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## Regulation of Regional Economic Law Laws Incorporating Adaptive Differential Evolutionary Algorithms from a Blockchain Perspective

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### Abstract

This paper firstly studies the regional economic law under the perspective of blockchain, using the characteristics of blockchain as a regulatory system outside the bottom layer, but also needs to combine the application scenario of supply chain finance and build a financial and economic regulatory system and a heterogeneous multi-chain cooperative regulatory system. Secondly, in response to the problems such as the irrationality of regional economic law, the price discrimination antitrust litigation system is proposed to play the role of economic recovery. Then the digital currency economic law is studied by using an adaptive differential evolutionary algorithm, using the process of crossover, variation, and selection to obtain digital currency behavioral characteristics so as to ensure the digital currency economic visualization analysis and to plan the monetary policy of economic law and analyze the digital currency economic risk. The results show that Bitcoin's daily average right-tail VaR (94.8%) is the lowest among the listed crypto-digital currencies at 2.58%, while the left-tail mean is the highest among the three crypto-digital currencies, which is consistent with the fact that BTC has been issued for the longest time and is more mature among the crypto-digital currencies with the most dramatic tail risk variation as well as the largest magnitude.

**Keywords:** Blockchain; Differential evolutionary algorithm; Visual analysis; Antitrust litigation system; Digital currency.

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## 1 Introduction

Blockchain technology is not just a simple concept such as “distributed” and “shared”, but a new application model formed by an innovative combination of peer-to-peer systems, cryptography, distributed databases, consensus mechanisms, and other technologies, which was first applied in the Bitcoin network [1-3]. Undoubtedly, the ideas of decentralization distributed bookkeeping, and consensus mechanisms of blockchain technology are innovative and forward-looking [4]. The 2018 China Blockchain White Paper published by the Ministry of Industry and Information Technology 2018 discussed the application scenarios of blockchain in supply chain finance, trade finance, energy, underlying technology, digital currency management, and other fields [5]. As of March 2018, 456 companies have been engaged in blockchain technology in China, with a concentration of over 80% of companies in the financial and physical sectors [6]. The use of blockchain in the business sector in China has gradually shown the scene of “blossoming”, but new technologies often have two sides, and while they achieve positive effects, they also inevitably bring some negative effects, and blockchain technology is no exception [7-8]. As an innovative technology, enterprises should rationally view its advantages and defects and objectively understand its development prospects and application scenarios [9-10].

The literature [11] shows the feasibility of digitalizing the closed-loop supply chain by applying blockchain technology and logistics solutions, through which the logistics information can be better tracked, and the transparency and reliability of the supply chain can be ensured. Also, some specific application scenarios are proposed in this paper, including the use of blockchain technology for sharing and protecting logistics information, as well as reducing carbon emissions and improving supply chain sustainability through logistics solutions. The literature [12] explores the transformative impact of blockchain technology on business models and ecosystems, which can change business models and ecosystems by providing decentralized, transparent, and trustworthy ways to manage and exchange data, and the synergy between blockchain technology and human and technological agents can facilitate innovation and development of business models and ecosystems. The literature [13] uses blockchain technology to improve the transparency and traceability of agrifood supply chains, thereby reducing problems such as information asymmetry and food fraud, and increasing consumer trust in agrifood products, as well as improving the performance and efficiency of agrifood supply chains. The literature [14] explored the issue of sustainable development in international economic law and argued that the development of international economic law should follow the principle of sustainability to ensure that economic development does not undermine environmental, social, and cultural sustainability. The literature [15] analyzed the relationship between these socioeconomic risk factors and the development and treatment of heart failure and made some specific recommendations in order to improve the treatment and prognosis of heart failure patients in the region. The importance of socioeconomic factors in the treatment of heart failure was emphasized, and medical institutions and governments were called upon to increase their attention and support to these patients. The literature [16] analyzed the impact of Moore’s law on different industries and explored its challenges and opportunities for economic structures and business strategies, and also discussed the adaptation of different structures in the economic system to Moore’s law and made some specific recommendations to achieve economic growth and innovative development in the context of Moore’s law.

This paper firstly constructs a credit supervision system under blockchain technology, researches three aspects of the subject innovation, means innovation, and model innovation, and reflects the legal regulation of economic law by improving the burden of the proof system of antitrust litigation for the example case of price discrimination in economic law. Then, according to the problem of regional economic law, the research of digital currency economic law based on an adaptive differential evolution algorithm is proposed, using crossover operation to improve the variation search strategy,

then the experimental vector will replace the present target vector to become the next generation target vector, so as to obtain the optimal individual vector. Under the constraint, the Lagrangian function is used to study consumption, labor supply, and market, respectively, to provide technical and theoretical support for the development of digital currency and market economy, which is more conducive to the analysis of digital currency economic visualization. Finally, in order to prevent the massive expansion of digital currency, a series of monetary policy planning of economic law is proposed, and the validity of this paper's research is verified through the analysis of the economic risk of digital cryptocurrency and the analysis of the dynamics of digital financial assets, which has certain reference guidance value for economic development.

## 2 Regional Economic Law in the Perspective of Blockchain

### 2.1 Blockchain supply chain finance credit supervision mechanism

#### 2.1.1 Blockchain supply chain finance credit regulation

As an innovative technical means, blockchain has natural regulatory functions, and in the main innovation, including blockchain technology regulation and application scene regulation, in addition to making full use of blockchain characteristics as the bottom layer of the regulatory system, it is also necessary to combine the application scene of supply chain finance and conduct regulatory research on blockchain combination for specific supply chain finance pain points, specifically in the heterogeneous multiple of different business relationship distinctions Business sub-chain, targeted regulatory measures for member management sub-chain, depository sub-chain, and fund transfer sub-chain. The credit supervision system is constructed under blockchain technology, and is studied from three aspects of the subject innovation, means innovation, and model innovation, and the framework of the credit supervision system is shown in Figure 1.

