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T1 ________________	05608	F1 ________________
T2 ________________		F2 ________________
T3 ________________	Problem Chosen	F3 ________________
T4 ________________	F	F4 ________________

2019 Interdisciplinary Contest in Modeling (ICM) Summary Sheet
Summary Sheet

A Global Decentralized Digital Currency System

With the further development of blockchain technology, digital cryptocurrency has gradually become the focus in the financial field today, due to its decentralization and free transaction fee. However, its extreme volatility and uncontrollability prevent the national acceptance. In this paper, we identify the key factors affecting digital currency stability, security and national acceptance, and then propose a new digital currency system, the feasibility and performance of which has been evaluated based on the establishment of two mathematical models, as well as a regulatory framework according to the different needs of countries. This paper constructed a brand-new global digital cryptocurrency system, which grants blockchain the permission to adjust the stability of currency value in a form similar to treasury bonds. The system combines digital currency with financial derivatives to satisfy various needs of investors and comprehensively considers all factors to form a complete system.

Accounting for the heavy tails and asymmetry similar to stock market in financial distribution, we established a Skew-GED stochastic volatility model to estimate parameters including volatility, volatility persistence and noise, and innovatively used a software called Winbugs to calculate the probability distribution of simulated parameters. Comparing the volatility of Bitcoin represented digital currencies and Dow Jones Industrial Index represented stock market, it is presented that the risk of the digital market are far greater than that of stock market which has already been considered highly risky. Therefore, in order to achieve its global circulation, we then formulated a Fractal Brownian Motion (FBM) model based on Least Squares Monte Carlo (LSM) approach, and combined with the previously constructed SV model to optimize the system. Prices of bonds currency under different volatility have been obtained, as well as the range of fluctuations, suggesting the small possibility of breaking through the artificial bottom line we set up, thus verifying the stability of our new system.

In order to measure the national acceptance of digital currency, we introduced several metrics which are sub-divided into two categories and reduced them into seven through Principal Component Analysis (PCA) by Matlab. The most influential indicators consist of quantifiable indicators such as ECI, KEI, Gini Coefficient and other non-quantifiable indicators like political form, culture. After comprehensively scoring, the top five countries with the highest level of acceptance of digital currency are the United States, Sweden, Singapore, the United Kingdom, and Germany, which is in line with the commonsense.

Anonymity of digital currency makes it a threat to national and personal security. Therefore, we formulate a strict regulatory mechanism by delegating the power of supervision to government and the central bank, rather than adopting a laissez-faire attitude. The specific means include shifting to weak centralization, generating initially a digital currency buffer pool, etc., which can effectively curb tax evasion and illegal trading.

Through our optimized currency issuance model, established digital currency system by simulating the national monetary policy, estimation of national acceptance and a series of regulatory measures, the circulation of digital currency will be promoted and benefit both individual and state, eventually become the global currency issued by ICM.

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1 Letter to National Leaders

Dear Sir,

We, the ICMRUN team, with great honor, are tasked to help your country identify the viability and effects of a global decentralized digital financial market. A new digital currency system has been developed, the feasibility and performance of which has been analyzed based on the establishment of two mathematical models. Meanwhile, we also propose a regulatory framework based on selected indicators.Here are our latest findings.

In order to achieve our primary goal of reduce the extreme volatility of digital currency's price which offset its benefits, we introduced bond and stock digital currency in our proposed global decentralized digital financial system. Furthermore, we set 'smart tokens' to implement the Banco Protocol and automatically promote price discovery and provide continuous liquidity. Several metrics have been introduced to determine whether a country is suitable for promoting digital currencies, the most influential factors among which consist of ECI, KEI, Gini Coefficient, etc. As for gray-black zone, we formulate strict regulatory mechanism by delegating the power of supervision to your government and the central bank, rather than adopting a laissez-faire attitude, which allows you to easily smear the illicit trading account, curb tax evasion and illegal trading. In a word, based on our evaluation models, selected indicators, and regulatory framework, we have several politic recommendations as follows, if your country belongs to

- **Developed countries.**We recommend you to partially adopt the global digital currencies while retaining your own national currencies, because the booming economy requires a convenient and convenient currency with no fees. Meanwhile, more attention ought to be paid against malicious attacks and currency crash by building digital currency buffer pools.
- **Developing countries.** Implementation of weak-centralized measures need to be focused on, such as setting up super accounts, clearing illegal trading accounts and setting transaction limits, which may affect the benefits of digital currency, but imperative in the initial establishment of our system.More specifically, you are suggested to consider the wide adoption of global digital currencies or even abolishment of the national ones if your country is suffering from serious inflation or unstable social unrest. If there is sufficient funds, more research resources can be put into economic development, so that your country can better deal with the increasingly complex economic environment in the future.

The popularity of a global digital financial market is an inevitable trend. We hope that you can consider applying these politic recommendations to your country, which will be a challenge as well as an opportunity to stimulate your country's economic development.

Yours Sincerely,

Team# 05608

2 Introduction

2.1 Background

Digital currency is an electronic cash system based on peer-to-peer thinking and technology, which has ignited around the world around 2012. Completely subverting the traditional trading model including overly-restrictive security and debt measures that rely on oversight by large banks and governments, its convenience, anonymity, irreversibility and significant decentralization have received attention from all walks of life. Admittedly, secure digital currencies is able to provide a more convenient and safer form of financial transactions; for example, a generally accepted currency will achieve a truly global financial market and protect individual assets from regional inflationary fluctuations and the manipulation of currency by regional governments. However, besides the security of cryptocurrencies, there is also concern that lack of regulation around these currencies and their anonymity expose citizens to dangerous and risky situations for they are easily used for illegal transactions, such as tax sheltering or drug abusing. Therefore, due to their inherent risk of being not yet scientifically assessed and controlled, and security issues being not yet properly addressed, digital currencies cannot be widely accepted around the world. If alternative digital systems become more sophisticated, current banking systems and nation-based currencies will be influenced in a great sense.

