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Research Article

Security Optimization Management for IoT-Assisted Bank Liquidity Risk Emergency Using Big Data Analytic-Based Case Reasoning

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In modern times, financial institutions are the core carrier of efficient operation of financial markets. With the continuous development of financial models such as IoT (Internet of Things) finance, commercial banks have made many attempts in the integration and innovation of finance and logistics, but they have also increased the types and complexity of risks they face while improving financing efficiency. It has the characteristics of great destructiveness, strong infectivity, and high complexity. The establishment of a perfect emergency security optimization management for early warning of bank liquidity risk is an important part of timely detection and effective management of liquidity risk. In order to enable decision makers to accurately use the effective disposal of similar liquidity risk emergencies as a reference for decision-making, this paper studies the generation method of emergency security plan for bank liquidity risk using big data analytic-based case reasoning. Firstly, analyze the characteristics of various types of bank liquidity emergencies a, and identify the key risk points, and form the accident case database. Secondly, carry out the interval division according to the different numerical distribution characteristics of the indicators, and calculate the repeatability of the involved stages. Finally, calculate the comprehensive similarity to obtain the emergency security plan for reference. At the same time, taking A commercial bank as an example, verify the effectiveness of the method by using the constructed case-based reasoning model to generate emergency security plans intelligently. It provides reference for commercial bank liquidity risk management.

1. Introduction

The progress of the whole society is inseparable from the development of economy and finance, and the health of financial markets directly affects enterprises, which plays an incomparable role in optimizing resource allocation and promoting the development of real economy. At present, great changes have taken place in the structure and development of the whole commercial bank system due to the impact of the century epidemic, the accelerated evolution of great changes unseen in a century, and the complexity and uncertainty of external environment. As a sector with extensive social connections and providing financial services to the public, it has become the core of the modern economy and the gathering place of various economic and social contradictions. In addition, it is a high-risk and highly leveraged industry, so it is particularly important to accelerate the establishment of emergency management mechanism for financial institutions. And the emergency security plan management for liquidity risk is the most important. Liquidity plays a very important role in the operation and development of commercial banks. How to better control liquidity risk is regarded as the focus of asset-liability management and financial risk management by commercial banks.

As an important part of the real economy, IoT finance is in a critical period of transformation and upgrading.

However, many problems have also been exposed in the process of its rapid development, which are particularly prominent in risk early warning and risk response. Because the IoT finance business involves many entities, its risk control has great change compared with the traditional business. As the leader and creditor of IoT finance business, financial institutions are the direct undertakers of losses, facing many risks, including policy risk, management risk, credit risk, liquidity risk, and market risk. Among them, liquidity risk and emergency security plan management for liquidity risk are the most important. Liquidity plays a very important role in the operation and development of commercial banks. How to better control liquidity risk is the focus of asset-liability management and financial risk management of commercial banks and also the key to promoting the further development of IoT finance.

In terms of liquidity management, the liquidity risk of China's commercial banks has existed for a long time. In 2019, the liquidity crisis of small and medium-sized banks in China broke out continuously, in which Hengfeng Bank, Baoshang Bank, and Jinzhou Bank have more than 500 billion yuan of assets, which has aroused widespread concern in public opinion. With the rise of IoT finance, the convenience of mobile payment, the rapid development IoT finance, and the loss of bank deposits and loan defaults have also increased the probability of bank liquidity risk events. Behind the risk events reflects the radical expansion of small and medium-sized banks in China in recent years, which makes the asset-liability maturity mismatch seriously, and the structure is not reasonable, resulting in the lack of adequate risk resilience to emergencies. In general, the long-term and structural trend of liquidity risk of China's commercial banks is increasingly obvious. Liquidity risk has become a major source of risk for the banking industry. It is necessary to conduct more in-depth research on it and build a more systematic response mechanism.

