A Fundamental Valuation Framework for Cryptoassets

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June 2018[1]

"All models are wrong, but some are useful."

~ George E.P. Box

[1] Earlier versions of this paper were drafted beginning in July 2017.

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DISCLOSURES: As a director of Ripple Labs, Susan Athey holds an equity position in Ripple Labs, which in turn has a large position in the cryptoasset XRP. She also holds various cryptoassets directly. All references to Ripple or XRP in this paper are based on only publicly available information.

1 INTRODUCTION

Over the past decade, the world has seen the introduction of an entirely new asset class in the form of cryptoassets (also commonly referred to as "cryptocurrencies," "digital currencies," or "digital assets"). These assets, which have been made possible through blockchain technology, have the potential to fundamentally alter the way value is transferred and stored across the world. In general, cryptoassets can be thought of as digital tokens where allocation and access rights are recorded in digital ledgers supported by software protocols. These assets have properties similar to global commodities, and can be transferred digitally, securely, and instantaneously across borders. Their potential to accelerate and transform global commerce while re-shaping industries has led to a surge in investor interest, resulting in rapid escalations in valuations.

To date, the cryptoasset investment community has struggled to define a cohesive framework for valuing these assets. Conventional tools of financial asset valuation such as discounted cash flow analysis (applied to equities, fixed income securities, land, etc.), marginal cost curves (commodities, physical goods), and relative purchasing power (fiat currencies) are not generally appropriate for cryptoassets. The popular press frequently describes cryptoassets as impossible to value due to a perceived "lack of intrinsic value."

At the same time, others argue that this new asset class is poised to provide real economic value. Cryptoassets have a number of distinct features that enable them to be used differently from fiat currency, and that thus open up new uses. These include: decentralization, universality across borders, transaction processing speed, data storage and reconciliation efficiency, security, the ability to facilitate trustless transactions, and conduciveness to "smart contracts" that can perform functions such as holding cryptoassets in escrow and distributing them in a state-contingent fashion.

This paper proposes a holistic approach to valuing cryptoassets that integrates economic utility and store-of-value use cases, adopting certain principles from prior work done in this space as well as from traditional finance principles.

2 VALUATION MODEL

2.1 Valuation Approach: Transaction + Storage

We consider an approach to valuing cryptoassets that integrates the two primary functions of money: (i) medium-of-exchange; and (ii) store-of-value. (We leave aside the use case as a unit of account, which is less relevant). Our hypothesis is that the leading cryptoassets today will come to fulfill a hybrid of the medium-of-exchange and store-of-value functions, and our model represents an aggregation of these two purposes. In order to quantify these two functions and capture their translation into price, we examine the supply and demand for cryptoassets in each use case. In the analysis that follows, we will denominate all value figures in US dollars ("$") as the reference currency.

2.2. Demand

We anticipate that even in a state of the world where cryptoassets are widely adopted, goods markets will continue to be priced in units of fiat currency. In this scenario, demand for cryptoassets as a medium of exchange is independent of the exchange rate (putting aside short-term exchange rate volatility for the moment).[2]

This gives us the ability to quantify demand in dollar terms independently of price. In this model, we will classify all actors as either holding coins for the purposes of effecting economic transactions ("medium-of-exchange") or for the purposes of being stored ("store-of-value"). What matters, then, is the aggregation of individuals' desired holding amounts (in $), across these two purposes. While in practice these two are imperfectly delineated, separating them allows us to more accurately model the underlying drivers of each component. Thus, we begin with the following simple equation:

$$D = X + I \tag{1}$$

D = Total demand value (in $)
X = Transaction demand value (in $)
I = Storage demand value (in $)

2.3 Transaction Demand

Each of the major cryptoassets was developed with an intention to support use cases in enabling transactions, though the types of transactions vary across currencies.[3] In spite of these differences, we can adapt the Quantity Theory of Money to understand the drivers of Transaction Demand. This model has been frequently invoked in early valuation frameworks in the cryptoasset space (see, e.g., Athey et al. (2016), Burniske (2017), and Pfeffer (2018), among others), but we will quickly review the components below.

We begin with the identity for the velocity of money in any economy:

$$MV = Y \tag{2}$$

M = Monetary base (in $)
V = Velocity of money (in average # of transactions per unit of currency per period)
Y = Transaction volume (in $ per period)

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[2] This is true in the fundamental sense, although in Section 3.2 we will explore the ways in which price can impact transaction demand indirectly by distorting transaction fees.

[3] Of the three largest cryptoassets, bitcoin was primarily conceived for peer-to-peer payments, Ether was conceived to enable transactions built on smart contracts, and XRP was conceived for use in cross-border payments. These envisioned use cases are reflected in differences in each's structure and their relative strengths and weaknesses.

Two simple steps will enable us to adapt this equation:

1) Create a variable t, equal to 1/V, which will represent the average time a unit of currency (across the subset of coins classified as being held for transaction purposes) is held between transactions:

$$\frac{M}{t} = Y$$

2) Observe that "Money Supply" actually refers to the total *value* of all currency in the economy, also denominated in \$. Therefore, *M* is actually equivalent to *X* (the total *value* of all currency held and used for transaction purposes) from Equation (1).