2.2 Restatement of the Problem

We are required to establish a model that adequately represents a global decentralized digital financial market to identify its viability and effects. Then we are expected to modify the current banking and monetary models with the consideration of different needs of countries and their willingness to work with this new financial marketplace. In addition, the long-term effects of such a system on the current banking industry, world economy and international relations between countries, as well as the mechanisms for oversight of such a global digital currency are also included. In order to solve those problems, we will proceed as follows:

- **Stating assumptions.**The focus of our approaches towards the problems will be narrowed under the stated assumptions.
- **Making notations.** Notations critical to clarify the models will be given.
- **Building a model.** Identifying key ingredients that would limit or facilitate its growth, access, security, and stability, the model is aimed to
- **Model testing and sensitivity analysis.**With the criteria based on the models above, we evaluate the viability and performance of our adopted strategies, and do the sensitivity analysis.
- **Further discussion.**We Then we improve our model to apply them in reality.
- **Evaluating the model.**Strengths and weaknesses of our model is analyzed in this part.

3 Assumptions and Justification

To simplify the problems and make it easy for us to simulate real-life conditions, we make the following basic assumptions, each of which is properly justified.

- **Volatility of digital currency must meet the Efficient Markets Hypothesis (EMH).**The market must be fluid and fair so that every participant can achieve the same amount of information. In addition, there is no need to pay additional transaction fees when trading.
- **The price change of potential assets is continuous and meets the Geometric Brownian Motion (GBM).**Since standard option pricing formula based on geometric Brownian motion requires transactions to be continuous, each price increment must be infinitely separable.
- **The risk-free rate is constant.**

4 Notations

The primary notations used in this paper are listed in **Table 1**.

Table 1: Notations

Symbol	Definition
y_t	the observable access return
h_t	volatility
μ	fluctuation level parameter
φ	volatility persistence parameter
τ	accuracy parameter
P	price
C	current supply of virtual currency
B	reserve virtual token balance
CRR	Constant Reserve Ratio

5 Model Overview

Firstly, we constructed a new digital currency circulation system, the volatility of which can be measured by Skew-GED stochastic volatility model and the market price be calculated through Fractal Brownian Motion (FBM) model based on Least Squares Monte Carlo (LSM) approach. According to the comparison between the original and new currency and the current stock market, a strong stability of the new system has been demonstrated.

Secondly, in order to analyze the national acceptance of digital currency, an evaluation model was established based on Principal Component Analysis (PCA). By combining quantifiable economic and social indicators with non-quantitative political and cultural indicators, we presented countries most suitable for promoting digital currencies.

Finally, in terms of security, new regulatory measures were proposed to solve the derived security problem.

6 Volatility Evaluation Model

6.1 Database

In order to explore the shortcomings of the existing digital currency, this paper selects Bitcoin as representative. Model testing is based on the data selected from the CoinMarketCap website, a well-known cryptocurrency data platform that provides users with comprehensive digital asset information by tracking over 1600 cryptocurrencies and summarizing more than 200 exchange data. Our adopted basic information of Bitcoin, such as market value, price, liquidity, total amount, and trading situation in detail is all achieved from CoinMarketCap and therefore the transparency and authenticity of data can be guaranteed.

6.2 A Skew-GED Stochastic Volatility Model

Accounting for the heavy tails and asymmetry in financial distribution characteristics, a biased generalized error distribution (Skew GED) in SV model is introduced, which substitute the conditional normal distribution of the returns.

Based on stochastic volatility model, the observable access return y_t can be defined as

$$y_t = \beta exp\{h_t/2\}\epsilon_t \tag{1}$$

where β is a scale factor, and ϵ is a random return shock with some known distribution. While the unobservable log of squared volatility h_t satisfies the following first-order autoregressive process

$$h_t = \mu + \varphi(h_t - \mu) + \sigma_\eta \eta_t \tag{2}$$

Letting x be a GED random variable with zero mean and variance one, the probability density function (PDF) of the GED is given by

$$f(x) = \frac{\upsilon}{\lambda(x)\Gamma(1/\upsilon)2^{1+1/\upsilon}} exp\{-\frac{1}{2}|\frac{x}{\lambda(x)}|^{\upsilon}\} \tag{3}$$

where

$$\lambda(x) = [2^{-2/\upsilon}\frac{\Gamma(1/\upsilon)}{\Gamma(3/\upsilon)}]^{1/2} \tag{4}$$

where $\Gamma(\cdot)$ denotes the gamma function, λ relates to the asymmetry and the parameter υ controls the thickness of the tails: for υ = 2 the GED reduces to the normal density while for υ < 2 a leptokurtic density (with heavier tails than the normal one) and a platykurtic density (with thinner tails than the normal one)for υ > 2.

6.3 Markov Chain Monte Carlo Method

Since the general financial time series has hundreds to tens of thousands of observations, it is difficult to calculate the parameters in the SV model using traditional numerical analysis techniques such as maximum likelihood method. Therefore, Bayesian method is extended by Markov Chain Monte Carlo (MCMC) method here to estimate the four parameters reasonably.

