Valuation of Loyalty Tokens

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Abstract

Valuation of tokens is a wager on the platform adoption. This study investigates the effect of platform adoption on the valuation of loyalty tokens and the contingent claims with the token as an underlying. The platform adoption is modelled using the classical Bass Model. The example selected is that of airmiles, but the approach could be extended to loyalty token with other numeraires as well.

After assuming few monetary policy rules for the platform governance, the proposed simple model predicts that the Bass Model parameters could have significant influence on the valuation of loyalty tokens and the contingent claims with the token as an underlying.

Keywords: Tokenomics, Cryptocurrencies, Initial Coin Offering (ICO), Blockchain applications, Bass Model, Option pricing with Bass Model parameters

JEL codes: E42, G12, G13, L86

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[2] *The seed thought presented in the paper was proposed by Ray Wang – Corporate Technology Board Member in his book "Everybody Wants to Rule the World: Surviving and Thriving in a World of Digital Giants" and conceptualized by K. Anant Krishnan, Chief Technology Officer of Tata Consultancy Services (TCS), India.*

[3] *I express my sincere gratitude to Ch Sathya, Sanjay Bhat, T.A.V Eswar, K Padmanabhan and the Insights and Foresights team of the Corporate Technology Office at Tata Consultancy Services (TCS), India*

[4] *The details, findings, interpretations, and conclusions expressed in this study are entirely those of the author. They do not necessarily represent the views of Tata Consultancy Services (TCS), India.*

1. Introduction

In COID-19 times, loyalty programs have transformed from a marketing lever that fosters customer loyalty, to a dependable collateral for financing transactions. Many US Airlines have collateralized the cash flows from the loyalty programs to raise financing. For example, Delta collateralized the cash flows from its SkyMiles program to raise USD 9 billion in June 2020 and American Airlines, banking on its AAdvantage program raised USD 10 billion in March 2021 (Chun and Boer, 2021). Hence, managing loyalty programs has become ever important for Airlines. In airline loyalty programs, customers/members usually earn miles for flying with the parent or other participating airlines and purchase of goods and services or usage of credit cards from non-airline partners such as banks, retail merchants, car rentals, hotels etc. Customers redeem their miles while buying future flight tickets or services offered by the partners. Loyalty programs generate cash flows for airlines by mostly selling miles to third parties such as banks and other partners such as those in retail, lifestyle and hospitality industry. In 2019, Delta Airline's loyalty program - SkyMiles had over 100 million members and the program generated a cash flow of ~ USD 6.1 billion; of which over USD 4 billion was from miles sales to American Express[5].

For airlines though, a part of airmiles value constitute a deferred revenue liability – a significant and growing balance sheet item. Delta Airline had a Loyalty program liability of ~ USD 7.18 billion on 31st December 2020, an increase of ~ 6.6% over that on 31st December 2019[6]. Chun, Iancu and Trichakis (2020) provide detailed review of the liabilities created by loyalty programs and its implications. The liability depends on the estimated mile value and consequently an increase in the mile value could increase deferred revenue liability and decrease the revenue. Delta Airline's 10-K report for 2021 stated that a hypothetical 10% increase in the value of the mile could decrease the annual revenue by ~ USD 40 million due to an increase in the amount of revenue deferred[7]. In 2008, Alaska Airlines effectively reduced the value of its mile and claimed an additional revenue of USD 42.3 million and reduced its net loss by 24% (Chun, Iancu and Trichakis, 2020). In fact, due to variety of policies adopted by the airlines the value of miles to customers is falling (Saxon and Spickenreuther, 2018). Hence, loyalty programs are plagued by customer account inactivity and low redemption rates defeating the very purpose of fostering customer loyalty, retention and engagement (Fromhart and Therattil, 2016).

[5] SkyMiles 8-K; https://sec.report/Document/0001193125-20-244688/

[6] Delta Airlines December 2020, 10-K; https://s2.q4cdn.com/181345880/files/doc_financials/2020/q4/DAL-12.31.2020-10K-2.12.21-Filed.pdf

[7] Delta Airlines 10-K report for 2021 page 46 -Section Critical Accounting Estimates.

