Crypto Valuation Series
The Equation of Exchange: A Flawed Approach

Since approximately 2017, there have been countless articles and blog posts describing methodologies for valuing cryptocurrency using the equation of exchange, also referred to as the quantitative theory of money (QTM). More recently, consensus has formed about the futility of this method, given various assumptions and common mistakes made by the authors of such valuations. In this article, we will share a review of the methodology, as well as walk through an example to demonstrate where the valuation breaks down. We will also highlight some aspects that may offer useful insight into the driving factors of cryptocurrency value.

Quantitative Theory of Money: A Long History

The QTM has a long history, dating back to as early as the 16th century. It was then socialized and refined for two centuries before undergoing widespread adoption in the monetary policy of the 1800s.[1] Economists such as John Locke and Milton Friedman and other prominent thinkers led the efforts in its development and refinement over centuries. But such recognizable names and a long history do not absolve it from debate or controversy. Of those debating the theory, the most prominent is arguably economist John Maynard Keynes. Before getting into the key points of controversy, let's briefly summarize the theory as described by Irving Fisher in his popular book, *The Purchasing Power of Money*, published in 1911.

The QTM is a macroeconomic model that describes the relationship between the total economic output and the value of circulating money in an economy over a period of time. The relationship is debated as an identity in macroeconomic theory and has been used to better understand the impact on price levels of changes in monetary supply as the result of various monetary policies. The equation is commonly referred to as the equation of exchange and is as follows:

$$M^c * V_t^c = P_t^c * Q_t$$

- M^c is the quantity of money in the economy in the units of currency *c.*
- V_t^c is velocity, the number of times a unit of M^c is spent in period *t.*
- Q_t is the quantity of output (in units of output) in the economy in period *t.*
- P_t^c is the weighted average price level in units of currency *c* per unit of output of the economy in period *t.*

The model states that the total value of output in an economy $P_t^c * Q_t$ equates to the total amount of monetary expenditures $M^c * V_t^c$ for a period.[2] Put succinctly by Smith and Crown, "the above formulation is true by definition given that *goods cost what you pay for them."*[3] It is worth noting that this is all in terms of currency *c* and has no relationship to any exchange rate to another currency.

[1] https://www.richmondfed.org/-/media/richmondfedorg/publications/research/economic_review/1974/pdf/er600301.pdf
[2] https://blog.coinfund.io/the-quantity-theory-of-money-for-tokens-dbfbc5472423
[3] https://smithandcrown.com/research/cryptofinancial-valuation-series-part-two-the-quantity-theory-of-money/

The key assumptions of the model can be summarized in the following:

- The price level (P_t^c) is an exogenous factor.
- The velocity of money (V_t^c) and the quantity of goods and services (Q_t) are not influenced by endogenous factors and are constant over the period *t*.
- People never hoard cash and never demand money directly; rather, they demand goods and services. The free market will naturally establish and maintain full employment equilibrium.

Economist John Maynard Keynes challenged these assumptions, even discrediting some. Most importantly, he recognized that velocity was dependent on other factors such as P_t^c, Q_t and M^c, refuting the second assumption. A recent example could be seen in the decline in M1 velocity during the financial crisis of 2008.[4] A decline in gross domestic product (GDP) ($P_t^c * Q_t$) in the wake of the implosion of the financial markets then resulted in people hoarding cash, reducing M1 velocity drastically as a result. A paper by the St. Louis Federal Reserve analyzes this concept in detail for the years after the financial crisis[5].

Equation of Exchange for Cryptocurrency Valuation: Misinterpretations and Flaws

Applications of the QTM to cryptocurrency first reached broad awareness with Vitalik Buterin's 2017 article, "On Medium-of-Exchange Token Valuations," which surmised about the effect of velocity on the value of a crypto asset.[6] As literature relating to this concept began to proliferate, crypto asset valuations derived from the equation of exchange followed. Thorough analyses performed by both individuals and institutions used this as a framework for assigning a fair value or price targets on various crypto assets.[7] Now, if you were to search the web for these valuations, you would find many detailed analyses. Due to common errors, as well as controversial assumptions that may confute the general application of QTM to the crypto space, all should be taken with a level of skepticism.

