income w. An individual's indirect utility $v(p, w)$ can be derived from their utility function $u(x)$, defined over vectors x of quantities of consumable goods.

Indirect utility can be computed by calculating the most preferred affordable bundle, or vector $x(p, w)$, by solving the utility maximization problem, and then deriving the utility $u(x(p, w))$ the individual derives. Therefore, the consequent indirect utility function is:

$$v(p, w) = u(x(p, w))$$

Indirect utility is commonly applied to the utility of money. For money, the indirect utility function is a non-linear function, bounded and asymmetric about the origin. The utility function is concave in the positive region, thereby reflecting the diminishing marginal utility of money. The bounded nature of the indirect utility function for money reflects the concept that beyond a certain point money ceases to be useful, since an economy's size is naturally bounded at any given time. The asymmetry about the origin reflects the notion that gaining and losing money can have fundamentally dissimilar consequences for individuals. The utility function's non-linearity reflects the variance in possible outcomes where choices influence utility through gains or losses of money, and the optimal decision in such instances depends on the possible outcomes of all other decisions. (Berger, 1985)

2.4 Contingent Claim Valuation

We will briefly discuss contingent claim valuation as the basis for option valuation, though will note that it is not generally used for asset class valuation but rather the value of contractual obligations associated with such assets.

An option is a contract that gives the buyer the right but not the obligation to buy or sell an underlying asset at a specified strike price on a specified date. The seller has the corresponding obligation to fulfill the transaction if the buyer "exercises" the option. An option that gives the owner the right to buy at a specified price is referred to as a call; an option that gives the owner the right to sell at a specified price is referred to as a put.

The value of an option is generally split into two parts.

- the intrinsic value, or the difference between the market value of the underlying, and the strike price of the given option; and

- the time value, which depends on a set of other factors which, through a multi-variable, non-linear interrelationship, reflect the discounted expected value of that difference at expiration.

2.4.1 Option Valuation Origins

Contemporary option valuation is based on a model first published by Black and Scholes in 1973. The model is a partial differential equation that must be satisfied by the price of any derivative dependent on a non-dividend-paying stock, driven by insight that one can perfectly hedge the option by buying and selling the underlying asset in a precise manner and consequently "eliminate risk." (Black & Scholes, 1973) This type of risk neutral dynamic revision is also known as "continuously revised delta hedging." Since its introduction, the model's assumptions have been generalized and led to the formulation in other models used in modern derivative pricing and risk management. The Black-Scholes equation can be concretely described as:

$$\frac{\partial V}{\partial t} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 V}{\partial S^2} + r\frac{\partial V}{\partial S} - rV = 0$$

where V is the price of the option as a function of stock price S and time t, r is the risk-free interest rate, and σ is the volatility of the stock.

The first two terms ($\frac{\partial V}{\partial t} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 V}{\partial S^2}$) consists of a "time decay" term, a "theta" term or the change in derivative value due to time increasing, and a "gamma" term involving the convexity of the derivative value with respect to the underlying value. The latter two terms ($r\frac{\partial V}{\partial S} - rV$) are the riskless return from a long position in the derivative and a short position consisting of $\frac{\partial V}{\partial S}$ shares of the underlying.

Utilizing the parameters of the Black-Scholes equation, the value of a call option C and corresponding put option P based on put–call parity for a non-dividend-paying underlying stock can be concretely as follows:

$$C(S,t) = N(d_1)S - N(d_2)Ke^{-r(T-t)}$$

$$d_1 = \frac{1}{\sigma\sqrt{T-t}}\left[\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)(T-t)\right]$$

$$d_2 = d_1 - \sigma\sqrt{T-t}$$

$$P(S,t) = Ke^{-r(T-t)} - S + C(S,t)$$

$$P(S,t) = N(-d_2)Ke^{-r(T-t)} - N(-d_1)S$$

where $N(\cdot)$ is the cumulative distribution function of a normal distribution, $T-t$ is the time to maturity in years, S is the spot price of the underlying asset, K is the strike price, r is the risk-free rate (annual rate expressed in terms of continuous compounding), and σ is the annual expected volatility of returns of the underlying asset.

2.4.2 Other Option Valuation Models

Lattice models & binomial tree pricing model

Cox, Ross, and Rubenstein developed the original version of the binomial tree pricing, modeling the dynamics of the option’s theoretical value for discrete time intervals over the option's life. (Cox, Ross, & Rubinstein, 1979; Cox & Rubinstein, 1985) Using a riskless portfolio of an option and stock such as in the Black Scholes model, the model creates a binomial tree of discrete future possible underlying asset prices at discrete times and a simple formula can be used to find the option price at each node in the tree.

Monte Carlo option models

Monte Carlo option models use Monte Carlo methods to calculate the value of an option with multiple sources of uncertainty or with complicated features, such as Asian or American options, that would be difficult to value through a Black–Scholes-style or lattice-based computation. (Boyle, 1977) Monte Carlo methods rely on repeated random sampling and use randomness to solve problems that may be deterministic in principle. The method involved includes 1) generating a large number of random potential price paths for the underlying asset via a simulation, 2) calculating the associated exercise value of the option for each path, 3) averaging the payoffs, and 4) discounting the value to $t = 0$.

Finite difference methods for option pricing

Similar to utilizing Monte Carlo option pricing methods when there are multiple sources of uncertainty, finite difference methods can be used to price options by approximating the continuous-time differential equation that describes how an option price may evolve over time using a set of discrete-time difference equations. (Schwartz, 1977) The price can be derived by iteratively solving the discrete difference equations.

3 Traditional Asset Valuation

Traditional assets in most cases are valued using the principles of valuation discussed in Section II. In Section III, we will briefly review existing valuation methodologies for traditional asset classes.

3.1 Fixed Income

Fixed income are debt instruments where the borrower or issuer is obligated to make payments of fixed amounts on a fixed schedule. In its simplest form, the borrower may be required to pay interest at a fixed rate during a year and to repay the principal amount on maturity. Fixed income products may have various features that affect the frequency of the payments and rate amounts: bullet bonds, where the entire principal value is paid all at once on the maturity date as opposed to amortizing the bond over its lifetime, variable rate bonds, where the payments are adjusted at specific intervals, prepayment bonds, where principal payments can be made earlier than schedule, and callable/puttable bonds where the bond holder or issuer has the right to redeem a bond or demand early repayment of principal, respectively.

Fixed income securities are valued based on the gross redemption yield, or the internal rate of return if all future cash interest and principal repayments are discounted back to the present. If an interest rate is equal to the gross redemption yield, then the discounted value is equal to the current market price of the bond. The gross redemption yield reflects a buyer's perception of how interest and exchange rates may change until maturity. Fixed income instruments are generally priced as a credit spread above a low-risk reference rate, such as LIBOR or U.S. bonds of the same duration. The credit spread reflects the risk of default by the issuer of the fixed income security. Risk free interest rates are determined by market forces and vary over time.

Fixed income securities bear a variety of inherent risks, and therefore holders of such securities must be compensated for these risks. Pricing and expected returns reflect these risk premia. Risk premia associated with fixed income include but are not limited to inflation risk (buying power of the principal and interest payments will decline during the term of the security), interest rate risk (interest rates will change from the levels available when the security is sold), currency risk (exchange rates with other currencies may change during the security's term, default risk (issuer may be unable to pay the scheduled interest payments or principal repayment), and liquidity risk (buyer will require the principal funds for another purpose on short notice, prior to the expiration of the security). (Fabozzi, 2005)

3.2 Equities

Equities represent an ownership position in a corporation and claim on a proportionate share in the corporation's assets and profits. A company's equity (or shareholder equity) is the difference between the value of the assets and the value of the liabilities. Common valuation methodologies for equities include discounted cash flow, accounting, and relative valuations.

3.2.1 Discounted Cash Flow Valuation

Financial statement and cash flow modeling serve as the basis for discounted cash flows valuation. The standard approach models out company cash flows based on future business operations and financing; alternative models focus solely on discounting future dividends paid to shareholders. (Damodaran, 2006a; Edwards & Williams, 1939; Fuller & Hsia, 1984; Graham & Dodd, 1934; Michaud & L Davis, 1982) Miller and Modigliani formed the origins of the firm valuation model, where they propose that the value of a firm can be described as the present value of its after-tax operating cash flows. (Modigliani & Miller, 1958)

3.2.2 Liquidation & Accounting Valuation

The value of an equity can be viewed as the sum of the values of the individual assets owned by the company. In an asset-based valuation or "liquidation" valuation, each asset's value is estimated separately using fair value methods and then aggregated. For fixed assets, the book value is generally should be reflective of the original cost of the asset and subsequent depletions and/or additions to that asset. For current assets, the book value is driven by the market current rate. Intangible assets, such as intellectual property or goodwill, are more difficult to value and have no objective valuation method.