Ray Wang (2021) proposed a blockchain based digital loyalty platform to make the loyalty programs more efficient and reduce the liabilities of issuers[8] such as airlines. In 2018, Singapore Airlines did launch "KrisPay" - a blockchain based airline loyalty digital wallet[9]. Thus, the loyalty program customers were able to convert their Singapore "KrisFlyer" Airlines into KrisPay miles that could then be redeemed for products and services of the partner brands (Wang R.; 2021). Thus, KrisPay became a quasi-fiat currency, except KrisPay did not allow the trading of miles between customers.

This study presents a simple model to value the loyalty token traded on a blockchain based and regulator mandated digital loyalty platform. The objective of the loyalty platform considered in this study is to foster customer loyalty by increasing the customer participation and decreasing the deferred revenue-based liability of the airlines. While the airmiles exhibit a decline in value, the loyalty tokens serve as a store of value thus increasing the customer participation. Miles though can be bought but cannot be traded in the open market, the proposed digital loyalty platform will address this need of the customers by pooling together many customers to transact with each other. Loyalty tokens will be used exclusively to trade miles on the platform and blockchain will facilitate smart contracts between the customers. But, unlike financial assets whose value depend on the underlying cash flows, the value of loyalty token is derived from the exclusivity that it provides the customers to trade miles on the platform and a prudent monetary policy adopted by the platform. An initial and future offering of tokens based on the platform adoption serves as financing for the development and maintenance of the platform. The initial offering of the loyalty tokens is different from a standard Initial Coin Offering where in, the initial sale of coin is auction based. The initial offering of loyalty tokens is proposed at a fixed – pre-set price and by a fair lottery, if the subscription is more than the quantity of initial offering.

Recent studies in token valuation (Pagnotta and Buraschi, 2018; Li and Mann, 2020; Sockin and Xiong, 2020; Cong, Li and Wang, 2021) have modelled token behaviour in a platform economy. Catalini and Gans (2019) and Gan, Tsoukalas and Netessiney (2020), among many, have studied the role of Initial Coin Offering (ICO) in funding the venture start-up costs. This study's contribution is to model the platform adoption based on the classical Bass model prevalent in the marketing literature and value loyalty tokens and derivative securities with the token price process as the underlying, albeit in an incomplete market.

[8] The idea was conceptualized by K. Anant Krishnan, Chief Technology Officer of Tata Consultancy Services (TCS), India.

[9] https://www.singaporeair.com/en_UK/kr/plan-travel/local-promotions/krispay19/

2. Assumptions

Following are the assumptions I make to simplify the analysis (You, Yang and Rogoff, 2019):

1. Loyalty tokens cannot be exchanged for fiat currency or exchanged for the other products and services available on the platform. Loyalty tokens can only be traded for the miles and miles in turn could be used to purchase products and services available on the loyalty platform.

2. Initial demand during the initial token offering for the loyalty tokens is considered exogenous because the customers already own miles and, the demand is created by the objective to preserve the "value" of the miles owned by the customer and to conduct transactions on the loyalty platform.

3. The loyalty platform makes credible commitment to its token issuance policy, i.e., amount and the dates of future loyalty token issuance is declared, and the conditions of issuance are pre-specified.

4. Loyalty platform sells tokens to customers at a pre-set price in a fiat currency during an initial token offering. A prerequisite to the allotment is that the customer registers miles of equivalent value to the allocated tokens, on the platform for trading. For example, if the initial allotment of tokens is at USD 0.16/ token and the valuation of a mile is assumed at USD 0.16/ mile, if one token is allocated to a customer, the customer registers one mile that he/she owns on the platform for trading. This condition does not apply to the later allotments. The initial allotment of the token is by a fair-lottery (if the demand for the tokens exceeds the supply). During the initial token allotment, the platform also sells European call options that gives the right but not an obligation to the customer to buy a token at a strike on an exercise date. The exercise date of the call option serves as the next token allotment date. The allocation of the token is only to the customers who exercise these platform traded European call options. Thus, if the implied price of the loyalty token is below the strike price, the option will not be exercised, restricting the supply of new tokens on the platform. These options can also be traded on the platform for fiat currency. The proceeds from the initial token offering and the European call option premium compensates the platform for the development and maintenance costs.

