

Regulatory Trilemma in China: A Game-Theoretic Exploration of Anti-Money Laundering in the Digital Currency Sphere

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Abstract

Digital currency is produced along with the development of Internet finance. Because of its virtuality, anonymity, low cost and so forth, it is easy to be used by criminals engaged in money laundering activities. Through the cases of money laundering of Q-coins and bitcoins, this paper discusses the causes of money laundering and points out that the four difficulties of the main content in the supervision of anti-money laundering of China's Digital Currency. Through making use of the game theory to conduct the game analysis between China's Digital Currency trading service agencies, this paper constructs the game model between China's Digital Currency trading service agencies and money launderers, as well as the game model between China's anti-money laundering supervision agencies and China's Digital Currency trading service agencies, selects the anti-money laundering supervision strategy of China's Digital Currency, and analyzes the question of its effectiveness. Finally, it concludes that in the anti-money laundering supervision of China's Digital Currency, firstly, it is necessary to establish clear laws and regulations to solve the problem of the difficulties of anti-money laundering compliance and execution; and secondly, it is necessary to force customer identification to solve the problem of the difficulties of identification; and then it is necessary to improve the internal control system to solve the problem of the difficulties of investigation and evidence collection.

Keywords

Digital Currency, Game Theory, Anti-Money Laundering, Regulation

1. Introduction

Referring to the relevant information in the statistical report of China Internet Network Information Center on the status of China's network development, it is shown that the scale of China's Internet users has reached 854 million as of the first half of 2019, an increase of 25.98 million from the end of 2018, and the penetration rate of the Internet has reached 61.2%, an increase of 1.6 percentage points compared with the end of 2018. According to CIC Industry Research Center, China's internet finance market is expected to reach 78.5 trillion yuan by December 2020. Online virtual currencies have become an inevitable product of the network technology revolution and the wave of virtual economy. On January 11, 2017, the Shanghai headquarters of the People's Bank of China, the Shanghai Municipal Finance Office and other joint on-site inspection of "Bitcoin China", the focus of the work is to check whether the enterprise has no unauthorized or unlicensed payment, credit, exchange and other related businesses, the hidden danger of capital security, money laundering the implementation of the relevant system, etc. Hayek Friedrich H. [1] in the Denationalization of Currency explicitly suggested that three hundred years ago, no one would have believed that the government would give up control over religion, and by the same token, after three hundred years, the government will not be able to control money, and the whole study will only be of great relevance if it is felt that virtual currencies will be able to achieve some degree of success. In a way, online virtual currencies were first specifically studied in Satoshi Nakamoto's [2] "*Bitcoin: A Peer-to-Peer Electronic Cash System*", in which he first introduced Bitcoin in his paper, as well as the specifics of how it operates and the specifics of the principles involved. Michael W. Wright. Michael W. Meredith [3] also researched bitcoin, pointing out that bitcoin, which is generated electronically and stored in virtual accounts, is essentially a decentralized and relatively decentralized Digital Currency, which does not have the stable credit support of fiat currencies and is not comparable to traditional payment methods. In contrast to traditional payment methods, Bitcoin's anonymity is more pronounced during specific transactions, and personal account information is not disclosed during specific transactions, which can directly lead to serious problems in terms of regulation. Marek Dabrowski, Lukasz Janikowski [3] believe that virtual currencies are a manifestation of modern private money. Because of their unique technological advantages, they have a relatively fast, transparent and secure global transaction network, which offers good prospects for their further development. However, they are still unlikely to challenge the dominance of central banks and sovereign currencies, especially in the realm of major currencies. As with other financial innovations, the anonymity and cross-border nature that virtual currencies possess poses significant challenges for financial regulators. Robby Houben [4] argues that a growing number of regulators are concerned that the use of cryptocurrencies to engage in illegal activities, such as money laundering, terrorist financing, and tax evasion, has become a major tool for criminals. Its legal perspective on this phenomenon focuses on the use of

cryptocurrencies for financial crimes, money laundering and tax evasion, which contains policy recommendations for future EU standards.

Domestic scholars in the Digital Currency research are relatively systematic, in the nature of the Digital Currency research: Lei Zhang [5] that the realization of the fundamental intelligence of the real money is the essence of the Digital Currency, the Digital Currency is a substitute for the real currency circulation of the equivalent of exchange goods. Zhihui Wang [6] points out that for the Digital Currency, its essence belongs to a kind of virtual commodity with some value, which can be used for network shopping, and also can be used as a medium of exchange. However, it should be noted that there is a big difference between it and legal tender in terms of the specific name and the specific unit. Delin Chen [7] argues that “virtual currencies” do not have the three conditions to become money, and the more people use “virtual currencies”, the longer the trans-action time and the higher the cost. It is difficult to expand the capacity of “virtual currencies” as opposed to electronic currencies based on central bank or commercial bank balances. In terms of the research on the process of Digital Currency transactions and the innovation of the regulatory system: Wei Li [8], the point of view is that network virtual currencies are essentially an important product of the development of the network industry, and its overall usage is greatly influenced by the number of Internet users, and its relationship with the number of users is in a positive proportional relationship. Yunhui Fan [9] points out that the most important function of the digital currency platform should be the payment business. As far as the current situation in China is concerned, the biggest risk of digital currency lies in the digital currency platform. Liping Xuan [10] puts forward in the analysis and research of money laundering crimes on the basis of the need to put forward targeted preventive measures, although, in terms of China’s current situation, The anti-money laundering mechanism in the establishment of the specific aspects has been constantly updated. However, because of the nature of the Digital Currency is constantly undergoing changes, so it is in the specific transaction, both in terms of the nature of the law and in terms of specific responsibility there is a more obvious ambiguity, in which the existence of money laundering crimes also need to attract sufficient attention and concern. Qingyong Wu [11] analyzes the outstanding achievements in the legal system, working system, regulatory investigation and international cooperation of anti-money laundering, and explains the regulatory process of domestic anti-money laundering. Mengting Liu [12] argues that the vigorous development of Internet finance promotes the continuous reform and innovation of the traditional financial industry, and improves the efficiency and quality of financial services. It puts forward the difficulties of anti-money laundering in Internet finance now, and conducts research on the user access system, Internet anti-money laundering law and anti-money laundering regulatory collaboration among various departments, and up to now, China has not yet had laws and regulations at the national level involving the risk prevention of online virtual currencies.