From the perspective of industry regulation, since the U. S. subprime mortgage crisis, domestic and foreign regulators have paid more and more attention to the liquidity risk management of commercial banks. The release of *Basel III* in 2010 is intended to improve the regulatory requirements to attract people's attention to liquidity risk management and also enhance the level of capital and liquidity supervision of commercial banks. Domestically, CBRC issued Commercial Bank Liquidity Risk Management Guidelines in 2009 and Commercial Bank Liquidity Risk Management Measures in 2014, aiming to guide commercial banks to continuously improve their liquidity and risk management level, while maintaining the stability and security of China's financial system. Subsequently, in 2016, China's central bank puts forward the macroprudential evaluation system, taking the liquidity situation as an important evaluation content. On May 23, 2018, the formal draft of *Commercial Bank Liquidity Risk Management Measures* puts forward more detailed and accurate policy requirements for the liquidity risk management of commercial banks [1]. It can be seen that liquidity risk is important and necessary for the stable and healthy development of banking business and financial system.

From the perspective of the government's response to bank emergencies, on September 1, 2018, the Beijing Municipal People's Government prepared the *Emergency security plan for Financial Emergencies in Beijing*, which is the latest model of the emergency security plan for urban financial emergencies, with more detailed attributes and classification of liquidity risk and more comprehensive emergency management content of financial emergencies. Subsequently, Shaoxing, Lishui, and other prefecture-level cities have formulated emergency security plans for financial emergencies that adapt to local financial development according to local conditions.

In the face of the complex external financing environment and regional development differences and how to identify the key factors affecting bank liquidity risk, designing bank liquidity risk monitoring indicators, building a database of bank liquidity risk emergencies, and intelligently generating emergency security plans are of great significance to help banks, regulatory authorities, and the government to take effective measures in the face of bank liquidity risk emergencies, resolve the potential systemic financial risks, and maintain social stability. Under the background of rapid development IoT finance, strengthening and perfecting bank liquidity risk emergency security plan management is an important basic work to establish and perfect emergency mechanism [2]. The establishment of liquidity risk emergency plan system can reduce the decision-making time of emergency response, reduce the pressure of decision makers, and enable banks to respond to liquidity emergencies and implement business recovery more scientifically and reasonably, so as to effectively respond to and resolve liquidity risks.

However, at present, the research field of financial emergencies caused by bank liquidity risk in China has just risen, and a relatively complete research system has not been formed. With the continuous development IoT finance service innovation products, the influencing factors of bank liquidity emergencies are also more diversified and complicated. In order to effectively deal with bank liquidity emergencies, this paper mainly uses case-based reasoning technology, constructs intelligent generation model of bank liquidity risk emergency security plan under the background IoT finance, and completes risk prevention and control contingency plans to ensure that commercial banks properly handle the liquidity crisis Black Swan event [3, 4]. According to the theory of risk evolution, bank liquidity risk is a unity from the continuity of quantitative change to the stage of qualitative change. There are some differences in the degree of risk in different stages, which require different emergency measures. Therefore, this paper divides the historical gene bank of the whole process of bank liquidity risk emergencies into stages, which are incubation period, attack period, deterioration period, and recovery period. Based on the liquidity risk regulatory documents at home and abroad, combined with the actual financial development in China, this paper selects the liquidity risk monitoring indicators of China's banks and constructs a bank liquidity risk historical case database. Then, the interval is divided according to the distribution characteristics of the monitoring index value, and the overall similarity is calculated to provide effective emergency reference measures for the current bank liquidity risk prevention and control plan. Finally, the effectiveness and feasibility of the proposed method are verified by practical examples.

Compared with the existing research, this paper has made some marginal contributions in the following aspects. First of all, combined with the rapid development IoT finance in China and the new problems of bank systemic risk in the postepidemic era, this paper puts forward an intelligent bank liquidity risk emergency security plan generation model from the perspective of liquidity risk, using case reasoning technology, and realizes the timely and effective disposal of financial risk emergencies. Secondly, it provides the basis for government departments to formulate emergency security plans for financial emergencies caused by liquidity risk of banking industry. Finally, it is helpful to improve the risk control IoT finance model, which can make decisions on IoT finance business and effectively manage business risks. The emergency security plan system proposed in this paper can help regulators and government departments to respond quickly to bank liquidity risks and effectively resolve potential systemic financial risks.