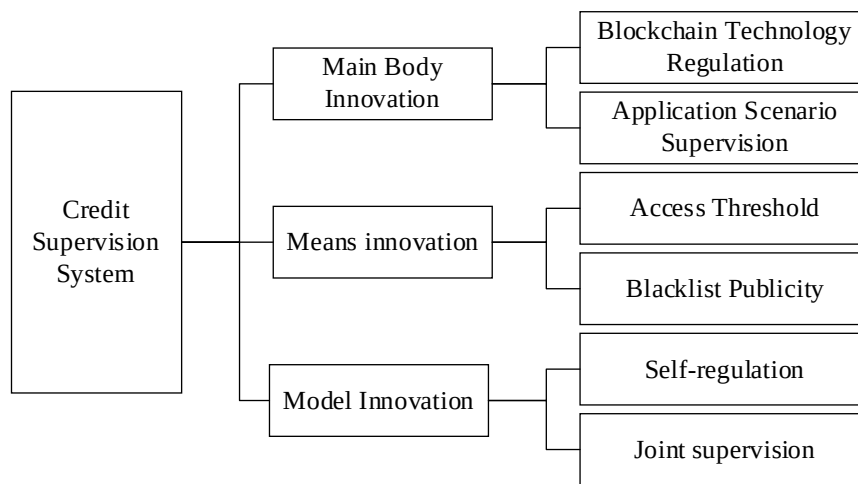


**Figure 1.** Innovative Research Framework for Credit Supervision System

The process of credit supervision of blockchain supply chain finance is divided into three stages of supervision: ex-ante deployment, ex-post analysis, and ex-post deposition. The credit supervision process is shown in Figure 2. Develop the necessary supply chain finance access threshold; firstly, there must be certain information technology means because the data are to be on the chain, it requires a standardized contract document processing. Secondly, the information is complete and true, and finally, the rules of the blockchain supply chain finance platform are required to be clear, and it is agreed that if there is a breach of trust and violation, it will face the risk of blacklist disclosure and be

punished by the legal agreement of the smart contract. The blacklist disclosure mechanism is characteristic of this simulation platform, the breach of trust and violation will be published in the form of the blacklist in the whole chain, and the blacklisted enterprises will lose the survival path on the credit network, so to maintain a stable supply chain status, we must keep the code of trust, and the blacklist disclosure mechanism becomes a natural credit red line, which will protect the enterprises while restraining them.

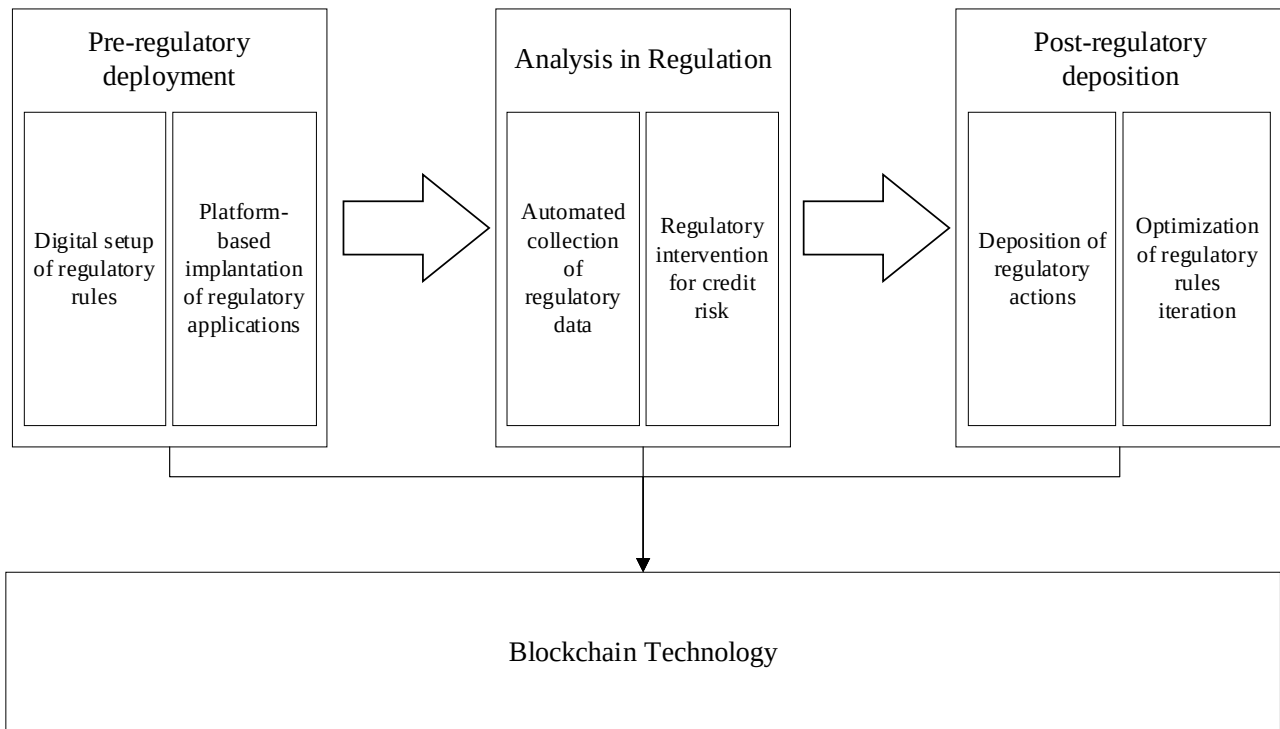


**Figure 2.** Blockchain supply chain finance credit supervision process

### 2.1.2 Heterogeneous multi-chain co-regulation

The platform can distinguish different sub-chains for different businesses in the consensus group, including enterprise information management business (member management sub-chain), contract depository business (depository sub-chain), and bill flow business (asset transfer sub-chain), so that regulators can formulate different and effective regulatory strategies for different business sub-chains to achieve regulatory focus while cooperating with multiple chains to open up information flow and capital flow and realize the whole process of supply chain finance. The regulator can formulate different and effective supervision strategies for different business sub-chains, realize supervision focus and cooperate with multiple chains, open up information flow and capital flow, and realize the whole process of supply chain finance. The specific regulatory content will be discussed from three aspects: identity supervision, depository supervision, and capital supervision. Blockchain realizes an efficient digital identity authentication mechanism, which makes the identity of enterprises to be regulated on the chain identifiable and non-repudiation. The process of depository supervision is actually the verification process after the depository, which can be used as effective and direct legal evidence due to the characteristics of blockchain's non-tampering and multi-point consensus, which does not allow anyone to modify it. The main purpose of fund supervision is to use the free and traceable flow of funds to solve the problem of enterprise financing and to measure the credit level of each enterprise by using the fundable amount.

## 2.2 Price discrimination antitrust litigation system

### 2.2.1 Expanding the scope of antitrust litigation subjects

In the specific case of price discrimination, the number of discriminated consumers is large, but the amount of individual damage is relatively small. A single person filing an antitrust lawsuit has high litigation costs, discourages private litigation, and cannot avoid the possibility of repeated lawsuits by other discriminated consumers, which will inevitably result in judicial waste, so it is necessary to expand the scope of plaintiffs in antitrust litigation. It is possible to establish antitrust public interest litigation led by the procuratorate or the antitrust enforcement agency, where the procuratorate or the antitrust enforcement agency exercises the plaintiff's right in its stead to collect evidence of price discrimination committed by operators and file public interest litigation. Alternatively, an anti-monopoly class action system can be constructed to resolve multiple disputes at once, avoiding the situation where the defendant is caught in untimely information bargaining and a large number of repeated lawsuits so that the rights and interests of the damaged party can be promptly and effectively remedied and the operator can quickly resume normal operation.