At surface level, the most common errors include the misinterpretations of the variable definitions, as well as misunderstanding the proper units. An example is the incorrect definition of velocity as the average time a crypto asset is held before being transacted, rather than the total number of transactions occurring in period *t*. Another is the failure to properly manipulate the equation to be in U.S. dollar (USD) terms rather than the crypto asset of interest. In other cases, some falsely assume the price (P_t^c) is referring to the price of the cryptocurrency, rather than the price level of units of output (Q_t), confusing matters more. Economist Warren Weber addresses these common pitfalls in more detail in his blog and explicitly highlights the proper approach to using QTM to price the crypto asset in USD terms[8]. The result is the equation below (with full notation) for deriving the crypto asset value in USD terms ($\frac{P_t^\$}{P_t^c}$) using the equation of exchange:

$$\frac{P_t^\$}{P_t^c} = \frac{P_t^\$ * Q_t}{M^c * V_t^c}$$

[4] https://smithandcrown.com/research/cryptofinancial-valuation-series-part-two-the-quantity-theory-of-money/
[5] https://www.stlouisfed.org/on-the-economy/2014/september/what-does-money-velocity-tell-us-about-low-inflation-in-the-us
[6] https://vitalik.ca/general/2017/10/17/moe.html
[7] https://cryptoresearch.report/wp-content/uploads/2020/06/Crypto-Research-Report-June-2020-ENG.pdf
[8] https://blog.coinfund.io/the-quantity-theory-of-money-for-tokens-dbfbc5472423

But Warren goes on to say, "this raises the question of what role crypto assets are playing in the project economy if the entire output is being sold for USD," and suggests the use of other models such as exchange rate models may be more fitting[9].

More importantly, this equation also highlights V_t^c as one of the key inputs, bringing up a much more foundational issue. Per the Keynesian perspective, velocity is dependent upon GDP and monetary supply. Put very nicely by Smith and Crown, "If velocity is, in fact, affected by changes in other QTM variables, the probability of model misspecification rises dramatically." They continue, "using [a derived] velocity for analysis in other periods implicitly assumes that user behavior will not change as a result of what could be dramatic changes in the asset pricing environment."[10] In short, velocity depends on GDP and therefore breaks the second assumption highlighted in the section above. Therefore, we agree with the claims made by Smith & Crown discrediting the validity of using the equation of exchange to assign a valuation to a crypto asset.

INET: The Original Valuation

Some seemingly very credible attempts at crypto valuation have been authored using QTM by various individuals and institutions, some by prominent players in the crypto space. One early example of this is the valuation of fictional crypto asset INET back in 2017.[11] The popularity of this methodology led to widespread adoption in the late 2010s, with many re-employing it for their own valuation forecasts. Though based on the same flawed assumptions as described above, the analysis is very thorough and shines a light on some of the inner workings of what may drive the value of a crypto economy, as well as the level of subjectivity involved. Also, by changing the assumptions of the model, the variability of the outcome demonstrates its infeasibility as a credible fair price forecast.

This overall approach to crypto asset valuation consists of three parts: forecasting the supply of the crypto asset (M^c), determining the GDP supported by the INET crypto asset economy ($P_t^c * Q_t$) and deriving a velocity V_t^c to use to calculate the final future value of the crypto asset. A final step of discounting the future value back to present value terms may also be applied.

