THE JBBA

PEER-REVIEWED RESEARCH

OPEN ACCESS
ISSN Online: 2516-3957
ISSN Print: 2516-3949
https://doi.org/10.31585/jbba-1-2-(2)2018

Competing Interests:
None declared.

Ethical approval:
Not applicable.

Author's contribution:
JP[1] designed and coordinated this research and prepared the manuscript in entirety.

Funding:
None declared.

Acknowledgments:
None declared.

Valuation of Utility Tokens based on the Quantity Theory of Money

Jay Pazos[1]
The University of Chicago Booth School of Business, USA
Correspondence: jpazos@uchicago.edu
Received: 24 July 2018 **Accepted**: 31 August 2018 **Published**: 1 September 2018

Abstract
A framework to value utility tokens would allow for more transparent Initial Coin Offerings (ICO) and help in the development of digital assets. In this paper, we derive a formula to value utility tokens and the network that supports it. We found that valuation is directly proportional to the price of the resource being provided and the size of the Serviceable Obtainable Market (SOM) for that resource. Also, it is inversely proportional to the velocity of the token. In section 4 we derive a formula for a *crypto conversion factor* that relates the price of the token to the price of the resource provided, the factor is not linear and has seven variables. For cases where the growth of SOM and the growth in price of the resource are not high, longer times to develop the network will decrease valuation; this is because discount rates for start-up and growth companies are high. On the other hand, if the build-up of the network goes on-time as planned, posterior valuations of the network will yield higher values. As expected, valuation doesn't depend on the number of tokens issued as that variable doesn't appear in the formula. We believe that by making these formulas available to the Blockchain/DLT community, we can help network developers to understand how key variables impact the valuation of the network they are trying to build.
Keywords: *ICO, Token, Money, Quantity Theory, DLT, Blockchain*

1. Introduction

A utility token is an asset based on cryptography that is generating or expected to generate cash flows in the future. Utility tokens generate cash by using them as a method of payment and incentives for goods or services that have utility in the community built around them. Tokens can be used to pay services like interest, fees for transactions or goods like meals or flying miles; we will call it in this paper the "resource provided." A company can decide to issue tokens for many reasons like increasing repeat business, servicing customers or merely raising cash. In this paper, we consider the valuation of the network a company creates when it develops its own monetary system based on utility tokens, say X, instead of fiat money.

To attain valuation, we need to find the size of the network when it is fully developed. To derive the valuation formula for utility tokens, we build upon the *TAM, SAM* and *SOM* concepts that are popular in the Blockchain community.

We start thinking about the size of the network by first considering the broadest market measure: The Total Addressable Market (*TAM*). From there, we continue narrowing down the possibilities to the Serviceable Available Market (*SAM*) and finally to the Serviceable Obtainable Market (*SOM*)– which is the market that the company can realistically address.

In the project network, the quantity of the resource provided Q for a one-year period can be expressed in terms of *SOM*:

- Let *SOM* be the Serviceable Obtainable Market in units of the resource provided for a 1-year period
- Let *PSOM* be the % Market Penetration of the company in *SOM*
- Let Q be the quantity of the resource provided in a one-year period

Then,

$$Q = \text{SOM} \times \text{PSOM} \quad (1)$$

Often, valuations are done before the buildup of the

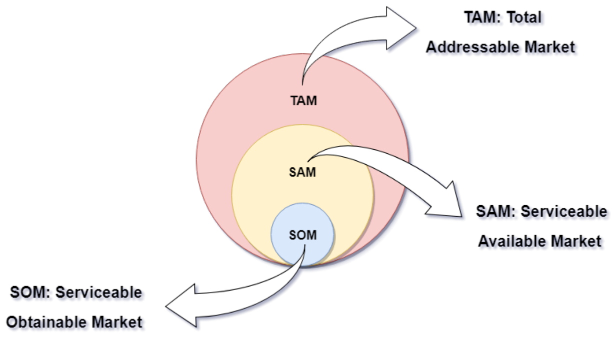

Figure 1: TAM, SAM, and SOM concepts

network has started, for this, we need to understand the evolution of the network throughout time.