Combining these transformations and re-arranging, we get:

$$X = M = Yt \tag{3}$$

X = Transaction demand value (in \$)
M = Monetary base (in \$)
Y = Transaction volume (in \$ per day)
t = Weighted-average time between transactions for each unit of transaction-held currency (in days)

This equation is consistent with prior work in the space, with minor semantic adjustments. Prior valuation frameworks built around the Quantity Theory of Money choose to model velocity rather than its inverse (time), though we take the opposite approach as it allows for a more natural representation of the underlying driver of behavior, making it easier to model. While doing so with validity and precision is a challenge; authors such as Athey et al (2016) provides descriptive statistics about this in the Bitcoin network (though they do not address the issue of forecasting future values of *t*).

Combining Equation (3) into Equation (1) yields:

$$D = Yt + I \tag{4}$$

2.4 Storage Demand

The storage demand for a cryptoasset is determined by the total value (in \$ terms) that the global population wishes to hold in the form of that cryptoasset as a means of storing value. Here, storing value is defined broadly to include all those treating the currency as an investment asset. What distinguishes this category of demand from transaction demand in our model is that the individual wishes to hold the asset on a long-term stored basis, rather than for purposes of effecting economic transactions.

In order for an asset to be appealing to individuals and institutions as an investment or store of value on a fundamental basis, an asset must fulfill at least *one* of the following criteria at the time it is held:

I. Intrinsic and enduring physical value that grows roughly in proportion to other important assets (eg. land)
II. The creation of economic value from the capital deployed while the investment is held (eg. all financial securities where the capital invested is used to generate an economic return)
III. A belief that the asset is undervalued and likely to see its market price appreciate abnormally on a risk-adjusted basis (eg. financial securities held actively)
IV. Widespread expectation that the asset will be broadly accepted over an indefinite horizon as an instrument of value (eg. gold, US dollars)

plus *both* of the following criteria:

V. The ability to store the asset securely without undue risk of seizure, theft, or destruction
VI. Confidence that the supply of the asset will not be increased arbitrarily

Cryptoassets do not meet criteria (I) and (II). And while (III) may be the motivation for a large portion of the current cryptoasset investor base, the basis for buying an undervalued asset is that eventually, the asset will be properly valued, at which point by definition the benefit of undervaluation is gone. Therefore, for a cryptoasset to have sustainable storage demand value, it must meet criteria (IV).

Today, cryptoassets have yet to establish a long enough history of widespread recognition as a standard of value to allow (IV) to hold. If this dynamic can be transformed over time as the industry matures and adoption grows, it has the ability to create a self-fulfilling cycle of adoption and credibility.

For an instrument like the US dollar, credibility developed as a result of the economy that underlies it and the institutions that endorse it. In the case of gold, its widespread recognition as an instrument of value developed over thousands of years. Gold trades at a premium above its industrial use case, and that premium derives from demand for gold as a store of value, based on the belief that it will continue to be used as a store of value in the future. The value of cryptoassets used as a store of value similarly may derive from the belief that it will be useful as a store of value in the future as well. Although it is difficult to model the source of this belief, a key supporting factor is likely to be the development of a robust underlying transaction economy. This transaction economy may promote the onset of the virtuous cycle of adoption and credibility. It is through this mechanism that transaction demand value therefore serves as a critical factor in driving storage demand value.[4]

Assuming (IV) can be achieved in a credible, sustainable way, a cryptoasset will then have to satisfy conditions (V) and (VI), without which storage demand on a large scale is still unlikely to occur. While cryptoasset blockchains are typically extremely secure cryptographically, the

[4] The lone exception where this condition may not be necessary is bitcoin. This will be explored in greater detail in Section 3.2.

actual mechanics of storing these assets (which occurs outside the blockchain) are still fraught with security issues. Relative to the convenience and security of storing assets with a bank or through the capital markets, cryptoassets currently present much higher risk of theft or loss (at least for ordinary citizens). However, as the industry ecosystem matures, this dynamic is likely to improve, expanding the pool of individuals contributing to storage demand.

Constraint (VI) is a generally attractive feature of cryptoassets, and is likely to support, rather than impair, the attractiveness of cryptoassets for storage purposes.

Once the necessary conditions for fundamental storage demand are in place, the magnitude of global demand will be driven by considerations of how the asset's risk and return prospects interact with an individual's existing risk and return profile on other portfolio assets. This will be explored in greater detail in Section 2.7.