The remaining part of this paper is structured as follows: the second part defines the relevant concepts and reviews the literature; the third part describes the bank liquidity risk and designs emergency security plan generation; the fourth part introduces the case-based reasoning process in detail; the fifth part is the specific application cases; and the sixth part is the research conclusion.

2. Literature Review

2.1. Connotation Analysis of Financial Emergencies. With the continuous improvement of people's awareness of the crisis, as well as the in-depth study of financial risks and financial crisis, financial emergency is more and more frequently mentioned in the financial field, but at present no matter in the theoretical circle or the practical operation level, there is no unanimous recognition of what is financial emergency. It is literally understood that financial emergency belongs to one of the financial emergent events mentioned above and erupts in a specific field—the financial system [5]. The generation mechanism of emergencies is complex, but the basic types can be roughly divided into two categories: one is random error type and the other is systematic error type [6]. Financial emergencies are a kind of emergencies that break out in the economic system. The specific characteristics of financial emergencies can be divided into the suddenness of the outbreak time, the polyphyly of inducing factors, the urgency of disposal timing, and the highness of disposal costs.

First, the sudden change of time. Financial emergencies have a common feature, that is "sudden". The first meaning of emergency is that it is a process of quantitative to qualitative change, which means the more risks accumulated, the greater the power of emergencies. Financial emergencies are the result of the continuous accumulation of financial risks, to a certain extent, triggered by some accidental factors. Such as IoT finance enterprise loan default led to the accumulation of bad debts so that the bank cannot bear, sudden collapse of bank bankruptcy [7, 8].

Second, the multi-source of incentives. The risk of inducing financial emergencies is the result of the joint action of many complex factors. In addition to the factors of finance itself, there are also many factors related to politics, economy, society, military and even psychology. The cause of the subprime mortgage crisis in the United States in 2008 was that under the pressure of inflation in the United States, the interest rate cost rose sharply, the loan repayment burden of home buyers surged, the housing market fell, resulting in credit default, bank bankruptcy, severe volatility in the stock market, and even the "occupy Wall Street" behavior, resulting in a serious lack of liquidity in the global market [9]. In terms of China's financial development environment, combined with the impact of the current epidemic, the risk of bank deposits loss and loan default caused by IoT finance also makes financial emergencies complicated.

Third, the urgency of disposal opportunity. Once a financial emergency occurs, such as the lack of timely and effective solutions and control, the harm of the event will spread rapidly with the passage of time and space, eventually leading to out of control and greater losses [10].

Fourth, the high cost of disposal. Financial emergencies spread quickly, and the loss caused by untimely disposal is a geometric multiple increase. At the same time, due to the leverage of financial innovation, the cost of event disposal is often very high. In the 1998 LTCM fund emergency in the United States, if *investors* demanded withdrawal (cash withdrawal), LCTM would be forced to liquidate all its investments, thus endangering USD 125 billion of financial contracts. Not only did these *investors* suffer losses, but the resulting panic selling would also destroy the world's financial markets.

2.2. Summary of IoT Finance Risk Research. As the starting point and foundation of the financial business of the Internet of things, the movable property financing business of commercial banks will flourish again. However, since IoT finance involves many subjects, the specific operation modes are also different, and different links and subjects have different risks. Therefore, domestic and foreign scholars have gradually studied and discussed the possible risks and prevention and control measures in the operation of IoT finance business.

Shin analyzed the decision-making behavior of banks based on asset financing in different situations and pointed out that the corresponding risk monitoring mechanism must be established for IoT finance services [11]. BAĞCI pointed out the possible risks of other subjects in participating in IoT finance business and proposed corresponding risk prevention measures [12]. Based on the perspective of financing companies, Rose et al. and Rajan and Winton pointed out that under the background of IoT finance business, it should constantly improve the credit rating model [13, 14].