2. Network Growth, from Zero to Maturity

Most typically, the market penetration of the network will evolve following a generalized logistic function curve as emphasize by Richards [1] and known as Richards' curve, similar to the one in Figure 2. For a specific business case, the network grows slowly at the beginning, picks up growth in the middle and slows down again at the end. For illustration, we have recreated one instance of Richard's curve with an upper bound of 2% of SAM.

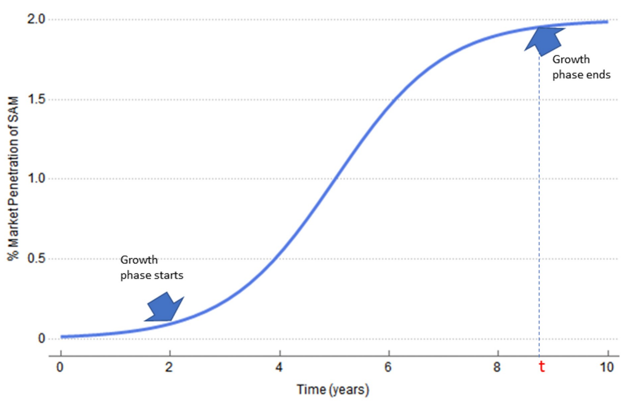

Figure 2: Evolution of Network towards Maturity

In our valuation model, we will consider the size of the network at time t, the time when the rate of growth of the network has slowed down to the rate of growth of TAM, the broadest market measure for the goods and services the company offers- at that point in time we say that the network has reached maturity. This is a reasonable assumption because in every Initial Coin Offering (ICO) there is an explicit or implicit promise that a utility token network will be fully built at some time in the future and, thus, it is this size of the network that we should consider for valuation. This assumption defines the value of the time variable, the time horizon for which we will do the valuation of the token using net present value methodology. Also, at maturity, when time= t, the % market penetration of SOM will be approaching 100%, hence, $PSOM_t = 1$ and, thus,

$$Q_t = SOM_t \tag{2}$$

The size of SOM is dependant on the type of network that the developer wants to build and the resources she has available. One network developer, for instance, for a chain of fast food restaurants, may have as her SOM target a network of restaurants in a single city as this is the size of network that the developer can initially afford. Later, if the business goes well, she may decide to expand her network to more cities, that expansion would be subject to a new valuation as the size of the target network has changed. The key issue is that the size of the network at the time of valuation has to be obtainable for the level of resources available to the developer- this is why we define it as SOM.

Next, we look for a framework to put together these concepts

3. The Quantity Theory of Money and Utility Tokens

The identities equating a flow of money payments to a flow of exchange of goods or services are quite old, Simon Newcomb [2] was the first on record to formulate the transactions version of the quantity equation that later was popularized by Irving Fisher [3].

$$M \times V = P \times Q \tag{3}$$

We use in our model one year as the period unit of time. The LHS of equation (3) corresponds to the flow of monetary transfers for a one-year period. Velocity V, a flow variable, represents the number of turnovers of the stock of utility tokens during a year. For a single transaction, the resolution of M and V is trivial, the utility token transferred is turned over once, or $V = 1$. For a 1-year interval, we can, in principle, classify the stock of utility tokens according to each unit entered into 0,1,2,3... transactions, that is, according to the units of utility tokens "turned over" 0,1,2,3...times. The weighted average of these numbers of turnover, weighted by the number of utility tokens that turned over that number of times, is the equivalent of V, as stated by Milton Friedman [4]. M corresponds to the stock of the X utility tokens available for transactions; it is treated as a stock variable, not as a flow or a mixture of flow and stock.

The right-hand side of equation (3) corresponds to the flow of transfers of real goods and services in the token economy for a one-year period. P is the price per unit of the resource provided (tokens per unit of quantity). As different transactions may occur at different prices, P is a suitably chosen average of the prices. Q, is a flow variable, it is the quantity of the resource provided during a one-year period.

Equation (3) is telling us that to support a project economy of transactions size $P \times Q$ we need to have in place a monetary system of size $M \times V$.

We adopt the following convention for flow variables: the value of flow variables V_t and Q_t, at time t, are calculated using data from the previous one-year period, that is, from *time* = $t-1$ to *time* = t. This is a reasonable assumption as it is customary to look at recent past data to evaluate such variables. The present time is denoted as *time* = 0, and the network reaches maturity at *time* = t.