Jack Ma [13] points out that online virtual currencies did not originate from

traditional financial institutions such as banks, as was expected, but rather from laymen such as Internet organizations. The main reason why people call virtual currencies is that they also have a certain scale of value, and they are also able to circulate and make payments. However, the scope of its coverage is relatively limited, firstly, because it can only be circulated in the Internet environment; secondly, because it can only be used in a certain scenario. In fact, if the Digital Currency and the Digital Currency trading service institutions are separated, then all its value will no longer exist. The development status of Digital Currency, for whether it can be exchanged for physical currency, whether it can be freely transferred between various accounts, this paper is divided into the following three categories: The first category is closed, there is no exchange between Digital Currency and legal tender. For example, on the game platform, by completing certain tasks to earn a certain amount of game currency without spending legal tender, etc. The second category is semi-open category, specifically refers to the Digital Currency and legal tender can be combined with the corresponding ratio of its exchange, for the specific exchange methods, mainly divided into one-way and two-way, the so-called one-way exchange in fact is the currency can be exchanged through the fiat currency exchange, however, cannot be exchanged back to the legal tender. The so-called two-way exchange refers to the ability to be exchanged for Digital Currency, and can also be exchanged back to the legal tender. For example, Q-coins, Baidu coins, etc., can be used to purchase the services of this website with legal tender. The third category is the open category, which means that the Digital Currency and legal tender can be exchanged according to a certain ratio, without any limitations, for the user. It can be exchanged through the intermediary, but also to buy and sell each other, such as based on the blockchain technology under the generation of bitcoin, Litecoin, and soon.

For the study of this paper, Digital Currency, as a kind of personalized currency generated in Internet enterprises and organizations, Digital Currency represents the value itself. Due to the existence of the financial market in the strict sense of the financial inhibition, that is, the national government on the interest rate, exchange rate control and the allocation of credit resources related to the control, resulting in a variety of inefficiencies in the financial industry, and the Internet technology to solve the problem of financial inhibition; in addition to the credit problem in the currency, the countries have experienced a series of currency crises, the inflation rate continues to rise, so that the trust of people in the bank continues to decline. People's trust in banks has been declining. The emergence of Bitcoin solved the dissatisfaction with high inflation and led to the emergence of a new type of currency, which led to a change in the provider of monetary credit to one that utilizes peer-to-peer blockchain technology to guarantee it. According to the algorithm of Foley *et al.* [14], 23% of Bitcoin users and 49% of Bitcoin holdings are associated with illegal activities.

2. Anti-Money Laundering Regulation Issues Case Studies

First of all, based on the relevant aspects of the case was analyzed, pointed out that

China's Digital Currency in the anti-money laundering of specific problems and the main reasons for the emergence of the summary analysis of its anti-money laundering regulation, the choice of gaming strategy, in the anti-money laundering regulation of pay attention to the effectiveness of the text of the cost of the analysis will be carried out to find ways to solve the problem of anti-money laundering regulation of China's network virtual currencies.

2.1. China's Digital Currency Money Laundering Cases and Problem Causes Analysis

In view of the cases of money laundering using network virtual currencies that have occurred in China in recent years, the author analyzes and researches the relevant problems existing in the process of money laundering of network virtual currencies through the following two cases.

2.1.1. Q Coin Money Laundering Cases and Problem Causes Analysis

Basic overview of the case: starting in August 2015, money laundering molecules will be obtained through network fraud and other illegal and criminal means of stolen money, through the purchase of Q coins and other network virtual currencies sold on the Internet, and then resold to the intermediary Lin X, Lin X and then resold, through other people's cell phone banking will be the funds of a number of people's accounts totaling CNY 803,274,545, the first together to a bank account, and through the bank to withdraw the Cash payment to the money launderer who sells Q coins etc. to him. The proceeds of crime were laundered. Analyze the problems and causes of Digital Currency money laundering from this case:

1) The value of the Digital Currency is not clear, after analysis found that the operation of the Q coin Digital Currency trading services, they do not have a clear pricing of the value of the Digital Currency. Take Q coins as an example. Exactly 1000 Q coins correspond to how much RMB, may be worth only a penny RMB, may also reach 10 million RMB. If you don't play the game, it's worthless to them, but if you're a fan of the game, it's worth a fortune. Money launderers can of course add the value of a game prop at will, unable to detect the suspicious operation.

2) Digital Currency customer identity cannot be identified, money laundering molecules use a variety of different identities to operate, cannot identify their true identity. And those Digital Currency trading service organizations simply cannot be detected, anti-money laundering regulatory authorities are also unable to determine the true identity of money laundering molecules, thus making the nature of money laundering be covered. At the same time, in the Digital Currency trading services, specific payments are made through the Digital Currency, although the anti-money laundering regulatory agencies also clearly put forward the relevant platforms must be through the ID card for the application of a specific account. However, this regulatory measure for the Digital Currency trading services has no practical benefits, so it is also not in accordance with relevant anti-money laun-

dering norms and requirements for the operation. According to the above characteristics, Digital Currency has become an excellent tool for money laundering.

3) The problem of costs and benefits in the process of laundering network virtual currencies, because network virtual currencies cannot be converted into real money in the transaction service organization, there will be cases such as the existence of certain intermediary institutions or individuals to provide exchange services. The existence of this service leads to money laundering molecules cannot be traced under the premise of money laundering: the specific method is that some money laundering molecules have a large number of hands of virtual currencies, intermediary institutions or individuals to lower prices to be exchanged (for example, the official provisions of the 10 virtual currencies need to be 10 yuan, then the intermediary institutions or individuals can be used to exchange 7 yuan for 10 virtual currencies as a counter-offer), and then intermediary institutions or individuals and then through the higher price (for example, 8 yuan for 10 yuan) The intermediary or individual then through a higher price (such as 8 yuan for 10 Digital Currency) sold to those who need Digital Currency players. In this way, the money laundering molecules realize the money laundering, the need for players to realize the low price to buy Digital Currency. In this process, the Digital Currency trading services do not have any losses, intermediary organizations or individual platforms to earn money, the need for players to save money, money laundering molecules as the loss of its realization, the cost of money laundering.

2.1.2. Analysis of Bitcoin Money Laundering Cases and Causes of Problems

This case is a bitcoin money laundering case. For Bitcoin, its specific transactions are completely transparent, that is to say, each bitcoin transaction can be traced, so there are many people who think that Bitcoin is impossible to exist money laundering problems. In fact, this is not the case. In real life, bitcoin money laundering problem is very serious. The main reason why the money laundering problem occurs is that bitcoin allows at the same time more than one “input” and no more “output”. For the holders of the black money, they are able to prevent the tracing of bitcoins through various Digital Currency trading services, and there is no clear limit to the number of bitcoin accounts, so the owners of the black money are able to split the accounts Yuguang Han [15]. At the end of the day, if you want to trace an illegal transaction, you may have to verify tens of thousands of legitimate accounts, which in turn makes it increasingly difficult to trace, requiring nationwide or even global tracking, with no way of knowing where the black money is going [16]. So it's only from the money laundering issue that you can relate to the essence of what Bitcoin is all about.