2.5 Supply

The supply of most cryptoassets is fixed and easily measurable. There exists, however, some disagreement in the market over whether coins not yet issued or large deposits of coins being held on an indefinite timeline should be counted as part of supply. Since this model aims to ascertain long-term fundamental value, the most appropriate approach is to include all coins that are in existence or will be issued in the supply calculation.[5,6] This is based on the assumption that market participants should, and will, consider the impact of all future in-circulation coins in projecting long-term value.

$$S = \frac{N + \gamma}{\rho} \tag{5}$$

S = Total supply (in units)
N = Number of coins currently outstanding
γ = Number of coins to be issued in the future or currently locked up by large institutions
ρ = Fractional reserve ratio of cryptoasset network

2.6 Value per Unit

To arrive at a fundamental value per unit, we must then divide total demand value by the currency's total supply:

$$v = \frac{D}{S} \tag{6}$$

[5] This approach will be theoretically valid so long as $\frac{Yt}{D} < \frac{N}{S}$, which is almost certain to be true in practice, now and indefinitely, for all cryptoassets except those that are highly inflationary.
[6] If a cryptoasset has coins that are widely expected to be locked up indefinitely, those should also be captured in the estimate of storage demand, which offsets their impact on supply.

v = Fundamental value per unit

Using the model we have built to this point, the equation becomes:

$$v = \frac{\rho(Y\mathrm{t} + I)}{N + \gamma} \tag{7}$$

This is our final definition of the long-term fundamental value per unit of a cryptoasset.

2.7 Present Value

Equation (7) gives the long-term fundamental value per unit of currency, which we then need to discount back to today. This long-term value describes a "steady state" at which the use-case applications of the cryptoasset have matured, and transaction demand and storage demand for it have stabilized.

Assumptions for the appropriate discount rate are likely to be a source of considerable disagreement amongst market participants. At one extreme, some will argue that a very high discount rate is required to compensate for the extraordinary volatility of these assets. Even though this volatility will likely decline meaningfully as the market matures, volatilities are nonetheless likely to exceed those of other publicly traded assets. Still, the majority of this volatility will be idiosyncratic from a broader capital market perspective. Hence, a more appropriate discount rate assessment requires an adaptation of the Capital Asset Pricing Model as a starting point.

Given our very low forecasted adoption rate as a percentage of investable assets, and the fact that the correlation between cryptoassets and equity markets are likely to be close to zero or negative for the foreseeable future,[7] the systematic risk contribution of a cryptoasset position to a well-diversified investor is likely to be close to zero, or negative. As a result, an appropriate discount rate for cryptoassets should in fact be a value that is closer to low-beta equity securities.

This assertion is likely to be the source of a certain degree of controversy based on the observation that cryptoasset investments are highly "risky." Nonetheless, the correct way to account for this idiosyncratic risk is in the probability weighting of the future value estimates. To use a high discount here would be to "double-count" the impact of the asset's riskiness, which is logically flawed. That is, the fact that the asset may have zero value in the future is already captured in the calculation of the future expected value of the asset. It is qualitatively similar to the fact that a company might go out of business in the future; that possibility is factored into the calculation of the discounted expected value of stock. Just as with a stock or any other risky asset, if the demand for the asset comes from well-diversified investors, volatility around the mean is relevant for pricing only to the extent it contributes to systematic risk, and a zero-beta asset does not contribute to systematic risk.

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[7] Bitcoin's historical Beta to the S&P 500 to date has been modestly above zero since inception.

$$P = \frac{\rho(Yt + I)}{N + \gamma}(1 + i)^{-T} \tag{8}$$

P = Present value of fundamental value per unit
i = Discount rate (annualized)
T = Time until steady-state (in years)

This final equation requires a total of 8 parameters to be estimated. Each of these parameters can be estimated reasonably tangibly, providing an opportunity for a rigorous valuation estimate applicable across a broad spectrum of cryptoassets.

Having now built the framework of our valuation model, in Section 3 we will attempt to demonstrate its practical application using two of the three largest cryptoassets: BTC and XRP.

3 MODEL APPLICATION – BTC and XRP

3.1 Model Application: Estimating Fundamental Value for BTC and XRP

A rigorous and comprehensive attempt to estimate fundamental value for a given cryptoasset using this model is an intricate process. Such a pursuit in its most comprehensive form is beyond the scope of this paper. Instead, we will attempt to provide a plausible range of estimates for each of the required parameters using straightforward and broadly available information in order to demonstrate this model's valuation framework at a functional level.

We will use a simple binary probabilistic model to account for the significant uncertainty in potential outcomes, and define these potential outcomes as a "Success Case" and a "Failure Case" for each. We emphasize that the "Success Case" is not intended to be a "most optimistic" scenario, but rather a realistic or even conservative scenario where the cryptoasset achieves some of the potential as it is understood today. We also note that there could be a healthy debate about the magnitudes used here; they are provided here to illustrate the logic of the model; we leave a more thorough evaluation of the magnitudes for future work.

For bitcoin, we define the "BTC Success Case" as a state of the world in which bitcoin retains its status as the preeminent asset in the industry over the long term. In this scenario, BTC will continue to be used as a gateway from fiat currencies to other cryptoassets, and will continue to be widely held as the default option for investment exposure to the asset class. We will assign the "BTC Success Case" a probability of 30%, and the "BTC Failure Case" a probability of 70%. The "BTC Failure Case" is composed of:

i. An estimated 30% probability that an emerging cryptoasset becomes so pervasive that it eventually supplants BTC as the industry's standard currency
ii. An estimated 25% probability of devastating external actions such as government intervention or a major security breach
iii. An estimated 15% probability that bitcoin cedes its predominance as a result of governance-related dysfunction (e.g. continued stakeholder disputes leading to multiple forks).