For this paper, we are considering a project economy that uses utility token X. Hence, the units on both sides of equation (3), are units of utility token per unit time (X/*year*).

4. Calculations

Since we are valuing the network at maturity, we will consider the flows for the quantity equation at time t, as expressed in equation (4) below:

$$M_t \times V_t = P_t \times Q_t \tag{4}$$

The variables are defined as follows:

- t is the time when the network reaches maturity
- M_t is the stock of utility tokens available, in units, valued at time t
- V_t is the velocity of utility token X, expressed in turnovers/year, valued at time t
- P_t is the average price of the resource provided, expressed in terms of X/*unit*, valued at time t
- Q_t is the quantity of the resource provided, expressed in units/year, valued at time t.

Next, we convert the flows in equation (4) from X/*year* to \$/*year* by introducing the exchange rate variable Z_t which represents the value \$/X at time= t. By multiplying both sides by Z_t we get both sides of the identity expressed in \$/*year*.

$$M_t \times V_t \times Z_t = P_t \times Q_t \times Z_t \tag{5}$$

Note that $P_t.Z_t$ is equivalent to the price expressed in dollars of the resource provided, we call it $P_{\$t}$ and substitute for it in equation (5)

Rearranging we have,

$$Z_t = \frac{P_{\$t} \times Q_t}{M_t \times V_t} \tag{6}$$

This equation serves us well because Z_t is also the value of one token in dollar terms, which is what we are trying to evaluate. Another benefit of equation (6) is that $P_{\$t}$, the price of the resource in dollar terms, is easier to obtain.

From equation (2) we know that, $Q_t = SOM_t$ Substituting (2) into

(6) we get:

$$Z_t = \frac{P_{\$t} \times SOM_t}{M_t \times V_t} \tag{7}$$

Now, let N_t be valuation, the value of the network at time t in dollars:

$$N_t = Z_t \times M_t \tag{8}$$

Substituting (7) into (8) we get the following expression:

$$N_t = \frac{P_{\$t} \times SOM_t}{\cancel{M_t} \times V_t} \times \cancel{M_t} \tag{9}$$

Which simplifying leave us:

$$N_t = \frac{P_{\$t} \times SOM_t}{V_t} \tag{10}$$

Note that valuation at time t is independent of the number of tokens issued, this makes intuitive sense because a company could issue 50 or 100 million coins, and valuation should be the same.

Next, we find the values of Z and N at time=0 (Z_0 and N_0) by calculating the net present value of equations (7) and (10). We do this by dividing by $(1 + r)^t$. Where, r, is the discount rate for the project economy.

$$Z_0 = \frac{P_{\$t} \times SOM_t}{M_t \times V_t \times (1+r)^t} \tag{11}$$

$$N_0 = \frac{P_{\$t} \times SOM_t}{V_t \times (1+r)^t} \tag{12}$$

To facilitate valuations, we express $P_{\$t}$, and SOM_t in terms of their values at time=0:

$$P_{\$t} = P_{\$0} \times \left(1 + g_{price}\right)^t \tag{13}$$

$$SOM_t = SOM_0 \times \left(1 + g_{SOM}\right)^t \tag{14}$$

Where,

- $P_{\$0}$ is the average price of the resource provided, in dollars, valued at time=0
- g_{price} is the expected rate of growth for the price of the resource provided, valued for the period from time=0 to t
- g_{SOM} is the expected rate of growth of SOM, valued for the period from time=0 to t

Substituting (13) and (14) into (11), we get the following expression:

$$Z_0 = P_{\$0} \times \frac{\left(1+g_{price}\right)^t \times SOM_0 \times \left(1+g_{SOM}\right)^t}{M_t \times V_t \times \left(1+r\right)^t} \qquad (15)$$

Simplifying we get:

$$Z_0 = P_{\$0} \times \frac{SOM_0}{M_t \times V_t} \times \left(\frac{(1+g_{price}) \times (1+g_{SOM})}{(1+r)}\right)^t \qquad (16)$$

This is the value in dollars of the token at time=0, expressed in terms of 8 variables

Equation (16) can be expressed in a different form:

$$Z_0 = P_{\$0} \times K \qquad (17)$$

Where,

$$K = \frac{SOM_0}{M_t \times V_t} \times \left(\frac{(1+g_{price}) \times (1+g_{SOM})}{(1+r)}\right)^t \qquad (18)$$

We will call K the *crypto conversion factor*. It relates the value of the token to the price of the resource provided.