Basic overview of the case (Heilongjiang Higher People's Court, 2016) [17]: on July 2, 2014, money launderer Xu X used “Jiang X's” ID card copy, bank card and its corresponding cell phone number to register an account in Lekuda's “OKCOIN”; at 3:42 on August 5, Xu X also used “Lin X's” ID card copy, bank card and its corresponding cell phone number to register an account in Lekuda's “OKCOIN”.

“Lin X” ID card copy, bank card, bank card corresponding cell phone number in Lekuda Company “OKCOIN” registered account. On the same day, Xiao X used of fraud 5 million through the phone to Xu X to ask for a bank card number. Xu X will be Jiang X’s Bank of Agriculture card number to tell Xiao X. 5 million yuan remitted to Jiang X Bank of Agriculture card, Xu X asked in the Lekuda company “OKCOIN” on the recharge. Customer service will Peng X bank card account told Xu X. On the same day Xu X twice through online banking operation from Jiang X’s bank card to customer service bank card account remittance of 2 million yuan. In the recharge, customer service found that the recharge party Jiang X and the recharge party Lin X were not the same person, and the amount of money, then asked to provide the recharge party’s ID card front and back photos and handheld ID card photos. Can money laundering molecules Xu X proposed to use the form of photos sent to customer service a Lin X identity card copy, customer service only check the identity card copy is Lin X, to “Lin X” account successfully recharge 2 million yuan. Money-laundering molecules Xu X use Lekuda company website “OKCOIN” trading platform, 34 strokes to buy about 2 million yuan worth of bitcoin 553.0346. In a very short period of time, the purchase of 553.0346 bitcoins in four strokes all put forward platform, transferred to the money launderer Xu X in the “blockchain” website registered bitcoin wallet. Later, through the underground money changers, bitcoin will be sold into cash, the money will be laundered. The entire bitcoin money laundering process is simplified as shown in **Figure 1**: Analyze the problems and causes of money laundering using online virtual currencies from this case:

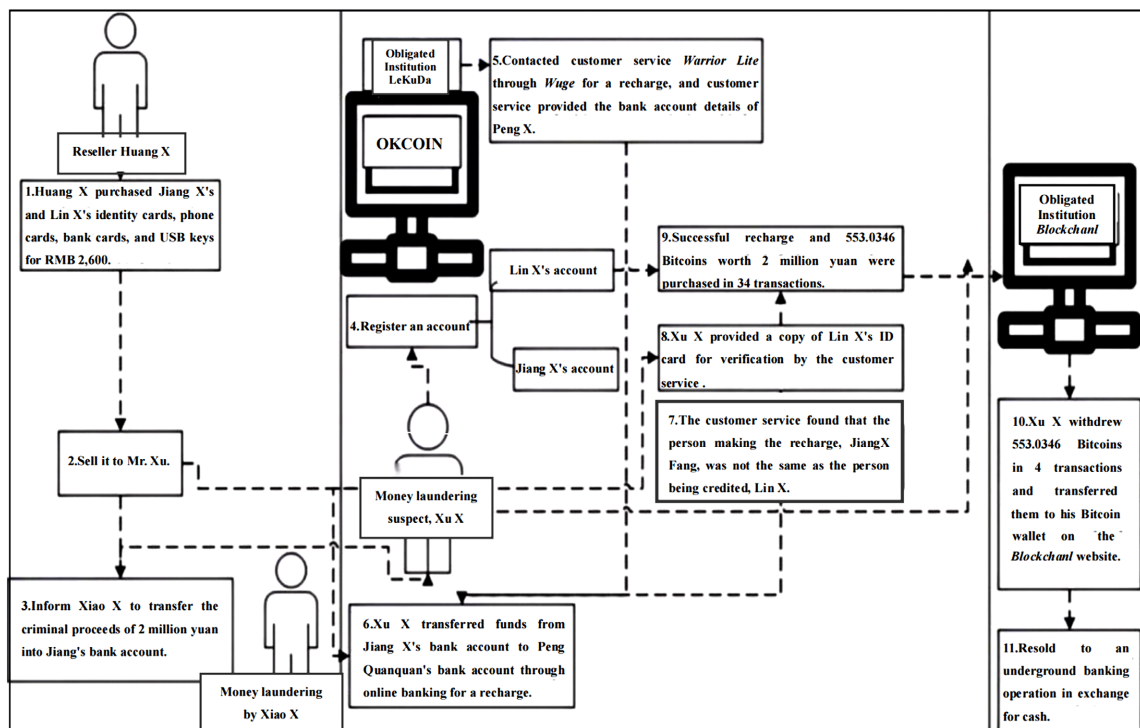


Figure 1. Money laundering process using bitcoin.

1) The Digital Currency trading service organization does not operate in accordance with the laws and regulations, Lekuda Company to the end of the court hearing, failed to provide its registration with the telecommunications regulatory agencies for the record of the relevant materials. Its main business is to operate the “OKCOIN” Digital Currency trading platform. The “Notice” clearly pointed out that the need to take reasonable and effective measures to further increase the intensity of bitcoin Internet regulation, the need to register, while the relevant website must also be filed with the telecommunications regulatory agencies, and the license must be processed in accordance with the requirements of the relevant parties.

2) The Digital Currency trading service organization did not carry out identification of registered users, and Lekuda Company did not carry out real-name identification when registering “Jiang X” and “Lin X”, but only registered them on the basis of the copy of ID card provided by the applicant. This is also to a certain extent for money laundering molecules to carry out criminal activities provides a very big convenience, in the recharge personnel and be recharged personnel is not the same person, at the same time the amount of relatively large recharge activities, money laundering molecules did not according to the relevant requirements of the ID card front and back, just provide a copy of ID card is also still money laundering molecules to provide transaction services.

3) The Digital Currency trading service provider did not fulfill its internal control and supervision responsibilities in line with anti-money-laundering requirements, and did not take the first steps to conduct a rigorous review when it discovered that there was a high probability of improper transactions in the account. The criminals had the opportunity to purchase two million dollars worth of bitcoins in 34 transactions within 60 minutes, and after the purchase was completed, they raised all the bitcoins in four transactions. This operation was in line with the payment mechanism of bitcoin, coupled with the fact that the transactions were carried out on different trading platforms, making the anti-money laundering traceability and investigation a breakpoint.