3.2.3 Relative Valuation

Equities are often valued in comparison to how similar assets are being valued in the market. In order to appropriately compare assets, practitioners standardize a company's values way by scaling them to a common variable, sometimes known as a multiple. Multiples are generally a function of growth, risk, and cash flow generating potential and can be compared across companies. (Damodaran, 2006b) Equity comparable valuation methods generally include a fairly simple discounted cash flow model for equity or firm value and using them to derive appropriate multiples. Comparable firms generally have similar cash flows, growth potential, and risk to the firm being valued. (Fernandez, 2001; Liu, Nissim, & Thomas, 2002) Common multiples include Price/Earnings (P/E) and Enterprise Value/Earnings Before Interest, Depreciation, and Amortization (EV/EBITDA) ratios. Other multiples compare the value of the equity or firm in comparison to sales or free cash flow. (Lie & Lie, 2002) Though the precise definition does not require comparable firms to be in the same industry or sector, in practice the assumption is that firms in the industry will have more similar risk, growth, and cash flow profiles and therefore are more appropriate comparable firms. (Bhojraj & Lee, 2002; Cheng & McNamara, 2000)

3.3 Currencies

The valuation of money has been a topic of much debate since commodity and fiat money replaced barter systems. Commodity money, like the Mesopotamian shekel, cowry shells, and Tyrian purple dye, transitioned to gold and silver standards with depository receipts and eventually government-authorized currencies forms as representative money. According to most economists, money has value because society demands the benefit it offers in purchasing power for goods and services. Because society is willing to accept and give money as forms of payment, its value is derived moreso from a social convention as opposed to a government mandate.

Economists suggest that the value of currencies is a result of network effects. As Berkeley economist Varian explains, "just as a fax machine is valuable to you only if lots of other people you correspond with also have fax machines, a currency is valuable to you only if a lot of people you transact with are willing to accept it as payment." (Varian, 2004)

The demand for money manifests itself in two manners: one, as a medium of exchange for goods and services, and two, as a store of value for the future purchase of goods and services. There are three two general approaches for analyzing the demand for money: the Classical approach (Fisher and Cambridge approach) and the Keynesian approach.

3.3.1 Fisher Approach

The Theory of Money, or sometimes known as the quantity theory of money, is a theory of the demand for money in an economy. The most common version, the "neo-quantity theory" or Fisherian theory, suggests there is a mechanical and fixed proportional relationship between changes in the money supply and the general price level. (Friedman, 1956, 2017)

$$M_b V = P_e Q_e$$

where M_b is the size of monetary base, V is the velocity of the monetary base, P_e is the price of provisioned resources, and Q_e is the quantity of provisioned resources. We interpret M_b as the size of the monetary base required to support the economy of purchasing goods and services ($P_e Q_e$) at velocity V. M_b, that serves as the money or means of exchange, is a function of the price and quantity of the outstanding money. Velocity, V, is the measure for the number of times an asset changes hands in a given time period. Generally, the velocity of an asset is viewed over the course of a single year, much like a country's GDP is calculated over the course of a single year.

3.3.2 Cambridge Approach

An alternative approach to the Fisher version of the quantity theory of money is the Cambridge cash-balance theory or more simply the Cambridge equation. (Keynes, 1923) This version of the quantity theory of money expresses a relationship among the amount of goods produced, the price level, the amount of the monetary base, and the mechanism through which the monetary base moves.

The Cambridge equation, in contrast to the Fisher version, focuses on monetary demand instead of monetary supply. The theories also diverge in the explanation of money movement. The Fisher version notes that money moves at a fixed rate and serves only as a medium of exchange while the Cambridge version suggests that money acts as a store of value and its movement depends on the desirability of holding money. Cambridge economists argue that a certain portion of the monetary base, k, will not be used as mediums of exchange; instead, it will be held for the security of having money on hand.

This portion of cash is commonly represented as $\boldsymbol{k}$, a portion of nominal income (the product of the price level and real income, P_eQ_e). The Cambridge equation can be concretely described as follows[1]:

$$M = kP_eQ_e$$

The Fisher approach stresses the medium of exchange purpose of money, notably that individuals want money in order to use it as a means of payment. In contrast, the Cambridge approach introduces the store-of-value function of money and suggest that individuals will hold money to store value for future spending.

3.3.3 Keynesian Approach

Keynes argued that "liquidity preference" drives the demand for money and is driven by three primary motives: transactions demand, precautionary demand, and the speculative demand. (Keynes, 1937) The demand for money

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[1] The original Cambridge equation is illustrated as $M = kPY$ where PY represents the nominal income. For consistency with the classical theory of money, we relabel the variables such that PY is concretely described as P_eQ_e.

is dependent on the interest foregone by not holding interest-bearing instruments. The Keynesian construct holds that interest is a reward is a reward for parting with liquidity and not saving.

The transactions demand for money arises from the medium of exchange function of money in making regular payments for goods and services, as well as the rate of interest, “since a higher rate of interest may lead to a more economical use of active balances.” (Keynes, 1937) The precautionary demand for money relates to holding money for sudden expenditures and for unforeseen opportunities, such as accidents, unemployment, or illness. According to Keynes, the speculative demand for money is driven by using money as a store of value that can be invested in interest-bearing securities at opportune moments. In essence, individuals retain liquidity such that if interest rates fall, individuals will demand more money to hold until the interest rate increases.

3.4 Commodities

Commodity are economic goods or services that are substantially fungible, or that instances of the good are equivalent regardless of who produced the good. As Marx explained, “from the taste of wheat, it is not possible to tell who produced it, a Russian serf, a French peasant or an English capitalist.” (Marx, 1887) Most commodities are basic resources, such as raw materials, agricultural, or mining products, but also can include mass-produced products such as chemicals and fabricated technology parts. Commodities are generally undifferentiated across its supply, generally due to the widespread intellectual capital necessary to acquire or produce a commodity efficiently.

The value and price of a commodity is determined by market forces. Commodity valuation is closely linked to utility theory. Modern utility valuation construction revolves around modeling demand for the asset, driven by aggregate preferences and utility functions, and the supply for the asset, given production and supply constraints.

4 Conclusion

We reviewed and evaluated the principles of valuation and economics in past literature, including discounted cash flow, relative, utility, and contingent claim valuation. We provided a brief overview of how leading valuation theories and methodologies for traditional asset classes are utilized in contemporary valuation and monetary theory.

Crypto Asset Valuation Series

Part II: Networks, Decentralization, and Asset Hybridization

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Abstract. Crypto assets and their networks have innate features and exhibit phenomena that have implications for the valuation of crypto assets. In particular, the network affects, decentralization, and asset hybridization are all notable features that affect crypto asset valuation. In this paper, we examine Metcalfe's and Zipf's Law and how they may pertain to crypto asset network effects. We review the key valuation considerations of decentralized and the impact it has on the safety, security, and dependability of a network and its infrastructure. We explore asset hybridization and valuation considerations for crypto assets.

1 Introduction

Crypto assets enable decentralized networks and represent means of exchange and commodities for their networks. The valuation of crypto assets remains a challenge to academics and practitioners alike, in part due to the variety of novel characteristics that crypto assets exhibit. Crypto assets and their networks have inherent characteristics and phenomena that have profound implications for the ultimate valuation of the crypto asset: network affects, decentralization, and asset hybridization. The community of peer-to-peer individuals and transactions on a crypto asset network exhibit network effects and a growth in value with more users and higher usage, similar to the modern Internet and other traditional assets. In addition, the decentralized nature of these systems creates multiple benefits to the safety, security, and dependability of the network that is conferred to the users and operators of the network. Finally, the hybridization of crypto assets, or the ability for the assets to serve multiple functional use cases such as concurrently being a generalized commodity, a store of value, and means of exchange, may also have valuation implications.

Part II of the series reviews the valuation considerations of networks, decentralization, and asset hybridization native to crypto asset systems. This paper is structured as follows. Section 2 reviews leading frameworks and models for assessing the value of a network. Section 3 examines the value of decentralization and assesses some of the valuation considerations. Section 4 explores asset hybridization, or how the multi-functional use of an asset can affect its value. Section 5 concludes the paper.

2 Network Value

2.1 Metcalfe's Law

Communication networks provide an efficient method for transferring information and value. Language, the written word, and the printing press enabled the growth of societies and culture throughout the millennia. The emergence and growth of communication and digital networks in the late 1900s sparked a debate over methodologies to value of networks.