Letting $\theta = (\mu, \varphi, \eta)$ be the main parameter vector, what we need to obtain is the posterior distribution of the parameter vector given the data, namely, $p(\theta|y)$.Starting with an initial given state $(\theta(0), h(0))$, a Markov chain can be generated as

6.4 Strengths and Weaknesses

6.4.1 Strengths

- Compared with the Garch model applied in the previous research, SV model has a higher flexibility, better fitting for financial time series, and has good predictive ability, and can handle the volatility of samples.
- With a large improvement in dynamics and accuracy, Our model is able to better capture the sequence correlation of heteroscedasticity and volatility.
- The proposed model adapt to the high kurtosis and heavy-tailed distribution in real financial market, so that the estimate is closer to actual value.

6.4.2 Weaknesses

- Although MCMC and EIC methods can be applied to simplify calculations, the model still requires considerable effort for calculation and statistical work.
- Although the parameter error estimated by the Kalman filter algorithm and the MCMC algorithm is within a reasonable range, it is still difficult to obtain an accurate likelihood function to estimate parameters.

7 Market Value Estimation Model

7.1 Fractal Brownian Motion

The key to the stability of the currency value lies in whether the value of the bonds will fall below the bottom line, that is, whether bond-type digital currency can be used to achieve the purpose of shrinking the currency, so the market value of such currency will be discussed preferentially. Therefore, we establish a digital currency market value estimation model based on Fractal Brownian Motion and realized with Least Squares Monte Carlo simulation.

A large number of studies have shown that the price of financial assets does not strictly follow the Geometric Brownian Motion (the premise of the Black-Scholes model), that is, the yield of financial assets with the characteristic of long-term autocorrelation is not subject to a normal distribution, but a 'heavy-tailed and skewed' empirical one. Fortunately, the increments in Fractal Brownian Motion (FBM) are not independent and thus more in line with the actual characteristics of financial option prices.

The fractional Stochastic Differential Equation (SDE) describing stock price process is as below,

$$dS(t) = \mu(t)S(t)st + \sigma(t)S(t)d\beta(t, H), 0 \leq t \leq T \tag{5}$$

where the drift term $\mu(t)$ refers to the riskless rate of return on this asset, and $S(T)$ is interpreted as the price of the stock at T, $\beta(t, H)$ denotes a fractional Brownian motion of order H as defined by the Riemann ˇ Liouville derivative.

Specifically, the mutually independent increments of $\beta(t, H)$ can be defined by Maruyama notation,

$$d\beta(t, H) = \omega(t)(dt)^H, 0 < H < 1 \tag{6}$$

where $\omega(t)$ is a Gaussian white noise with zero mean and the variance σ^2.

In order to determine respectively the yield and volatility coefficients μ and σ in the Brownian equation of motion, we substitute the historical return of the US 10-year Treasuries,Standard & Poor's 500 Index and bitcoins for nearly six years into the first model and sample from non-stationary time series by block bootstrapping.

7.2 Least Squares Monte Carlo Estimation

Since the American option allows the option holder to execute the option at any time prior to the expiration date of the option, and the gain of an option depends on the underlying asset price history information, the Least-Squares Monte Carlo (LSM) Approach is applied to estimate the conditional expected payoff to the option holder from continuation.

Though LSM method, a sample path for the underlying asset price can be first generated, then a simple quadratic polynomial of the current underlying asset price S, which is approximated as the conditional expectation,

$$E^Q[e^{-\gamma\Delta t}f_{t+1}(S_{t+1}|S_t)] \approx a_1 + a_2S_t + a + 3{S_t}^2 \tag{7}$$

And the coefficients a1, a2, a3 in the above conditional expectation can be calculated by regression.

In order to obtain the optimal option execution time and corresponding payoff on each sample path, one must compare the expectation with the immediate exercise value to determine whether to exercise at each point t.

$$S = \max(u(t), \tilde{S}) \tag{8}$$

where $u(t)$ is the payoff representing value of early exercise, and $\tilde{S}$ is the expected value Let the discount factor over a single time period be $e^{-\gamma\Delta t}$. By discounting the option income of each sample path with a risk-free rate, the expected price S at a point t is

$$\tilde{S'} = E_t[e^{-\gamma\Delta t}S_{t+1}] \tag{9}$$

This procedure is recursively backwards until the first exercise date, that is, the price of the American option is found when discounting the obtained cash-flows to time zero, which is in fact the empirical average over a chosen set of branches continuing from t.

7.3 Strengths and Weaknesses

7.3.1 Strengths

- Since the Fractal Brownian Motion used in this paper is an improvement of the original theory, namely, the Geometric Brownian Motion, it can better interpret the heavy tail distribution of the real financial market, therefore performs better on pricing and analyzing future trend.
- This model ensures the reliability of the obtained parameters by considering the historical returns of Bitcoin, Ethereum, Standard & Poor's 500 Index, and US 10-year Treasury and extracting yield and volatility samples from non-stationary time series by block bootstrapping.
- In the pricing process, the proposed LCM algorithm greatly reduce the iterative calculation amount under the premise of guaranteeing the accuracy of the market value. In addition, LCM algorithm can also be applied to multidimensional problem.

7.3.2 Weaknesses

- The LCM algorithm highly dependent on the path and have high requirements on the fitting degree of the function.