5. Loyalty platform will not suffer failure. If the airline issuing the airmiles suffers bankruptcy, the loyalty tokens issued by the loyalty platform could be adversely impacted. I assume that this may not happen, or a corresponding default premium is already built into the airmiles pricing.

3. A Model of Token Price Process:

Though airlines and many other on-line retailers sell miles[10], I use the inherent mile valuation proposed by analysts[11] (Saxon and Spickenreuther, 2018, Exhibit 3, pg. 5) as a benchmark to model the valuation of a mile $\left(D_t^{\$/m}\right)$ using Merton Jump Diffusion (MJD) process under the real world - P measure. This process is assumed to be not affected by the trading on the loyalty platform. In MJD model the changes in mile price consist of a diffusion component modelled by a Brownian motion with drift and the jump component modelled by a compound Poisson process. Jumps represent the policy changes implemented by airline that results in a decrease in the valuation of the miles. The probability that $D_t^{\$/m}$ jumps once during a small-time interval dt is modelled by a Poisson process, dN_t and $\cong \lambda dt$ where λ is the mean number of jumps per unit time. The probability of more than one jump in the time interval dt is zero. Percentage change in $D_t^{\$/m}$ caused by a jump is given as:

$$\frac{dD_t^{\$/m}}{D_t^{\$/m}} = y_t - 1 \tag{1}$$

Where y_t is the absolute price jump size and could follow a lognormal distribution but this assumption is not required for the present analysis. Few example sample paths are depicted in the figure 1. The MJD process is given below:

$$\frac{dD_t^{\$/m}}{D_t^{\$/m}} = \mu^{\$/m}dt + \sigma^{\$/m}dB_t^{\$/m} + (y_t - 1)dN_t \tag{2}$$

[10] https://www.delta.com/buygftxfer/displayBuyMiles.action
https://buyairlinemiles.com/
https://www.buyflightmiles.com/
https://www.forbes.com/advisor/credit-cards/is-buying-frequent-flyer-miles-ever-a-good-deal/
[11] https://thepointsguy.com/guide/monthly-valuations/

Where $D_t^{\$/m}$ represents valuation of 1 mile in US dollars at time *t*; $\mu^{\$/m}$ is the expected continuously compounded return per annum conditional on non-occurrence of the jump i.e. excluding the drift due to jump, $\sigma^{\$/m}$ is the instantaneous volatility again conditional on the non-occurrence of the jump, assumed constant in this analysis, $B_t^{\$/m}$is the *P* Brownian motion and N_t is the Poisson process with λ intensity. I assume that $B_t^{\$/m}, N_t,$ and y_t are independent (Matsuda, 2004).

As loyalty tokens are traded on the loyalty platform, let the token price process $\left(X_t^{l/m}\right)$ in terms of miles (numeraire good) under *P* measure be expressed using Merton Jump Diffusion model as:

$$\frac{dX_t^{l/m}}{X_t^{l/m}} = \mu_t^{l/m}dt + \sigma^{l/m}dB_t^{l/m} + (y_t - 1)dN_t, \qquad \{0 \leq t \leq T\} \tag{3}$$

$$dB_t^{\$/m}dB_t^{l/m} = \rho dt \tag{4}$$

Where $\mu_t^{l/m}$ is the expected continuously compounded return per annum conditional on non-occurrence of the jump i.e. excluding the drift due to jump, $\sigma^{l/m}$is the instantaneous volatility again conditional on the non-occurrence of the jump, assumed constant in this analysis, $B_t^{l/m}$is the *P* Brownian motion, N_t is the Poisson process with λ intensity and $B_t^{l/m}, N_t,$ and y_t are independent. The initial $X_0^{l/m}$ for the following allocation date is the $X_T^{l/m}$post dilution. ρ is the correlation coefficient between $B_t^{\$/m}$ and $B_t^{l/m}$. Note, $\mu_t^{l/m}$ is assumed to be constant in this analysis and depends on the rate of platform adoption. Few sample paths of $X_t^{l/m}$ are depicted in figure2.