### 2.2.2 Sound system of burden of proof in antitrust litigation

A reasonable burden of proof system is a necessary condition for balancing the litigation position of the parties. In the case of algorithmic price discrimination and other private antitrust litigation, consumers are already in a vulnerable position, and an unreasonable burden of the proof system will further increase the risk of litigation for consumers and indirectly discourage them from litigation. Therefore, it is imperative to improve the burden of proof systems for antitrust litigation in China. In the case of abuse of the dominant position, the burden of proof can be allocated to the defendant so as to reduce the burden of proof on the plaintiff. The plaintiff is only required to prove the existence of damage, and the defendant is required to prove that it has not abused its dominant position to implement algorithmic price discrimination, as well as reasonable defenses that meet justifiable reasons, and the defendant is required to bear the adverse consequences of insufficient evidence.

## 3 Economic and legal research on digital currency based on adaptive differential evolutionary algorithm

### 3.1 Characterization of legal digital currency behavior

#### 3.1.1 Adaptive differential evolution algorithm

The main process of the adaptive differential evolution algorithm includes initialization of the population, variation, crossover, and selection, maintaining a pair of vector populations containing  $N_p$   $D$ -dimensional vectors in a generic implementation of differential evolution, with the  $i$ th vector in the population called  $x_{i,j}$  and  $j$  denoting the  $j$ th parameter [17]. Before initializing the population, the upper and lower bounds of the parameters are first determined, forming all domains of the  $N_p$  vectors in the initial population selected:

$$X_{i,o} \mid x_{i,j}^L \leq x_{i,j}^U, i=1,2,L, N_p, j=1,2,L, D \quad (1)$$

$$x_{i,j,0} = x_{i,j}^L + rand(0,1)(x_{i,j}^U - x_{i,j}^L) \quad (2)$$

where  $x_{i,j}^U$  and  $x_{i,j}^L$  denote the upper and lower bounds of dimension  $j$ , respectively, and  $rand(0,1)$  denotes the random number on the interval  $[0,1]$ . After initialization, differential evolution uses variation and recombination to build a new population, which contains  $N_p$  trial vectors. A schematic representation of individual differential variation is shown in Figure 3, where the operator first differs and scales two individual vectors  $x_{r1,g}$  and  $x_{r2,g}$  in the agreed population and subsequently adds them to a third individual vector  $x_{r0,g}$ , to obtain the variation vector  $v_{ig}$ .

$$v_{i,g} = x_{r0,g} + F \cdot (x_{r1,g} - x_{r2,g}) \quad (3)$$

Where  $r_0$  is the basis vector index,  $r1$  and  $r2$  are the difference vector indexes, which are all three random numbers.  $F$  is the scaling factor, which is a positive real number controlling the evolution rate of the population, and  $g$  denotes the number of generations.

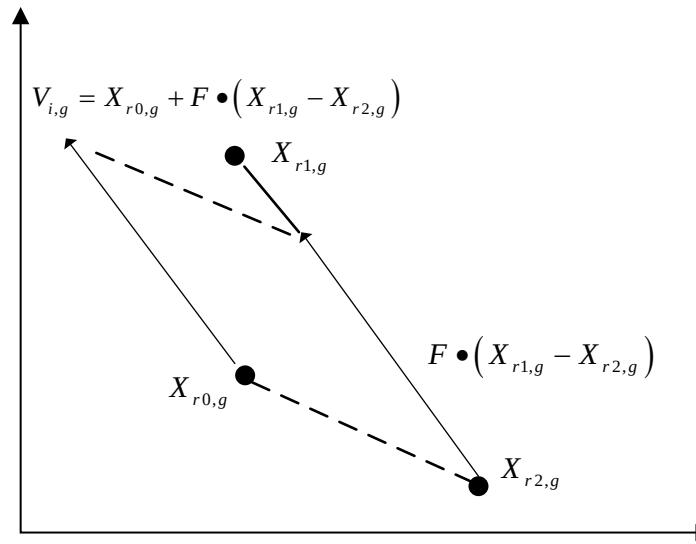


**Figure 3.** Schematic diagram of individual differential variation

The variance search strategy is refined using a crossover operation, also known as “uniform crossover” or “discrete recombination”, in which the vectors in each population are hybridized with a variance vector to produce a test vector  $u_{i,g}$ :

$$u_{i,g} = u_{j,i,g} = \begin{cases} v_{j,i,g}, & rand_j(0,1) \leq Cr, j = j_{rand} \\ x_{j,i,g}, & otherwise \end{cases} \quad (4)$$

$Cr$  denotes a user-defined crossover rate,  $Cr \in [0,1]$  and the crossover rate is compared with the result generated by a uniform random number generator  $rand_j(0,1)$ . If the random number is smaller than the crossover rate, the experimental parameter set is selected as the variant variable  $v_{i,g}$ . Otherwise, it is copied from the vector  $x_{i,g}$ .

If the objective function value of the experimental vector  $u_{i,g}$ , i.e., the adaptation value, is equal to

or smaller than the adaptation value of the target vector  $x_{i,g}$ , the experimental vector will replace the present target vector as the next generation target vector, and Figure 4 shows the overall flow of the differential evolution algorithm.

