Bancor Opportunities and Better Options (BOBO)

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Abstract. We detail how the foundational equations with which Bancor determines reserves and prices is fundamentally flawed. We first analyze price data to a test group of tokens on the Bancor Network to confirm the existence of price inaccuracies - specifically, price inaccuracies from distributed lag, and missing terms for price volatility and price shocks. Second, we derive an improved pricing formula for Bancor. We take into account the stochastic nature of supply and prices, which allows us to augment the main Bancor formulas with terms involving supply, volatility, and price shocks. This term increases the price per unit when transacting (buying or selling) on the Bancor Network. Supply drops resulting from increased volatility are further dampened by price increases relative to Bancor's original formulas. When including jumps in the analysis, they enter in a similar manner to volatility. As a result, our pricing formula will more accurately represent the price of a given token with fewer arbitrage opportunities.

Keywords: Bancor · Cryptocurrencies · Finance · Mathematical Finance

1 Introduction

Bancor is an automated market maker famous for having one of the most successful crowdfunding efforts of all time. It uses a protocol to allow anyone to add "Smart Token" functionality to an ERC20 token on the Ethereum blockchain. It allows the token's contract to serve as its own market maker when backed by reserves in the Bancor Network Token (BNT). This protocol claims to create continuous liquidity at an accurate price for all tokens on the network.

In this paper, we analyze the Bancor Network for false claims, faults, and inaccuracies. We first explain their market making formulas using industry standard terms. We then address Bancor's key guarantees about their network, finding that many have real issues including high fees which make the network surprisingly expensive for such guarantees which could be given just as easily from alternative solutions such as SegWit integration.

Following that, we analyze real price data from their network to demonstrate that their price formula does little apart from peg the prices of tokens on their network to a certain rate, which is arbitraged to follow the real price of the tokens. As a result, there is a statistically significant lag between the real price and the price offered by Bancor.

From there, we start analyzing the math behind Bancor's formulas for price slippage. From here, we find mathematical issues that actually decrease Bancor's efficiency at capturing the real price of the tokens on its network. We derive an improved pricing formula for Bancor. We take into account the stochastic nature of supply and prices, which allows us to augment the main Bancor formulas with terms involving supply, volatility, and price shocks. This term increases the price per unit when transacting (buying or selling) on the Bancor Network. Supply drops resulting from increased volatility are further dampened by price increases relative to Bancor's original formulas. When we include jumps in the analysis, they enter in a similar manner to volatility. As a result, our pricing formula will more accurately represent the price of a given token. If Bancor refined and implemented our findings, we predict that they would greatly reduce the lag observed in their prices and the arbitrage opportunities present in their protocol.

2 A review of Bancor's Reserve System and Liquid Currency Issuance

The Bancor Network primarily promises liquidity through formulas that they claim accurately model the price of ERC20 tokens.

The core model of Bancor is to create an automatic market maker which holds a reserve for many ERC20 tokens in the Bancor Network Token. The Bancor Network Token (BNT) is, in turn, backed by a reserve in Ether. We explain their market making formulas below with normal economic terms.

To begin, a Smart Token owner can implement the Bancor Protocol. At this point, they must select a Constant Reserve Ratio (CRR), equal to intended reserves divided by the Smart Token's market cap. The owner then deposits the matching reserve value in Bancor Network Token.

$$CRR = \frac{Reserves\ in\ BNT}{Market\ Cap\ of\ Smart\ Token}$$

Once a CRR is chosen, it can be used to find the price with the Bancor Price Formula:

$$Price\ Of\ Smart\ Token = \frac{Reserves\ in\ BNT}{Supply\ Of\ Smart\ Token\ In\ Conversion\ Contract \cdot CRR}$$

This formula, where CRR is held constant, determines price as a factor of how many reserves there are versus the supply of the Smart Token. So, when the Smart Token is sold the price decreases, and when the Smart Token is bought the price increases.

2.1 Issues with Bancor's Formulations

From the resulting reserves and prices, Bancor calculates and displays their calculated Market Cap, which we can see to be very inaccurate.