For XRP, we will define the "XRP Success Case" as a state of the world in XRP is adopted as part of a widely-used cross-border payments standard, and in which XRP is adopted for use by financial institutions, corporations, and individuals to effect FX transactions.

We will use an estimated 25% probability for the "XRP Success Case" and a 75% probability for the "XRP Failure Case." Maintaining the caveat that this paper does not rely on any new information into the likelihood of various scenarios, such that the magnitudes presented should be taken as illustrative of the approach, the "XRP Failure Case" is composed of:

i. An estimated 30% chance that cryptoassets either never gain meaningful adoption for cross-border transactions, or that government-sponsored alternatives prevail instead
ii. An estimated 20% probability that the SWIFT banking consortium manages to innovate and defend its position as the entrenched standard by successfully implementing alternative technology that does not rely on XRP

iii. An estimated 15% probability that a scattered collection of competitors create a fragmented set of alternatives
iv. An estimated 10% probability that one out of the set of possible competitors in this sub-industry will create an alternative standard.

In both the "BTC Failure Case" and the "XRP Failure Case," the assets will likely have some value, but these values are likely to be sufficiently small relative to the assets' current prices and their values in each's "Success Case," such that we can reasonably assign them values of zero without materially impacting the conclusion of this analysis.

3.2 Estimating Parameter Ranges

1) Y – Total transaction value, in $ per day

BTC: The significant technological limitations of Bitcoin cast doubt on the prospect that BTC will generate large-scale usage in facilitating the transfer of value, despite Bitcoin's original design for this purpose. The Bitcoin network is encumbered by very low transaction throughput, slow confirmation times, and high transaction costs. The controversies within the Bitcoin community throughout 2017 over how to resolve Bitcoin's scaling problem have cast significant doubt over the community's ability to effectively find an enduring long-term solution to this issue.

As a result of these technological limitations and enduring governance issues, we can consider Bitcoin's current transaction volume to be a reasonable starting point in estimating what future volumes might look like. To estimate today's magnitude of transaction volumes used for actual economic transaction processing (as opposed to trades related to storage/investment activity) we take total bitcoin transaction volumes (in $ per day) and exclude the component that comes from the major exchanges, since the vast majority of exchange volume is investment-related.

Using this data, we will make the following assumptions:

- Average dollar value of transactions will increase between 3.5-5.5% per year. This is based on the fact that low-value transactions are likely to be crowded out as a result of bitcoin's transaction costs, pushing the average value of transactions higher
- Bitcoin's network capacity will increase by a factor between 2-8x from today, and new demand will fully occupy this increased supply of transaction capacity given this modest projected growth in capacity.[8]
- The time (T) to reach the steady state is 12 years. This assumption is explored in a later section.

[8] For context, the SegWit2x protocol change would have increased capacity by a factor of 4x, and to date only the first half of this upgrade has been realized. While proposals for the Bitcoin "lightning network" have the potential to increase capacity by a much larger order of magnitude, the viability of this concept in supporting practical transaction is yet unproven.

Table 1 - Bitcoin Transaction Volume Estimates		
Data for Q1 2018		
Total daily volume	$3.0bn	
Less: Volume on exchanges	$1.1bn	
Economic transaction volume	$1.9bn	
	High Estimate	**Low Estimate**
Transaction avg. value growth rate:	5.5%	3.5%
Assumed capacity increase	8x	2x
Projected transaction volume	**$28.2bn**	**$5.6bn**
Source: Blockchain.info		

Using these assumptions,[9] we arrive at an estimated daily transaction volume of ~$5.6-28.2bn by 2030.

XRP: Technologically, XRP was designed for the use case of facilitating cross-border payments – a market of enormous magnitude. Cross-border remittances constitute $1.3bn per day,[10] cross-border payments constitute ~$85bn per day,[11] and FOREX trading constitutes ~$5tn per day.[12] XRP has the ability to substantially improve foreign exchange transactions by allowing instantaneous settlement, superior liquidity provisioning (thereby reducing FX costs), and the ability to transact without nostro/vostro networks. Despite its technological advantages, gaining substantial adoption for use in facilitating these cross-border transactions is an extremely daunting task given the inertia of the international banking system.

In our "XRP Success Case," XRP secures very high adoption for remittances (through the adoption by companies such as Moneygram, Western Union, Cuallix, who have already announced pilots or plans to use XRP), strong adoption for cross-border payments, and comparatively modest adoption for global FOREX trading (limited to lower-volume corridors not well served by financial institutions today).

Retail remittances represent the first proven use case for cryptocurrency-enabled cross border payments, and XRP appears to be the clear early leader in attempting to disrupt the existing costly and inefficient infrastructure in this area. With the ability to deliver a large cost and speed advantage over both fiat-based retail FX trading and other cryptoassets, XRP appears poised to capture a substantial share of this space.