I assume that the jumps are simultaneous in both $D_t^{\$/m}$ and $X_t^{l/m}$ and the percentage change caused by a jump are equal:

$$\frac{dD_t^{\$/m}}{D_t^{\$/m}} = \frac{dX_t^{l/m}}{X_t^{l/m}} = y_t - 1 \tag{5}$$

The implied token price process, $L_t^{\$/l}$ USD per loyalty token is given as:

$$L_t^{\$/l} = \frac{D_t^{\$/m}}{X_t^{l/m}} \tag{6}$$

A simple application of Ito's lemma yields:

$$\frac{dL_t^{\$/l}}{L_t^{\$/l}} = \mu_t^{\$/l} dt + \sigma^{\$/l} dB_t^{\$/l} \tag{7}$$

Where $\mu_t^{\$/l} = \left(\mu^{\$/m} - \mu_t^{l/m} + \left(\sigma^{l/m}\right)^2 - \rho\sigma^{\$/m}\sigma^{l/m}\right)$ and

$$\sigma^{\$/l} = \sqrt{\left(\sigma^{\$/m}\right)^2 + \left(\sigma^{l/m}\right)^2 - 2\rho\sigma^{\$/m}\sigma^{l/m}}$$

And $L_T^{\$/l} = L_0^{\$/l} exp\left(\left(\mu^{\$/m} - R + \frac{1}{2}\left(\sigma^{l/m}\right)^2 - \frac{1}{2}\left(\sigma^{\$/m}\right)^2\right)T + \sigma^{\$/l}\sqrt{T}Z\right)$

Where $R = \frac{1}{T}\int_0^T \mu_t^{l/m}\, dt$ and $Z \sim N(0,1)$

Note: the jumps in $D_t^{\$/m}$ and $X_t^{l/m}$ cancel each other, thus $L_t^{\$/l}$ exhibits Geometric Brownian Motion. As $L_t^{\$/l}$ is lognormally distributed, the expectation and variance of $L_T^{\$/l}$, at option expiry are given as:

$$E\left(L_T^{\$/l}\right) = L_0^{\$/l} exp\left(\left(\mu^{\$/m} - R + \frac{1}{2}\left(\sigma^{l/m}\right)^2 - \frac{1}{2}\left(\sigma^{\$/m}\right)^2\right)T\right) \tag{8}$$

$$Var\left(L_T^{\$/l}\right) = \left(L_0^{\$/l}\right)^2 \left(exp\left(\left(\sigma^{\$/l}\right)^2 T\right) - 1\right)$$
$$\times exp\left(2\left(\mu^{\$/m} - R + \frac{1}{2}\left(\sigma^{l/m}\right)^2 - \frac{1}{2}\left(\sigma^{\$/m}\right)^2\right)T + \left(\sigma^{\$/l}\right)^2 T\right)$$

4. Adoption Rate:

In this section, I explain the dependency of $\mu_t^{l/m}$ on the adoption rate of the Loyalty platform by customers, using the classical Bass Model (Bass, 1969; Bass, Krishnan and Jain, 1994). The loyalty platform is likely to be adopted by both the "innovators" and "imitators" (Rogers 1962; Bass 1969). Innovators will adopt the loyalty platform independently, irrespective of the miles already registered for trading on the platform while adopters will decide to register their miles based on the miles already registered on the loyalty platform. Obviously, an innovator post satisfactory trading experience may choose to further trade by registering new air miles on the platform. I assume, that the probability that a customer registers a mile for trading on the loyalty platform is a linear function of the number of air miles already registered on the loyalty platform. Over the first T_n years of platform, let M miles be registered. The likelihood of registration of a mile on the loyalty platform at time t given that mile was not registered by a customer is:

$$\frac{f(t)}{1 - F(t)} = p + \frac{q}{M}Y(t) = p + qF(t) \tag{9}$$

Here p is coefficient of innovation, and q is the coefficient of imitation, $Y(t)$ is the number of previously registered miles, $f(t)$ is the likelihood of registration of mile at t and $F(t)$ is the cumulative function.