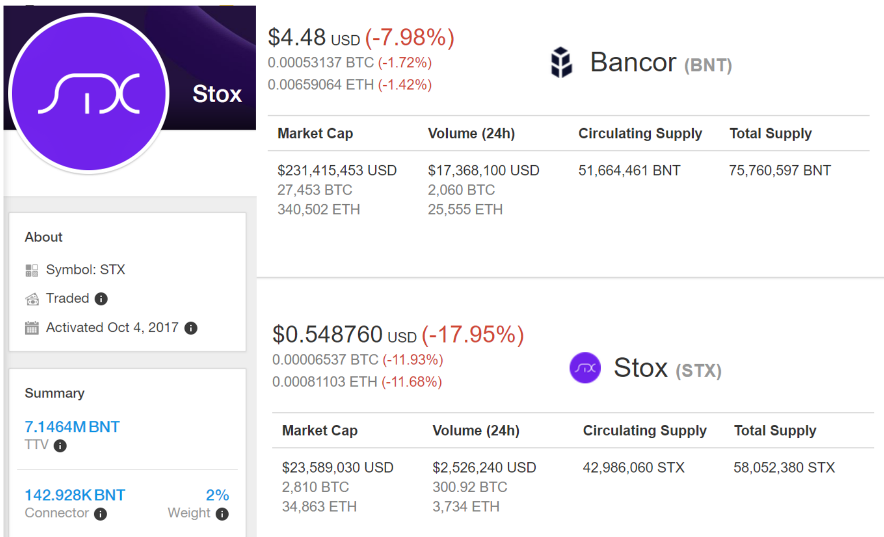

Fig. 0. STOX Market Cap on Bancor vs. CoinMarketCap

(Calculated at 8:10PM, 5/11/2018, with data from CoinMarketCap and Bancor's website: Bancor estimates a 7.1464M BNT TTV, equating to a $32m market cap. Coin Market Cap estimates a $23.6M market cap.)

The relationship for Bancor's Price Formula does allow the Bancor Protocol to algebraically solve for each Smart Token's price, but it is determined based off arbitrage (this issue, and others, are discussed more in detail by Hacking, Distributed [5]). This system inherently lags behind the real price of each Smart Token and introduces losses that can easily be equivalent or greater to those from counterparty risk and spread.

As a result, the benefits of the protocol are reduced to the liquidity that it provides, at a cost of price inaccuracies and high fees.

2.2 A Look Into Bancor's Guarantees

The Bancor Network claims a few key guarantees on their website [1]:

1. No Spread
2. Continuous Liquidity
3. No Counterparty Risk

4. No Registration Required
5. Predictable Price Slippage

We address these claims as follows.

No Spread It is true that there is no spread when converting tokens on the Bancor Network, but there are other costs that make conversions more expensive than alternatives. The major issue that we address later in the paper is the spread between the price of tokens versus their conversion rate on the Bancor Network. Additionally, the average gas cost when the Ethereum of a Bancor Network conversion is ˜$10 [2], while the fees of a GDAX transaction is 0.25% [4]. These issues combine to make trading on the Bancor Network more expensive than a traditional exchange. We can see this with a simple example: to reach the ˜$10 fee on GDAX, which is equivalent to the minimum gas costs for the Bancor Network, you need to make a $4,000 transaction. To reach the congested-network fee highs on Bancor of $100, you would need to make a $40,000 transaction. This simple example demonstrates how expensive the Bancor Protocol is for most transactions, especially considering that a $4,000 transaction on the Bancor Network would represent 1500% of the 24h volume of Rivetz on the Bancor Network.

Continuous Liquidity The Bancor Network does provide continuous liquidity. This can be beneficial for certain ERC20 token projects with low trading volume and low market cap value. However, this factor may not necessarily be enough of a beneficial factor to justify some of the other issues listed in this paper. Additionally, Bancor can be linked to price inaccuracies and failed tokens and unnecessarily provide wrongly priced liquidity to assets which may be unwanted or worthless.

No Counterparty Risk By introducing support for SegWit [6], GDAX has drastically minimized their fees while potentially allowing them to eliminate the counterparty risk for their users. This solution is an elegant strategy to ensure the same counterparty risk that Bancor guarantees without introducing the high fees of on-chain computation that Bancor requires. The network has also proven susceptible to front-running to the tune of 90% monthly returns [3].

No Registration Required This is true, however, the simplest way to interact with the Bancor Network is through their app, which goes against the benefits of privacy that could be assumed by this guarantee. In order to take advantage of this guarantee, Bancor recommends using MetaMask [7], which has potential security vulnerabilities [8].

Predictable Price Slippage The Bancor Network does provide Predictable Price Slippage. However, we detail various shortcomings of Bancor's approach to price prediction within the paper which demonstrate that the Price Slippage, while predictable, does not accurately represent the price. The formulas actively ignore volatility and price shocks, which result in substantial lag from the real price to the Bancor price.

2.3 Price Inaccuracies On The Bancor Network

We measured the price of 5 top traded tokens on the Bancor Network over a 3 week period, and compared it against data from regular exchanges. We went with Cryptocompare due to high availability of data for smaller market cap tokens (such as those on the Bancor Network). We plotted out the time series for token prices, and found that Bancor regularly lags the real price. This demonstrates how the Bancor Network merely lags behind real prices and adjusts primarily through arbitrage. Interestingly, this even happens for BNT, but not under all circumstances. This could be explained through a high percentage of trading volume for BNT going through the Bancor Network. From those prices, we then calculated distributed lag for each token between the Bancor Network and Cryptocompare, finding that EOS and STORM had substantially higher lags. However, every token we analyzed had statistically significant lags (statistical significance is demonstrated when the ACF goes above or below the blue dotted lines).