Metcalfe's Law (formulated by George Gilder in 1993 but named after Robert Metcalfe, the inventor of the Ethernet) was originally theorized to explain the relationship between the value of a telecommunications network and the number of connected users to the system. (W. E. Becker, Shapiro, & Varian, 1999) Metcalfe's Law was originally presented in terms of "compatible communicating devices" (for example, fax machines, telephones, etc.), though with the globalization of the Internet the law transitioned over to users or nodes on a network. Metcalfe's Law suggests that the value of a network is proportional to the square of the number of connected users of the network (n^2), where n is number of users or nodes on a network. Anecdotally, the number of unique possible connections in a network of n nodes can be expressed mathematically as the triangular number $n(n-1)/2$, which is asymptotically proportional to n^2. The foundation of Metcalfe's Law is the observation that in a network with n members, each member can make $n-1$ connections with other participants. Assuming the connections are valued equally, the aggregate network value is equal to $n * (n - 1)$ or roughly n^2. A network with 5 members has 20 unique possible connections. If the network doubles in size (to $n = 10$), the number of connections increases to 90 (roughly quadratically).

2.2 Limitations of Metcalfe's Law & Zipf's Law

Metcalfe's Law notwithstanding has its limitations. In particular, the model only provides a mathematical justification for the *potential* number of connections that can be made (the potential capacity of a network), not the *actual* number of connections (the actual utility of a network). In addition, a key assumption of Metcalfe's Law is that the value of each connection provides equal benefit to its users (marginal user utility remains constant with the number of users). However, other models argue that marginal value decreases with each additional user. Early adopters of a network may derive significant benefit from joining and using a network, while later adopters may derive a smaller benefit. Therefore, the incremental value that additional users of a network add to the overall network diminishes as the network grows.

Many have proposed modified models: notably, one model suggests that the value of a network grows as $n * \log(n)$ rather than n^2. This model follows a discrete power law probability distribution known as a Zipfian distribution. Originally used to describe the empirical phenomenon that the frequencies of certain words are inversely proportional to their rank on a frequency table, Zipf's Law can be applied to a wide variety of real-world phenomena where the k th-ranked item in a rank order will measure about $1/k$ of the first one. Earlier work had already applied Zipf's Law to the Internet, noting how data transmission, website selection, user growth peer-to-peer community formation, and web caching strategies exhibited Zipfian power law distributions. (Adamic & Huberman, 2002)

Briscoe, Odlyzko, and Tilly noted that Zipf's Law can be applied to network valuation, and argued that the increasing value of a network as its size increases lies somewhere between linear and exponential growth. (Briscoe, Odlyzko, & Tilly, 2006) Linear models, such as Sarnoff's Law which argues that the value of a broadcast network grows linearly, and exponential models, such as Reed's Law which proposes that the value of networks grows proportionally with 2^n since they allow for the formation of groups, make a fundamental mistake in assigning equal value to all connections. They reference Henry David Thoreau's Walden, where Thoreau notes that early telecommunication networks faced similar issues: "We are in great haste to construct a magnetic telegraph from Maine to Texas; but Maine and Texas, it may be, have nothing important to communicate." (Thoreau, 1854) Briscoe et al. describe how Zipf's law can be used as basis to justify the $n * \log(n)$ methodology of a general communications network of size n using an email mailing list as the key example. In their example, the authors argue that members of an email mailing list can be ranked based on their rank value and each contributes $1/k$ "value" to the aggregate list, where k is the individual's rank. Assuming the person ranked $k = 1$ creates an arbitrary value of 1, the person ranked 1^{st} creates value of $1/1$, or 1, the person ranked 2^{nd} creates value of $1/2$, and so on. The total value of the email network is the sum of the decreasing $1/k$ values of all the other members of the network. For a network with n members, the value of the network is $1 + 1/2 + 1/3 + \cdots + 1/(\ n - 1)$, which approaches $\log(n)$ plus a constant value. Generalizing, there are $n - 1$ other members who derive similar value from the network, so the aggregate value of the network can be concretely described as $n * \log(n)$. Metcalfe later acknowledged this development and noted that Zipf's Law may be more applicable for modeling network valuations. (Metcalfe, 2006)

2.3 Model Validation

Later empirical analysis suggests that Metcalfe's and Zipf's Law may be applicable for modeling user growth and network valuation. Madureira et al. used European Internet usage patterns and found that network value grew n^2 for small networks, and $n * \log(n)$ for larger networks. (Madureira, den Hartog, Bouwman, & Baken, 2013) Metcalfe modeled Facebook's user growth over a 10-year period and found that it closely followed the n^2 proportional growth. (Metcalfe, 2013) Further research built upon Metcalfe's findings and modeled Tencent, a large Chinese social network company, and Facebook's revenue and user growth; their findings suggested that Metcalfe's Law held for both companies despite the differences in geographic focus of each social network. (Zhang, Liu, & Xu, 2015)

2.4 Extension to Crypto Assets

Crypto asset networks are groups of peer-to-peer users or nodes transacting using a decentralized system and transmitting information and/or value digitally. Naturally, these groups of users exhibit network effects as the incremental user growth corresponds to increases in the value of the crypto asset with more active users and higher usage.

Despite the relatively short history of the crypto asset ecosystem and limited data sets, some preliminary empirical work suggests that the valuation of crypto asset networks do in fact follow Metcalfe's Law in relation to user growth. Alabi modeled the price of a crypto asset and the number of unique addresses each day that engage in transactions on the network. The analysis suggests that the crypto asset networks follow Metcalfe's Law, and a new proposed model where the network value is proportional to the exponential of the root of the number of users participating in the network was also applicable. (Alabi, 2017) Furthermore, the author notes that value bubbles can be spotted anecdotally from deviations in the model when rapid price growth are not accompanied by a corresponding growth in the number of active users. Wheatley et al. used a generalized Metcalfe's model based on fundamental network properties and showed bubble creation and collapse on occasions when the value heavily exceeded the underlying model. (Wheatley, Sornette, Huber, Reppen, & N. Gantner, 2018) The authors also modeled a Log-Periodic Power Law Singularity (LPPLS) model in an effort to quantify a high crash hazard and probabilistic bracket of the crash time consistent with the actual corrections.

The protocol, data, and user transparency and immutability of most of the large market capitalization crypto assets provide a remarkably good source for user and transaction data, including breadth, frequency, and magnitude. Using blockchain and pricing data from Coin Metrics and Bitcoin.com, we can plot and analyze Bitcoin's daily active users and its network value. (Bitcoin.com, 2018; Coin Metrics, 2018)

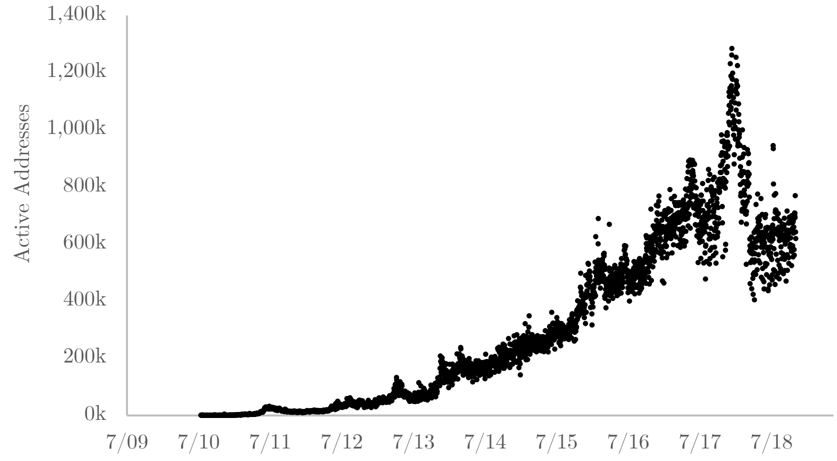

Fig. 1: Bitcoin active addresses over time. (Coin Metrics, 2018)

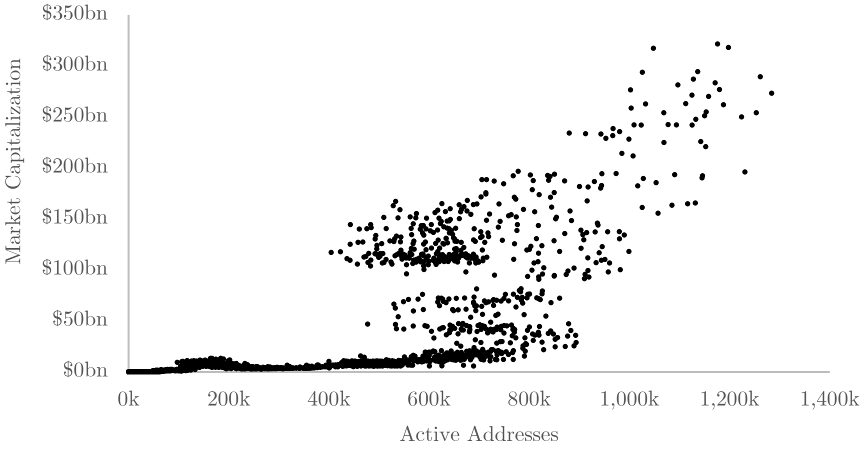

Fig. 2: Bitcoin active addresses and price. (Bitcoin.com, 2018; Coin Metrics, 2018)

Figure 2 above suggests that there is an exponential or power relationship between user growth and network valuation. We can transform n into Metcalfe and Zipf relationships and run relatively simplistic regressions to check for fit. Tables 1 and 2 shows the summary regression output statistics for Bitcoin Metcalfe and Zipf relationships.