For the purposes of determining the amount of circulating currency, the methodology includes the calculation of a supply schedule of the crypto asset based on the protocol of the cryptocurrency of interest. This provides the number of crypto assets in float to be used as M^c at various periods after the initial crypto asset offering. To determine this supply schedule, assumptions are made—around the percentages of crypto assets initially released, issued to founders, the lockup period, the percent of crypto assets bonded by nodes (like a security deposit when joining the network), "hodled"—and the rates for which these may change. By applying these assumptions and forecasting them out into the future, a time series of circulating supply is the result. This serves as the M^c for different time periods in the equation above, or the supply schedule of the crypto asset.

In the second part of the analysis, the crypto economy GDP denoted in USD ($P_t^{\$} * Q_t$) is calculated based on the goods and services transacted in said crypto economy. To do so, the total addressable market of the crypto asset across multiple use-cases is estimated. A few examples of these are online transactions, consumer loans and remittance,[12] in addition to the many DeFi applications that have evolved more recently. Assumptions around market penetration and adoption rate must also be applied to calculate an aggregate future GDP value.

The last part of the analysis is to determine the velocity of the cryptocurrency V_t^c, which ruses the debate for the model's validity for valuation as prior stated. Many analyses assume a value for velocity based on current fiat

[9] https://blog.coinfund.io/the-quantity-theory-of-money-for-tokens-dbfbc5472423
[10] https://smithandcrown.com/research/cryptofinancial-valuation-series-part-two-the-quantity-theory-of-money/
[11] https://medium.com/@cburniske/cryptoasset-valuations-ac83479ffca7
[12] https://cryptoresearch.report/wp-content/uploads/2020/06/Crypto-Research-Report-June-2020-ENG.pdf

currencies or in line with historical values for the crypto asset of interest, which completely disregards the correlation between the velocity and the GDP.

Though built on a shaky foundation, this valuation methodology was so convincing and widely adopted that many others followed, placing a wide range of value estimates for bitcoin assets and other crypto assets, using a vast array of assumptions. A similarly thorough approach for multiple crypto assets was performed by Crypto Research Report in 2020.[13]

	Change in GDP from Base Case													
Velocity	-25%	-20%	-15%	-10%	-5%	-3%	-1%	0%	1%	3%	5%	10%	15%	20%	25%
5	$ 22.36	$ 23.85	$ 25.34	$ 26.83	$ 28.32	$ 28.92	$ 29.51	$ 29.81	$ 30.11	$ 30.71	$ 31.30	$ 32.79	$ 34.28	$ 35.78	$ 37.27
7	$ 15.97	$ 17.04	$ 18.10	$ 19.17	$ 20.23	$ 20.66	$ 21.08	$ 21.29	$ 21.51	$ 21.93	$ 22.36	$ 23.42	$ 24.49	$ 25.55	$ 26.62
10	$ 11.18	$ 11.93	$ 12.67	$ 13.42	$ 14.16	$ 14.46	$ 14.76	$ 14.91	$ 15.06	$ 15.35	$ 15.65	$ 16.40	$ 17.14	$ 17.89	$ 18.63
13	$ 8.60	$ 9.17	$ 9.75	$ 10.32	$ 10.89	$ 11.12	$ 11.35	$ 11.47	$ 11.58	$ 11.81	$ 12.04	$ 12.61	$ 13.19	$ 13.76	$ 14.33
15	$ 7.45	$ 7.95	$ 8.45	$ 8.94	$ 9.44	$ 9.64	$ 9.84	$ 9.94	$ 10.04	$ 10.24	$ 10.43	$ 10.93	$ 11.43	$ 11.93	$ 12.42
17	$ 6.58	$ 7.01	$ 7.45	$ 7.89	$ 8.33	$ 8.51	$ 8.68	$ 8.77	$ 8.86	$ 9.03	$ 9.21	$ 9.65	$ 10.08	$ 10.52	$ 10.96
20	$ 5.59	$ 5.96	$ 6.34	$ 6.71	$ 7.08	$ 7.23	$ 7.38	**$ 7.45**	$ 7.53	$ 7.68	$ 7.83	$ 8.20	$ 8.57	$ 8.94	$ 9.32
23	$ 4.86	$ 5.18	$ 5.51	$ 5.83	$ 6.16	$ 6.29	$ 6.42	$ 6.48	$ 6.55	$ 6.68	$ 6.81	$ 7.13	$ 7.45	$ 7.78	$ 8.10
25	$ 4.47	$ 4.77	$ 5.07	$ 5.37	$ 5.66	$ 5.78	$ 5.90	$ 5.96	$ 6.02	$ 6.14	$ 6.26	$ 6.56	$ 6.86	$ 7.16	$ 7.45