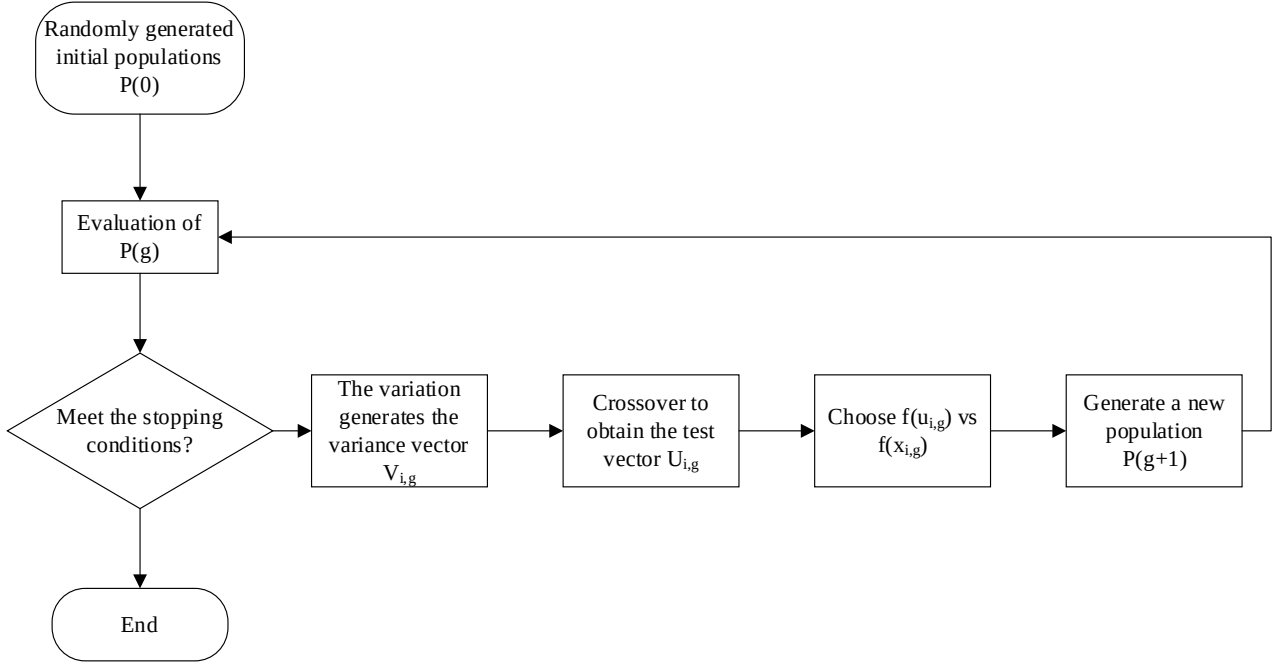


**Figure 4.** Differential evolution algorithm flow chart

### 3.1.2 Digital Currency Economic Visualization Analysis

maximizing its lifetime utility under the constraint, the Bellman equation for this problem is:

$$\left\{ \begin{array}{l} V_t = \max \left\{ \ln C_t + \zeta \ln \frac{M_t}{P_t} + \xi \ln (1 - H_t) + \beta E_t V_{t+1} \right\} \\ s.t. \left\{ \begin{array}{l} C_t = W_t H_t - T_t + \Pi_t + R_{t-1}^D D_{t-1} - D_t + \frac{R_{t-1}^B}{\Pi_t^P} B_{t-1} - B_t \\ C_t \leq \frac{M_t}{P_t} \end{array} \right. \end{array} \right. \quad (5)$$

The Lagrangian function is:

$$\begin{aligned} L_t = & \ln C_t + \xi \ln (1 - H_t) + \beta E_t V_{t+1} + \lambda_t \left[ W_t H_t - T_t + \Pi_t + R_{t-1}^D D_{t-1} - D_t + \frac{R_{t-1}^B}{\Pi_t^P} B_{t-1} - \right. \\ & \left. B_t - C_t \right] + \mu_t (m_t - C_t) + \eta_t \left\{ \left[ \alpha D_t^{1-\frac{1}{\theta_t}} + (1-\alpha) B_t^{1-\frac{1}{\theta_t}} \right]^{\frac{\theta_t}{\theta_t-1}} - m_t \right\} \end{aligned} \quad (6)$$

where  $\lambda$ ,  $\mu$  and  $\eta$  are Lagrange multipliers with different constraints. Taking derivatives of consumption, labor supply, CBDC balance, and bank balance, respectively, the following first-order

conditions are obtained:

$$\left\{ \begin{array}{l} \frac{1}{C_t} = \lambda_t + \eta_t \\ C_t = m_t \\ \frac{\xi}{1-H_t} = \lambda_t W_t \\ \lambda_t = \beta R_t^B E_t \frac{\lambda_{t+1}}{\Pi_{t+1}^P} + \eta_t (1-\alpha) \left( \frac{B_t}{m_t} \right)^{-\frac{1}{\theta_t}} \\ \lambda_t = \beta R_t^D E_t \lambda_{t+1} + \eta_t \alpha \left( \frac{D_t}{m_t} \right)^{-\frac{1}{\theta_t}} \\ (1-\alpha) \left( \frac{B_t}{m_t} \right)^{1-\frac{1}{\theta_t}} + \alpha \left( \frac{D_t}{m_t} \right)^{1-\frac{1}{\theta_t}} = 1 \end{array} \right. \quad (7)$$

Rectification leads to:

$$\left\{ \begin{array}{l} \lambda_t = \beta R_t^B E_t \frac{\lambda_{t+1}}{\Pi_{t+1}^P} + \left[ (\zeta + 1) \frac{1}{C_t} - \lambda_t \right] (1-\alpha) \left( \frac{B_t}{c_t} \right)^{-\frac{1}{\theta_t}} \\ \lambda_t = \beta R_t^D E_t \lambda_{t+1} + \left[ (\zeta + 1) \frac{1}{C_t} - \lambda_t \right] \alpha \left( \frac{D_t}{C_t} \right)^{-\frac{1}{\theta_t}} \\ (1-\alpha) \left( \frac{B_t}{c_t} \right)^{1-\frac{1}{\theta_t}} + \alpha \left( \frac{D_t}{C_t} \right)^{1-\frac{1}{\theta_t}} = 1 \end{array} \right. \quad (8)$$

In the steady state, the inflation rate is equal to 1, and the remaining variables are held constant, i.e., we have:

$$\left\{ \begin{array}{l} (1-\beta R^B) \lambda = \left[ \frac{1}{c} - \lambda \right] (1-\alpha) \left( \frac{B}{c} \right)^{-\frac{1}{\theta}} \\ (1-\beta R^D) \lambda = \left[ \frac{1}{c} - \lambda \right] \alpha \left( \frac{D}{c} \right)^{-\frac{1}{\theta}} \\ (1-\alpha) \left( \frac{B}{c} \right)^{1-\frac{1}{\theta}} + \alpha \left( \frac{D}{c} \right)^{1-\frac{1}{\theta}} = 1 \end{array} \right. \quad (9)$$

The solution yields:

$$\frac{B}{C} = \left[ (1-\alpha) + \alpha \left( \frac{\alpha}{1-\alpha} \frac{1-\beta R^B}{1-\beta R^D} \right)^{\theta-1} \right]^{-\frac{\theta}{\theta-1}} \quad (10)$$

$$\frac{D}{C} = \left[ \alpha + (1-\alpha) \left( \frac{1-\alpha}{\alpha} \frac{1-\beta R^D}{1-\beta R^B} \right)^{\theta-1} \right]^{-\frac{\theta}{\theta-1}} \quad (11)$$

### 3.2 Monetary policy planning for economic law

#### 3.2.1 Capitalist Digital Currency Planning

The final product manufacturer purchases the intermediate product and synthesizes it into the final product using the following techniques:

$$Y_t = \left( \int_0^1 Y_t(j)^{\frac{\dot{\theta}_p-1}{\dot{\theta}_p}} dj \right)^{\frac{\dot{\theta}_p}{\dot{\theta}_p-1}} \quad (12)$$

Where  $Y_t(j)$  the  $j$  nd intermediate good,  $\varepsilon_p$  denotes the elasticity of substitution between intermediate goods. The demand function for the producer of the  $j$  th intermediate good can be obtained from the profit maximization condition for the producer of the final good as:

$$Y_t(j) = \left( \frac{P_t(j)}{P_t} \right)^{-\dot{\theta}_p} Y_t \quad (13)$$

From the zero profit condition for a perfectly competitive market, the price index is also obtained as:

$$P_t = \left( \int_0^1 P_t(j)^{1-\dot{\theta}_p} dj \right)^{\frac{1}{1-\dot{\theta}_p}} \quad (14)$$