Regression Statistics	
Multiple R	0.79348
R Square	0.629611
Adjusted R Square	0.629488
Standard Error	3.06E+10
Observations	3032

ANOVA

	df	*SS*	*MS*	*F*	*Sig. F*
Regression	1	4.84E+24	4.84E+24	5150.579	0
Residual	3030	2.85E+24	9.39E+20		
Total	3031	7.68E+24			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-2.7E+09	6.74E+08	-4.01655	6.05E-05
n^2	0.161059	0.002244	71.76753	0

	Lower 95%	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-4E+09	-1.4E+09	-4E+09	-1.4E+09
n^2	0.156659	0.16546	0.156659	0.16546

Table 1: Regression, function $y = an^2 + b$

Regression Statistics	
Multiple R	0.730801
R Square	0.53407
Adjusted R Square	0.533917
Standard Error	3.44E+10
Observations	3032

ANOVA

	df	*SS*	*MS*	*F*	*Sig. F*
Regression	1	4.1E+24	4.1E+24	3473.129	0
Residual	3030	3.58E+24	1.18E+21		
Total	3031	7.68E+24			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-1.2E+10	8.76E+08	-13.2593	4.78E-39
n*log(n)	21569.91	366.0056	58.93326	0

	Lower 95%	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-1.3E+10	-9.9E+09	-1.3E+10	-9.9E+09
n*log(n)	20852.26	22287.55	20852.26	22287.55

Table 2: Regression, function $y = a(n * \log(n)) + b$

Both models (R^2 of 0.63 with Metcalfe's Law, R^2 of 0.53 with Zipf's Law) suggest that peer-to-peer crypto systems do exhibit some network effects and the overall network value grows with more users.

3 Decentralization

3.1 Background

Decentralization is often heralded as the raison d'être for today's crypto networks and assets, stemming from the original Bitcoin white paper where a novel system was described to be "a purely peer-to-peer version of electronic cash [that] would allow online payments to be sent directly from one party to another without going through a financial institution." (Nakamoto, 2008) In particular, many argue that the peer-to-peer nature of the systems removes untrusted intermediaries and create a frictionless exchange of value and information. Moreover, the ability to create "trustless" digital systems with transparent, programmable logic that eliminates the necessity for counterparty trust may provide a multitude of valuable benefits to the users of a decentralized network.

Before we delve into the key valuation considerations for decentralized networks, it is imperative to first properly define what precisely is decentralization, especially given common misconceptions. Buterin, one of the co-creators of the Ethereum network, notes that there are three types of decentralization: architectural, political, and logical. (Buterin, 2017) Architectural decentralization focuses on how many physical computers comprise a network, and how many could potentially break down at any time. Political decentralization refers to how many individuals or organizations who ultimately control the computers. Finally, logical decentralization looks at the interface and the data structures that system presents and maintains, either representing an object or an unstructured group. Figure 2 provides a useful dimensional comparison of the varieties of decentralization and examples by Buterin.

	Logically Centralized		Logically Decentralized	
	Politically Centralized	Politically Decentralized	Politically Centralized	Politically Decentralized
Architecturally Centralized	Traditional corporation	Direct democracy	?	?
Architecturally Decentralized	?	Blockchains, Common Law	Traditional CDNs	BitTorrent, Spoken/ Written Languages

Figure 2: Dimensionality of decentralization. (Buterin, 2017)

Buterin notes that for the most part, blockchains are “politically decentralized (no one controls them) and architecturally decentralized (no infrastructural central point of failure) but they are logically centralized (there is one commonly agreed state and the system *behaves* like a single computer).” Despite this, crypto networks come in many varieties and architectural and social decisions with respect to the design, governance, and operation of these systems can create situations where the networks may be politically and architecturally centralized.

The value of decentralization comes in a variety of forms but can be succinctly described in five key points arguments: fault tolerance, attack resistance, collusion resistance, censorship resistance, and information ownership. (Buterin, 2017; Dixon, 2018)

3.1.1 Fault Tolerance

Fault tolerance refers to the principle that decentralized systems are less likely to fail accidentally because they rely on many separate components. A fault-tolerant network design allows the network to continue its intended operations rather than failing completely when a part of the system fails.

Many crypto asset networks rely on a distributed ledger of historical transactions and replicated operations across many nodes that eliminate single points of failure. Part of the fault tolerance of crypto networks is the redundancy of the system, or essentially “backup” components that allow the system to continue to operate if a component fails. For example, in contrast to a centralized ledger of transactions, most crypto networks replicate the history of transactions to prevent the loss of the ledger if there is an error or prevention of a node operation. The architectural decentralization of most crypto networks allows the network to continue even if a portion of the network fails. Crypto asset networks also incorporate replication, or providing identical instances of the same system, directing tasks to all in parallel, and choosing the correct result on the basis of a quorum through common transaction confirmation processes and an encoded consensus mechanism.

3.1.2 Attack Resistance

Decentralized systems are practically attack resistant as they are more expensive to attack or manipulate because they lack central points. In contrast to fault tolerance, attack resistance is a feature in systems where all nodes or users may not be honest actors. Consensus on a shared vision of truth in crypto protocols is based on consensus mechanisms that decide how the network achieves agreement on the state of the ledger. In Bitcoin and other "proof of work" consensus schemes, transaction validators expend computing cycles and electricity to add timestamped transactions to an ongoing chain or ledger of hash-based proof-of-work that cannot be changed without redoing the proof-of-work. The longest chain with the highest amount of accumulated difficulty serves as proof of the historical sequence of events witnessed and that it came from the largest pool of CPU power. Proof-of-work networks can continue to operate and propagate a valid ledger if the majority of CPU power is controlled by honest nodes even in the presence of malicious actors. As described in the original Bitcoin white paper: "As long as a majority of CPU power is controlled by nodes that are not cooperating to attack the network, they'll generate the longest chain and outpace attackers." (Nakamoto, 2008)

Decentralized networks pose new requirements in forging consensus: a shared version of truth. In modern networks, achieving consensus in the presence of faulty or malicious information is a challenge best described as the Byzantine General's Problem. Originally described in 1982, the Byzantine General's Problem is an agreement problem in distributed systems where participants on a network must agree on a single strategy in order to avoid complete failure. However, some of the involved parties may be corrupt, disseminating suboptimal (false or faulty) information. In the Byzantine General's Problem, a group of generals each command a portion of the Byzantine army and encircle a city. The generals must decide whether to attack or retreat. Every general must agree on a path forward. If only some generals attack, the Byzantine army will lose and both the attacking and retreating factions will be defeated. Success can only be achieved through a coordinated attack or a coordinated retreat. The generals are physically separated and have to send their messages in a peer to peer manner.[2] (Jankovic & Brightly, 2018)

The situation is complicated by the presence of malicious generals who intend to disseminate suboptimal information. The malicious generals will distribute suboptimal information and may do so selectively based on the recipient. For example, imagine five generals are voting, two who support

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[2] This paragraph and the following paragraphs in this section Attack Resistance are taken from the working paper Jankovic, L., & Brightly, I. (2018). Crypto Assets: Extending Permissionless Innovation.

attacking, two who support retreating, and one malicious general. The malicious general may send a vote of retreat to those generals in favor of retreat, and a vote of attack to the generals who favor an attack. The problem is illustrated in Figure 3.