Crabtree et al. used case study method to analyze the different types of risks faced by IoT finance processes, such as environment, operation, and management, as the basis for risk rating [15].

IoT finance is a relatively new business model. Brass and Sowell proposed for the first time that IoT finance is a new service project generated by IoT finance and financial institutions. Through the effective attributes of their respective industries, it can effectively revitalize the circulation of semi-finished products and accelerate the flow of funds [16]. Cheryl et al., taking the IoT financial business of listed companies as a sample, it is found that IoT finance has become a new driving force for the development of the research object [17].

Borgia summarizes the basic business model of domestic IoT finance enterprises and believes that there are great risks in its business model [18]. Lu from the perspective of commercial banks, from the perspective of financial institutions, and on the basis of existing risks puts forward new risk control and puts forward the relative prevention and control measures, such as the construction of perfect risk transfer mechanism, improve the business level of IoT finance enterprises, to do a good job of risk prevention, and control measures for market volatility [19]. Li divides risks in IoT finance into operational risks and credit risks. He believes that IoT finance enterprises should seek the help of other institutions, such as third-party institutions, for risk supervision of the enterprise [20].

2.3. Summary of Case-Based Reasoning Research. Case-based reasoning technology originated from the CBR cognitive model and framework described by Roger Schank in Dynamic Memory of Yale University in 1982. It is an important knowledge-based problem solving and learning method in the field of artificial intelligence. It solves practical problems by reusing or modifying solutions to previous similar problems.

2.3.1. Theoretical Research on Case-Based Reasoning. Usually, the problem to be solved is called target case, the historical case is called base case, and the collection of source cases is called case base. CBR is to match the target case with the source case.

Research on case representation is divided into case representation content and representation method. Yan et al. considered that the content of the case representation should cover problem, solution, and outcome, and that the criteria for measurement could be considered as two indicators of the utility and simplicity of the information expressed in the case [21]. Yuan et al. believe that knowledge representation and case representation are interlinked, and cases can be represented as long as knowledge can, so different case representation methods can be selected according to the application field [22]. Different representation methods have different advantages and disadvantages, so they are suitable for problem description in different fields. Domestic and foreign studies have tried to choose suitable representation methods in different fields [23–25].

In the field of emergency management in China, Haibo proposed a general emergency case representation and storage mode based on the three-tier architecture of *emergency concept tree-emergency ontology model-event element model*, which can uniformly represent and store four types of emergencies [26]. She at al. expressed the temporal knowledge in the emergency field with the structure of five tuples to formalize the various information in the emergency decision support system [27]. Qinghua proposed a spatiotemporal expression model of structured multidimensional grid emergency cases and unified management and expression of spatiotemporal attribute characteristics and non-spatiotemporal attribute characteristics of cases [28]. Xu et al. analyzed an emergency case ontology model based on process description and used three-level ontology structure to describe the attribute information of the case, so that it can be applied to different types of emergency events [29]. ElAlami structured the case into event types, key attributes, subordinate attributes, environmental attributes, and hazard assessment attributes from the perspective of attribute characteristics. Attributes are divided into internal attributes and external attributes. Attributes at different levels have different functions, and subordinate attributes are used to assist in depicting key attributes [30].

Case retrieval methods include index design and matching algorithm. There are various retrieval methods, among which the nearest neighbor algorithm, decision tree method, and knowledge guidance method are the most common [31]. Due to the increase in solving uncertain problems and the limitation of people's judgment on uncertain knowledge, researchers have also incorporated some methods to deal with uncertain knowledge into case-based reasoning technology. For example, the rough set theory is introduced into season et al.'s ingenious case retrieval method, and the knowledge reduction strategy of rough set theory is used to remove redundant case feature attributes, which improves the retrieval efficiency [32].