*Figure 1: Valuation sensitivity analysis using the INET model from https://medium.com/@cburniske/cryptoasset-valuations-ac83479ffca7. Holding all other variables constant, the forecasted 10-year **future** values of the INET crypto asset are shown above. The base case **future** value from the author is highlighted in the center using a velocity of 20 and a GDP of approximately $4B USD.*

To demonstrate the variability of forecasted values, we used the INET model,[14] inputting an array of values for two of the 20 possible assumptions, GDP and velocity. The GDP ends up being a result of many other assumptions that can significantly change the GDP values beyond what is shown above. Thus, it is fair to say this is a small subset of the possible valuations that could be generated from the model. Given the prior statements made regarding the velocity, a wide array of values could be inputted into the model. The result is a swath of future valuations for the INET crypto asset ranging from $4.47 to $37.27.

Conclusion

With such a wide array of valuations and shaky foundations based on forecasting interdependent endogenous variables $P_t^{\$}, Q_t$ and V_t^c, the credibility of the application of QTM for cryptocurrency valuation is called into question. This brings us to our conclusion that the models above are useful for understanding the levers that may affect the overall value of a crypto asset or its economy, but the foundational usage of the equation of exchange for the purpose of assigning a valuation is extremely controversial. The resulting valuations are sporadic, and often contain a vast number of debateable, or even broken, assumptions. The QTM suffices as the observable macroeconomic identity outside of the Keynesian view in currency-based economies, including crypto, but going further to extrapolate a fair valuation or price target via a forecasted exchange rate would exaggerate its applicability to garner inconsistent results on questionable assumptions. As controversial as the QTM has been for centuries, adding an additional layer of complexity to exaggerate the model to formulate cryptocurrency valuations seems like an irresponsible shortcut to offer numerical support to our own speculations. More useful, may be the analysis of the market penetrations of cryptocurrencies across use-cases, for formulating various qualitative hypotheses for which crypto assets may provide the most economic value in society.

[13] https://cryptoresearch.report/wp-content/uploads/2020/06/Crypto-Research-Report-June-2020-ENG.pdf
[14] https://medium.com/@cburniske/cryptoasset-valuations-ac83479ffca7

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Quantitative theory of money (QTM): In monetary economics, the QTM is one of the directions of Western economic thought that emerged in the 16th–17th centuries. The QTM states that the general price level of goods and services is directly proportional to the amount of money in circulation, or money supply.

Cryptocurrency: A digital or virtual currency that is secured by cryptography, which makes it nearly impossible to counterfeit or double-spend.

Macroeconomic: A branch of economics dealing with performance, structure, behavior and decision-making of an economy as a whole.

M1: Refers to the M1 money supply that includes physical money, such as coins and currency, as well as demand deposits, checking accounts and negotiable order of withdrawal accounts.

Velocity: Measure of the frequency that money changes hands within a broader economy. Higher levels indicate the potential for greater levels of economic activity.

Gross domestic product (GDP): The debt-to-GDP ratio is the ratio between a country's government debt and its gross domestic product (GDP).

Decentralized finance (DeFi): A blockchain-based form of finance that does not rely on central financial intermediaries such as brokerages, exchanges or banks to offer traditional financial instruments, and instead utilizes smart contracts on blockchains, the most common being Ethereum.

Fiat currencies: Any money that is accepted by a government for paying taxes or debt, but is not pegged to or backed directly by gold and other valuables.