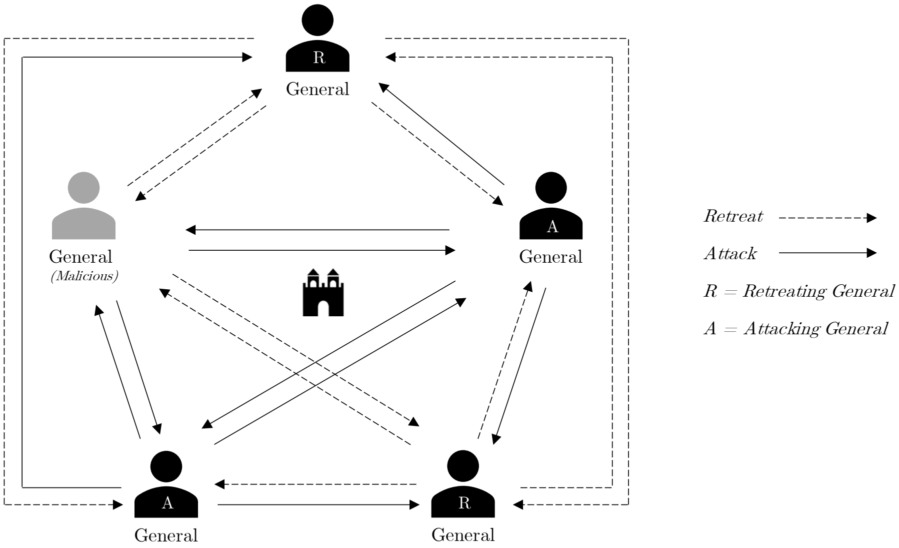

Figure 3: Byzantine General's Problem

Byzantine fault tolerance can be achieved if the non-malicious generals have a majority agreement on their strategy. Malicious generals may be present, but the system can remain Byzantine fault-tolerant as long as the number of malicious generals does not equal or exceed one third of all generals. It is not possible for an asynchronous system to provide both safety (the guarantee that all honest generals will eventually agree on what progress was made) and liveness (the ability to continue to make forward progress) with more than one third of the generals being malicious.

3.1.3 Collusion Resistance

Crypto networks are practically collusion resistant as it's more difficult for participants in decentralized systems to collude to act in suboptimal ways in comparison to centralized systems. The safety of the network consensus relies on the uncoordinated choice model, or the assumption that all protocol participants are united under the same do not coordinate with each other, make independent decisions, and are smaller than a particular size. In the uncoordinated choice model, the assumption is that there is an honest majority in which no participant has more than 50% of the hashing power in a proof of work system. The security of the network may be compromised if someone acquires 1/3 of the hashing power and engages in selfish mining: in selfish mining, a miner does not publish and distribute a valid solution to the rest of the network. Instead, the selfish miner continues to mine the next block and so on maintaining its lead. When the rest of the network is about to catch up with the selfish miner, the miner releases their portion of solved blocks into the network. The result is that their chain and proof of work is longer and more difficult so the rest of the network adopts their block solutions and the selfish miner claims the block rewards.

Practically speaking, today's proof of work systems are relatively centralized: as of November 2018, the four largest bitcoin mining pools accounted for 50.4% of the total hashing power and the three largest Ethereum mining pools accounted for 62.0% of the total hashing power. (Blockchain Luxembourg S.A., 2018; Etherscan, 2018) Furthermore, much of the core software development of the protocols takes place in relatively centralized organizations or companies and thereby act in somewhat coordinated fashions. However, the centralized coordination and organization of crypto networks is somewhat paradoxical. In many instances, coordinated development and mining communities architect protocol roadmaps and build future software upgrades more efficiently than a disparate group of individuals. In addition, the centralization and communication among the coordinated entities enable quicker fixes and implementations in the event of bugs or denial-of-service issues. In essence, there are tradeoffs between the efficiency and potential risks of coordinated participants.

3.1.4 Censorship Resistance & Information Ownership

Decentralized systems limit the ability for the censorship, deletion, or abuse of information. Crypto asset payments and information transfers are irreversible upon the network's consensus, natively digital and integrated, and globally operational 24/7. Given that consensus is decentralized, there are no centralized entities that can censor or delete information. Decentralization also enables full ownership of information and can only be shared with the user's permission. Many Web 2.0 companies give themselves broad discretion over user information through lax Terms of Service, allowing them to censor, block, delete, and sell data to third parties. In contrast, only the users can permission others to receive or view information on crypto networks.

If external payment mechanisms were used in crypto networks, they would run into a variety of challenges. External payments depend on standard legal contracts and the rule of law, which requires an inefficient external party intervention in the event of a disagreement. External payments can be reversed, which creates an incentive to cheat miners, while native transactions cannot. External payments could be targeted and blocked by intermediaries, which would reduce the ability for the system to function under duress.

3.2 Measuring Decentralization

Decentralized consensus based on incentives driven by a statistical difficulty and economic reward aligning decision-makers within a decentralized system influences value within that system. Without the coordination of disparate contributing parties, the peer-to-peer network cannot safely determine how to proceed past a certain point, as untrusted nodes could take advantage of the asynchronous nature of the network. Decentralization therefore underpins the economic value of a crypto asset at a fundamental level because a poorly decentralized crypto network is vulnerable to attacks on its consensus mechanism.

As public crypto networks are comprised of multiple subsystems, the overall measure of decentralization of a network is dependent on the decentralization of its subsystems. The decentralization of mining, software clients (unique codebases), developers and engineers who continue to improve and maintain the codebase (commits to the main client), geographic distribution of nodes, exchange volume, and wealth distribution are critical to the decentralization of the broader crypto network. (Srinivasan, 2017) Mining and ownership are particularly relevant for various consensus mechanism in crypto networks.

Examining the value of decentralization with cryptocurrency begins with measuring the significance of decentralization in each of the popular consensus systems. In a proof-of-work network, any number of dishonest nodes above 51% of the total hashing power is a failure scenario for the network. The possibility of a 51% attack grows higher if mining power is centralized under a single entity's control. In addition, miners with significant hashpower under 51% could participate in selfish mining, giving them an advantage over other honest miners and compromising the monetary incentive provided by the block subsidy. Although the consequences of selfish mining are not as disastrous as the consequences of double-spend attacks, any miner willing to compromise the effectiveness of the worldwide network's incentive for short term personal gain will harm the health of the system.

Within a proof-of-stake consensus system, decentralization is critically important because the barrier to entry is a one-time cost rather than ongoing. Compared to the ongoing cost of electricity incurred by proof-of-work miners, gaining enough funds to have a significant influence on block production and decision-making within a proof-of-stake system is a single up-front cost. Critical to safety of proof-of-stake crypto network is the distribution of crypto assets and equality of wealth. In these instances, popular wealth inequality metrics such as the Gini coefficient and Lorenz curve can be used to examine the distribution of wealth in crypto networks.

3.3 Value of Decentralization

Valuing decentralization comes with many challenges. In part, individual utility curves with respect to decentralization (in essence, what is someone willing to pay for decentralization) varies from individual to individual. The amount that individuals are willing to pay for decentralization (a "decentralization premium") in some ways is a subjective analysis more so than an objective one, as there is not enough robust economic and transactional data to support an ex-post quantitative analysis of the decentralization premium. What an individual is willing to pay for decentralization hinders on the value of 24/7 permissionless operation, near guaranteed execution, prevention of manipulation or censorship, fault tolerance and attack resistance in systems. The value of these are dependent on the associated costs and potential attack vectors. For example:

- What is someone willing to pay to send value across borders without any possibility of the transaction from being censored, stopped, or manipulated?
- What is someone willing to pay to ensure continued digital infrastructure operations that are mission critical and are practically resistance to accidental failure or attack?

Given the nascency of the broader crypto asset space and the limited usage of these systems for their intended or potential uses, the benefits of decentralization and their value remain to be seen.

4 Hybridization

Crypto assets are defined as digital assets secured by strong cryptography allowing for financial transactions such as creation, transfer and verification. These assets have a few shared characteristics and numerous differing goals, attributes, and properties resulting in a variety of sub-asset classes: money assets (stores of value and mediums of exchange), smart contract platform assets, and utility tokens. The ability for crypto assets to serve multiple purposes have considerations for asset pricing and valuation.

Past theorems and schools of thought have attempted to understand the evolution of non-fiat money pricing. In particular, the Menger-Mises Regression Theorem applies the subjective theory of value to the objective-exchange value (purchasing power of money). (Mises, 1954) The theorem holds that once a commodity begins taking on characteristics of money, its exchange value is no longer limited to its underlying use value as just a commodity. The asset has additional exchange value by its new function as money such that the commodity trades at a premium in comparison to its pure commodity value. For example, gold, a store of value and medium of exchange, trades at a premium to its commodity usage in industrial production or decorative purposes.