3. Game Analysis of Anti-Money Laundering Regulatory Issues

3.1. Anti-Money Laundering Regulatory Game Strategies for Online Virtual Currencies in China

Understanding the problem of anti-money laundering regulation of China’s Digital Currency, then, for the participants of China’s Digital Currency, the choice of its strategy is very important. There are three main participants. The first is the anti-money laundering regulator (mainly the People’s Bank of China); the second is China’s Digital Currency transaction service organizations; the third is money launderers. In this paper Digital Currency transaction service institutions as a bridge in the middle, on the bridge where to set up regulatory agencies. Discussion of the establishment of a regulatory body leads to a balance between the Digital

Currency trading services and money launderers, as well as a balance between the regulatory body and the Digital Currency trading services, how to be a “reasonable” existence? Whether it can successfully reach the destination at the other end of the bridge. For the People’s Bank of China, the anti-money laundering regulator, it is impossible to shut down the Internet, there are only two options, one is to regulate, the other is not to regulate. For the Digital Currency trading service organizations in order to survive, there must be revenue, either in accordance with the anti-money laundering regulatory requirements to implement anti-money laundering work and bear the cost of anti-money laundering obligations, or not in accordance with the anti-money laundering regulatory requirements to implement anti-money laundering work and bear the penalties that may be due to violations of the law. For the money laundering molecules, its ultimate goal is to be able to whitewash the black money. The face of the two choices is money laundering or not money laundering. In the face of the various choices of the parties, the author hopes that through the game theory tools and methods, and through the construction of the evolution of the game model for regulatory strategy game choice to analyze, to make the problem clear, so as to provide a theoretical guide to practice possible.

3.1.1. The Game between China’s Digital Currency Trading Service Providers

The previous section has analyzed a lot of money laundering molecules using the Digital Currency, low cost, anonymity, transfer speed and other characteristics, will be illegal funds in the Digital Currency trading service institutions to carry out money laundering activities. And for profit considerations, many Digital Currency trading services also “turn a blind eye”. The following will be from the perspective of game theory to briefly understand the game between the Digital Currency trading services.

1) Assuming that there are A, B two Digital Currency trading services, in the face of money laundering molecules to choose its time, the two organizations will choose “anti-money laundering” or “not anti-money laundering” operation, and we would like to be able to know each other’s mode of operation. In the normal state, assuming that the two gains are 200, the cost of 60, the net gain of 140. When the money laundering molecules use it for money laundering, the “anti-money laundering” operation will cost 40 of the cost, while the “not anti-money laundering” operation will get 40 of the proceeds.

2) In the above scenario, platforms A and B both carry out AML operations, and their net income will be reduced to 100; if organization A is “anti-money-laundering” and organization B is “not anti-money-laundering”, then the net income of organization A will be 100 and that of organization B will be 180, and vice versa. The reverse is also true. If both organizations carry out “no anti-money laundering” operation, assuming that the money launderer will deposit the illegal funds into both organizations equally, the net proceeds of both organizations can reach 160. Since the operations between the two institutions will not affect each

other, both of them will choose to conduct “no AML” operation to obtain relatively higher returns. And once this situation spreads, it will make the whole industry more and more rampant money laundering problems.

3.1.2. The Game between China’s Digital Currency Trading Services and Money Launderers

1) Conditions under which the People’s Bank of China, the anti-money-laundering regulatory body is absent.

Assuming that our Digital Currency trading services and money laundering molecules are limited rationality, *i.e.* network, exists in the rational state between complete rationality and non-complete rationality, the Digital Currency trading services need to seek reputation and income and other long-term stable development. First of all, we must consciously abide by the relevant laws and regulations on anti-money laundering and anti-money laundering. Money laundering molecules due to the lack of familiarity with the Digital Currency trading service institutions What to prevent money laundering mode, and afraid of Digital Currency trading service institutions will be found and reported for its money laundering behavior, and do not choose to use the Digital Currency trading service institutions for money laundering behavior; but due to the money laundering molecules for their own trans-action behavior is correct or not cannot judge, can only be based on the success of the transaction behavior, according to the specific earnings, to develop the relevant aspects of the network, analysis, but the rationality of the counterparty As well as the existence of mutual mismatch of information, resulting in a transaction between the two sides did not do, on the specific situation of the proceeds of a rough estimate, then the transaction between the two sides will need to be in a long period of time in the scope of time, to analyze their own trading behavior strategy, is notable to meet their own needs, and at the same time to carry out the relevant aspects of the measures of its adjustment. Judgment to choose the best trading behavior strategy.

Assuming that the two sides of the game is a Digital Currency trading services and money laundering molecules, in the absence of anti-money laundering regulatory agencies under the conditions of the Digital Currency trading services for the choice of lawful and illegal two kinds of legal that is to say that the Digital Currency trading services will not become a money laundering molecules of money laundering channels, not legal that the Digital Currency trading services may become a money laundering molecules of money laundering channels. And the choice of money laundering molecules also exists in the same legal and illegal two kinds, if legal means that the money laundering molecules will not choose the Digital Currency trading services as a channel for money laundering, if not legal means that the money laundering molecules they tend to pass the way of Digital Currency services, will be used as a channel for money laundering. And assume that all the Digital Currency trading service institutions and money laundering molecules are randomly combined to form a repeated game. The following assumptions are made on the parameters of the game model:

- a) Both parties' legitimate gains are indicated at a ;
- b) An indication of gain that is lawful to oneself but not to the other b ;
- c) Gains that are not legitimate for oneself but legitimate for the other party are expressed c ;
- d) Gains that are not legal for either party are indicated d .

By establishing a static game model similar to the "Prisoner's Dilemma" for Digital Currency trading service organizations and money launderers, the benefit matrices of both parties are shown in **Table 1**:

Table 1. The game between digital currency transaction service providers and money launderers under the condition of absence of anti-money laundering regulators.

		Digital Currency Trading Service	
		licit	unlawful
money launderer	licit	(a, a)	(b, c)
	unlawful	(c, b)	(d, d)

According to the Digital Currency trading service organizations and money launderers are limited rationality premise, and both sides in the initial stage of the information asymmetry of the reasons for the formation of uncertainty in the proceeds. It is assumed that in the initial state, the percentage of Digital Currency trading services and money launderers adopting legitimate tactics is P , then the percentage adopting illegitimate tactics is $1 - P$.