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[9] Attempts to delineate economic transactions from exchange activity and other forms of noise are unscientific as a result of the ambiguity present in blockchain data, which is muddled by mixing, change, and exchange churn activity. See www.coinmetrics.io/difficulty-estimating-chain-transaction-volume/ for greater insight on these issues, as well as an explanation behind the Blockchain.info approach we have adopted herein.
[10] Source: World Bank
[11] Source: BCG
[12] Source: Bank for International Settlements

Corporate payments represent another large opportunity for XRP, though it is unlikely that XRP will achieve the same dominant share of this market as in retail remittances. Large corporates tend to adopt new technologies more slowly and reluctantly than consumers, and certain corporates will likely opt to stay on the SWIFT system despite its technological limitations. Ultimately, in our "XRP Success Case", XRP will be adopted by a large *minority* segment of the market that is most willing to adopt new technologies and for whom cross-border payment efficiency gains would represent a strategically critical business improvement.

The enormous foreign exchange trading market is the most difficult category to predict. Even in the "XRP Success Case" many corridors may continue to be served by fiat currency exchange. Rather, XRP usage for foreign exchange trading between banks will likely be limited to less liquid currency corridors.

Geographically, XRP's adoption pattern will most likely reflect a dominant standard in certain emerging market regions rather than a single, uniform pattern of adoption across the globe. Asia and the Middle East have demonstrated early and broad engagement with exploring emerging technology to enable more efficient cross-border payments, as they are less well served by the incumbent international payments system. Outside of the fastest adopting regions, a large set of global banks have signed on to adopt Ripple's xCurrent software, and several central banks have done trials with it. xCurrent does not rely on XRP, but banks that adopt more modern solutions may be well positioned to further improve their efficiency in sourcing liquidity for cross-border payments, particularly in smaller corridors, and thus may be more likely to adopt XRP. Each of these corridors may be individually small, but in aggregate may account for a non-trivial share of their transactions.

Basic projections for growth rates and XRP's adoption share of these three categories of uses under the "XRP Success Case" are shown in Table 2.[14]

Table 2 - XRP Transaction Volume Estimates

High Estimate

	Current Market Size (2018)	Annualized Growth Rate	Projected Market Size (2030)	Assumed XRP Adoption	Daily XRP Transaction Volume
Foreign Exchange Trading	$5.0tn	3%	$7.1tn	3%	$428bn
Corporate Payments	$85bn	5%	$153bn	40%	$122bn
Retail Remittances	$1.5bn	8%	$3.8bn	75%	$6bn
				Total:	**$556bn**

Low Estimate

	Current Market Size (2018)	Annualized Growth Rate	Projected Market Size (2030)	Assumed XRP Adoption	Daily XRP Transaction Volume
Foreign Exchange Trading	$5.0tn	3%	$7.1tn	1%	$143bn
Corporate Payments	$85bn	5%	$153bn	15%	$46bn
Retail Remittances	$1.5bn	8%	$3.8bn	35%	$3bn
				Total:	**$191bn**

[14] The calculation of daily XRP transaction volumes in Table 2 includes a multiplication by a factor of 2x because FX transactions that use a cryptoasset involves two transactions: one to purchase with the originating currency and one to sell for the destination currency.

Using these assumptions, we derive an estimate for daily XRP transaction volume at 2030 of ~$190-560bn under the "XRP Success Case."

2) t – Weighted average time between transactions per unit of currency, in days

Of the 8 parameters, this is likely the most difficult to estimate at present given the immaturity of the market and the limited data available.

BTC: We will use a simple estimate of *t* for bitcoin by adapting the methodology utilized by Blockchain.info, in which estimated investment-related activity, exchange churn, mixing, and change outputs are removed from the data in order to isolate underlying transaction volume. Replicating this approach with data from Q1 2018 yields an estimated annual velocity for Bitcoin's transaction-related volume of 9, implying a value for *t* of ~40 days. This estimate represents a middle-ground between certain prior works that have suggested annualized bitcoin velocities as low as 4-5 (using USD M1 velocity as a proxy) and other works that have suggested values in the 12-15 range (typically using unadjusted volume data).

XRP: Estimating *t* for XRP is similarly difficult. The ultimate structure that the XRP market will take is yet unknown, including the ways in which banks and liquidity providers will hold, account for, and exchange XRP.

As such, this parameter has the potential to take on a wide range of values. For instance, many corporations currently hold excess cash that is orders of magnitude larger in quantity than what would be required to efficiently manage liquidity needs (suggesting a value for *t* of perhaps many months), at the same time as the instantaneous settlement capabilities of XRP might enable extraordinarily short holding periods between transactions (suggesting a much lower estimate – perhaps minutes). We will therefore use a range of values for this parameter of 0.5-10 days.

The value for *t* of 0.5 corresponds to a model of the banking world where liquidity is re-provisioned daily to adapt to expected daily needs, which would imply a total of two transactions per coin per day (one in and one out), resulting in an average time between transactions of 0.5 days.