To participate in the Initial Token Offering i.e., avail the loyalty tokens, at $t = 0$, let customers register $F(0)M$ miles. It also possible to use the boundary condition of $F(T_n) = 1$ and then derive the value of $F(0)$ for the Initial Token offering.

As $dF = f(t)dt$, solving the differential equation in 9, I get:

$$F(t) = \frac{1 - \frac{p}{q} A e^{-t(p+q)}}{1 + A e^{-t(p+q)}} \tag{10}$$

Where $A = \frac{1-F(0)}{F(0)+\frac{p}{q}}$

$$f(t) = \frac{A(p+q)^2 e^{-t(p+q)}}{q(1 + A e^{-t(p+q)})^2} \tag{11}$$

Miles registered on the platform for trading could be redeemed or miles despite registration may not trade. Thus, I introduce, $\varphi_1$the trade factor and φ_2 the redemption factor in the analysis. Let the trading volume TV experienced on the platform at time *t* be:

$$TV_t = F(t) M \varphi_1 (1 - \varphi_2) \tag{12}$$

Where $\varphi_1$is the trade factor, $\varphi_1 > 0$ and φ_2 is the redemption factor, $0 \leq \varphi_2 < 1$. Both φ_1 and φ_2 are assumed to be constant.

Next, I assume, Quantity Theory of Money applies to the Loyalty Platform at all times, thus in discrete time,

$$Q\bar{V} = X_t^{l/m} TV_t \quad t = 0,1 \ldots . T \tag{13}$$

Where Q is the quantity of tokens issued in the initial token offering and is constant till the next issuance or at the exercise of the call option, $\bar{V}$ is the velocity of the tokens and is assumed to be constant. Thus[12],

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$$\frac{X_{t+1}^{l/m}}{X_t^{l/m}} = \frac{TV_t}{TV_{t+1}} = \frac{F(t)}{F(t+1)}$$

$$ln\left(\frac{X_{t+1}^{l/m}}{X_t^{l/m}}\right) = -ln\left(\frac{F(t+1)}{F(t)}\right) \tag{14}$$

Hence, in continuous time,

$$R = -\frac{1}{T}\int_0^T \frac{A(p+q)^2 e^{-t(p+q)}}{q(1+Ae^{-t(p+q)})\left(1-\frac{p}{q}Ae^{-t(p+q)}\right)} dt \tag{15}$$

5. Pricing of a Contingent Claim:

As $D_t^{\$/m}$ is not a price process of a traded asset, the market for Loyalty tokens is incomplete. I assume that underlying risk factor of the Loyalty token price process $L_t^{\$/l}$ is idiosyncratic and thus fully diversifiable for the customers. Consequently, the price of a European call option on $L_t^{\$/l}$ is given as:

$$C_0 = e^{-r_f T} E^P\left(\max\left(L_T^{\$/l} - k, 0\right)\right) \tag{16}$$

Where C_0 is the fair price at which the European call options could be sold during the initial token offering with a strike of *k* and an exercise date of *T*; the expectation of the options payoff is under the *P* measure and r_f is the risk free rate.

On taking the expectation, the price of European call option, C_0 is given as:

$$C_0 = e^{-r_f T}\left[L_0^{\$/l} e^{\left(\overline{\mu^{\$/l}}+\frac{1}{2}\left(\sigma^{\$/l}\right)^2\right)T} N(d_1) - kN(d_2)\right] \tag{17}$$