We can now find the valuation at time=0 (N_0) :

To do so, we substitute equations (13) and (14) into (12) and obtain the following expression for the valuation:

$$N_0 = \frac{P_{\$0} \times SOM_0}{V_t} \times \left(\frac{(1+g_{price}) \times (1+g_{SOM})}{(1+r)}\right)^t \qquad (19)$$

Also, by inspecting equations (16) and (19), obviously:

$$Z_0 = \frac{N_0}{M_t} \qquad (20)$$

5. Filling the Gaps: A word on Velocity and Discount Rates

Variables $P_{\$0}$ and SOM_0 can be estimated directly or indirectly from the state of the market at time=0 via market research. Variables g_{price} and g_{SOM} are expected values that could be determined using historical data and statistical analysis. M_t is the expected value of the stock of utility token X at time= t and should be easy to estimate as developers usually have a good idea of how many tokens they are going to issue and when.

Since most of the tokens are based on public digital ledger technologies, it is possible to evaluate the velocity of *already existing tokens* as it is computationally feasible to classify the stock of tokens according to each unit entered into 0,1,2,3... transactions, that is, according to the units of tokens "turned over" 0,1,2,3...times. The weighted average of these numbers of turnover, weighted by the number of units of tokens that turned over that number of times, is the equivalent of V. In our formula, V_t, the expected value of velocity at time= t is not readily available because, most likely, the tokens have not been issued yet, however, estimating methods based on company policies can be devised.

For a one-year period, from time=t-1 to time=t, let us classify each token in the stock of money (M_t) according to the number of transactions entered for the given period. Let x_0 be the number of tokens in M_t that have been turned 0 times, let x_1 be the number of tokens turned 1 time, and so on, until x_n, which is the number of tokens in M_t that has turned the maximum number of times n.

Hence,

$$M_t = x_0 + x_1 + x_2 + \cdots + x_n \qquad (21)$$

Dividing both sides by M_t we get:

$$1 = \frac{x_0}{M_t} + \frac{x_1}{M_t} + \cdots + \frac{x_n}{M_t} \qquad (22)$$

Where, $\frac{x_0}{M_t}$ is the fraction of the total number of tokens with velocity equal zero.

Hence, V_t, the weighted average of the number of turnovers at time = t, is expressed as follows:

$$V_t = \frac{x_0}{M_t} \times 0 + \frac{x_1}{M_t} \times 1 + \cdots + \frac{x_n}{M_t} \times n \qquad (23)$$

We believe that velocity is not an exogenous variable whose value can be found somewhere but a variable to be *managed* during and after the ICO. Velocity is a variable that in a great measure depends on company policies that affect the company's monetary system. The reasons for wanting a reasonably stable velocity are twofold (1) The need to have a stable monetary system and velocity, together with the money supply, are the two key variables; (2) Valuation is inversely proportional to velocity, a low, stable velocity is good for valuation. It is not the objective of this paper to discover the optimum monetary policy for an ICO; we just want to point out the importance of managing the company's policies that affect velocity. Hence, equation (23) above, is relevant as it can help the developer to devise policies that stabilize velocity at a lower value. We will see an example of this in section 6.

Variable t is the expected time it will take for the network to reach maturity; this value can be estimated from historical data for similar networks or from a consideration of the resources available to deploy the network.

Variable r is most interesting because it is the variable that captures the risk of the project network, we expect discount rate r to follow valuation methods and target rates of return in the same vein as those used in the Venture Capital industry: 25-35% for a Bridge/IPO stage, 35-50% for a second stage, 40-60% for a first stage, and 50-70% for the start-up stage as stated by Damodaran [5]. There is a difference, though, discount rates applied in Venture Capital investments include an illiquidity premium since most of the companies invested in by VC firms can only be exited via IPO or M&A activities. Investments in utility tokens don't require such illiquidity premium as they can be sold at any time in the specialized exchanges where they trade.

If we look at equation (19) we observe that, for normal growth rates of g_{price} and g_{SOM} in the expression

$$\frac{\left(1+g_{price}\right)\times\left(1+g_{SOM}\right)}{\left(1+r\right)}$$

the numerator will be smaller than the denominator, making the expression less than 1. This has the effect in equation (19) that as time to maturity in the project increases, valuation decreases. Hence, to maximize valuation, the developer has the economic incentive to complete it as soon as she can.