It is difficult to find the problem completely matching with the new problem in the case library, so it is necessary to modify the solution of historical cases to adapt to the solution of new problems, which is the necessity of case modification. Since case correction is domain-dependent and involves complex problems, case correction is also a difficulty in CBR technology [33]. Erdogan proposed a dynamic learning method using data mining method to extract case modification knowledge. knockaert et al. used the advantages of genetic algorithm automatic search to modify the case [34].

The purpose of case study is to store the solution of new problems and the description of the problem itself. Sunarti et al. proposed a decision tree-based case learning method [35]. Qu studied case maintenance problems based on machine learning [36]. Qu Xu (2009) studied the polling mechanism of case learning process based on the multiagent model. Nov and Ye use clustering algorithm to realize case learning and improve learning efficiency [37].

To sum up, the theoretical research of case-based reasoning has involved each step, and there are also innovative studies after adaptive adjustment in many fields. However, there is still a large research space on the reasoning mechanism, reasoning rules, and how to solve the similarity calculation of emergency cases.

2.3.2. Application Research on Case-Based Reasoning. Case-based reasoning technology has been widely concerned by domestic and foreign research institutions and scholars and applied to different areas to solve practical problems, such as medical diagnosis, financial, planning and design, agriculture, forestry and fishery, law, knowledge discovery, and other fields.

The research of emergency decision support system based on case-based reasoning is based on the theory of emergency decision-making and computer technology. It refers to the idea and technology of case-based reasoning to build a system that can provide solutions or information processing. In the field of accident disposal, Hsiao et al. proposed CBR and multiagent and multilibrary collaborative intelligent decision support system [38]. Zhou et al. built a fire emergency response decision support system based on CBR [39]. Zhou Yunhai (2007) designed a case-based reasoning system for large area blackout recovery. Based on the artificial intelligence method of case-based reasoning, Li and Liu proposed the overall framework and workflow of the comprehensive decision support system for water supply failure management [40]. In the field of early warning, Lou et al. case-based reasoning technology, the composition, framework structure, function, and working principle of enterprise crisis early warning system are described, and some key technologies of enterprise crisis early warning system based on case-based reasoning are pointed out [41]. In the field of emergency security plan management, Guo et al. studied the shortcomings of railway hub stations in emergency decision-making and proposed a new emergency security plan management model based on case-based reasoning method [42]. With regard to the overall architecture of emergency decision support system, Li et al. apply new technologies of data warehouse, OLAP, and data mining to emergency decision support system, constructs case base, and designs reasoning mechanism of case base [43]. Li Fenggang (2010) designed a case-based reasoning emergency decision support system from the perspective of theoretical framework.

In summary, case-based reasoning has a wide range of applications, especially in the context of the extensive development of IoT finance, but there are few relevant studies in the financial field, especially in the field of bank liquidity risk. It is urgent to build a targeted emergency security plan system according to different types and levels of commercial bank liquidity risk to prevent the further expansion of commercial bank liquidity risk and cause serious financial crisis.

3. Introduction of Emergency Security Plan Generation Methods

3.1. Problem Description. This paper focuses on the problem of bank liquidity risk emergency security plan generation method based on case-based reasoning. The whole cycle consists of four parts, a total of m stages. The first i stages are the incubation period and attack period, the middle j stages are the deterioration period, and the $m-i-j$ stages are the recovery period, that is, $M=\{1,2\cdots,m\}, i\in M$. Let $S=\{S1,S2\cdots,Si\}$ denote the collection of all phases of liquidity risk emergencies in historical banks, where S_i denotes the i stage of bank liquidity risk emergencies. The index number $N=\{1,2\cdots,n\}, j\in N$, let $C=\{C_{i1},C_{i2}\cdots,C_{in}\}$ denote the indicator set of liquidity risk emergencies of historical banks, where C_{in} denotes the nth index in the first stage of liquidity risk emergencies in historical banks. $C*=\{C^{*1},C^{*2}\cdots,C^{*n}\}$ denotes the index set of current bank liquidity risk events, where C^{*n} denotes the nth index of current bank liquidity risk events. Setting the stage $Z*$ of the current bank liquidity risk event is unknown. Historical database refers to the index value of similar bank liquidity risk events and the detailed records of each stage of the complete cycle of emergency measures. The problem solved in this paper is how to quickly and effectively provide a reference for the current bank liquidity risk events according to the emergency work of similar bank liquidity risk events in the past.