8 Proposed Digital Currency System

In terms of stability, since digital currency has no real value but a fluctuation mode of similar to that of stock, there is an extreme volatility of its price with no lower limit, making it difficult to be widely circulated on a global scale. What's more, digital currency lacks a negative feedback mechanism, which offers reliable adjustment when the currency value rises and falls, also resulting in its instability.Based on the above analysis, we have developed two solutions.

8.1 Stability Strategy

8.1.1 Parallelization of Three different Tokens

The system we want to issue is not just a single form, but one composed of three tokens, determining the issuance and destruction of digital currency together. Each type of digital currency consists of three components,namely A, B and C, to maintain the stability of currency system.

- **The first one: A currency.**Similar to the original one, A currency can be exchanged directly with the US dollar or euro. As the core of the whole system, its value is related to the exchange rate.
- **The second one: B currency.**B currency can be analogized to bonds in the real market, which does not directly trade with any real currency. The following provisions are made for the B currency: 1)It does not directly trade with any real currency, but a B currency can be exchanged for an A currency in the future. 2)The newly issued B currency will sell for less than one at auction, which is similar to the bond's discounted issue. 3)The validity period of the B currency is tentatively set at 5 years. 4) The condition for reclaiming the B currency are: the blockchain needs more digital currency while the bond coins issued before this have expired.
- **The third one: C currency.** C currency is the stock currency, which is supplied quantitatively when the blockchain is created. Their value comes from share dividends–shareholders may obtain in proportion a newly created virtual currency meant for meeting current demand.
- **The fourth one: D currency.** Similar to option currency, D currency symbolized the integration of blockchain technology and financial derivatives. Unlike traditional options which have an obvious centralization feature, that is, most investors' losses will flow into the platform, the total amount of D currencies will be issued in the initial stage of operation and the unsold proportion will be automatically destroyed. Except for a small part of the necessary transaction costs, the remaining 100% of payoff is completely distributed to option holders. The platform does not participate in the distribution of benefits in the process, significantly reducing mistrust between investors and between investors and the platform.

Similar to option currency, D currency symbolized the integration of blockchain technology and financial derivatives. Unlike traditional options which have an obvious centralization feature, that is, most investors' losses will flow into the platform, the total amount of D currencies will be issued in the initial stage of operation and the unsold proportion will be automatically destroyed. Except for a small part of the necessary transaction costs, the remaining 100

The ideal system is expected to measure the market supply of digital currency so that it can match the exchange rate of A currency and US dollars. In this paper, we propose the weakly centralized blockchain technology to adjust the money supply through B and C currency in this model. The procedure is as follows: Determine the real-time digital currency exchange rate. This model constructs a weighted trustee mechanism. Among the investors holding a certain amount of A-type coins, a total of ten investors are randomly selected to vote for the average exchange rate of the previous 10 minutes. Then the rates are weighted based on the proportion of their holdings of digital currency, and the average is taken as the final rate. Investors who deviate from the average exchange rate in consecutive voting will be eliminated by the system and no longer have voting rights.

Expansion of money supply coping with continued currency appreciation When A currencies are needed the market, blockchain will repay B holders chronologically. If all issued B currencies have been repaid, the remaining A currencies required to be issued are distributed to C holders in proportion to the amount of their holding. The specific procedure is as follows:

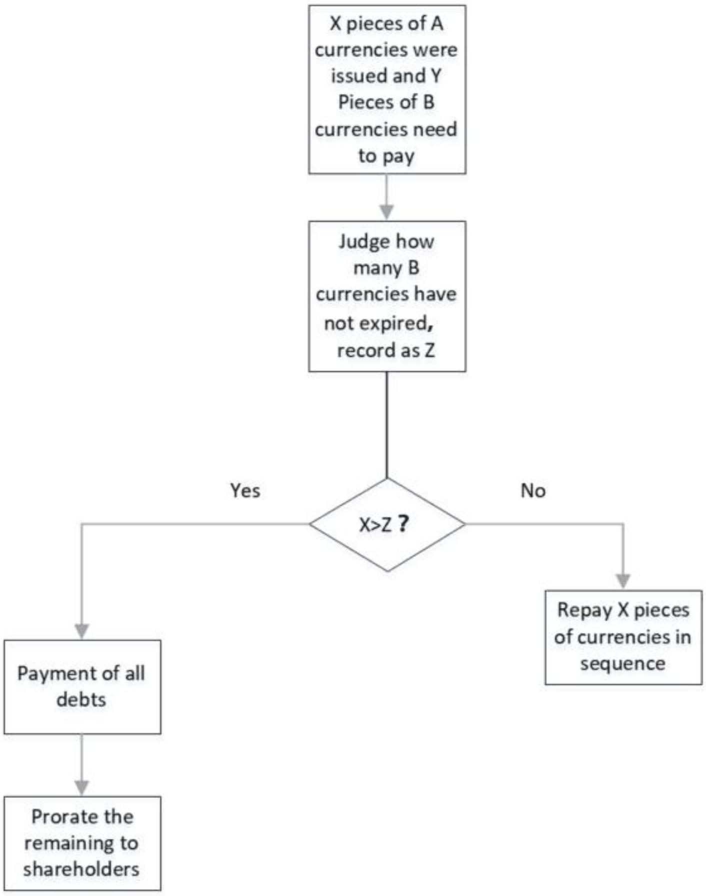

Figure 1: Expansion of Money Supply

Shrinkage of money supply coping with continued currency depreciation Currency circulating in the market is recycled through selling B currency in the way of competitive bidding. Each investor can decide their own bid for the B currency, but not lower than the artificial bottom line established by the system (usually 0.1-0.15 times of A). The specific procedure is as follows:

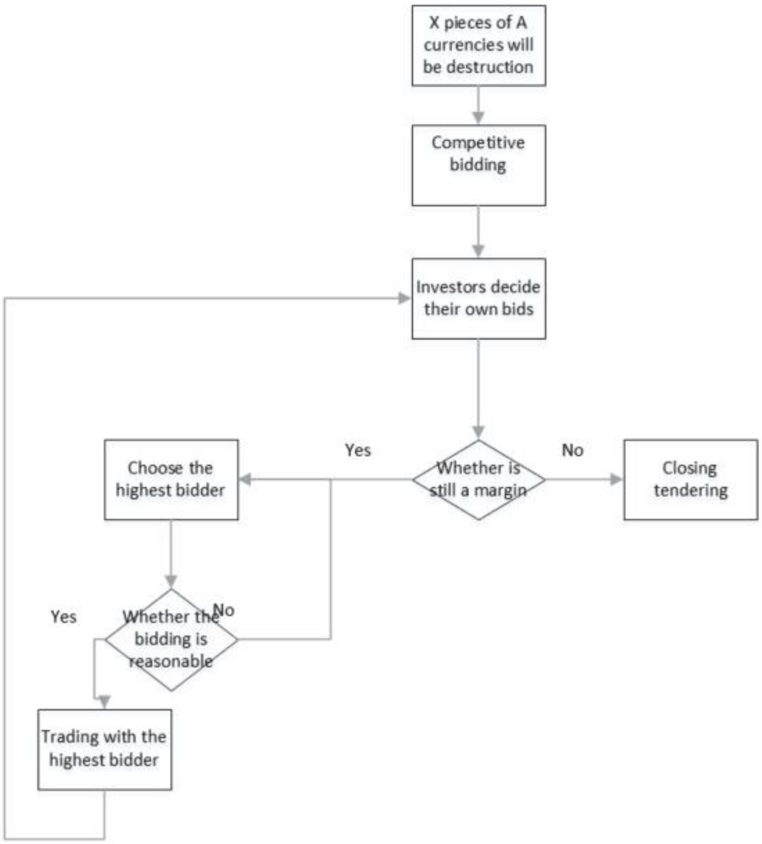

Figure 2: Shrinkage of Money Supply

8.1.2 Smart Tokens Based on Banker Protocol

We introduced ′smart tokens′, which are mainly used to implement the Banco Protocol and automatically promote price discovery and provide continuous liquidity. The creators of ′smart tokens′ contributed to price discovery by setting a Constant Reserve Ratio (CRR) for each digital currency. The current price is calculated as follows

$$P = \frac{B}{S \cdot CRR} \tag{10}$$

where S refers to the current supply of virtual currency, B indicates the reserve virtual token balance, and CRR is short for Constant Reserve Ratio which is set by the issuer of the token. According to the above formula, if a token with a CRR less than 100% is paid, increasing both the balance and supply of the currency, its price will eventually rise, for the latter is multiplied by a score. Similarly, when token is cleared, it will be subtracted from the supply, and then the currency be transferred to the "liquidator" based on the current price.Therefore, it is demonstrated that this kind of asynchronous price discovery process balances the amount of payment and liquidation by constantly adjusting the current price.

In particular, a token exchanger can be set up at the beginning of the blockchain, which is a "smart token" that holds multiple digital currencies with a total CRR of 100%. The so-called exchanger is designed for providing an exchange intermediary service among digital currencies it holds, which is done in two steps: pay this "token converter" with a digital currency; immediately clear the "token exchanger" to another digital currency. Each time a digital currency X is converted to another digital currency Y, the price of X decreases and the price of Y rises. Although larger trading volumes affect prices more sharply, more digital currency balances will eventually reduce price volatility.

8.2 Model Implementation and Results

8.2.1 Previous Performance

By comparing the stock market (represented by Dow Jones Industrial Average) and the digital currency market (represented by Bitcoin), we analyze the particularity of the digital currency market. The solution process is performed by a Bayesian statistical software called WinBUGs. The simulated posterior distributions of parameter are as follows:

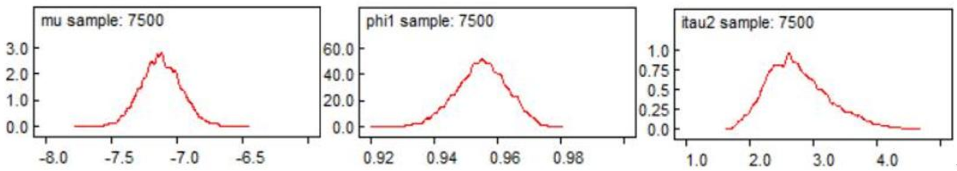

Figure 3: Distribution of Bitcoin's Parameters

Table 2
Parameters by Bitcoins

Node	mean	sd	MC error	2.5%	median	97.5%
μ	-7.122	0.1558	0.004251	-7.419	-7.126	-6.808
ϕ	0.955	0.0081	5.767E-4	0.934	0.9525	0.9674
τ	2.762	0.4868	0.041223	1.957	2.697	3.854

Table 3
Parameters by DJI

Node	mean	sd	MC error	2.5%	median	97.5%
μ	-0.5152	0.1573	0.00379	-0.822	-0.5154	-0.1976
ϕ	0.9694	0.0068	3.682E-4	0.9555	0.9696	0.982
τ	8.467	1.673	0.127	5.612	8.315	12.05

According to the fluctuation level parameter μ and its posteriori confidence interval of the bitcoin in the table, the absolute value of the fluctuation level is much larger than that of Shanghai Stock Index. Even if compared with the stock market with great uncertainty, the existing digital currency such as Bitcoin is far more risky than that, which demonstrates the risk of digital currencies uncontrollable and difficult to assess.