Where,

$$\overline{\mu^{\$/l}} = \mu^{\$/m} - R + \frac{1}{2}\left(\sigma^{l/m}\right)^2 - \frac{1}{2}\left(\sigma^{\$/m}\right)^2$$

$$R = -\frac{1}{T}\int_0^T \frac{A(p+q)^2 e^{-t(p+q)}}{q\left(1+Ae^{-t(p+q)}\right)\left(1-\frac{p}{q}Ae^{-t(p+q)}\right)}dt$$

$$A = \frac{1-F(0)}{F(0)+\frac{p}{q}}$$

$$\sigma^{\$/l} = \sqrt{\left(\sigma^{\$/m}\right)^2 + \left(\sigma^{l/m}\right)^2 - 2\rho\sigma^{\$/m}\sigma^{l/m}}$$

$$d_1 = \frac{ln\left(\frac{L_0^{\$/l}}{k}\right) + \left(\overline{\mu^{\$/l}} + \left(\sigma^{\$/l}\right)^2\right)T}{\sigma^{\$/l}\sqrt{T}}$$

$$d_2 = d_1 - \sigma^{\$/l}\sqrt{T}$$

6. Numerical Example:

Next, I present a numerical example to illustrate various processes and sensitivity of option prices to the Bass model parameters.

Table 1: Variables /Parameters and Numerical values used in the Simulation

Variable /Parameter	***Value***
r_f	5%
T	1 year
Simulation period, Sample paths	2 years, 1000
ΔT	0.0133 years
$\mu^{\$/m}$	5%
$\sigma^{\$/m}$	3%
y_t	0.85
λ	1
$\sigma^{l/m}$	10%
ρ	0.2
$F(0)$	0.05
p	0.002
q	0.2
$D_0^{\$/m}$	0.16 USD/mile
$X_0^{l/m}$	1 Token/mile
k	0.16 USD/Token

Figure 1 below depicts three example sample paths of the $D_t^{\$/m}$ process. Note: the new token offering/ option exercise is assumed to have no effect on these sample paths. The jumps represent potential changes in the loyalty program policies that could cause mile devaluation.

Figure 1: Example sample paths of $D_t^{\$/m}$ (USD/Mile) process

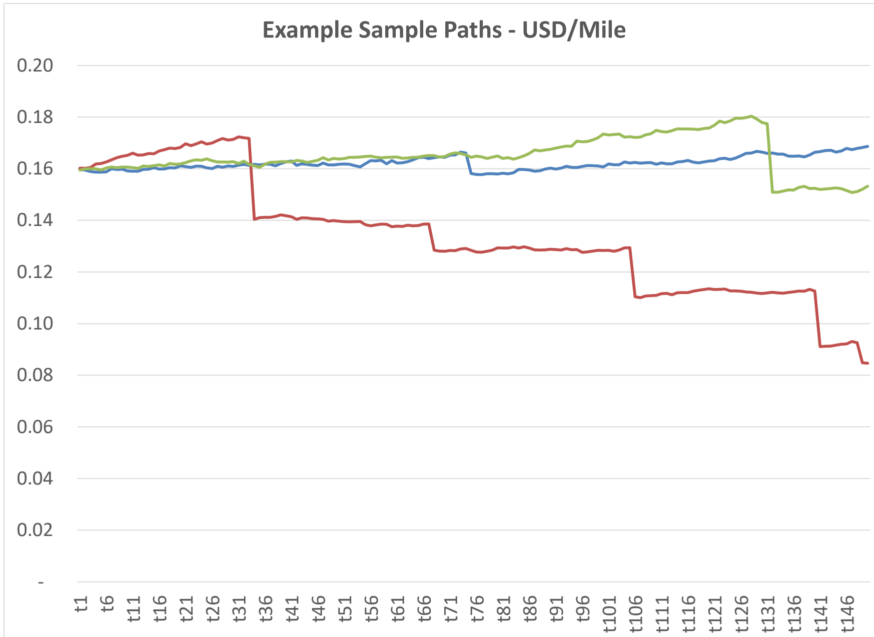
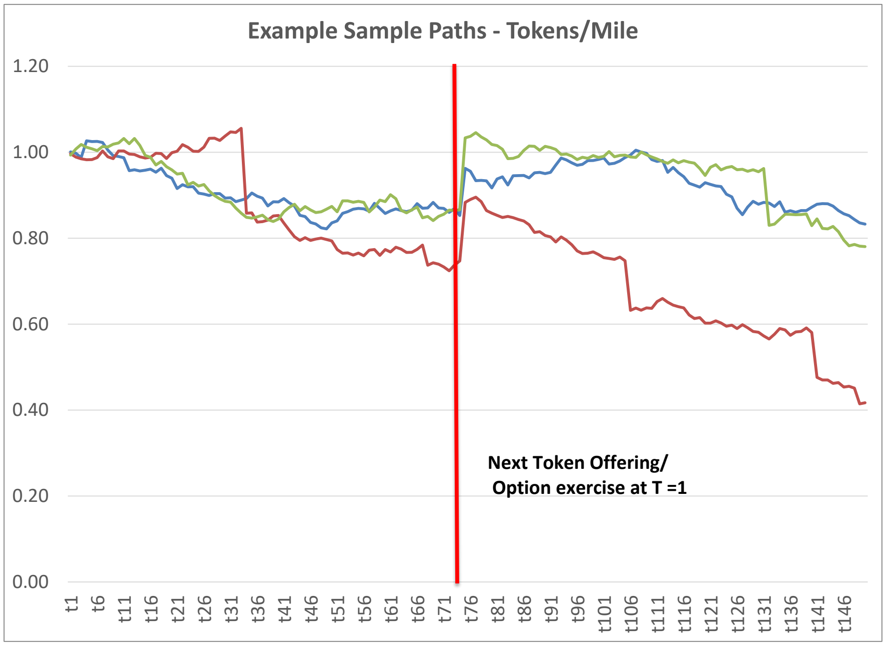