If the Digital Currency trading service providers consciously comply with the laws and regulations of anti-money laundering, that is, to adopt legitimate strategies period of expectation of gains for:

$$U_1 = P * a + (1 - P) * b \quad (1)$$

If the Digital Currency trading service providers do not consciously comply with the laws and regulations of anti-money laundering, that is, to adopt illegal strategies period of expectation of gains for:

$$U_2 = P * c + (1 - P) * d \quad (2)$$

So we need to know that the average expected return of a Digital Currency trading service provider can be expressed by the following expression:

$$\bar{U} = P * U_1 + (1 - P) * U_2 \quad (3)$$

Combined with the evolutionary game model, its specific expression is shown below:

$$F(P) = \frac{dx}{dy} = p * (U_1 - \bar{U}) = p(1 - p) * [p(a - c) + (1 - p)(b - d)] \quad (4)$$

Make $F(P) = 0$ can be solved: $p = 0$, $p = 1$, $p = \frac{d - b}{a - b - c + d}$ replication of dynamic equations in (4) for local stability solution, through Jacobi iteration Yuanmin Zhou [18] can be obtained $P = 0$ is a local stability solution in the dynamic

evolution process. That is to say: in the absence of anti-money laundering regulatory agencies, if the Digital Currency trading services consciously comply with anti-money laundering laws and regulations will only be an unstable strategy; on the contrary, once the Digital Currency trading services do not consciously comply with anti-money laundering laws and regulations, money laundering molecules will be allied with them either actively or passively to obtain illegal gains, and other more Digital Currency trading services will learn and imitate. Other more digital currency trading service organizations will learn and imitate, change their own way of doing business, and make Digital Currency trading service organizations become an important money laundering channel for money laundering molecules.

2) The introduction of anti-money laundering regulatory agencies under the conditions of the Digital Currency trading services and money laundering molecules game.

The above model obviously shows that under the condition of no anti-money laundering regulator, the Digital Currency trading service organization eventually develops with money laundering molecules all the way in the direction of illegitimacy, which is obviously not the result we want to see. Here, the introduction of anti-money laundering regulatory agency conditions again for evolutionary game analysis.

The introduction of anti-money laundering regulators makes it necessary to consider various aspects of the strategy of Digital Currency trading service providers in choosing to fulfill their anti-money laundering obligations: firstly, the implementation of anti-money laundering regulation is not carried out strictly in accordance with the requirements of the relevant parties; secondly, the implementation of anti-money laundering regulation is carried out strictly in accordance with the requirements of the relevant parties, which leads to an increase in various costs; in addition, regardless of whether the Digital Currency trading In addition, regardless of whether the Digital Currency trading service organizations in accordance with the regulatory requirements to perform anti-money laundering obligations, money laundering molecules will make their own choices accordingly.

Assuming that the two sides of the game or Digital Currency trading services and money laundering molecules, the choice of Digital Currency trading services is divided into two kinds of legal and illegal work, in addition to the money laundering molecules is the question of whether to choose the Digital Currency trading services, and therefore the money laundering molecules are divided into two cases of choice and non-choice. Money laundering molecules in the case of non-choice for both sides will not produce any costs and benefits. The following assumptions are made about the parameters of this game situation:

- a) The probability that a Digital Currency trading service provider will fulfill its AML work obligations in accordance with AML regulatory requirements is set at p ($0 < p < 1$);
- b) The fixed costs of the Digital Currency trading service provider are set at c ;

c) The implementation of anti-money laundering work by the Digital Currency trading service organisations in accordance with the anti-money laundering regulatory requirements requires a large amount of manpower and material resources to support the implementation of anti-money laundering work, and its operating costs are set at $e(p)$;

d) The fixed income of the Digital Currency Trading Service is g ;

e) The additional gain of the Digital Currency transaction service organization for not fulfilling the anti-money laundering obligation in accordance with the anti-money laundering regulatory requirements is $g(p)$;

f) The probability that a Digital Currency trading service provider will be penalized for failing to strictly implement anti-money laundering regulatory processes is h and the amount of the penalty is i ;

g) The Digital Currency trading service organizations in accordance with the anti-money laundering regulatory requirements to implement anti-money laundering work, then set the money laundering molecules fixed proceeds of j ;

h) The Digital Currency transaction service organization does not fulfill the work obligation of anti-money laundering in accordance with the anti-money laundering regulatory requirements, then the additional proceeds of money launderers are set to be $j(p)$.

With the participation of anti-money laundering regulators, the game matrix between Digital Currency trading service organizations and money launderers is established as shown in **Table 2**.

Table 2. The game between digital currency trading service providers and money launderers under the condition of introducing an anti-money laundering regulator.

		Digital Currency Trading Service	
		In accordance with anti-money laundering regulatory requirements	Failure to comply with anti-money laundering regulatory requirements
money launderer	option non-selectivity	$(j, g - e - e(p))$ (0,0)	$(j + j(p), g + g(p) - e - h * i)$ (0,0)

The expected return to a Digital Currency trading service provider when it goes about fulfilling its AML work obligations in accordance with AML regulatory requirements is:

$$U_1 = g - e - e(p) \quad (5)$$

The expected benefit to a Digital Currency trading service provider when it does not comply with AML regulatory requirements to fulfill its AML work obligations is:

$$U_2 = g + g(p) - e - h * i \quad (6)$$

In the whole game process, if you want to make the Digital Currency transaction service organization perform the work obligation of anti-money laundering in accordance with the anti-money laundering regulatory requirements, you have to let

its expected return be greater than the expected return if you don't perform the work obligation of anti-money laundering in accordance with the anti-money laundering regulatory requirements, and the Digital Currency transaction service organization will choose the former, which means that you have to let, at this time, there is:

$$U_1 - U_2 = h * i - e(p) - g(p) > 0 \quad (7)$$

On the contrary, when $U_1 < U_2$, the Digital Currency trading service organization will choose not to fulfill the AML work obligations according to the AML regulatory requirements. From (7), the variables affecting the Digital Currency trading service providers to fulfill their AML obligations in accordance with AML regulatory requirements are: probability of punishment h , amount of punishment i , operating costs $e(p)$, and additional benefits of not fulfilling AML obligations in accordance with AML regulatory requirements $g(p)$. When the variable $h * i$ is bigger and the variables $e(p)$ and $g(p)$ are smaller, the probability that the Digital Currency accordance with AML regulatory requirements will be bigger. On the contrary, the probability that the Digital Currency trading service providers will not fulfill AML obligations in accordance with AML regulatory requirements will be bigger. The greater the probability that the Digital Currency transaction service organization will fulfill its AML work obligations in accordance with AML regulatory requirements; on the contrary, the smaller the probability that the Digital Currency transaction service organization will fulfill its AML work obligations in accordance with AML regulatory requirements. The following conclusions can be summarized: firstly, under the conditions of AML regulator's participation, the cost of penalties faced by Digital Currency trading service providers when they choose the strategy of not fulfilling AML obligations according to AML regulatory requirements $h * i$ will be very high, and it is possible to choose to reverse incentives for them to actively fulfill their AML obligations; secondly, the AML regulator can indirectly regulate the reduction of the probability of Digital Currency trading service providers' fulfilling AML obligations according to AML regulatory requirements by formulating the scientific regulatory model. Secondly, The AML regulatory body can indirectly regulate to reduce the operating costs of the Digital Currency transaction service providers in fulfilling their AML obligations in accordance with the AML regulatory requirements $e(p)$, and improve the ability of the Digital Currency transaction service providers in fulfilling their AML obligations in accordance with the regulatory requirements; thirdly, the inclusion of the AML regulatory body can to a certain extent prevent or reduce the additional revenue gained by the Digital Currency transaction service providers in the event that the Digital Currency transaction service providers fail to fulfill their AML obligations according to the AML regulatory requirements. Additional benefits $g(p)$ to make them believe that if they do not fulfill their AML obligations in accordance with AML regulatory requirements, they will certainly be punished by the AML regulatory body, which will promote them to fulfill their AML obligations efficiently and prevent the occurrence of money laundering crimes.