A value for *t* of 10 could manifest if corporations become significant holders of XRP, taking advantage of its functionality as a form of ultra-liquid working capital. Such adoption would result in XRP regularly being held for multiple days or weeks between its usage in transactions.

3) I – Storage Demand Value

The total value of all investable assets is approximately ~$450tn,[15] and total global household wealth is approximately ~$300tn.[16] In a state of the world where cryptoassets emerge as an important foundation of the global economy and develop robust underlying transaction

[15] Source: Zero Hedge. Includes real estate, debt markets, equity markets, cash, and gold.
[16] Source: Credit Suisse

markets, these assets are likely to draw significant investment "market share" from traditional hard assets, such as gold, as well as from other investment alternatives. If cryptoassets capture a share of total global investable assets comparable to gold's current share (~2%), this will imply an estimated combined value of ~$11tn on a 12-year time horizon.

We can build to this asset share figure in a more granular way by projecting a plausible long-term distribution of wealth concentration in cryptoassets across the global population in the table below, which is modeled to follow the profile of a power law distribution:[17,18]

Table 3 - Projected Storage Demand Distribution

Percentile Range	Number of People (millions)	Average Digital Asset Exposure
0.1%	9	100%
0.1-1%	77	35%
1-5%	340	18%
5-10%	425	10%
10-20%	850	5%
Rest of population	6,800	0%
Total:	**8,500**	**2.1%**

This exposure distribution is in stark contrast to today, where the number of individuals with digital wallets is estimated at 20-30 million,[19] representing just 0.3-0.4% of the global population. To date, the lack of widespread acceptance of blockchain technology, combined with technological barriers to ownership, have constrained penetration. These limitations are likely to continue to erode in the decades to come, consistent with the current trend in which digital wallet penetration has doubled in each of the last 3 years.

In the environment where cryptoassets emerge as a core asset class, we believe 2-4 cryptoassets are likely to emerge as the dominant standards, and as such will most likely compose upwards of 90% of the total storage value of the asset class.

BTC: We defined the "BTC Success Case" as a state of the world in which BTC maintains its status as the predominant cryptoasset. However, within the 30% probability assigned to the "BTC Success Case," a significant portion of those outcomes would be associated with cryptoassets *not* achieving widespread adoption in the global economy. The reason is that a key precursor to this asset class gaining widespread adoption is having numerous cryptoassets succeed in becoming economically transformational and widely adopted. In such a state of the world, the probability that bitcoin loses its preeminence is higher on a relative basis. Therefore,

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[17] We make the simplifying assumption that cryptoasset exposure on a percentage basis will be relatively uncorrelated with prior wealth, consistent with today's market where bitcoin evangelists can be found across the socioeconomic spectrum.

[18] While the majority of global wealth is invested through institutions, these institutions almost universally have individuals as ultimate beneficiaries, to whom this exposure can be "allocated".

[19] Source: Statista and Blockchain.info. Since the mapping of wallets to users is not 1:1, this figure is difficult to pinpoint.

somewhat paradoxically for bitcoin, the conditions that would cause global storage demand to be enormous are the same conditions that make it most plausible that bitcoin will lose its dominant status within the cryptoasset hierarchy.

Within the “BTC Success Case”, we will assign only a 50% probability that cryptoassets concurrently achieve meaningful storage demand adoption. Conditional on this joint probability, we will assume BTC achieves 20-30% share of the asset class by value, down from ~35% at the time of publishing. Based on our $11tn estimate above, this multiplies out to an average of ~$1.1-1.6tn of storage demand value in the “BTC Success Case.”

XRP: In the “XRP Success Case”, in which XRP succeeds in generating signification adoption for cross-border transactions, it will achieve the model’s key criterion of establishing a robust underlying transaction economy to provide a fundamental underpinning for storage demand. Over time, as XRP develops a persistent presence within the global financial system, it will also achieve the key criterion of creating widespread expectation that it will be broadly recognized over an indefinite horizon as an instrument of value. Collectively, these two factors will enable XRP to “unlock” a large share of cryptoasset storage demand value.

Unlike in the “BTC Success Case”, the conditional probability of cryptoassets gaining widespread adoption within the “XRP Success Case” is likely close to 1. The reason is that all plausible scenarios in which XRP achieves widespread adoption likely require broad-based acceptance of cryptoassets in the global economy. In the “XRP Success Case,” XRP could secure an estimated 15-30% market share of the total storage demand value for cryptoassets, equivalent to ~$1.6-3.2tn. Note that while this estimate for storage demand value for XRP is higher than that for BTC, it is contingent on realizing the “XRP Success Case”, which has a lower probability than the 30% assigned to the “BTC Success Case.”

4) N – Number of coins currently in circulation

BTC: 14.2m[20]

XRP: 39.2bn

5) γ – Number of coins to be issued in the future or currently locked up by large institutions

BTC: 4.0m

XRP: 60.8bn. This reserve is held by Ripple, of which 55.0bn are in escrow and are cryptographically sealed to be released into the market on a predefined timetable.