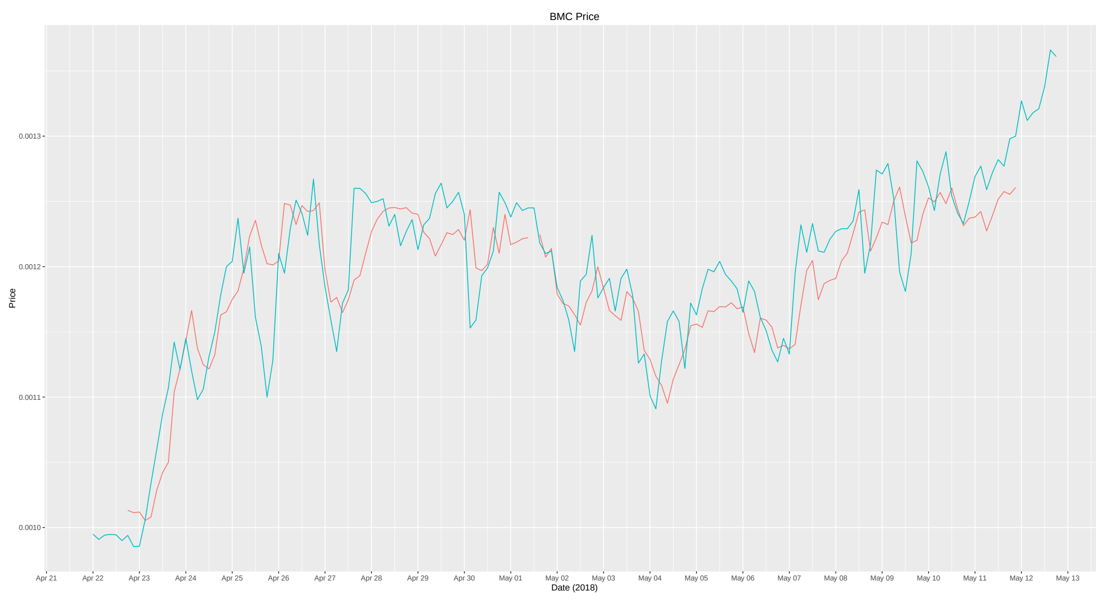

Fig. 1. Price Of BMC on Bancor & Cryptocompare

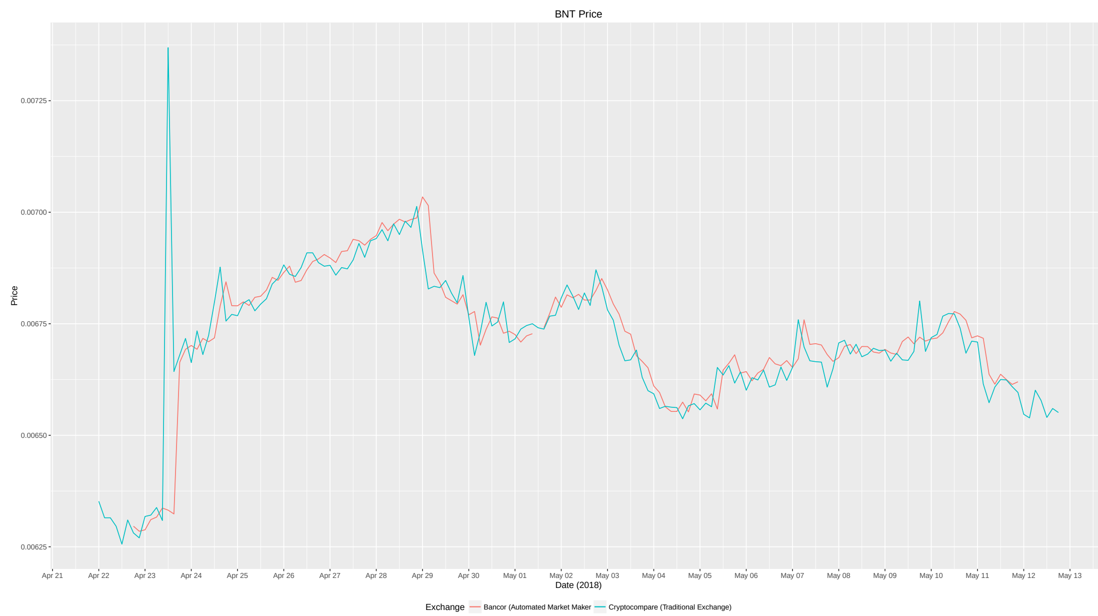

Fig. 2. Price Of BNT on Bancor & Cryptocompare

Fig. 3. Price Of EOS on Bancor & Cryptocompare

Fig. 4. Price Of KIN on Bancor & Cryptocompare

Fig. 5. Price Of STORM on Bancor & Cryptocompare

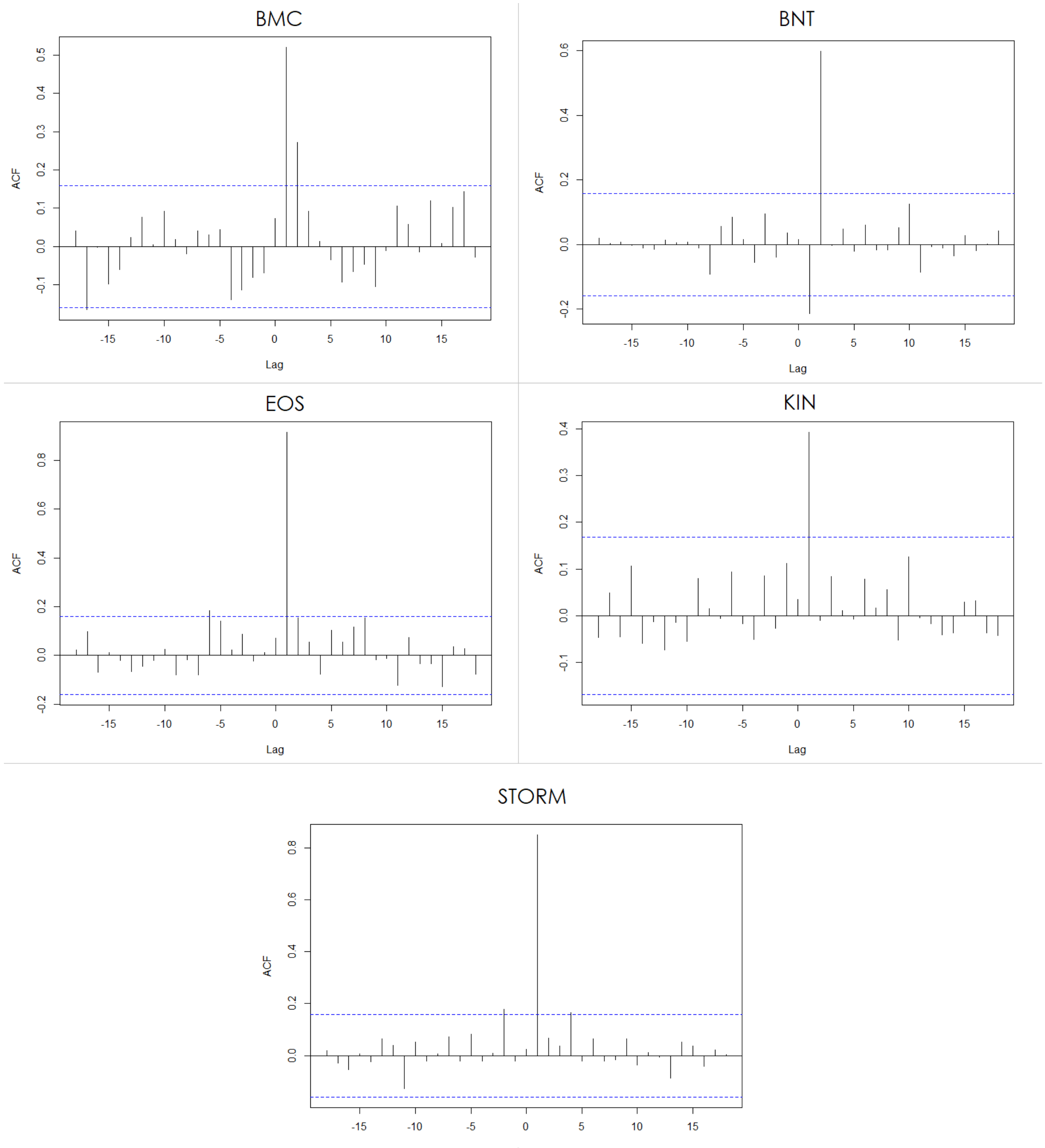

Fig. 6. Lags between Bancor & Cryptocompare

2.4 Bancor's Pricing Formulas

Let R_t be the reserve at time t of the parent coin (Bancor or ETH). Let N_t be the date t supply of the connected coins (child coins), P_t the date t price of the child coin in terms of the parent coin and $F_t = \frac{R_t}{S_t P_t}$ be the reserve ratio. In what follows, we impose $F_t = F$, a constant.

Bancor's automatic market maker makes decisions, at each time t, in isolation from the past or expectations of the future. They proceed as follows. Consider a buyer who wants to purchase T total tokens. Break this order up into infinitesimal pieces so that we can understand how to price each piece given it's quantity impact on prices. Then quote a price which is the sum (integral) total of the price of each piece.

Price is determined by formulating changes in reserves brought about by the infinitesimal purchase in two different ways and equating them

- **Buyer perspective**: buyer pays $P_t dN_t$ in terms of the parent coin and this amount is added to the reserve of the child coin
- **Bancor's (AMM's) perspective**: $dR_t = d(FP_tN_t) = Fd(P_tN_t)$
- It's important to note that the notation d does not mean changes wrt t but instead N.