3.1.3. The Game between Anti-Money Laundering Regulators and China's Digital Currency Trading Service Organizations

Through the above model, we observe that under the condition of introducing the People's Bank of China as the anti-money laundering regulator, the Digital Currency trading service organizations must also actively carry out anti-money laundering work in order to effectively prevent the occurrence of money laundering crimes. Then the next step is to find the optimal solution between the regulator and the Digital Currency trading service provider to get the optimal choice of the regulatory game.

Although in recent years, more and more Digital Currency trading service organizations have been paying more and more attention to anti-money laundering work. In order to maintain their own sound development, Digital Currency trading service organizations must comply with anti-money laundering laws and regulations to avoid external risks. However, objectively speaking, the implementation of anti-money laundering work in the early stage is unlikely to bring economic benefits to the Digital Currency trading service organizations, such as the problems seen in the previous bitcoin case, the Digital Currency trading service organizations in order to simply the pursuit of economic benefits, for the user's information in all aspects of the review are more formal, and even if there are found to be a problem, but also may be directly ignored. If Digital Currency trading service organizations are required to embed anti-money laundering work in all aspects of customer group selection, customer access, account management and monitoring of transactions of funds from all parties, it is indispensable to invest a large amount of manpower, funds and regulatory technology to support the work Chang Yu [19]. As a profit-oriented Digital Currency trading service providers need to analyze the costs of AML work, there will be a process of thinking about choices before investing resources: for example, when there is no regulation, whether the Digital Currency trading service providers will take the initiative to carry out anti-money laundering work; and if the penalties imposed under AML regulation are lower than the cost of fulfilling the obligation to carry out AML work, the Digital Currency trading service providers will have to bear the cost of AML work. In fact, it is undeniable that the association between AML regulators and Digital Currency trading service providers is more like that of gamers.

Under the conditions of the existing mechanism of the market, the anti-money laundering regulator and the Digital Currency trading service providers will complete the transmission of the legal system of anti-money laundering and the regulatory approach through a relatively long period of time.

Assuming that the two sides of the game are the anti-money laundering regulator and the Digital Currency trading service organization, both sides have ratio consciousness and the ability to analyze and judge, etc. This means that the two sides of the game will not find the optimal strategy at the beginning, but will continue to improve and obtain the optimal. The choice of the two sides of the game, based on the need to consider the regulatory body, the assessment of the Digital Currency trading service institutions of the work obligations of anti-money laun-

dering, management costs and the emergence of money laundering cases resulting in systemic risk. The regulator is categorized into two kinds of regulation and non-regulation. Based on the need to consider the Digital Currency transaction service institutions, Digital Currency transaction service institutions are pursuing the benefits and regulatory agencies on its regulatory coverage and penalty rate, then the Digital Currency transaction service institutions are divided into according to the anti-money laundering regulatory requirements to perform anti-money laundering work obligations and not according to the anti-money laundering regulatory requirements to perform anti-money laundering work obligations. The parameters of the game model are assumed below:

1) The anti-money laundering operating costs for system construction, anti-money laundering system construction, and human resources, etc., required for Digital Currency trading service organizations to fulfill their anti-money laundering obligations in accordance with anti-money laundering regulatory requirements are set at k ;

2) Digital Currency trading service institutions do not fulfill the anti-money laundering work obligations in accordance with the anti-money laundering regulatory requirements and the formation of the non-anti-money laundering regulatory bodies caused losses, for example, due to the emergence of anti-money laundering problems caused by the decline in reputation and legal sanctions, etc. For l , due to the emergence of anti-money laundering issues caused by the probability of the decline in reputation and legal sanctions is m ;

3) The loss of penalties imposed on a Digital Currency trading service provider for failing to fulfill its anti-money laundering obligations in accordance with the anti-money laundering regulatory requirements is q , and the probability of regulatory penalties being imposed on the Digital Currency trading service provider is n ;

4) The operating costs of the AML regulator are due to the human, material and financial resources required to carry out the regulation;

5) The anti-money laundering regulator has caused various money laundering problems to emerge due to inadequate management, which in turn has caused the emergence of systemic problems, with a systemic risk of loss of s and a probability of loss of t .

Based on the above assumptions and exploration of the choices of the two sides of the game, the game matrix between the AML regulator and the Digital Currency trading service provider on regulation can be obtained as shown in **Table 3**.

Table 3. Regulatory gaming between AML regulators and digital currency transaction service providers.

		regulatory body	
		supervisory	unregulated
Digital Currency Trading Service	In accordance with anti-money laundering regulatory requirements	$(-k, -r)$	$(-k, 0)$
	Failure to comply with the requirements of relevant aspects of anti-money laundering regulation	$(-nq, -r)$	$(-ml, -st)$

This game is an asymmetric game with two different players: the Digital Currency trading service provider and the AML regulator. By random sampling and comparison, the proportion of players adopting the strategy of following the AML regulatory requirements is x , and the proportion of players adopting the strategy of not following the AML regulatory requirements is $1 - x$; similarly, assuming that the proportion of players adopting the strategy of “regulating” for the AML regulator is y , and the proportion of players adopting the strategy of “not regulating” for the AML regulator is $1 - y$. Similarly, suppose the proportion of players adopting the “regulate” strategy for the AML regulator is y , and the proportion adopting the “do not regulate” strategy is $1 - y$.