The most difficult cases to value are those in which developers claim that their product doesn't exist in the market today. In those cases, the interested developers will have to find, via proxies or through the aggregation of other existing products, equivalent solutions that can be used to estimate values.

6. A worked example

Lola and Victoria (L&V) are two computer scientists co-founders of StereoWorld, a company that has developed a 3D Stereo-Photographic software that converts videos taken with a smartphone into 3D still images. They have protected the intellectual property of their invention with six patents and have the idea of creating a new social media site where users can upload 3D Stereographic Photographs and share it with friends. L&V have a working prototype and a basic website where people can enjoy the benefits of their new software. The website is free for users and StereoWorld will use an advertising business model. L&V want to issue their utility token called STO in an ICO. Advertisers will be able to pay advertisements with STO and token holders will have special rights to vote on the implementation of new platform functionality and enjoy better ad placements.

The Total Addressable Market (TAM) is considered to be 2029 million users, the size of Facebook's monthly active users at the end of 2017. The Serviceable Available Market (SAM) is thought to be 239 million users, the size of Facebook's Monthly active users in the US & Canada. The Serviceable Obtainable Market (SOM) is thought to be 3% of SAM, that is, 7.17 million users. The Average Revenue per User (ARPU) is expected to be 30% that of Facebook for 2017 in North America, that is, 0.30×84.41 = 25.32$/*year*. SOM is growing at 3.5%/year, ARPU is growing at 35%/year. StereoWorld is planning to issue 100 million tokens. The network is expected to be completed in 3 years.[1]

We will use a discount rate 5% below the lower value of the typical range for a Venture Capital investment start-up (50-70%) [5]. Since STO will trade in specialized exchanges and doesn't require the illiquidity premium of Venture Capital Investments, we will use 45% for the discount rate. We understand this is a subjective assumption, more on this issue in the recommendations part of section 7

L&V have decided that velocity is going to be managed during and after the ICO. L&V will use incentives to promote savings (larger account balances) in the STO wallet. The policies put in place to stabilize velocity at a lower level are as follows:

- Give voting rights, for platform new developments, to long-term token holders. Voting rights will be proportional to the number of STO tokens that have been in the wallet for one year or more. Tokens that don't move during the one-year period have velocity=0.
- Payment of ads with tokens that have holding periods in the wallet longer than three months will get best ad placements. Tokens used only every three months have velocity=4
- Payment of ads with tokens that have holding periods in the wallet longer than one month, but less than three months, get premium ad placement. Tokens used only once a month have velocity=12
- Payment of ads with tokens that have holding periods in the wallet less than a month but more than 24 hours will get standard ad placement. Tokens used only once a day have velocity=365, which is also the maximum velocity allowed as no ad can be placed earlier than 24 hours from having purchased its corresponding STO tokens.

For this example, we will assume that the advertisers' decisions on the holding periods of STO will cluster around the incentives designed to manage the velocity. We could make a more elaborate distribution model for the results, but, for this example, we will assume a simpler distribution that still captures the essence of the method. For the one-year period, from time= t-1 to time= t, that is: from time=2 to time=3, we assume that 20% of the tokens will be either stored for speculation or for voting rights (velocity=0), 30% will be continually used for purchases three months in advance for best placement ads(velocity=4), 49% will be continually used for purchases one month ahead for premium ad placement(velocity=12), and 1% will be continually used for convenience purchases one day before the ad being placed(velocity=365).

Hence, substituting these values into equation (23) we get the following:

$$V_t = 0.20\times 0 + 0.30\times 4 + 0.49\times 12 + 0.01\times 365 = 10.73$$

Now we have estimations for the eight variables that allow us to Value the ICO and the STO utility token.