The entrepreneur's production uses the Cobb-Douglas production function:

$$Y_t^i = A_t K_t^\gamma H_t^{1-\gamma} \quad (15)$$

Where  $Y_t^i$  denotes undifferentiated intermediate goods,  $K_t$  is the capital invested, and  $A_t$  is the technical parameter by which the entrepreneur, at the end of each period  $t$ , needs external financing with the help of financial institutions (in this case, commercial banks only) in an amount equal to the difference between the price of capital goods and its own net value in the period  $t+1$ , i.e., a net value equal to assets minus liabilities:

$$B_t^j = Q_t K_{t+1}^j - N_{t+1}^j \quad (16)$$

where  $Q_t$  is the price of capital goods in the period  $t$  and  $N_{t+1}^j$  is the net value of the entrepreneur  $j$  in the period  $t+1$ . Capital follows the following process of change:

$$K_{t+1} = \Phi\left(\frac{I_t}{K_t}\right) K_t + (1-\delta)K_t \quad (17)$$

$I_t$  denotes the investment expenditure and  $\Phi()$  denotes the adjustment cost of the investment. Assuming the existence of a production sector of capital goods with the objective of maximizing its profit, the price of capital can be determined as follows:

$$\begin{cases} V_t = \max E_t \sum_{s=0}^{\infty} \Lambda_{t,t+s} [Q_{t+s} (K_{t+s+1} - K_{t+s}) - I_{t+s}] \\ \text{s.t. } K_{t+1} = \Phi\left(\frac{I_t}{K_t}\right) K_t + (1-\delta)K_t \end{cases} \quad (18)$$

The Bellman equation for this problem is given by

$$V_t(K_t) = \max \left\{ Q_t (K_{t+1} - K_t) - I_t + E_t [\Lambda_{t,t+1} V_{t+1}(K_{t+1})] \right\} \quad (19)$$

The Lagrangian function is:

$$L_t = Q_t (K_{t+1} - K_t) - I_t + E_t [\Lambda_{t,t+1} V_{t+1}] + \lambda_t \left[ \Phi\left(\frac{I_t}{K_t}\right) K_t + (1-\delta)K_t - K_{t+1} \right] \quad (20)$$

Its first-order conditions are:

$$0 = \frac{\partial L_t}{\partial K_{t+1}} = Q_t + E_t \left[ \Lambda_{t,t+1} \frac{\partial V_{t+1}}{\partial K_{t+1}} \right] - \lambda_t \quad (21)$$

$$\frac{\partial V_{t+1}}{\partial K_{t+1}} = -Q_{t+1} + \lambda_{t+1} \left[ \Phi\left(\frac{I_{t+1}}{K_{t+1}}\right) - \Phi'\left(\frac{I_{t+1}}{K_{t+1}}\right) \frac{I_{t+1}}{K_{t+1}} + 1 - \delta \right] \quad (22)$$

$$0 = \frac{\partial L_t}{\partial I_t} = -1 + \lambda_t \Phi'\left(\frac{I_t}{K_t}\right) \quad (23)$$

Thus there are:

$$Q_t = \left[ \Phi\left(\frac{I_t}{K_t}\right) \right]^{-1} \quad (24)$$

At the end of the period  $t$ , the entrepreneur needs to determine the optimal leverage ratio based on his own circumstances. Assuming that the bank loan interest rate is  $Z_{j,t}$  in period  $t$  and that the expected return on capital  $R_{t+1}^K$  is a random variable with a distribution of  $F(R_{t+1}^K)$ , and assuming that there is a threshold value such that the entrepreneur's entire capital value is just enough to repay the loan, set at  $\bar{R}_{t+1}^K$ , the entrepreneur should choose the optimal loan contract that maximizes the value of his assets:

$$\left\{ \begin{array}{l} V_t = \max \left\{ Q_t K_{j,t+1} \int_{\bar{R}_{t+1}^K}^{\infty} R_{t+1}^K dF_R(R_{t+1}^K) - \left[ 1 - F_R(\bar{R}_{t+1}^K) \right] Z_{j,t} B_{j,t+1} \right\} \\ s.t. \left\{ \begin{array}{l} Q_t K_{j,t+1} = B_{j,t+1} + N_{j,t+1} \\ \bar{R}_{t+1}^K Q_t K_{j,t+1} = Z_{j,t} B_{j,t+1} \\ \left[ 1 - F_R(\bar{R}_{t+1}^K) \right] Z_{j,t} B_{j,t+1} + (1 - \mu) Q_t K_{j,t+1} \int_0^{\bar{R}_{t+1}^K} R_{t+1}^K dF_R(R_{t+1}^K) \geq R_t B_{j,t+1} \end{array} \right. \end{array} \right. \quad (25)$$

where the value function represents the expected level of the value of the entrepreneur's assets in the period  $t+1$  at  $R_{t+1}^K > \bar{R}_{t+1}^K$ . At  $R_{t+1}^K < \bar{R}_{t+1}^K$ , all of the firm's assets are used to pay off liabilities, and the value of the firm's assets is 0. What should be recovered when the firm's earnings are less than a critical value is the expected value of the firm's own assets, excluding state verification costs [18].

### 3.2.2 Bank monetary policy planning

In order to prevent a large loss of bank deposits, commercial banks would have to passively raise deposit rates, which would lead to a further narrowing of the spread between  $R_{t+1}^K$  and deposit rates, thus making the economy as a whole less leveraged, which is one of the main mechanisms explored in this paper. It should be noted, however, that while such a mechanism may exist, it depends heavily on exactly how elastic the CBDC is with respect to bank deposits in terms of substitution, a question that is currently difficult to conclude with precision. The non-payment of interest on CBDCs in various countries, including DC/EP, is only an equity measure to avoid risk in the early stages of launch, and as CBDCs mature, the payment of interest (whether positive or negative) is an inevitable trend. In fact, non-payment of interest is only a special case of payment of interest rate. In this paper, we set the central bank to pay interest on CBDC and use it as a price-based policy instrument with the monetary policy rule of:

$$R_t^B = (1 - \rho) \left[ \frac{1}{\beta} + \varphi_{\Pi} (\Pi_t - 1) \right] \rho R_{t-1}^B + \varepsilon_t^B \quad (26)$$

where  $\varepsilon_t^B$  represents a monetary policy shock. For convenience, this paper orders:

$$\omega = \frac{R_{t+1}^K}{E_t R_{t+1}^K} \quad (27)$$

$$F(\omega) = F_R(R_{t+1}^K) \quad (28)$$

$$\bar{\omega}_{j,t+1} = \frac{\bar{R}_{t+1}^K}{E_t R_{t+1}^K} \quad (29)$$

The optimization problem can be rewritten as follows

$$\left\{ \begin{array}{l} V_t = \max \left\{ R_t^K Q_t K_{j,t+1} \int_{\bar{\omega}_j}^{\infty} \omega dF(\omega) - \left[ 1 - F(\bar{\omega}_j) \right] Z_{j,t} B_{j,t+1} \right\} \\ \text{s.t.} \left\{ \begin{array}{l} Q_t K_{j,t+1} = B_{j,t+1} + N_{j,t+1} \\ \bar{\omega}_{j,t+1} R_{t+1}^K Q_t K_{j,t+1} = Z_{j,t} B_{j,t+1} \\ \left[ 1 - F(\bar{\omega}_{j,t+1}) \right] Z_{j,t} B_{j,t+1} + (1 - \mu) R_{t+1}^K Q_t K_{j,t+1} \int_0^{\bar{\omega}_{j,t+1}} \omega dF(\omega) \geq R_t B_{j,t+1} \end{array} \right. \end{array} \right. \quad (30)$$