The origin of the objective-use value of money is the point at which the asset is being valued to the point where the monetary good served only non-monetary uses, an essential point preceding the first use of anything as money. At this point, its objective-exchange value is explained by the general theory of subjective value and marginal utility. Individuals trade real good for units of money because they have higher marginal utility for the money than the real goods given away. A farmer will trade away a pig for units of money because they derive higher marginal utility from having flexible money in comparison to the marginal utility of a pig and its limited flexibility in a barter system with a coincidence of wants. Money is demanded for future expected purchasing power and money allows individuals to receive real goods and services in the future. Given that people are willing to give up real goods and services in the present to own units for future spending, it logically follows that the current exchange value of money is dependent on the future purchasing power of money.

Optically, there is a circularity to the purchasing power: the purchasing power of money is dependent on the purchasing power of money. However, due to the temporal differences, money today has purchasing power because of its past purchasing power: the purchasing power of money today is in part due to its purchasing power yesterday for goods and services. "Regressing" backwards, the exercise reaches a point in time in which the money was first used in a state of barter. At that point, the purchasing power of the commodity money can be explained similarly to the way that the exchange value of a commodity is determined. Gold had value in isolation as a commodity before it became money, and therefore an adequate theory of its current market value can be traced back until the point when gold was not used as money.

Although novel in the form of a digital bearer asset, digital money assets have analogies to traditional forms of payment used over time, in particular that of precious metal coinage and paper notes. From a hybridization standpoint, physical cash has largely moved away from multiple use purposes toward a single use asset. Gold and silver have been used both as medium of exchange and store of value as well as for jewelry and decorative purposes since at least 3000 BC. (Perl & Weihs, 1987) Industrial use cases were added over the years – examples include dentistry (gold teeth were used as early as 700 BC), printed circuit boards (gold has excellent conductive properties) and treated glass (designed to reduce solar radiation). (M. J. Becker & Turfa, 2017) Any valuation of gold must take into account the multiple use cases which will create demand for the asset. In contrast, paper notes have essentially no other use other than stores of value and mediums of exchange exhibiting minimal hybridization qualities.

Continuing the analogy, similar to gold, money assets such as Bitcoin exhibit hybridization beyond the use of stores of value and mediums of exchange. Bitcoin is currently used as an immutable, albeit expensive and special purpose database for projects such Factom, which maintains its own database of transactions but inserts cryptographic anchors into the Bitcoin blockchain proving the consistency of the Factom database. Omni, CounterParty and Colored Coins all use various mechanisms for creating and transferring token assets using specially formed Bitcoin transactions. Other projects such as Liquid and RootStock are building sidechains which maintain a two-way peg between bitcoins and sidechain tokens. The money purposes for assets likely create a floor of price while the monetary stores of value and mediums of exchange make for the bulk of the current and future value. Still, it appears likely that any valuation needs to factor all use cases for these assets.

Smart contract platform tokens are primarily used as native commodities for accessing general purpose compute resources. Ethereum smart contract users pay a gas fee in ether, the native currency of Ethereum, relative in size to the complexity of the execution of the contract and the network usage. Assuming a degree of adoption by users, application developers and businesses implies a degree of demand for the native platform tokens. Predicated on the notion that platform token share some of the properties that money asset do such as scarcity and censor resistance, the demand imbues the tokens with a degree of stores of value and mediums of exchange properties. Given the early state of smart contract application adoption, the store of value property is a relatively weak. Utility tokens can be viewed as similar to platform tokens but with a narrower use. Examples include governance of decentralized exchange protocols and renting of idle compute and storage resources. Assuming a level of adoption is achieved for the primary use case, the ability to transact with the token for hedging, investment, or payment purposes means that some of the value will come from a store of value and mediums of exchange component, albeit seemingly less so than a general-purpose platform token.

5 Conclusion

We examined some valuation considerations for crypto asset networks and the growth of connected users of the network. We reviewed the types of decentralization, how to measure decentralization, and the value of denaturalization. Finally, we explored the concept of asset hybridization, existing theories of objective-exchange value for money, and hybridization in crypto assets.

Crypto Asset Valuation Series

Part III: Valuation of Stores of Value & Mediums of Exchange

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Abstract. We examine how traditional valuation and economic constructs can be applied to crypto assets designed to be mediums of exchange and stores of value. In particular, we review quantity theory of money and Keynesian constructs for mediums of exchanges. We propose a "transfer of wealth" methodology and briefly review comparative valuations for crypto asset stores of value.

1 Introduction

Cryptographic peer-to-peer forms of money provides multiple opportunities for disintermediation of traditional financial systems and a safe haven from economic stresses. The crypto asset landscape has grown into a highly diverse ecosystem, with the largest portion of the asset class by market capitalization to date are held in crypto assets designed to be decentralized means of exchange and stores of value. In particular, bitcoin is the largest and oldest peer to peer means of exchange and store of wealth.

As interest in the asset class grows with higher utilization of the assets as utilities and financial instruments, the need for valuation methodologies is imperative. Crypto asset valuation methodologies are relatively nascent, in part due to the their relatively short history, the novel nature and variety of characteristics the asset exhibit, and lack of robust data. Our motivation for this series is to formulate valuation frameworks that academics and practitioners may utilize for further research and to make informed investment decisions. In Part I, we explored traditional valuation and economic theory as it pertains to traditional asset classes. In this paper, we apply these traditional valuation and economic theory to crypto assets that are primarily used as stores of value and mediums of exchange.

This paper is structured as follows. Section 2 provides a brief background on the history of money and a discussion on the value of money. Section 3 reviews leading monetary theories and valuation methodologies for crypto asset money as a means of exchange. Section 4 discusses valuation methodologies for crypto asset stores of value. Section 5 concludes the paper.

2 Background

2.1 A Brief History of Money

Money serves an integral role in society: providing a means of exchange for labor, goods, and services. Barter systems and economies date back tens of thousands of years, though became inefficient once economies scaled and division of labor became widely accepted. Aside from representing a means of exchange, money also serves as a store of value, or the ability for a money to transfer value through time and maintain wealth representation.

Money took on various forms throughout history, with the majority of civilized economies utilizing commodity money or money backed by commodity assets. Commodity money, such as the Mesopotamian shekel, cowry shells, Tyrian purple dye, and even salt served useful roles in society, facilitating trade and commerce globally. However, the relative ease by which the commodity supply could be created led to inflation, and the low worth per unit made transferring large wealth for trade challenging.

Metal commodity money, primarily gold and silver, have existed for millennia. In particular, gold became the social standard for a metal store of value. Gold was relatively rare to find, but not exceedingly impossible. It was relatively inert, preventing unwanted corrosion, reactions, or tarnish. The first known uses of gold as money and a store of value date back to the fourth millennium BCE when the Egyptians used gold bars of a set weight as a medium of exchange. Incan and Mayan empires, 650 BCE Lydia (now

Turkey), and Europeans used gold as a means of exchange, store of value, and for decorations and jewelry. Coins were frequently minted using various metals and alloys, including bronze, silver, and gold.

Paper money as a form of promissory banknotes was first introduced by the Song Dynasty in 11th century China. Twelfth century England and thirteenth century Italy and Flanders also utilized forms of banknotes, depository receipts, and tallies. Government-authorized currencies soon emerged as representative money, first as a currency backed by gold or other monetary standards deposited at a central bank and later by the full faith and credit of the issuer.

2.2 The Value of Money

According to most economists, money has value because society demands the benefit it offers in purchasing power for goods and services. Because society is willing to accept and give money as forms of payment, its value is derived moreso from a social convention as opposed to a government mandate. Economists suggest that the value of currencies is a result of network effects. As Berkeley economist Varian explains, "just as a fax machine is valuable to you only if lots of other people you correspond with also have fax machines, a currency is valuable to you only if a lot of people you transact with are willing to accept it as payment." (Varian, 2004)

We also see that there is a certain circularity in the value of money, similar to arguments presented in Part I regarding utility: the demand for money is explained by the power of money while the demand for money is explained by its purchasing power. Laws of supply and demand govern pricing and production dynamics for goods, but become more muddled when scrutinizing money. If the demand for money is based on its purchasing power, then money must have a pre-existent price, or purchasing power, prior to its price being explained by demand.

Mises explains demand for money is determined by the ex-post purchasing power of money. (Mises, 1949) Given the supply of money today, today's price of money, or purchasing power, is established. Similarly, yesterday's purchasing power was based on the prior day's purchasing power of money. Recursing back through time eventually arrives at a time *0* where ordinary demand and supply set the purchasing power of money in terms of other commodities. Simply put, at $t = 0$ when a commodity becomes money, it already has an established purchasing power, thereby creating demand for this commodity as money. As Rothbard explained, "in contrast to directly used consumers' or producers' goods, money must have pre-existing prices on which to ground a demand. But the only way this can happen is by beginning with a useful commodity under barter, and then adding demand for a medium to the previous demand for direct use (e.g., for ornaments, in the case of gold). Thus government is powerless to create money for the economy; the process of the free market can only develop it." (Rothbard, 2014)

The demand for money manifests itself in two manners: one, as a medium of exchange for goods and services, and two, as a store of value for the future purchase of goods and services. There is no requirement that a money be both a means of exchange and a store of value: means of exchange can be poor stores of wealth in the long term, such as the case with inflationary currencies, while some stores of value such as gold may be difficult to transact with.