Volatility persistence parameter φ and its corresponding a posteriori confidence interval confirm that the risk persistence of both markets have strong persistence, and the sustainability of the Dow Jones Industrial Average even slightly stronger than Bitcoin.

The accuracy parameter τ is used to measure the level of disturbance of market fluctuations, which is inversely proportional to the noise level. Since Dow Jones Industrial Average's τ is much larger than Bitcoin's, the existing digital currency market has a far greater noise.

8.2.2 Improved Performance

The probability density distribution function of the volatility of S&P 500 Index, US 10-year national debt and Bitcoin is obtained by the volatility evaluation model. Their images and parameters are as follows:

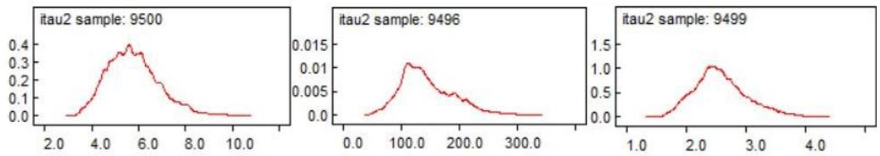

Figure 4: Distribution of τ

Table 4
Parameters by S&P 500 Index

Node	mean	sd	MC error	2.5%	median	97.5%
μ	-0.6239	0.1479	0.00315	0.9117	-0.6234	-0.337
ϕ	0.9603	0.0086	5.335E-4	0.9412	0.961	0.9753
τ	5.489	1.122	0.087	3.478	5.428	7.865

Table 5
Parameters by US Ten-year Debt

Node	mean	sd	MC error	2.5%	median	97.5%
μ	-0.3622	0.2207	0.01543	-0.834	-0.3474	0.04812
ϕ	0.9957	0.0021	1.413E-4	0.991	0.9959	0.999
τ	144.5	46.68	4.428	71.45	135.4	253.8

Table 6
Parameters by Bitcoins

Node	mean	sd	MC error	2.5%	median	97.5%
μ	-0.8824	0.1533	0.00324	-1.178	-0.8849	0.5742
ϕ	0.952	0.0085	5.263E-4	0.934	0.9525	0.9674
τ	2.576	0.4454	0.03435	1.823	2.528	3.582

Substitute the samples collected by block bootstrapping into market value estimation model. Take N=5000 and M=10000, we can plot the price of the B currency with respect to volatility as follows,

It can be seen that as volatility rises in the interval [0,1], the peak value of bond currency B will always converge to a value, which is the price of A currency, in line with the theory that bond coins are generally not issued at a premium. Moreover, the minimum value of B currency is slightly less than 0.5, which is about 0.18 times of the

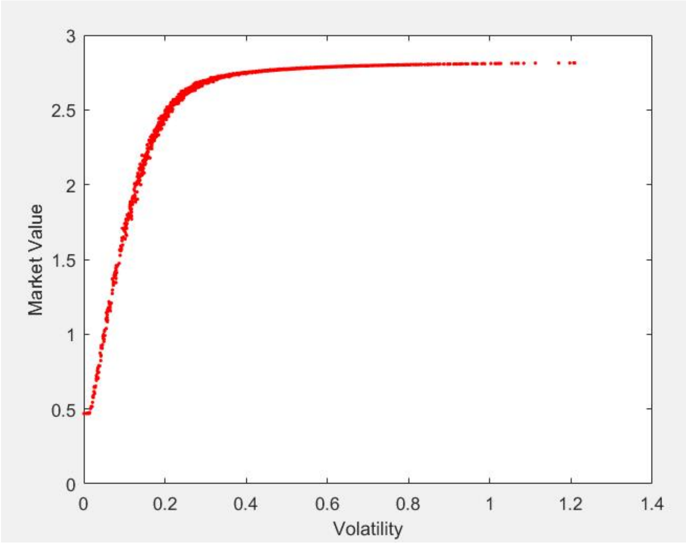

Figure 5: Price of B Currency to Volatility

maximum value of A, allowing a large margin with the current artificially-set bottom line 0.1 Therefore, even under a strong continuous fluctuation, little chances are there for the price of B currency to reach the bottom line, that is, there will be no excessive borrowing that causes the demand to exceed supply. In terms of stability, the existence of B currency can effectively guarantee the stability of the digital currency system. Although there is still a gap compared to the real currency, it has already achieved remarkable improvement theoretically.

9 National Acceptance of Digital Currency

9.1 Indicators for Measuring Acceptance

From a number of indicators, this paper elects the nine factors that most influence the national acceptance of digital currency, sub-divided into two categories, one is used to describe economic development, the other to measure social environment. The economic indicators include the Economic Complexity Index (ECI), the Inflation Rate (IR), the Share of Exports in GDP, the Knowledge Economy Index (KEI), Purchasing Power Index (PPI) and the GDP Growth Rate, while the social ones consist of Gini Coefficient, Crime Rate Index (CI). According to the definition of each factors, the negative correlated ones (i.e. CI and Gini Coefficient) should be considered as the reciprocal form.