Thus, the main equilibrium condition is

$$P_t dN_t = dR_t = d(FP_tN_t) = Fd(P_tN_t) \tag{1}$$

Equating these and then solving for P in terms of N yields the following

$$P_t = \left(\frac{N_t}{N_0}\right)^{\alpha} P_0 \tag{2}$$

where $\alpha = 1/F - 1$. Thus, if a user buys a total of c tokens, the total amount paid is

$$E_t = \int_{N_0}^{N_0+c} P_t dN_t = \int_{N_0}^{N_0+c} \left(\frac{N_t}{N_0}\right)^{\alpha} P_0 dN_t \tag{3}$$

$$= R_0 \left(\left(1 + \frac{c}{N_0}\right)^{\frac{1}{F}} - 1 \right) \tag{4}$$

This formula can also be used to figure out how much of the parent coin you would get if you redeemed a certain amount of child coin $c > 0$

$$E_t = \int_{N_0+c}^{N_0} P_t dN_t = -\int_{N_0}^{N_0+c} P_t dN_t = \int_{N_0}^{N_0+c} \left(\frac{N_t}{N_0}\right)^{\alpha} P_0 dN_t \tag{5}$$

$$= -R_0 \left(\left(1 + \frac{c}{N_0}\right)^{\frac{1}{F}} - 1 \right) \tag{6}$$

Note that the negative can just be interpreted as amount received as the non-negative version above is the amount paid. This last equation can be interpreted in words:

$$parent\ coins\ rec = reserve\left(\sqrt[F]{\left(1+\frac{child\ coins\ redeemed}{supply}\right)}-1\right)$$

Equation (4) can also be inverted to get the amount of child tokens issued for a particular payment E

$$\begin{aligned} child\ coins\ issued \equiv c_t &= N_0\left(\left(1+\frac{E_t}{R_0}\right)^F-1\right) \\ &= supply\left(\left(1+\frac{parent\ tokens\ paid}{reserve}\right)^F-1\right) \end{aligned}$$

Finally, the effective price P^E (average price of the buying the child coin on Bancor) is calculated as

$$P^E = \frac{E}{T} = \frac{parent\ coins\ paid}{child\ coins\ issued} \tag{7}$$

Bancor claims that the way they calculate prices has "the desired property of 10 small transactions or one large transaction of the same cumulative amount leading exactly to the same cost." Although unjustified in the paper, this seems to be predicated on an argument similar to the following. Suppose that a user considers two different ways to buy an order of size c of child tokens. If the user buys them all at once, they pay (4) as calculated before. However, if the user decides to split her order into c_1 and c_2 s.t. $c = c_1 + c_2$ they get

$$E_1 + E_2 = \int_{N_0}^{N_0+c_1}\left(\frac{N_t}{N_0}\right)^\alpha P_0 dN_t + \int_{N_0+c_1}^{N_0+c}\left(\frac{N_t}{N_0}\right)^\alpha P_0 dN_t \tag{8}$$

$$= \int_{N_0}^{N_0+c} P_t dN_t = E \tag{9}$$

However, this logic only holds if P_0 and N_0 are kept the same across the transactions. This will not be the case. Taking the changing initial values into account, the correct price, in their framework will be

$$E_1 + E_2 = \int_{N_0}^{N_0+c_1}\left(\frac{N_t}{N_0}\right)^\alpha P_0 dN_t + \int_{N_0+c_0}^{N_0+c}\left(\frac{N_t}{N_0+c_0}\right)^\alpha P_1 dN_t \tag{10}$$

where P_1 can be taken to be the marginal price of buying an additional coin past c_1 or $\frac{\partial E_1}{\partial c_1}$. As far as we can tell, (10) does not simplify to (9). In what follows below, we take into account the dynamic stochastic order flow that Bancor receives and reformulate the pricing formula.

3 Corrected Reserve and Issuance Model

We start by considering the order supply process $\{N_t\}$ that Bancor faces. This will be modeled as a generalized geometric Brownian motion process or a jump diffusion process (see below). Once we have the dynamic stochastic asset pricing models, we then revisit the equilibrium condition (1) which is maintained in this setting and solve for a new price expression that incorporates volatility and a jump component (in the jump process model).

3.1 Exposition of Selected Asset Pricing Models

3.2 Black-Scholes-Merton Model (BSM)

The BSM model makes the assumption that the underlying asset price has the following (stochastic) dynamics

$$\frac{dP_t}{P_t} = \mu dt + \sigma dW_t \tag{11}$$

where W_t is a standard Brownian motion with the formal definition given below. Intuitively, the LHS represents (instantaneous) net returns at time t and the RHS consists of two components, a drift term and a white noise (or diffusion) term. The drift term represents how in the absence of white noise shocks to (instantaneous) expected returns and the diffusion term σ

Definition 1 (Brownian Motion). *Let $(\Omega, \mathcal{F}, \mathbb{P})$ be a probability space. For each $\omega \in \Omega$, suppose there is a continuous function W_t of $t \geq 0$ that satisfies $W_0 = 0$ and that depends on ω. Then W_t is a Brownian motion if for all $0 = t_0 < t_1 < \cdots < t_m$ the increments*

$$W_{t_i} - W_{t_j} \sim N(0, t_i - t_j), \tag{12}$$

and, for non-overlapping intervals, are mutually independent.