Figure 2 shows the sample paths of the $X_t^{l/m}$ process. The tokens are traded on the loyalty platform for miles. The jumps due to changes in the mile valuation are also reflected in the price of token with mile as a numeraire. Post a jump, fewer tokens are required to buy the cheaper miles. The change in the token value due to new token offering/ option exercise is visible at $T = 1$ or 75th time step.

Figure 2: Example sample paths of $X_t^{l/m}$ (Token/Mile) process



Figures 3 and 4 show the sample paths of the implied token prices $L_t^{\$/l}$ and its expected value respectively. Note, the customer is now protected from the policy-based devaluation of the miles by investing in the loyalty tokens. An initial declaration of future token issuance/ call option exercise at $T = 1$, i.e., a declared monetary policy, increases customer confidence. If the new token offering is large compared to the existing token base on the platform, there could be stark decline in the value of tokens as the customers could trade in tokens for miles before the offering and buy cheaper tokens with the bought miles after the offering. It may be advisable to have a large initial token offering following by a smaller and frequent token offerings based on the platform adoption so that the token value is preserved and exhibits steady increase.

Figure 3: Example sample paths of $L_t^{\$/l}$ (USD/Token) process

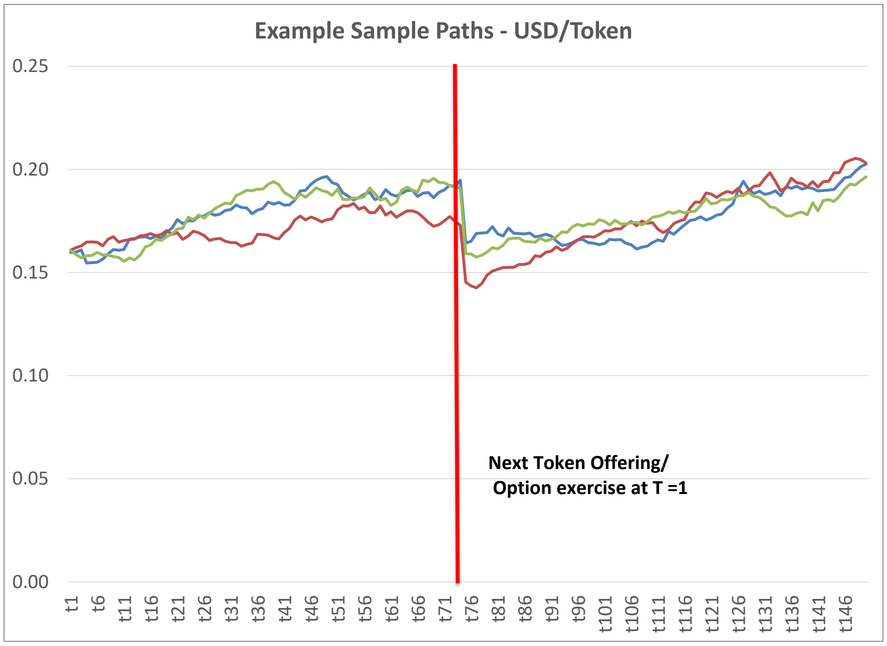


Figure 4: Expected Token Prices (USD/Token)