The expected value of “AML compliance” and “non-AML compliance” returns for Digital Currency trading service providers U_{A1} , U_{A2} and the average return $\overline{U}_A$ are.

$$\begin{aligned} U_{A1} &= y * (-k) + (1 - y) * (-k) = -k \\ U_{A2} &= y * (-nq) + (1 - y) * (-ml) = -nqy - ml + mly \\ \overline{U}_A &= x * U_{A1} + (1 - x) * U_{A2} = -kx + (1 - x) * (-nqy - ml + mly) \end{aligned} \quad (8)$$

The “regulated” and “unregulated” expected returns U_{B1} , U_{B2} and the average return $\overline{U}_B$ of the regulator are respectively:

$$\begin{aligned} U_{B1} &= -r \\ U_{B2} &= 0 * x + (1 - x) * (-st) = -st * (1 - x) \\ \overline{U}_B &= y * U_{B1} + (1 - y) * U_{B2} = -ry + (1 - y) * (-st) * (1 - x) \end{aligned} \quad (9)$$

Solved by replicating the dynamic equations for the change in the proportion of the game between the two parties:

$$x = 1 - \frac{r}{s} \quad \text{respond in singing} \quad y = \frac{k - ml}{nq - ml}$$

Analyzing evolutionary games through asymmetric replica dynamic models:

1) In an unstable state, the game process between the regulator and the Digital Currency trading service provider will show a cyclic pattern, showing the cyclic circle of “the regulator is not in place to regulate $\rightarrow$ the illegal behavior of the Digital Currency trading service provider not in accordance with the anti-money laundering regulatory requirements will increase $\rightarrow$ the regulator is prompted to strengthen the regulation $\rightarrow$ leading to the Digital Currency trading service institutions do not follow the anti-money laundering regulatory requirements of the behavior will be reduced $\rightarrow$ and will allow regulators to relax the regulation $\rightarrow$ Digital Currency trading service institutions do not follow the anti-money laundering regulatory requirements of illegal behavior increases” of the cyclical circle of the situation, that is, has not yet formed a relatively stable measurements, the game state at this time the expression for $0 < \frac{k - ml}{nq - ml} < 1$, $0 < 1 - \frac{r}{s} < 1$. For the regulatory body, in the supervision of money laundering behavior, it is necessary to ensure

that its specific regulatory efforts and specific regulatory frequency coincide. In addition, it is also necessary to ensure that all regulatory information openness and transparency, through a variety of measures to continue to promote the improvement of the quality of supervision.

2) In the equilibrium state: based on the cost-benefit, the cost of fulfilling the anti-money laundering work obligations in accordance with the anti-money laundering regulatory requirements, including institutional construction, anti-money laundering system construction and human resources, etc., for the regulator, it should take the field investigation to carry out the relevant aspects of the specific operating costs of the measurement work, which can be combined with the supervision of the specific situation in each region to carry out, if it is found that the cost of punishment far exceeds the operating costs. If it is found that the cost of penalties far exceeds the operating costs, then the state of the game is, $\frac{k - ml}{nq - ml} < 1$, that is to say, $k < nq$ in the case of $x = 1$ for the stabilization of the

value, at this time, the efficiency of the regulation is relatively high. However, if the institution's regulatory penalties do not reach the actual operating costs, then the state of the game at this time will be manifested as $\frac{k - ml}{nq - ml} > 1$, that is, $k > nq$

in the case of $x = 0$ is a stable value, this time, the efficiency and quality of the regulation is relatively poor, the need to take effective measures to promote the continuous improvement of the regulatory efficiency, you can be the Digital Currency trading services institutions operating costs k , increase the failure to fulfill the anti-money laundering requirements of the regulatory requirements of the AML will suffer losses. The two paths can be the operating cost of Digital Currency trading service organizations q , increasing the probability of loss when not fulfilling anti-money laundering obligations in accordance with anti-money laundering regulatory requirements n and increasing the loss of penalties for failing to fulfill anti-money laundering obligations.

3) In the state of fixed costs, it is necessary to optimize the regulatory resources. When the amount of regulatory penalties nq and the operating costs k are determined, the choice of the Digital Currency transaction service providers will depend on the relationship between the size of the regulatory ratio of the regulator y and $\frac{k - ml}{nq - ml}$, when $\frac{k - ml}{nq - ml} < y$, the Digital Currency transaction service providers will choose to fulfill the anti-money laundering work obligations in accordance with the anti-money laundering regulatory requirements, when $\frac{k - ml}{nq - ml} > y$, the Digital Currency transaction service provider will choose not to fulfill its anti-money laundering obligations in accordance with the anti-money laundering regulatory requirements. In order to improve the level of Digital Currency trading service institutions to fulfill their anti-money laundering obligations, the goal should be achieved with the help of the increase in the proportion

of supervision. For the supervisory body, it can continuously increase the strength of input, and at the same time, in accordance with the principle of scientific supervision, to promote the legitimate operation of Digital Currency trading service institutions.

3.2. The Effectiveness of Anti-Money Laundering Regulation of Online Virtual Currencies in China

Using the instrumental approach of game theory to further verify the effectiveness of the anti-money laundering regulation of China's network virtual currencies the problem is mainly the problem of anti-money laundering costs. With the enhancement of money laundering technology means of money laundering molecules using Digital Currency as a tool, the scope of Digital Currency transaction service organizations is expanding, and the types of business continue to increase. Regulatory resources cannot keep pace with the pace, and it is difficult to achieve full coverage of regulation has become the main problem faced by anti-money laundering regulation. Therefore, no matter from the perspective of the People's Bank of China as an anti-money laundering regulator, or from the perspective of China's Digital Currency trading service institutions, what measures need to be taken to minimize the cost of anti-money laundering supervision of China's Digital Currency in the context of Internet finance, making anti-money laundering supervision more effective has become a difficult problem.

The effectiveness of anti-money laundering (FATF, 2013) [20] refers to the extent to which the global threat of money laundering is mitigated by the establishment of AML laws, regulations and regulatory systems and their effective implementation. According to the definition, it can be seen that the work of anti-money laundering is nothing more than the relevant laws, regulations and regulatory systems embedded in the construction of internal control, as well as customer identification, large and suspicious transaction records and so on. That is to say, the effectiveness of China's Digital Currency anti-money laundering supervision depends on the national laws and regulations, anti-money laundering regulatory agencies related to the establishment of the regulatory system, the Digital Currency trading services institutions own anti-money laundering internal control system to establish, fulfill the identification of customers, focusing on monitoring of large-value transactions and suspicious transactions and other legal obligations to combat money laundering to provide evidence of the crime.