In words, a Brownian motion is a continuous time stochastic process which starts at 0, has continuous paths, and has independent normally distributed increments (for non-overlapping time intervals) with variance equal to the time interval between the increments.

3.3 Generalized Geometric Brownian Motion (Merton)

Generalized geometric Brownian Motion (GGBM) relaxes the assumption of constant mean and volatility:

$$\frac{dP_t}{P_t} = \mu_t dt + \sigma_t dW_t \tag{13}$$

There are many specifications of the processes governing the **drift** μ and **volatility** σ processes. Popular examples include processes that take into account mean reversion and leverage effects (volatility increases when prices drop).

3.4 Jump Diffusion Processes

As our final asset pricing model, we consider the jump-diffusion model of Merton (1976). This model has models the white noise process out of two types of changes. The "normal" changes and the "abnormal" or jump changes. The first is modeled by a Brownian motion component and can be thought of as marginal information being incorporated into prices. The second is modeled as the (infinitesimal) increment of a Poisson process and represents incorporation of non-marginal (important) information into prices. Let $\{J_t\}$ be a Poisson process with intensity $\{\lambda_t\}$ and let ν_t be the random variable representing the size of time t jump, if any, with mean $m_t = E(\nu_t)$. We assume that the jump process is independent from the Brownian process. In the interval $(t, t+dt]$, the Poisson process increment $dJ_t = J(t+dt) - J(t)$ takes on the values of either 0 or 1:

$$P_t(dJ_t = 1) = 1 - P_t(dJ_t = 0) = \lambda_t dt \tag{14}$$

where P_t denotes the conditional expectation $P(\cdot|\mathcal{F}_t)$. Armed with this intuition, we can express the (instantaneous) rate of return as

$$\frac{dP_t}{P_t} = (\mu_t - \lambda_t m_t)dt + \sigma_t dW_t + \nu_t dJ_t \tag{15}$$

To get a more tractable form, Merton (1976) assumed $\lambda_t = \lambda$ and $\mu_t = \mu$ to be constants and $\nu_t = e^{Y_t} - 1$ where $\{Y_t\}$ is assumed to be iid $N(\mu_Y, \sigma_Y^2)$ with

$$m = E(e^{Y_t} - 1) = \exp\left\{\mu_Y + \sigma_Y^2 + \frac{\sigma_Y^2}{2} - 1\right\} \tag{16}$$

It is assumed that $\{W_t\}$, $\{J_t\}$, and $\{Y_t\}$ are all independent processes. With these assumptions, we can derive the following equation

$$d\log P_t = \left(\mu - \frac{\sigma^2}{2} - \lambda m\right) dt + \sigma dW_t + Y_t dJ_t \tag{17}$$

$$= \frac{dP_t}{P_t} - \frac{\sigma^2}{2}dt - \underbrace{(\nu_t + Y_t)}_{\tilde{\nu}_t} dJ_t \tag{18}$$

$$= \frac{dP_t}{P_t} - \frac{\sigma^2}{2}dt - \tilde{\nu}_t dJ_t \tag{19}$$

where $\tilde{\nu}_t = \nu_t + Y_t = e^{Y_t} - 1 + Y_t$.

4 Reformulation of Bancor Formulas

We will maintain the assumption that no arbitrage holds. In particular, that P should be approximately the market dynamics of the underlying coin. From the main equilibrium condition in Bancor, that

$$\begin{aligned} P_t dN_t = dR_t &= Fd(N_t P_t) \\ &= F(P_t dN_t + NdP_t + dN_t dP_t) \\ \implies \underbrace{\left(\frac{1}{F} - 1\right)}_{\alpha} \frac{dN_t}{N_t} &= \frac{dP_t}{P_t} + \frac{dP_t}{P_t}\frac{dN_t}{N_t} \end{aligned}$$

4.1 Under Generalized Geometric Brownian Motion

Next, we assume that the supply and price processes are driven by a common source of randomness modeled by a Brownian motion W_t.

$$\begin{aligned} \frac{dN_t}{N_t} &= \mu_{N,t} dt + \sigma_{N,t} dW_t \\ \frac{dP_t}{P_t} &= \mu_{P,t} dt + \sigma_{P,t} dW_t \end{aligned} \tag{20}$$

Using the heuristics about quadratic variation $dtdt = 0$, $dtdW_t = 0$, and $dW_t dW_t = dt$ ([9]) Quadratic variation (QV) is the sum over infinitesimal differences of a process (or two processes). The intuition behind these is that t is a smooth function (in itself) and so, the small changes in it will dominate the changes in W. In addition, because $dW_t \sim N(0, dt)$ the quadratic variation, which is similar to variance, will be dt.