- **Economic Complexity Index (ECI):**It calculated by the MIT Economic Complex Observatory is based on data provided by the United Nations Commodity Trade Commission, which indicate the complexity of a country's economic system and its acceptance to a new one. The larger the indicator, the higher the complexity of national economic system.
- **Inflation Rate (IR):**This parameter describes the ratio of the currency excess and the actual amount of money needed. It is intended to reflect the extent of infla-

tion and currency depreciation and mainly measure the stability of the domestic currency.

- **Knowledge Economy Index (KEI):**It is proposed by the World Bank Institute using the Knowledge Assessment Method (KAM) to measure whether a country can provide appropriate conditions for knowledge to contribute to economic development.
- **Share of Exports in GDP:**It refers to the total export value of a country as a percentage of total GDP, which reflects the dependence of a country's economic development on foreign trade. The data come from CIA WORLD FACTBOOK.
- **GDP Growth Rate:**It is an important indicator to measure a country's development level and prospects, representing the length of time required for the improvement of national living standards.
- **Gini Coefficient:**It is an indicator that reflects the degree of social stability, representing the income or wealth distribution of residents in a country, which is proportional to the gap between rich and poor.
- **Crime Rate Index (CI):**It refers to the ratio of criminals to total population, which is one of the important factors in crime statistics and indicators to measure social stability in our model.
- **Purchasing Power Index (PPI):**It is an important factor that constitutes the market and affects its size. It can also suggest the consumption habits and consumption patterns of the citizens.

Apart from the above quantifiable factors, there are other non-quantifiable indicators such as political form and culture, in determining the level of acceptance of digital currency. Therefore, before the recommendations are given, we must conduct a specific analysis of the countries with relatively higher rankings.

- **Political Form.** Due to its decentralization, digital currency enables transactions across national borders without the interference of sovereign entities or central banks, which is not easily accepted by socialist countries, even with high scores based on economic and social factors. Therefore, before the implementation of digital currency circulation, it should also be balanced with the specific political environment of the country and its recent developing strategies.
- **Culture** The generally biased attitude of residents towards investment risk and the prosperity of a country's investment culture also directly affects the acceptance of digital currency. For example, in Japan where investment culture is prevalent, people are prone to invest, while Chinese people fear of the risk are more inclined to save their income.

9.2 Principal Component Analysis

Through Principal Component Analysis (PCA), the first eight variables are reduced to seven, each of which will be analyzed separately as below:

PV =

	The first component	The second component	The third component	The third component	The third component	The third component	The third component
ECI	0.4208	-0.0331	-0.0531	0.1773	0.0533	-0.1558	0.8645
IR	-0.2382	-0.0428	-0.5511	0.7192	-0.0233	0.3459	-0.0028
Share of Exports in GDP	0.1485	-0.3671	0.7192	0.4326	-0.2287	0.2866	-0.0643
KEI	0.4439	0.1848	-0.0434	0.1137	0.1823	-0.0058	-0.2355
Gini Coefficient	-0.3037	0.5376	0.2628	0.1146	-0.0315	0.0281	0.2584
The GDP Growth Rate	0.3653	0.2857	-0.0065	0.4098	-0.1053	-0.5668	-0.3407
the GDP Growth Rate	-0.2861	-0.4148	0.1183	0.1889	0.7056	-0.4091	-0.0029
CI	0.3034	-0.5031	-0.3007	-0.1722	-0.2323	0.0057	-0.0437
PP1	0.3841	0.1799	0.0282	-0.0696	0.5892	0.5333	-0.0912

Figure 6: Shrinkage of Money Supply

- **The first component: KEI and ECI with the ratio of 0.4782.** It is demonstrated that these two indicators have the greatest impact, close to 50%, on the overall, for that countries with high acceptance of digital currency are willing to invest more resources in innovative industries, that is, they are willing to conduct researches and analyses on digital currency and try to make it positively affect the national economy. Besides, the relatively high economic complexity also indicate that the country is more likely to embrace the new financial system, so is the digital currency. Conclusively, consistent with our commonsense, subjective will and value orientation of a country are the decisive factors, which has been confirmed by the example of Japan. With the highest degree of economic complexity, Japan has few restrictions on bitcoin—-over 400,000 shops have announced acceptance of Bitcoin payments, even under the trend of suppressing digital currency.

- **The second component: CI and Gini Coefficient with the ratio of 0.1729.** These two indicators analyze the impact of social stability on digital currency acceptance, because countries with higher crime rates and Gini coefficients are not suitable for large-scale circulation of digital currency. Due to its anonymity, the circulation of digital currency will in a sense protect transactions that are illegal or even endangering social stability, such as drug trafficking and arms trading. If countries with insufficient social stability, especially those with terrorist organizations, the large-scale circulation of digital currency is undoubtedly bringing convenience to the perpetrators. Therefore, in terms of national security, the acceptance of digital currencies in such countries will decline.

- **The third component: Share of Exports in GDP with the ratio of 0.1036.**This component is closely related to the important characteristics of the digital currency, including no exchange rate, tax exemption. Digital currency with an extreme low transaction fee, for example, Bitcoin only needs 1 bit per transaction to ensure the fast execution of the transaction. Therefore, countries with high dependence on foreign trade have higher demand for digital currency, which is well demonstrated by Share of Exports in GDP.