6) ρ– Fractional reserve ratio of cryptoasset network

[20] While the current figure is 17.0m, work done by Chainanalysis, a blockchain analytics firm, estimates that at least 2.8m BTC are permanently lost or unrecoverable.

At present, neither BTC nor XRP is held on a fractional reserve basis, in contrast to fiat currency banking systems. This is unlikely to change given the strong incentives from a governance perspective to prevent fractional reserving from being systematically enabled because of its severely detrimental effect on cryptoasset value. Therefore, we use a value for ρ of 1.0.

7) i – Discount rate

In Section 2.7, we explained why the volatility of this asset class does not merit reflection in the discount rate used. The uncertainty of outcomes is captured elsewhere (through the probability estimates used), and the volatility is nearly entirely unsystematic risk within the global macroeconomic context, and is likely to dissipate substantially as the asset class matures. Of course, applying a low discount rate to this asset class for those holding *large* concentrations of their wealth in it would be inappropriate, but such individuals are not likely to be the marginal holders in the market. Instead, we assume that the marginal holders will be retail and institutional investors who are recent entrants to this market and take on modest exposure to the asset class as a supplement to a broader diversified portfolio of wealth concentrated in more traditional assets.

BTC: As noted in Section 2.7, bitcoin's historical Beta to the S&P500 has been modestly positive, but this is likely due to the anomalous time period in question. Over the long term, we expect BTC will exhibit a zero or negative Beta to the global economy, mirroring the historical behavior of gold. Investors will likely turn disproportionately to bitcoin as a means of storing value during fearful periods in equity markets. As such, we can conservatively assume a zero Beta for BTC, and assign it a discount rate of modest discount rate of 4.0%, slightly above the current US Treasury 10-yr and 30-yr range of 3.0-3.5%.

XRP: The historical Beta of XRP to the S&P500 has been lower than BTC's. However, over a longer time horizon, XRP is likely to have a modestly positive Beta to the global economy, given its usage in cross-border transactions, which are stronger during times of global economic expansion. This effect is likely to be stronger than the negative Beta characteristics of cryptoassets more broadly. Consequently, XRP should be discounted with a risk premium above that of BTC. This should be closer to traditional equity market risk premiums than other cryptoassets. With the US 10-yr and 30-yr Treasuries yielding in the 2.0-3.5% range, and long-term equity market risk premiums generally considered to be 4.5-5.5%, we use a reasonably conservative 8.5% figure.

8) *T* – Time until steady-state

BTC: The time to steady state for bitcoin depends primarily on the time it will take more economically impactful cryptoassets to mature. Assuming it maintains its preeminent status, BTC will continue to benefit from growth and adoption of the asset class more broadly, serving as the proxy for and gateway to other cryptoassets. The two most likely candidates to drive widespread usage of cryptoassets at an economic level are ETH and XRP, which are #2 and #3 by market cap and have a significant lead over all other cryptoassets in terms of adoption and advancement towards use case maturity. As such, we will use the same 12-year time until steady-state for BTC as we do for XRP, with the explanation for that estimate given below.

XRP: The timespan of adoption of new technologies has steadily compressed over centuries and recent decades. Certain technologies have been successful in transforming an industry and becoming a global standard in less than a decade (ie. smartphones, Facebook, Google, etc.), but these are exceptional cases. A more common timeframe for today's transformational technologies appears to range from 10-20 years between inception and widespread adoption. XRP was created in 2012, but began to see accelerated adoption in 2017. At this stage, an estimate of closer to 12 years from today for XRP to reach a steady-state in the "XRP Success Case" is more appropriately conservative.

3.3 Calculating Fundamental Value per Unit

Now we are able to combine all these parameters by inserting them into the model. Note that the "High" and "Low" estimates are used to acknowledge the significant imprecision in assigning values to the most complex parameters. They do not reflect the overall range of potential values that these parameters might take, but instead serve as a plausible range of values *within* the Success Cases for BTC and XRP.

BTC:

<u>High Estimates:</u>

$$P_H = \frac{\beta(Y\mathrm{t} + \mathrm{I})}{N + \gamma}(1 + i)^{-T}$$

$$P_H = \frac{1.0(\$28.2bn * 40 + \$1.6\mathrm{tn})}{14.2m + 4.0m}(1.04)^{-12}$$

$$P_H = \$93{,}621$$

<u>Low Estimates:</u>

$$P_L = \frac{\beta(Y\mathrm{t} + \mathrm{I})}{N + \gamma}(1 + i)^{-T}$$

$$P_L = \frac{1.0(\$6.8bn * 40 + \$1.1\mathrm{tn})}{14.2m + 4.0m}(1.04)^{-12}$$

$$P_L = \$45{,}438$$

As a final step, we need to convert this into an expected value based on our simple binary model of outcomes. We assigned a 30% probability to the "BTC Success Case," and assumed BTC was effectively worthless in the "BTC Failure Case." Therefore:

$$E(P_H) = 0.30 * \$93{,}621$$

$$E(P_H) = \$28{,}086$$

E(P_L) = 0.30 * $45,438

E(P_L) = $13,631

The resulting fundamental value range of $13,600-28,100 compares to a trading range of ~$6,100-17,900 YTD at the time of publishing.