Using the heuristics above, we get

$$\frac{dP_t}{P_t}\frac{dN_t}{N_t} = \sigma_{N,t}\sigma_{P,t} dt \tag{21}$$

Plugging this into (20), we obtain

$$\alpha \frac{dN_t}{N_t} = \frac{dP_t}{P_t} + \sigma_{N,t}\sigma_{P,t} dt \tag{22}$$

We also have the relationship from Itô's lemma ([9]) for any Itô process X:

$$\begin{aligned} d\log X_t &= \frac{dX_t}{X_t} - \frac{dX_t dX_t}{X_t^2} = \frac{dX_t}{X_t} - \frac{1}{2}\sigma_{X,t}^2 dt \\ \implies \frac{dX_t}{X_t} &= d\log X_t + \frac{1}{2}\sigma_{X,t}^2 dt \end{aligned} \tag{23}$$

essentially when dealing with processes driven by Brownian motion we must also account for second order variation since the process has variation at any scale. This results in differentiation looking like a second order Taylor expansion. For our purposes, this boils down to having an extra "error" term when (total) differentiating $\log X_t$ given by $\sigma^2 t/2$. As briefly discussed in section 2.4, this extra

term is nowhere to be seen in Bancor's math. What follows is a reformulation including this "error term" that grows with time.
Using (23) for (22), we obtain

$$\alpha\left(d\log N_t + \frac{\sigma_{N,t}^2}{2}dt\right) = d\log P_t + \frac{\sigma_{P,t}^2}{2} + \sigma_{N,t}\sigma_{P,t}dt \tag{24}$$

Integrating from 0 to t yields and **imposing the assumption** $\sigma_{N,t} = \gamma\sigma_{P,t}$ **(volatility of supply is proportional to price volatility)**, we get the following formula

$$P_t = \left(\frac{N_t}{N_0}\right)^{\alpha} P_0 \exp\left\{\frac{1}{2}\int_0^t \sigma_{P,t}^2 \underbrace{(\alpha\gamma^2 - 2\gamma - 1)}_{\eta} dt\right\} \tag{25}$$

where $\alpha = \frac{1}{F} - 1$ where F typically around 0.05 is the reserve ratio. When $\eta = (\alpha\gamma^2 - 2\gamma - 1) > 0$, we get a fairly intuitive result: the accumulated volatility of returns over a standardized time frame should augment the price paid by the user to buy in to the child coin on the Bancor network. When $\eta = 0$ we get Bancor's result. When $\eta < 0$ we get a rather unintuitive result which is that accumulated volatility will actually discount the price. If justifying this model with an equilibrium model as opposed to just imposing that $\sigma_{S,t} = \gamma\sigma_{P,t}$ it would almost surely be the case that the parameters γ and α would have to satisfy $\eta > 0$ in order for the equilibrium to exist.

Let us explore just how much of a constraint the condition $\eta > 0$ imposes on the parameters γ and $\alpha = \frac{1}{F} - 1$. $\eta > 0$ corresponds to $\gamma > F + \sqrt{F(1+F)}$. A graph of this bound on γ for $F \in [0, 1)$ is shown below.

Unfortunately, data on reserve ratios on Bancor is very hard to come by, but we consider one of the few reserve ratios that is actually listed, STOX (see section 2.1), with a reserve ratio $F = 0.02$. In order for $\eta > 0$, it must be the case that $\gamma > 0.02 + \sqrt{0.02(1+0.02)} \approx 0.163$. It seems reasonable that supply should have less volatility than prices but having a lower bound of 0.163 times as much vol as prices does not seem terribly restrictive. Given the figure below, we can see that for F small, it will generally be the case that the bound is close to 0. It appears that Bancor's largest reserve is the backing of BNT itself by ETH at $F = 0.1$ or 10%, so the constraint doesn't seem to restrict the volatility of supply relative to that of prices too much.

BSM Model Specialization In the BSM model setting, (25) becomes

$$P_t = \left(\frac{N_t}{N_0}\right)^{\alpha} P_0 \exp\left\{\frac{1}{2}\eta\sigma^2 t\right\} \tag{26}$$

where σ is the constant volatility of prices. It should be noted that for (26) to hold, no assumption on μ_t is needed–all that is needed is that $\sigma_{P,t}$ is a constant–so that this holds for more general models than BSM with time varying expected returns.