- **The fourth component: Inflation Rate with the ratio of 0.0925.**If a country's inflation is too rapid, the national trust in the local currency will gradually decline, while the enthusiasm for foreign exchange investment such as digital currency will rise, leading to the country's acceptance of digital currency. This parameter is mainly from the perspective of the needs of the people rather than the entire national level, so its impact is not as great as the previous factors.
- **The fifth component: GDP Growth Rate with the ratio of 0.0624.**If the GDP growth rate is maintained at a high level, the state will adopt a series of policies of lowering the central bank deposit and loan interest rate, as well as reducing the tax rate to stimulate corporation investment and personal consumption levels. Such policies increase the amount of money available in people's hands and their willingness for investments, and spare the state enough energy to invest in the exploration of new financial markets, which will in turn promote the entry of the digital currency market.
- **The sixth component: Purchasing Power Index with the ratio of 0.0362.**The increase in purchasing power means that the accelerating speed of social production,as well as the growing ratio between residents' consumption and income, leading to a higher state's acceptance of digital currency. However, the reason for its small weight is similar to IR.
- **The seventh component: ECI with the ratio of 0.0292.**Although the last component is relatively small, it is still determined by ECI, which suggests that ECI plays a significant role in determining the extent to which a country accepts digital currency.

9.3 Results

According to our model, the top six countries with higher acceptance of digital currency are: the United States, Sweden, Singapore, the United Kingdom, Belgium and Germany.

The United States is the world's greatest economy, whose ECI and KEI are among the top in the world, which is the main reason why it is easy for the US to accept the digital currency system. Meanwhile, we can note that even though Share of Exports in GDP is relatively small, the total export value of the US ranks first in the world, indicating a great demand for foreign trade. Therefore, this country is a very suitable soil for digital currency development if it can be effectively regulated.

Next to the US, is a highly developed capitalist country, Sweden, which also has a high ECI and KEI. From the perspective of import and export, due to climatic and geographical conditions, Sweden prefers to industrial development and becomes the largest exporter of iron ore in Europe. Sweden has a small Gini Coefficient compared to other developed countries, in other words, the gap between rich and poor is slight while the social stability is high. Therefore, in line with the facts, the inferred acceptance of digital currency in Sweden is high.

Singapore ranks third. The country is the trading center across the world, with a high ECI and a strong purchasing power. Besides the degree of social stability in Singapore as well as the happiness index of the residents are among the highest in the world, which contribute to the circulation of digital currency.

However, it is not excluded that some countries with high degree of acceptance, such as Turkey, Zimbabwe which are plagued by high inflation rate, simply from economic perspective, but the implementation will be hindered by their own policies. In general, based on our overall rankings, the acceptance of digital currency by developed countries is higher than that of developing countries. Considering the Belgium's tough attitude towards digital currency, while a more friendly one is adopted by the German government which shares a similar result of acceptance calculated by indicators, we recommend to ICM five suitable countries for development, including the United States, Sweden, Singapore, the United Kingdom and Germany.

10 Regulatory Framework

- **Transform decentralization into weak centralization.** It is well known that at the current stage, many countries are still skeptical or even unacceptable for digital currencies, due to the difficulty in regulating digital currencies with the characteristic of decentralization. Therefore, ICM's new digital currency can turn decentralization into weak centralization, leaving some super accounts the privilege to suspend or freeze illegal accounts. However, in order to ensure fairness, the operation of these super accounts needs to be confined with certain legal standards and judgments. ICM can set up an arbitration committee, joined with representative of each country which legalizes the digital currency, to decide whether to suspend the account in the form of a court judgement by submitting a list or voting at the conference. By suspending the confirmed criminals' accounts, such as drug lords or extortionists, it is possible to prevent crimes and minimize the black areas effectively.

- **Turn full anonymity into incomplete anonymity.** Define the maximum amount of transactions that can be traded in a given period of time all transactions are anonymous and traded online freely within the transaction amount. However, once the rated amount is exceeded, in order to ensure the legality of the transactions, they must be traded at a specific exchange set by ICM, and subject to certain supervision by the local government. On one hand, such monitoring measure destroys neither convenience nor privacy of the small transactions that account for the highest proportion of the total volume. and can monitor large-scale illegal transactions such as bulk drug and arms trading that criminal groups like to deal in digital currency. In this way, illegal behaviors can be reduced without compromising the characteristics of the digital currency.

- **Generate a portion of the digital currency buffer pool initially.** This part of the buffer pool is used to defend against malicious attacks on the currency, such as illegal shorting, currency crashes similar to the herding effect, making digital currency more vital. Its use must be monitored under the ICM Arbitration Commission.

- **Limit the type of exchanged currency** If the digital currency is exchanged for US dollars, it will be stamped with a dollar brand which can be cancelled after the transaction. This regulation, in conjunction with the previous measures, can prevent money laundering, especially the most common multinational ones.

11 General Evaluation

11.0.1 Strengths

- Due to the protection mechanism of B and C currencies, the new digital currency system has greater overall risk resistance than the existing digital currency, and the stability of currency value can be relatively guaranteed, which is crucial for future promotion.
- The possibility of accepting the digital currency system in each country is greater than that of the original system. First, because of the diversification of investment forms, the degree of risk in various forms is different. Secondly, at the national level, the characteristics of weak centralization facilitate the country's regulatory measures, making the state more receptive to such initiatives.
- The system innovatively introduces a regulatory mechanism, similar to national debt, which can give money a stable means of regulation. Through the reverse repurchase of bond currency, we can increase the money supply and ease liquidity, thus strengthen investors' trust in the currency.

11.0.2 Weaknesses

- Weak centralization weakens the decentralization, which can minimize control and insider trading.
- Many details of the system, such as a more specific digital currency circulation process, are not given in this paper because of the lack of data and the limitations of research energy. If there is still an opportunity to study the topic in the future, it can continue based on this system through real realization of the code.

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