There are two general approaches for analyzing the demand for money: the Classical approach (Fisher and Cambridge approach) and the Keynesian approach. Pure stores of value can be valued using two perspectives: 1) that the store of value serves as a "flight to safety" financial instrument during periods of economic or geopolitical stress, and 2) as a relative valuation in comparison to a similar asset that exists today.

3 Monetary Theory

3.1 Fisher Approach

The Theory of Money, or sometimes known as the quantity theory of money, is a theory of the demand for money in an economy. The most common version, the "neo-quantity theory" or Fisherian theory, suggests there is a mechanical and fixed proportional relationship between changes in the money supply and the general price level. (Friedman, 1956, 2017)

$$M_b V = P_e Q_e$$

where M_b is the size of monetary base, V is the velocity of the monetary base, P_e is the price of provisioned resources, and Q_e is the quantity of provisioned resources.

We can see from equation that $P_e * Q_e$ yields a dollar amount, the aggregate dollar amount produced by the economy that represents the total value exchanges in the economy. In other words, this dollar value would be the Gross Domestic Product (GDP). We interpret M_b as the size of the monetary base required to support the economy of purchasing goods and services $(P_e Q_e)$ at velocity V. M_b, that serves as the money or means of exchange, is a function of the price and quantity of the outstanding money. US dollars have a "fixed" price of \$1 and the Federal Reserve has the ability to control the supply of dollars in our financial systems. We may also concretely describe M_b as:

$$M_b = P_b Q_b$$

where P_b is the price of the base money, and Q_b is the quantity base money in circulation.

Velocity, V, is the measure for the number of times an asset changes hands in a given time period. Generally, the velocity of an asset is viewed over the course of a single year, much like a country's GDP is calculated over the course of a single year. For reference, the USD M1 money stock is roughly 5.5, meaning that each US dollar exchanges hands roughly 5.5 times a year. (Federal Reserve Bank of St. Louis, 2018)

3.2 Cambridge Approach

An alternative approach to the Fisher version of the quantity theory of money is the Cambridge cash-balance theory or more simply the Cambridge equation. (Keynes, 1923) This version of the quantity theory of money expresses a relationship among the amount of goods produced, the price level, the amount of the monetary base, and the mechanism through which the monetary base moves.

The Cambridge equation, in contrast to the Fisher version, focuses on monetary demand instead of monetary supply. The theories also diverge in the explanation of money movement. The Fisher version notes that money moves at a fixed rate and serves only as a medium of exchange while the Cambridge version suggests that money acts as a store of value and its movement depends on the desirability of holding money. Cambridge economists argue that a certain portion of the monetary base will not be used as mediums of exchange; instead, it will be held for the security of having money on hand.

This portion of cash is commonly represented as $\boldsymbol{k}$, a portion of nominal income (the product of the price level and real income, $P_e * Q_e$). The Cambridge equation can be concretely described as follows[3]:

$$M = kP_eQ_e$$

As noted previously, $\boldsymbol{k}$ is the fraction of the real money income (P_eQ_e) that individuals wish to hold as opposed to use as a medium of exchange. Formally, the Cambridge equation is identical with the income version of the Fisher equation. In this instance, $k = 1/V$ in Fisher's equation. We can rearrange the original theory of money equation to look as follows and see that $\boldsymbol{k}$ in the Cambridge theory is the inverse of the money velocity in Fisher's equation:

$$M = \frac{1}{V}P_eQ_e$$

The velocity of circulation, in part, is determined by the mechanical aspects and friction inherent to the payment methods and practices. For example, the frequency of wages and other factor payments, the speed with which transactions can be sent and settled, and the prevalence of which bank deposits are used in transactions, all affect the velocity of the money supply. The Fisher approach stresses the medium of exchange purpose of money, notably that individuals want money in order to use it as a means of payment. In contrast, the Cambridge approach introduces the store-of-value function of money and suggest that individuals will hold money to store value for future spending.

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[3] The original Cambridge equation is illustrated as $M = kPY$ where PY represents the nominal income. For consistency with the classical theory of money, we relabel the variables such that PY is concretely described as P_eQ_e.

In addition, the proportion of the money supply stored for future consumption, k, is also determined by human nature. Personal risk tolerances and desires for a "safety net" of money affect the aggregate k. The Cambridge approach suggests that in the short run k is constant, but over time k can increase or decrease, particularly in response to external stimuli. Stressed market and labor conditions will, ceteris paribus, increase k. Regularity of income also affects k. If the labor force receives income at regular intervals, they will spend their income more freely and the velocity of money will increase. However, if income is paid at irregular intervals, individuals may prefer to hold more money to meet uncertain conditions in the future. In this instance, the velocity of money will fall. Finally, behavior such as speculation will lead individuals to hoard money and increase k.

3.3 Keynesian Approach

Keynes argued that "liquidity preference" drives the demand for money and is driven by three primary motives: transactions demand, precautionary demand, and the speculative demand. (Keynes, 1937) The demand for money is dependent on the interest foregone by not holding interest-bearing instruments. The Keynesian construct holds that interest is a reward is a reward for parting with liquidity and not saving.

The transactions demand for money arises from the medium of exchange function of money in making regular payments for goods and services, as well as the rate of interest, "since a higher rate of interest may lead to a more economical use of active balances." (Keynes, 1937) The precautionary demand for money relates to holding money for sudden expenditures and for unforeseen opportunities, such as accidents, unemployment, or illness. According to Keynes, the speculative demand for money is driven by using money as a store of value that can be invested in interest-bearing securities at opportune moments. In essence, individuals retain liquidity to speculate that bond prices will fall such that if interest rates fall, individuals will demand more money to hold until the interest rate increases.

Money demand for transactions and precautionary purposes is a function of the level of income, while the speculative demand for money is a function of the interest rate. The Keynesian total demand for money can be described as:

$$L_T + L_P + L_S \; = \; f(k, r, Y)$$

where $L_{T \to S}$ are the transactional, precautionary, and speculative demands for money, r is the interest rate, and Y is the level of income.

3.4 Post-Keynesian Approach

Keynes argued that transactional money demand was primarily interest rate inelastic. Two separated post-Keynesian economists, however, argued that there is a tradeoff between the liquidity provided by money and the interest forgone by holding one's assets in non-interest bearing assets. (Baumol, 1952; Tobin, 1956) Baumol held that the relationship between transactional demand and the level of income is neither linear or proportional, but rather that changes in income lead to smaller relative changes in the transactional money demand. In addition, the Baumol's inventory theoretic model eliminates the distinction between transactions and speculative demand for money, by taking both interest and non-interest costs into account in a transactions demand and capital-theory approach. (Baumol, 1952) Tobin's risk aversion theory of portfolio selection doesn't depend on the inelasticity of expected future interest rates, but rather that the expected value of capital gains or losses from holding interest-bearing assets is always zero. In addition, Tobin argued that individuals tend to hold portfolios of both money and bonds, and not one or the other, as Keynes originally believed. (Tobin, 1956)

4 Stores of Value

4.1 Safe Haven Assets

Apart from serving as a medium of exchange for goods, services, and labor, money serves the critical function of being a store of value, or the ability to transfer wealth or value through time. More generally, it is the function of an asset that allows it to be saved, retrieved and exchanged in the future, and predictably retain its purchasing power. Most money tends to exist along the spectrum between a medium of exchange and a store of value, and some assets can be great mediums of exchange but poor stores of value and vice versa.

Paper money tends to be an effective means of exchange, but a poor store of value in the long run. In contrast, gold is commonly viewed as a store of value, but is a poor medium of exchange.

In financial markets, stores of value are safe haven assets that should retain its value in during adverse market conditions, including economic and geopolitical calamities. Such assets offer investors the opportunity to protect wealth in negative market conditions. Gold is perhaps the best example of a safe haven asset; US Treasuries are another example of a safe haven asset that investors tend to turn to during severe market shocks.