- $P_{\$0} = \$25.32$
- $SOM_0 = 7.170.000$ users
- $M_t = 100.000.000$ tokens
- $V_t = 10.73$

[1] TAM, SAM and ARPU numbers are derived from data taken from Facebook's 2017 annual report as published on Feb 01, 2018

- g_{price} = 35%
- g_{SOM} = 3.5%
- r = 45%
- t = 3 years

Hence, from equation (19), the ICO valuation is as follows:

$$N_0 = \frac{25.32 \times 7.170.000}{10.73} \times \left(\frac{(1+0.35)\times(1+0.035)}{(1+0.45)}\right)^3 = \$15.139.150$$

And, from equation (20), the value of the STO utility token is as follows:

$$Z_0 = \frac{N_0}{M_t} = \frac{15.139.150}{100.000.000} = 0.151 \text{ \$/Token}$$

Now, let us consider valuation 2 years after the ICO. Assuming that everything has gone as planned, we want to value again the network and its tokens. The new set of values are as follows:

- $P_{\$2} = 25.32 \times (1 + 0.35)^2 = \$46.15$
- $SOM_2 = 7.170.000 \times (1 + 0.035)^2 = 7.680.683$ users
- M_t = 100.000.000 tokens
- V_t = 10.73
- g_{price} = 35%
- g_{SOM} = 3.5%
- r = 45%
- t = 1 year (as everything has gone as planned and there is only one year left until the network reaches maturity)

From equation (19), the post-ICO valuation, after two years, would be as follows:

$$N_2 = \frac{46.15 \times 7.680.683}{10.73} \times \left(\frac{(1+0.35)\times(1+0.035)}{(1+0.45)}\right)^1 = \$31.833.027$$

And, from equation (20), after two years, the value of the STO utility token would be as follows:

$$Z_2 = \frac{N_2}{M_t} = \frac{31.833.027}{100.000.000} = 0.318 \text{ \$/Token}$$

As we can observe, if the project goes as planned, the value of the network will appreciate considerably, and the holders of tokens as a store of value will be well rewarded. In two years, valuation had a compound annual growth rate (CAGR) equal to:

$\sqrt{\frac{31.833.027}{15.139.150}} - 1 = 45\%$, similarly, utility token STO valuation had a CAGR equal to: $\sqrt{\frac{0.318}{0.151}} - 1 = 45\%$

Investors that expect this scenario will find financially advantageous to hold STO tokens for speculation and as a store of value. It makes a case for the 20% of utility tokens with velocity=0. This is intuitively correct, as time passes, and the build-up of the network goes as planned, uncertainty decreases and, thus, valuation increases.

7. Conclusion and Recommendations

In this paper, we developed a valuation framework for utility tokens. We found that the formula to value a token has eight variables. Valuation is directly proportional to the price of the resource being provided and the size of SOM, and inversely proportional to the velocity of the utility token. We also found a formula for a *crypto conversion factor* that relates the price of the token to the price of the resource provided, the factor is not linear and has seven variables. We suggested that velocity of the token is not a value to be found somewhere but a variable to manage as an integral part of the utility token monetary system, and we offered a simple example of how it could be managed. To calculate the value for the discount rate, we looked at the Venture Capital industry for inspiration as they also invest in start-ups and growth companies, we made the distinction that ICOs don't require the illiquidity premium of the VC industry. For cases where the growth of SOM and the growth in price of the resource are not high, longer times for network completion will decrease valuation; this is because the discount rate for start-up and growth companies is high. On the other hand, if the build-up of the network goes as planned, posterior valuations of the network will yield higher values. We also found that ICO valuation doesn't depend on the number of tokens issued as such a variable doesn't appear in the formula.

For future direction, we would recommend further work on two areas: (1) research on factors that influence the high discount rates of ICOs, such as market, default, and illiquidity risks; (2) research on best practices to manage the monetary system of tokens; velocity, money (token) supply and timing of initial and secondary coin offerings. Also, it would be propitious if organizations responsible for crypto commodities, like the Ethereum Foundation, provided velocity statistics of their supported tokens. These statistics will help to value and monitor existing utility tokens.

References

[1] Richards F. A flexible growth function for empirical use. Journal of experimental Botany. 1959;10(2):290–301.

[2] Newcomb S. Principles of political economy. Harper; 1885.

[3] Fisher I. The purchasing power of money: its' determination and relation to credit interest and crises. New York: Cosimo, Inc.; 2006.

[4] Friedman M. Quantity theory of money. The New Palgrave Dictionary of Economics. 2017;p. 1–31.

[5] Damodaran A. Valuing young, start-up and growth companies: estimation issues and valuation challenges. 2009 May;p. 15.