The Lagrangian function for this problem is

$$\begin{aligned} L_t = & E_t R_{t+1}^K Q_t K_{j,t+1} \int_{\bar{\omega}_{j,t+1}}^{\infty} \omega dF(\omega) - \left[ 1 - F(\bar{\omega}_{j,t+1}) \right] Z_{j,t} B_{j,t+1} \\ & + \lambda_{1,t} \left( B_{j,t+1} + N_{j,t+1} - Q_t K_{j,t+1} \right) + \lambda_{2,t} \left( \bar{\omega}_{j,t+1} E_t R_{t+1}^K Q_t K_{j,t+1} - Z_{j,t} B_{j,t+1} \right) \\ & + \lambda_{3,t} \left\{ \left[ 1 - F(\bar{\omega}_{j,t+1}) \right] Z_{j,t} B_{j,t+1} + (1 - \mu) E_t R_{t+1}^K Q_t K_{j,t+1} \int_0^{\bar{\omega}_{j,t+1}} \omega dF(\omega) \right. \\ & \left. - R_t B_{j,t+1} \right\} \end{aligned} \quad (31)$$

Its first-order condition is obtained as

$$\left\{ \begin{array}{l} 0 = E_t R_{t+1}^K \int_{\bar{\omega}_{j,t+1}}^{\infty} \omega dF(\omega) - \lambda_{1,t} + \lambda_{2,t} \bar{\omega}_{j,t+1} E_t R_{t+1}^K + \lambda_{3,t} (1 - \mu) E_t R_{t+1}^K \int_0^{\bar{\omega}_{j,t+1}} \omega dF(\omega) \\ 0 = - \left[ 1 - F(\bar{\omega}_{j,t+1}) \right] Z_{j,t} + \lambda_{1,t} - \lambda_{2,t} Z_{j,t} + \lambda_{3,t} \left[ 1 - F(\bar{\omega}_{j,t+1}) \right] Z_{j,t} - \lambda_{3,t} R_t \\ 0 = \lambda_{2,t} - \lambda_{3,t} \mu \bar{\omega}_{j,t+1} f(\bar{\omega}_{j,t+1}) \\ 0 = - \left[ 1 - F(\bar{\omega}_{j,t+1}) \right] - \lambda_{2,t} + \lambda_{3,t} \left[ 1 - F(\bar{\omega}_{j,t+1}) \right] \\ \lambda_{3,t} \left\{ \left[ 1 - F(\bar{\omega}_{j,t+1}) \right] \bar{\omega}_{j,t+1} + (1 - \mu) \int_0^{\bar{\omega}_{j,t+1}} \omega dF(\omega) - \chi_{t+1}^{-1} (1 - \kappa_{j,t+1}^{-1}) \right\} = 0 \\ \left[ 1 - F(\bar{\omega}_{j,t+1}) \right] \bar{\omega}_{j,t+1} + (1 - \mu) \int_0^{\bar{\omega}_{j,t+1}} \omega dF(\omega) \geq \chi_{t+1}^{-1} (1 - \kappa_{j,t+1}^{-1}) \\ \lambda_{3,t} \geq 0 \end{array} \right. \quad (32)$$

Order:

$$h(\bar{\omega}_{j,t+1}) = \frac{\bar{\omega}_{j,t+1} f(\bar{\omega}_{j,t+1})}{1 - F(\bar{\omega}_{j,t+1})} \quad (33)$$

$$p(\bar{\omega}_{j,t+1}) = \frac{\int_0^{\bar{\omega}_{j,t+1}} \omega dF(\omega)}{\left[ 1 - F(\bar{\omega}_{j,t+1}) \right] \bar{\omega}_{j,t+1}} \quad (34)$$

$$q(\bar{\omega}_j) = \frac{\int_{\bar{\omega}_{j,t+1}}^{\infty} \omega dF(\omega)}{\left[ 1 - F(\bar{\omega}_{j,t+1}) \right] \bar{\omega}_{j,t+1}} \quad (35)$$

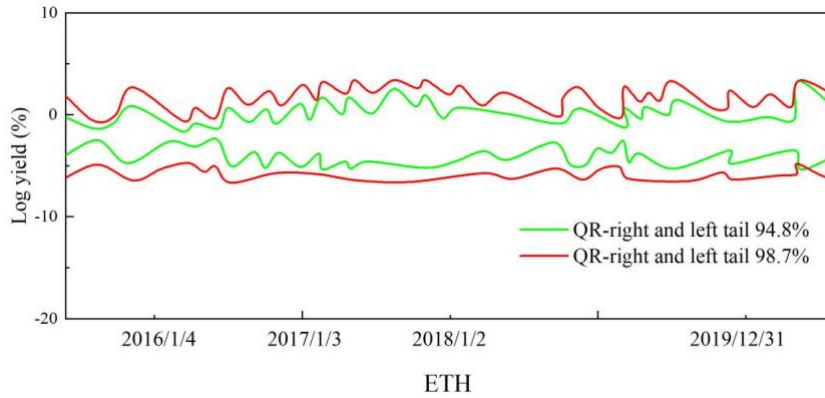
The expression for the optimal leverage ratio can be obtained by rectification as

$$\kappa_{j,t+1} = 1 + \frac{1 + (1 - \mu)p(\bar{\omega}_{j,t+1})}{\left[1 - \mu h(\bar{\omega}_{j,t+1})\right] \left[q(\bar{\omega}_{j,t+1}) - 1\right]} \quad (36)$$

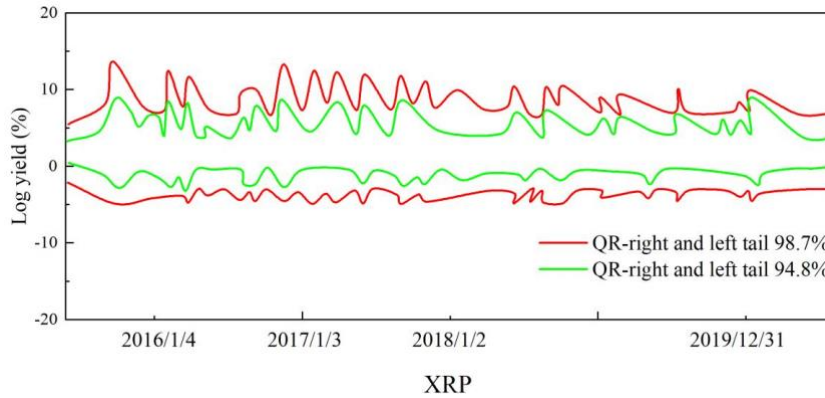
## 4 Regional economic law empirical research analysis