XRP:

High Estimates:

$$P_H = \frac{\beta(Y\mathrm{t} + \mathrm{I})}{N + \gamma}(1 + i)^{-T}$$

$$P_H = \frac{1.0(\$0.56tn * 10 + \$3.2tn)}{3.92 * 10^{10} + 6.08 * 10^{10}}(1.085)^{-12}$$

$$P_H = \$32.91$$

Low Estimates:

$$P_L = \frac{\beta(Y\mathrm{t} + \mathrm{I})}{N + \gamma}(1 + i)^{-T}$$

$$P_L = \frac{1.0(\$0.19tn * 0.5 + \$1.6tn)}{3.92 * 10^{10} + 6.08 * 10^{10}}(1.085)^{-12}$$

$$P_L = \$6.37$$

This represents the potential value of XRP, in present value terms, if the "XRP Success Case" is realized. As a final step, we need to convert this into an expected value based on our simplified binary model of outcomes. We assigned a 25% probability to the "XRP Success Case," and assumed XRP was effectively worthless in the "XRP Failure Case." Therefore:

$E(P_H) = 0.25 * \$32.91$

$E(P_H) = \$8.23$

E(P_L) = 0.25 * $6.37

E(P_L) = $1.59

The resulting fundamental value range of $1.59-8.23 compares to a trading range of ~$0.49-3.72 YTD at the time of publishing.

4 CONCLUSION

This paper has produced a novel comprehensive fundamental valuation framework for the emerging cryptoasset class. Our model requires estimating a total of 8 parameters in arriving at an assessment of long-term fundamental value, which can be applied across a broad universe of cryptoassets. We have demonstrated the practical application of the model on two leading cryptoassets, BTC and XRP, and arrived at a fundamental value range today for BTC of $13,600-28,100 and for XRP of $1.59-8.23. This result, though calculated using imperfectly precise estimates, suggests that both BTC and XRP may have significant upside from current price levels despite the spectacular price appreciation in both currencies since early 2017.

In discovering the conclusion that both BTC and XRP appear to be undervalued, the imperfectly fundamental nature of the model becomes apparent. Long-term value depends on eventual steady-state demand, but in an efficient market where price today should converge to the present value of that long-term valuation, this requires storage demand to effectively "roll forward" to the present – well in excess of what the current underlying storage demand would be. The result will be that either speculative storage demand will bridge that gap, or the currency will be perennially underpriced relative to its long-term trajectory, enabling an abnormally high expected return over an extended time period.

This creates a dynamic that fundamentally diverges from traditional financial asset valuations: as a result of storage demand being the predominant contributor to long-term value, it is possible for cryptoassets that are many years from reaching steady-state to be perennially underpriced in their early years, as a result of present-day storage demand being "unwilling" to immediately converge to the asset's long-term trajectory. However, the willingness of speculators to bridge this gap by holding extremely high concentrations of their appreciated positions appears to be high, as evidenced by the explosive speculation-based rally observed in 2017. This recent pattern of behavior can likely be explained by the existence of widely disparate expectations prevailing in the investor community, as well as the introduction of new participants entering the market and forming their own expectations. Over time, this highly-concentrated speculative demand should give way to a demand distribution that comprises a more risk-efficient portfolio allocation amongst a broader base of global investors. The task of a fundamental investor in the cryptoasset market will be to assess whether this speculative demand has outrun the projected long-term fundamental demand, or has left room for abnormal returns to be earned before storage demand value reaches its long-term trajectory.

Despite the massive price appreciation in the asset class over the past year, those who believe that blockchain technology and cryptoassets are destined to become a powerful force for innovation in the new global economy may yet find that there remain opportunities to generate outsized returns by correctly predicting the long-term winners within this asset class.

5 RELATED WORK

Our approach in this paper is unique in bringing together in one coherent model many of the themes that have been discussed formally and informally in the academic literature and in industry commentary. The velocity relationships have been widely discussed and empirically analyzed in the academic literature (Athey et al, 2016) and in a variety of articles and blogs (e.g. Burniske (2017), Pfeffer (2018), and Evans (2018)). Similarly, storage value dynamics have been contemplated in multiple articles (e.g. Pfeffer (2018)), though the relationship between economic utility and storage value is analyzed here in a way that is distinct.

In terms of the details of the modeling, the approach to discounting used here is taken from traditional approaches to valuing assets using a portfolio theory perspective. Where industry commentators have commonly utilized very high discount rates (typically 30%+) to account for the riskiness of these assets, these rates have not been founded in per-period failure probabilities and for this and other reasons, the discount rates are much higher than the rates that would derive from first principles. We instead employ much lower discount rates founded in portfolio theory, in concert with incorporating an explicit probability of success or failure for each asset.

Most valuation work to-date utilizes the number of currently outstanding units as supply, consistent with the emphasis from most prior work on velocity relationships. This paper, by contrast, incorporates future unit issuances, consistent with standard finance theory for valuing assets in a dynamic environment.

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