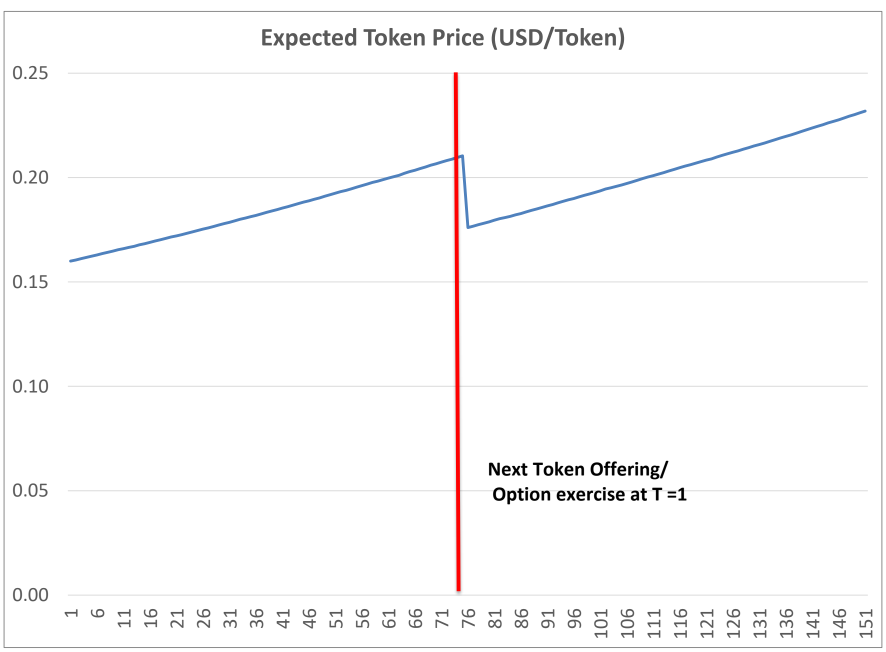


Table 2 below shows the sensitivity of the European call option prices to the Bass model parameters. Both the coefficient of innovation, p and the coefficient of imitation, q have huge influence on the option prices, indicating the importance of adoption rate.

Table 2: Value of the Contingent Claim (European Call Option) for various vales of Bass Model parameters (p and q)

		p Values →				
		0.002	***0.032***	***0.062***	***0.092***	***0.122***
	0.2	0.050	0.148	0.245	0.338	0.430
	0.3	0.069	0.172	0.272	0.369	0.464
q Values ↓	***0.4***	0.090	0.198	0.301	0.402	0.500
	0.5	0.113	0.225	0.333	0.437	0.538
	0.6	0.138	0.255	0.367	0.474	0.578
	0.7	0.166	0.287	0.403	0.514	0.621
	0.8	0.195	0.321	0.441	0.556	0.666
	0.9	0.227	0.357	0.482	0.600	0.713
	1	0.262	0.397	0.525	0.647	0.762

6 Conclusion:

Valuation of tokens is a wager on the platform adoption. This study investigates the effect of platform adoption on the valuation of loyalty tokens and the contingent claims with the token as an underlying. The platform adoption is modelled using the classical Bass Model. The example selected is that of airmiles, but the approach could be extended to loyalty token with other numeraires as well. After assuming few monetary policy rules for the platform governance, the proposed simple model predicts that the Bass Model parameters could have significant influence on the valuation of loyalty tokens and the contingent claims with the token as an underlying.

The model presented in the study is very simple and can be augmented in many ways. For example, the instantaneous volatility in the token price process is considered as constant and thus does not depend on the adoption rate. This is quite unlikely.

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