Empirical econometric evidence suggests that gold has served as a safe haven against international equity and currency markets. An analysis by Baur and McDermott spanning a 30-year period from 1979 to 2009 shows that gold is both a hedge and a safe haven for major US and European stock markets. (Baur & McDermott, 2010) Baur and McDermott also argue that gold may act as a stabilizing force for the financial system by reducing losses in the face of extreme negative market shocks. Furthermore, they show that gold served as a hedge and safe haven asset in periods of financial crises (October 1987, Asian Crisis October 1997 and Financial Crisis of 2008), particularly in the global financial crisis in September 2008. Capie et al. show that there is a negative and typically inelastic relationship between gold and sterling-dollar and yen-dollar exchange rates. (Capie, Mills, & Wood, 2005) They also find that although gold has broadly served as a hedge against fluctuations in the exchange rate of the US dollar, it tends to serve as a better hedge during higher magnitude currency changes brought on by unpredictable events. Tulley and Lucey show that the US dollar is main macroeconomic variable which influences gold price changes using APGARCH models. (Tully & Lucey, 2007) Sjaastad and Scacciavillani find that floating exchange rates among the major global currencies have been a major source of price instability in the world gold market and as exchange rate changes in European currencies have strong effects on the price of gold in other currencies. (Sjaastad & Scacciavillani, 1996)

The value and price of stores of value is determined by market forces, driven primarily by the value of direct and indirect utility the asset confers. We also distinguish between “primary” and “secondary” stores of value: general, local currency money such as the US dollar serve as a “primary” store of value in addition to being the primary accepted means of exchange, while “secondary” stores of value are non-local currency assets priced relative to the primary money. In the case of secondary stores of value, the demand for these assets is driven by the utility of the asset as a means to preserve wealth, particularly in times of economic stress. Ceteris paribus, value transfer from a primary to secondary store of value coincides with price increases in the secondary asset, and vice versa.

We propose two valuation methodologies for crypto assets that primarily serve as secondary stores of value and safe haven assets: (1) a “transfer of wealth” valuation construct where wealth transfers from a primary money to a secondary store of value/safe haven asset during adverse market conditions, and (2) a relative valuation where a secondary, crypto asset store of value is compared to the existing valuation of a commonly used store of value.

4.2 Transfer of Wealth Valuation

A crypto store of value such as bitcoin can serve as an alternate global means of payment and store of value during times when the primary means of exchange is stressed. This can be in times of economic stress when monetary inflation threatens commerce, individual wealth, or when faith in centrally controlled fiat money is questioned. For the purposes of this discussion, we will keep the valuation methodology limited to global fiat currencies, but will note that value transfer can also take place from other assets such as equities and fixed income which are innately tied to local economies and currencies.

During adverse market events, wealth (value representation) transfers from a primary money to a secondary store of value as a “flight to safety.” In this instance, a portion of the underlying monetary base transfers into the secondary store of value during periods of adverse market conditions (we shall denote this proportion of wealth transfer as t). It is also important to note that economies and markets are in generally productive and calm environments, and states of adversity or economic stress happen infrequently with some probability s. Using this construct, the aggregate value of a crypto store of wealth as a secondary store of value in times of fiat stress is the probability-weighted, transfer-of-wealth in economic stress events of global fiat currencies. Concretely:

$$Value = \sum_{i=1}^{n} M_i s_i t_i$$

where n is the total number of fiat-denominated monetary bases, M is the value of a country's fiat monetary base, s is the probability of a stressed economic event, and t is the proportion of the fiat monetary base transferred to a crypto store of value. Table 1 below shows a simple example of the valuation methodology in practice on a hypothetical store of wealth under the transfer of wealth methodology.

	M - Fiat Base ($)	*t - Transfer Amount (%)*	*s - Probability of Adverse Conditions (%)*	*Expected Value ($)*
Country A	$10,000 bn	1.0%	6%	$6.0 bn
Country B	$6,000 bn	1.5%	7%	$6.3 bn
Country C	$900 bn	2.0%	10%	$1.8 bn
			Sum	$14.1 bn

Table 1: Illustrative valuation methodology example for a hypothetical secondary store of value.

The probability of a stressed economic event is a long run variable – at any point in time, the probability of adverse market conditions can increase or decrease as a result of changing economic and political climates. During periods of economic stress, this probability is equal to or near 100%, so in essence there is a 100% probability that a proportion of the fiat monetary base transfers to a crypto store of value.

Though estimates vary, the total value of the world's money in 2017 was roughly $36.8 trillion including the world's coins, banknotes, and checking deposits. (Desjardins, 2017) A slighter broader view of money, including money market accounts, savings, and time deposits, puts the total near $90.4 trillion. For reference, the global stock market is worth roughly $73 trillion and the value of all outstanding debt across governments, corporations, and household debt is approximately $215 trillion. (Desjardins, 2017)

An alternate store of value that also has requisite money properties and is an acceptable means of exchange can also be readily accepted for goods and services in any country without needing to convert to the domestic currency during periods of adverse market conditions. For example, assume Brazil wakes up to economic turmoil and the BRL has runaway inflation. Citizens will wish to preserve their wealth (in essence, the representation of the redemption value of a discrete set of goods and services) and transfer it through time by converting the wealth into a global currency. As opposed to transferring wealth into another global currency like the RMB, USD, or EUR where the currency can only be redeemed in a certain region and would require additional conversions to move that value from country to country, citizens can use a borderless means of payment such as bitcoin that is not tied to any nation or economic block. In this instance, commerce and wealth preservation can continue during periods of economic stress.

4.3 Relative Valuation

Crypto assets stores of value can also be valued using a relative or comparative valuation by examining how similar assets are being valued in the market. Anecdotally, many believe that bitcoin can and does serve a purpose of being “digital gold” or “gold 2.0,” one that is provably finite, deflationary, and democratic in its creation and usage. As a result, a comparative valuation to gold may be appropriate.

According to the World Gold Council, the world’s total above-ground gold reserves are estimated at 187,200 tons. (World Gold Council, 2018) At a $1,234 per ounce spot price on October 25, 2018, the world’s gold is worth an estimated $7.4 trillion. (Bloomberg LP, 2018) Gold usage is not strictly limited to private investment. According to the World Gold Council, gold is demanded for four primary uses: jewelry, investment (encompassing physical demand as well as ETF and similar products), Central Banks and other institutional demand, and technology (electronics and other industrial use). Figure 1 below illustrates the breakdown of the demand for gold.

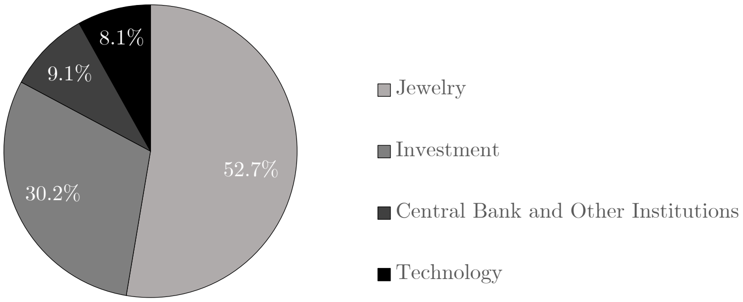

Fig. 1: Global demand for gold in 2017. (World Gold Council, 2018)

Using figures from the World Gold Council, we assume that sum of the usage of gold for investment purposes and by Central Banks and other institutions (39.3%) represents gold's function as a financial instrument while the remaining usage for jewelry, technology, and industrial use isn't particularly relevant for gold's use as a store of value. Using these estimates, approximately \$2.9 trillion of gold's value is for its use a financial instrument, providing a base upon which to compare a crypto asset store of wealth.

There are a few more considerations that should be reflected upon for a relative valuation. First: market share adoption. Demand for a crypto asset store of wealth can come from existing gold holders (basically cannibalizing market share from gold) or it can come from new demand sources that did not own gold as a store of wealth. In the case of new demand sources, the aggregate value of these stores of wealth may surpass that of traditional assets, which adds additional complexity when attempting to run comparative valuations given that it would also require modeling new demand. In addition, there is a temporal element to this valuation: it remains unclear when a store of value utility is achieved by a crypto asset. In particular, simply holding the asset itself is the expression of its utility and therefore the realization of a crypto store of wealth can take place in a month or a millennia. Assuming that at some point in the future a crypto asset becomes an acceptable alternative store of value (with some probability of success), this future value should be discounted back to a present value using an appropriate discount rate.

5 Conclusion

We examined how traditional valuation and economic constructs can be applied to crypto assets designed to be mediums of exchange and stores of value. Specifically, we reviewed how the quantity theory of money and Keynesian constructs for mediums of exchanges can be applied to crypto assets. We proposed a "transfer of wealth" methodology for crypto asset safe havens, and briefly reviewed comparative valuations for crypto asset stores of value.

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