For China's Digital Currency trading services, anti-money laundering supervision is not the result of independent choice, but passive behavior, the cost of anti-money laundering supervision is mainly in two aspects: 1) internal costs, first of all, the Digital Currency trading services to carry out anti-money laundering supervision of the work of a long time, will certainly produce operating costs, including labor costs, management costs, etc.; secondly, the anti-money laundering monitoring The second is the system construction cost for the maintenance and development of the AML monitoring system; in addition, the opportunity cost

and the loss cost of customer loss due to the spending of the first two costs. 2) The external cost is only the cost of the penalty received because of the supervision and the cost of the damage to the reputation after the penalty. Digital Currency trading service organizations rely on profit to survive. Any increase in anti-money laundering regulatory measures will increase the cost, and vice versa. If there is no anti-money laundering work, the operating costs will lead to the Digital Currency trading services being abused by money laundering molecules, resulting in reputation damage and legal sanctions. So the asymmetry of cost and benefit directly affects the effectiveness of the Digital Currency anti-money laundering supervision. Therefore, the lower the regulatory cost of the Digital Currency transaction service organizations, the simpler its implementation of the main elements of anti-money laundering supervision, the better the effect of combating money laundering, the higher the effectiveness. In addition, for the anti-money laundering regulatory agencies, its benefits are to the country, if the anti-money laundering regulatory agencies do not regulate will lead to the occurrence of systemic financial risks, anti-money laundering regulatory agencies need to increase the operating costs and manpower costs to improve the effectiveness of supervision. To help the Digital Currency service providers to jointly build an anti-money laundering monitoring system at the same time, they need to be punished for unlawful behavior in order to the Digital Currency It is necessary to penalize illegal acts in order to form a strong deterrent effect on the illegal operation behavior of Digital Currency trading service institutions, and to effectively promote the fulfillment of anti-money laundering work obligations.

3.3. Summary of Anti-Money Laundering Regulatory Issues of Online Virtual Currencies in China

The anti-money laundering regulation of China's Digital Currency can be divided into three main categories: the first is the main content of anti-money laundering regulation; the second is the intuitive impact of the formation of anti-money laundering regulatory strategy; the third is the direct cause of the size of the effectiveness of anti-money laundering regulation is the cost problem. So combined with the analysis above, the anti-money laundering supervision of China's Digital Currency needs to start from the following three aspects:

1) Changing the anti-money laundering supervision status quo of China's network virtual currencies and solving the "four difficulties" problem.

The rapid development of China's network of virtual currencies, accompanied by a variety of money laundering means, forms, due to the entry of the restrictions are not much, not subject to the influence of time, space, resulting in the intensification of money laundering crimes, China's network of virtual currencies of the anti-money laundering supervision of the main content of the formation of the "four difficult" problems, including "Anti-money laundering related laws and regulations to establish compliance with the implementation of difficult", "customer identification is difficult", "internal control management costs and revenues con-

trol is difficult”, “anti-money laundering supervision and technical means difficult”, is the direct cause of the formation of the status quo of anti-money laundering supervision of China’s network virtual currencies, so we should focus on solving these “four difficult” problems, if solved, can change the status quo of anti-money laundering supervision of China’s network virtual currencies, and enhance the effectiveness of anti-money laundering supervision.

2) Combine with the game analysis in this chapter, change the anti-money laundering regulatory strategy of China’s Digital Currency accordingly.

Through the game between China’s Digital Currency trading service organizations and the same industry, money launderers and the People’s Bank of China anti-money laundering regulator, found that the impact of regulatory strategy in the selection process, there are three main aspects:

a) Money laundering molecules use the Digital Currency money laundering, the cost is reduced, so China’s Digital Currency transaction service institutions must use effective anti-money laundering regulatory measures to impact money laundering molecules, and at the same time, due to the use of regulatory measures led to the increase in the cost of anti-money laundering regulation of China’s Digital Currency transaction service institutions.

b) in the face of mutual competition in the same industry, the Digital Currency trading services will choose “not anti-money laundering” operation, reduce losses, so that money laundering molecules use the Digital Currency money laundering costs are also reduced, the harm of money laundering is very big, then the People’s Bank of China as an anti-money laundering regulatory body must have a set of strict The People’s Bank of China as the anti-money laundering regulatory body must have a set of strict regulatory system and means to increase penalties, in order to make the Digital Currency trading services more losses.

c) In the face of strong external regulation, China’s Digital Currency trading services must do a good job of its own anti-money laundering regulatory measures, internal and external coordination, prevention and control of network virtual currencies brought about by the danger of money laundering.

3) Impact of applying science-based regulatory measures to reduce costs

To summarize, it is centered on the “four difficulties” problem, for the optimal solution in the game process, in the face of the challenge of Digital Currency, a new physical object, cannot simply use the existing anti-money laundering regulation, but should explore the adoption of positive anti-money laundering regulatory measures, and ultimately solve the problem of China’s network of virtual currencies of anti-money laundering regulation, to achieve inclusive Finance.

4. Summary and Outlook

The fulfillment of anti-money laundering obligations of online virtual currencies is influenced by anti-money laundering regulators, and at the same time, forms its own anti-money laundering regulatory system. Publicity is a characteristic of anti-money laundering, and Digital Currency transaction service organizations

have become the main bearer of anti-money laundering regulatory costs under the premise of pursuing maximum returns. In this paper, the current situation of China's network virtual currency anti-money laundering supervision system is sorted out, pointing out the specific problems in China's Digital Currency anti-money laundering supervision and the main reasons for the emergence of various problems, including "Difficulty in establishing and complying with anti-money laws and regulations", "Difficulty in identifying customers", "Difficulty in controlling the cost and benefit of internal control and management", and "Difficulty in supervisory and technical means of anti-money laundering". And the use of game theory from the Digital Currency trading services peer institutions, money launderers and anti-money laundering regulatory agencies, three aspects of the game analysis between peer institutions, the construction of the Digital Currency trading services and money laundering molecules between the game model and the Digital Currency trading services and anti-money laundering regulatory bodies between the game model, the Digital Currency anti-money laundering regulatory strategy to choose, and analyze the effectiveness, cost issues.

The countermeasures of anti-money laundering technology and the inevitability of technological development can only move forward. Digital Currency anti-money laundering regulation should avoid becoming a passive follower of illegal means, keep pace with the pace of technological progress, keep pace with the development of the times and economic trends, not only because it is the use of new technologies that can improve the pain points of the current work, more importantly, the development of science and technology for the public to bring positive energy, but also for the money laundering molecules engaged in money laundering activities to provide a breeding ground. The devil is one foot taller, and the road needs to be taller. How to master and use the new technology, the use of the same means of timely and effective control of financial risks and money laundering behavior that exist under the new technology is the challenge that must be faced after the birth of the new technology. Accompanied by the continuous development of Internet technology, the future of the Digital Currency anti-money laundering regulation will certainly show a new posture to combat money laundering crimes, so that the work of anti-money laundering has become the responsibility of each of us, so that money laundering has become a thing of the past, and to contribute to the security and stability of financial inclusion.

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Data Availability

Data will be made available on request.

Author Contribution

Yin Lianqian: Conceptualization, Data curation, Formal analysis, Funding acquisition, Writing original draft. Wu Tong: Writing original draft, Writing review and editing. Guizhou Wang: Writing original draft, Writing review and editing.

Submission Declaration

We declare that this paper is our original work, hasn't received prior publication and isn't under consideration for publication elsewhere.

Conflicts of Interest

The authors (Yin Lianqian, Wu Tong and Guizhou Wang) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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