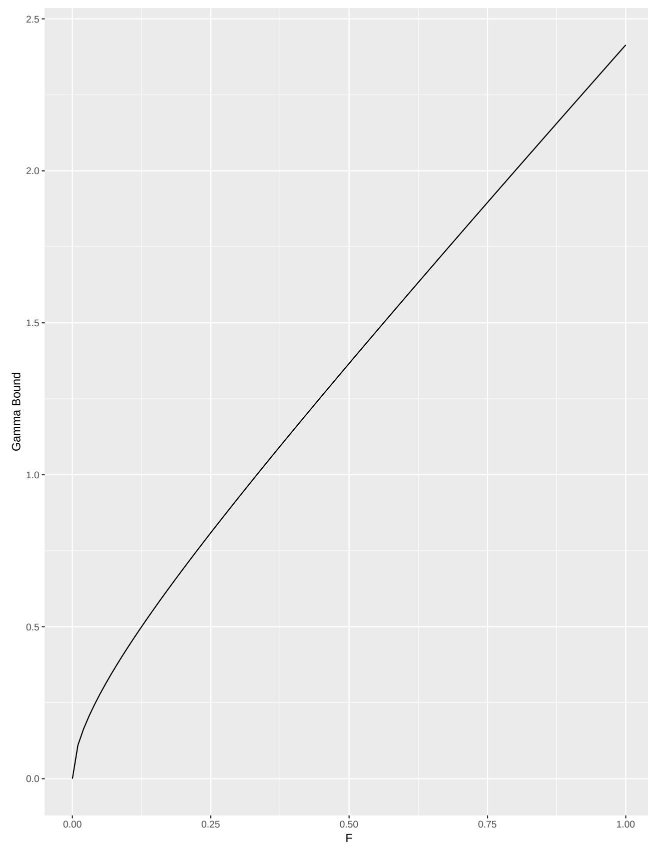

Fig. 7. γ Bound Plot

4.2 Implications of New Pricing Formula

In progress: The new pricing formula affects Bancor's main formulas by adding an additional term that compounds volatility over time. To simplify notation, we focus on the case of constant volatility. For the total amount of parent coin paid for an amount of child coin c at time t is $\tilde{E}_t$

$$\tilde{E}_t = \int_{N_0}^{N_0+c} P_t dN_t = \int_{N_0}^{N_0+c} \left(\frac{N_t}{N_0}\right)^{\alpha} P_0 \exp\left\{\frac{1}{2}\eta\sigma^2 t\right\} dN_t \tag{27}$$

$$= R_0 \left(\left(1 + \frac{c}{N_0}\right)^{\frac{1}{F}} - 1\right) \times \exp\left\{\frac{1}{2}\eta\sigma^2 t\right\} \tag{28}$$

$$= E_t \times \exp\left\{\frac{1}{2}\eta\sigma^2 t\right\} \tag{29}$$

where E_t is the price under the original Bancor set up. Assuming $\eta > 0$, the total price paid to obtain c child coins is relatively higher than under the Bancor formulation.

We can also see what happens to the redemption value of the child coin

4.3 How to Choose the Time Interval

A natural question arises on how much volatility should be accumulated to provide enough liquidity. Although we haven't tackled this question theoretically, it does seem that

4.4 Under Jump Diffusion

In progress Using Merton's jump diffusion model from section 3.4, we assume that the supply process and the price process are affected by a common Brownian component $\{W_t\}$ and a common Poisson component $\{J_t\}$.

$$\frac{dN_t}{N_t} = \mu_{N,t}dt + \sigma_{N,t}dW_t + \nu_{N,t}dJ_t$$
$$\frac{dP_t}{P_t} = \mu_{P,t}dt + \sigma_{P,t}dW_t + \nu_{P,t}dJ_t \qquad (30)$$

5 Issues With Further Expansion Potential Or Concern

1. We were concerned with the fact that any token on the Bancor Network is connected with doubly linked reserve ratios, resulting in an extremely low real reserve ratio. In other words, when going from ETH to BNT you have a 10% reserve ratio and then going from BNT to STX you have a 2% reserve ratio. This results in a real reserve ratio of 0.2%. This has the potential to artificially amplify the value of cryptocurrencies on the Bancor Network; if that is true, then the Bancor Network could result in substantial losses for investors of tokens on their network.
2. We touched upon this in the paper to some degree, but we are very worried by the high gas cost of transactions. From our research, there seem to be many users of Bancor who were charged (or simply lost due to insufficient gas provided) up to $100, with a minimum of $8 in gas cost per Bancor transaction. These fees, while not thoroughly quantitatively measured in this paper, are much higher than the fees from using a manual market maker. This eliminates many of the potential benefits of an automated market maker, and demonstrates how high a fee someone could pay a manual market maker to be slightly more efficient than Bancor. Once the fees are so high, we must consider factors reinforcing the trustworthiness of manual market makers. Furthermore, manual market makers can be even more trustworthy by using modern technology such as SegWit.

3. This claim by a Bancor subreddit moderator, and supposed employee with the position of "Growth Hacker" for the company, seems to indicate a desire to insider trade, which is behavior restricted and monitored by the SEC for criminal acts. : "As we build the Bancor protocol, we'll be the first early adopters to profitable Bancor tech (like token baskets, token sales on the Bancor network, token changers with fees, etc.). So we'll make money by being most informed." https://www.reddit.com/r/Bancor/comments/6f8y27/how_will_the_bancor_foundation_make_money/dih6tc8/

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