### 4.1 Crypto-digital currency economic risk analysis

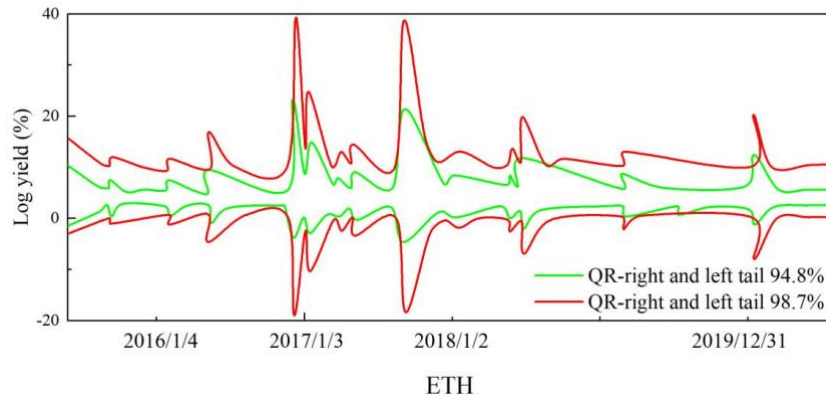
Figure 5 shows the VAR of cryptocurrencies based on the fused adaptive differential evolution algorithm. Looking at the tail risk of cryptocurrencies in Figure 5, comparing the VaR magnitude based on the 94.8% and 98.7% VaR plots, we can see that Bitcoin (BTC) has less high losses and high gains than Ether (ETH) and Ripple (XRP), and based on the fluctuations of VaR, we find that Bitcoin's tail risk fluctuations are also more moderate, which means that Bitcoin, as the oldest and largest cryptocurrency in existence, is more stable than other cryptocurrencies, while Ether has a higher degree of high losses and high gains than Bitcoin, but its tail risk is also more dramatic than Bitcoin. Ripple has the most dramatic tail risk variation and the largest magnitude among the three cryptocurrencies. In order to compare the VaR of each series over the whole period of time, the estimated 94.8% VaR of the cryptocurrencies was averaged, and it was also found that the daily average right-tail VaR of BTC (94.8%) was the lowest among the listed cryptocurrencies at 2.58%, while the left-tail average was the highest among the three cryptocurrencies, which is consistent with the fact that BTC has been issued for the longest time and is more mature among the cryptocurrencies.



(a)



(b)



(c)

**Figure 5.** Cryptocurrency VaR Based on Fusion Adaptive Differential Evolution Algorithm

Based on the calculated VaR, this paper initially explores whether there is a certain simultaneity in the occurrence of tail risk spill events within the cryptocurrency market, with the mean value of 94.8% VaR over the sample period shown in Table 1. At 94.8% VaR (the value of each series theoretically experiencing tail events is 58),  $TE=n$  represents  $n$  cryptocurrency simultaneous risk spill events during the sample period, and the corresponding number of days of occurrence is presented in Table 1, where the number of simultaneous left-tail events for at least two cryptocurrencies is 45, and the number of simultaneous right-tail events for at least two cryptocurrencies is 21, which indicates that there may be a tail correlation in cryptocurrencies, as three cryptocurrencies have a higher percentage of simultaneous tail events. This also provides some basis for exploring the tail risk correlation among cryptocurrencies.

**Table 1.** 94.8% VaR mean during the sample period

| Name | Mean (%)  |            | TE=1      |            | TE=2      |            | TE=3      |            |
|------|-----------|------------|-----------|------------|-----------|------------|-----------|------------|
|      | Left Tail | Right tail | Left Tail | Right tail | Left Tail | Right tail | Left Tail | Right tail |
| BTC  | -2.581    | 2.645      | 58        | 123        | 21        | 14         | 24        | 7          |
| ETH  | -3.881    | 4.391      |           |            |           |            |           |            |
| XRH  | -3.402    | 4.251      |           |            |           |            |           |            |

## 4.2 Analysis of Digital Financial Asset Dynamics from a Blockchain Perspective

The dynamic correlation coefficients of the bitcoin market with the uncertainty index are examined. The dynamic correlation coefficients between bitcoin price and trading volume and the policy uncertainty index are shown in Figures 6 and 7. Overall, the correlation coefficient between the bitcoin price and the Policy Uncertainty Index PUI remains greater than 0 throughout the sample period, except for a brief drop below 0 at the end of 2017. Bitcoin trading volume, on the other hand, consistently shows a more stable negative relationship with the Policy Uncertainty Index, with the correlation coefficient remaining between -0.0185 and -0.01825. This may be due to the fact that in times of high macroeconomic volatility, investors tend to react by reducing their investments in all types of assets. Considering that until 2018 over 70% of Bitcoin was still held by long-term investors Bitcoin market is illiquid, and the volume of transactions is a more important indicator relative to the price, thus Bitcoin cannot hedge the risk from macroeconomics from a dynamic time-varying chart.