3.2. Research Framework of Emergency Security Plan. In order to solve the above problem of emergency security plan generation, this paper proposes a method of emergency security plan generation for bank liquidity risk based on case-based reasoning. Firstly, the complete cycle of bank liquidity risk events includes the historical gene bank of all stages. Calculate the local similarity between historical cases and target cases; secondly, carry out the interval division according to the distribution characteristics of the bank liquidity index in the value, and screen all indexes by the pruning method. Finally, calculate the comprehensive similarity to obtain similar cases. The research framework of bank liquidity risk emergency plan is shown in Figure 1.

3.3. Index Selection and Data Sources. According to the China Banking and Insurance Regulatory Commission's off-site regulatory statement, the 1104 statement, there are seven statements on bank liquidity risk, each of which has different angles of monitoring. Further, for bank liquidity management, it can be divided into regulatory indicators and monitoring indicators. Among them, the regulatory indicators are mandatory indicators of the regulatory red line of the CBRC. According to the liquidity management approach of commercial banks, commercial banks should continue to meet the minimum regulatory standards of liquidity risk regulatory indicators stipulated by the CBRC. There are five liquidity risk regulatory indicators stipulated by the CBRC, which are liquidity matching ratio, liquidity ratio, liquidity coverage ratio, net stable funding ratio, and high-quality liquidity asset adequacy ratio. Taking into account the actual situation of China's banking industry, the CBRC set different regulatory standards for commercial banks to reach 200 billion yuan of assets. Among them, commercial banks with assets of CNY 200 billion or more should meet the minimum regulatory standards of liquidity matching ratio, liquidity ratio, net stable funding ratio, and liquidity coverage ratio; commercial banks that do not reach

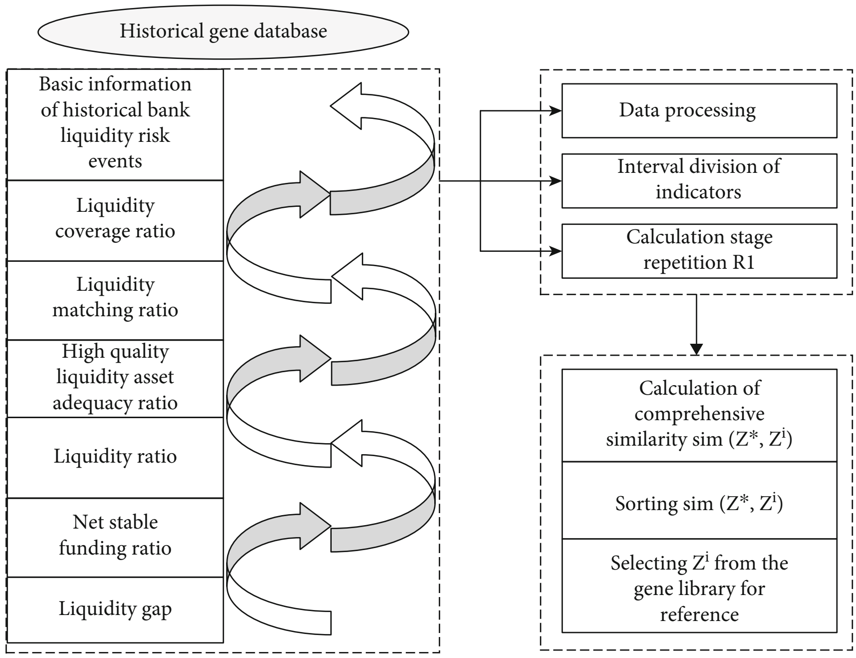

Figure 1: Research framework of bank liquidity risk emergency security plan.