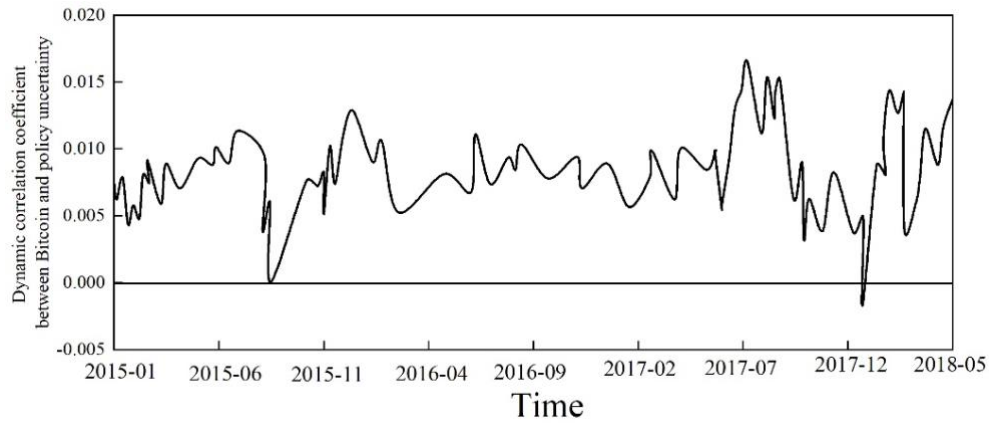


**Figure 6.** Correlation coefficient between Bitcoin price and policy uncertainty

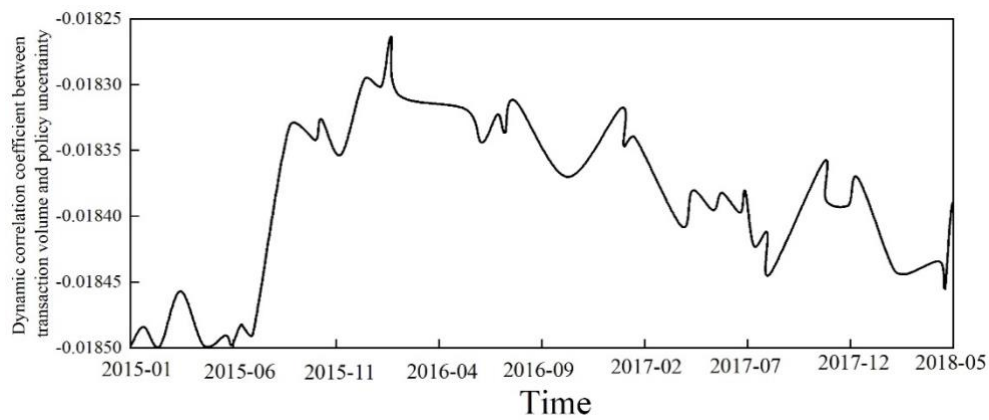


**Figure 7.** Correlation coefficient between Bitcoin transaction volume and policy uncertainty

The dynamic correlation coefficients of bitcoin price and trading volume with the VIX index are shown in Figure 8 and Figure 9. From the results in Figure 8 and Figure 9, it can be seen that bitcoin price shows a relatively stable negative correlation with the VIX index during the sample period, while bitcoin trading volume shows a relatively stable positive correlation with the VIX index during the sample period, basically stable between +0.0428 and +0.0431. This is consistent with the previous analysis of information spillover effects, where Bitcoin has significant risk aversion properties for traditional financial markets. In terms of more effective volume metrics over the medium to long term, bitcoin's risk aversion to financial markets showed a seismic upward trend over the time period from January 2015 to December 2016 and a seismic downward trend over the time period from December 2016 to April 2018. This may be related to the fact that since entering December 2016, Bitcoin has started a major bull market, rising from around \$730 in December 2016 to nearly \$21,000 in late 2017, with the enhanced speculative properties of Bitcoin weakening its risk aversion properties. Nonetheless, increased uncertainty in traditional financial markets will still drive increased bitcoin trading volumes.

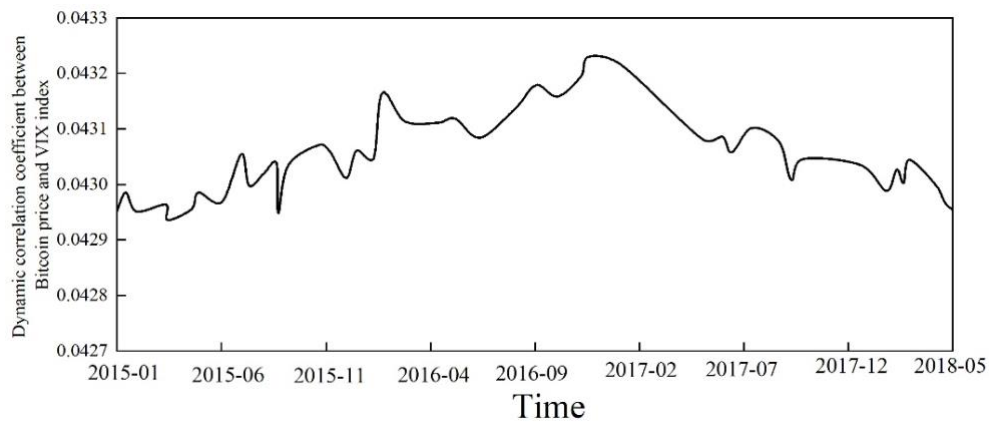


**Figure 8.** Dynamic correlation coefficient between Bitcoin price and VIX index

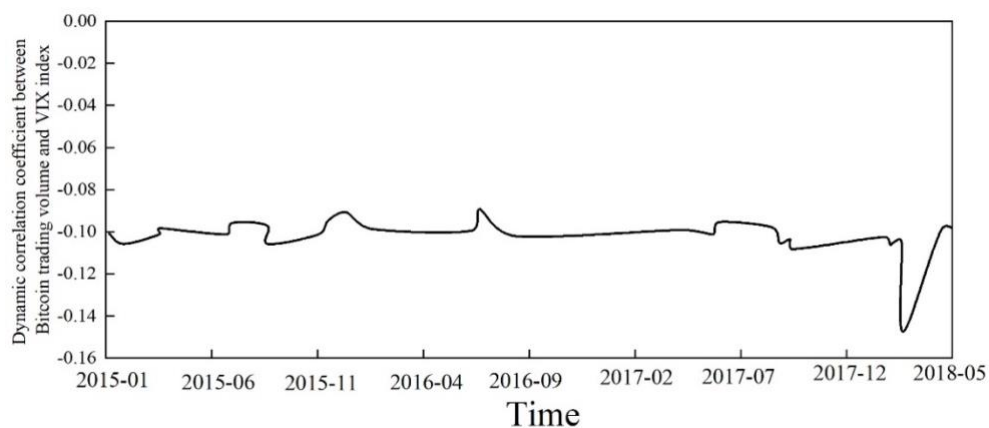


**Figure 9.** Dynamic correlation coefficient between Bitcoin trading volume and VIX index

## 5 Conclusion

In this paper, we propose an empirical research analysis of regional economic laws using adaptive differential evolutionary algorithms from the perspective of blockchain and big data to address the limitations of economic laws. The following conclusions can be drawn:

- 1) Crypto-digital currency economic risk analysis. Under 94.8% VaR, the number of left-tailed events occurring in at least two cryptographic digital currencies at the same time is 45, indicating the existence of tail correlation in cryptographic digital currencies, which provides a certain basis for tail risk correlation among cryptographic digital currencies, and the central bank can control the flow of money to avoid the de-realization of the financial sector and realize the precise placement of money, and the market economic regulation can also be adopted according to different interest rates Different monetary policies
- 2) Analysis of the dynamics of digital financial assets from the perspective of blockchain. The correlation coefficient between the bitcoin price and the policy uncertainty index PUI stays at a level greater than 0 at all times except for a brief drop below 0 at the end of 2017. The bitcoin trading volume and the policy uncertainty index always show a more stable negative relationship, and the correlation coefficient always stays between -0.0185 and -0.01825. Cryptocurrencies, mainly bitcoin, let speculators smell arbitrage opportunities and intensify the generation of bubbles, so there is a need for strict digital asset regulation to promote the effective integration and development of the digital economy and the real economy.

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