CNY 200 billion should meet the minimum regulatory standards of liquidity matching ratio, liquidity ratio, and high-quality liquidity asset adequacy ratio.

Monitoring indicators are not mandatory indicators of regulatory requirements. In different periods, the CBRC compares and analyzes the anomalies of various monitoring indicators of commercial banks with historical data and industry data and puts forward corresponding window guidance and regulatory opinions. *Commercial Bank Liquidity Management Measures* stipulates that the liquidity risk management framework of commercial banks must contain all liquidity risk monitoring indicators. At present, there are nine liquidity risk monitoring indicators. In summary, based on China's national conditions, this paper comprehensively considers the characteristics of bank liquidity risk emergencies under the background of IoT finance, selects all five regulatory indicators and nine monitoring indicators to reflect the event state according to the 1104 report, and constructs the bank liquidity risk historical gene database. The index calculation formula is shown in Table 1.

The relevant regulatory indicators and monitoring index data used in this paper are from CSMAR database, and the relevant historical case emergency security plan data are from the CBRC and related news websites (including but not limited to microblog, Oriental Finance Network, Sina Finance, Netease Finance, etc.)

3.4. Construction of Bank Liquidity Risk Historical Gene Database. Since there are different stages in the whole cycle of bank liquidity risk emergencies, banks, regulators, and government departments give different emergency measures according to different stages, and the response measures of similar bank liquidity risk emergencies are basically the same across the country, the most effective way to deal with such incidents is to build historical information databases at different stages, so as to provide reference for subsequent similar emergencies. Based on this, according to the different stages of bank liquidity risk emergencies, this paper constructs the historical case gene library of different stages and lists the index values and related emergency measures of each stage in detail. The specific measures come from the policy contents issued by the official website of the bank, the news website, the CBRC of the People's Republic of China, and relevant places. The specific case organization framework is shown in Table 2.

4. Specific Steps of Case Screening

4.1. Data Processing and Interval Division. In order to avoid overconsidering the whole and ignoring the local or overconsidering the local and ignoring the whole, the local and the whole are considered simultaneously in the value of the index. This paper draws on the practice of Yao Xin et al. (2021) to divide the interval for the regions where the index values are concentrated. Finally, the similarity between vectors is used to represent the overall similarity between historical cases and target cases.

Firstly, this paper centralizes, standardizes, and normalizes the index data in the historical gene database of bank liquidity risk events and then takes the average which reflects the centralized trend of a group of numbers and the standard deviation which reflects the discrete trend of a group of numbers into account. Thus, this paper obtains the appropriate group spacing. Then, it uses STATA for normal distribution test to determine that the index values are all normal distribution. Combine with the application of normal distribution in practice, and select the data in the interval $(\mu - 1.96\sigma, \mu + 1.96\sigma)$ as normal values, and the data outside

Table 1: Liquidity risk index system.

Index type	Name	1104 report	Symbol	Calculation formula
Regulatory indicators	Liquidity coverage ratio	《G25_1 liquidity coverage ratio》	C_1	$\frac{\text{Qualified high} - \text{quality liquidity assets}}{\text{net cash outflow in the next 30 days}}$
	Liquidity matching ratio	《G21 statistical table of liquidity term gap》	C_2	$\frac{\text{Weighted source of funds}}{\text{weighted using of funds}}$
	High-quality liquidity asset adequacy ratio.	《G26 high quality liquidity asset adequacy ratio table》	C_3	$\frac{\text{High} - \text{quality liquidity assets}}{\text{net short} - \text{term cash outflow}}$
	Liquidity ratio	《G22 liquidity ratio monitoring table》	C_4	$\frac{\text{Liquidity assets due within one month}}{\text{liquidity liabilities due within one month}}$
	Net stable funding ratio	《G25_2 net stable funding ratio》	C_5	$\frac{\text{Available stable funds}}{\text{required stable funds}}$
Monitoring indicators	Liquidity gap	《G21 statistical table of liquidity term gap》	C_6	Assets due in each future period − liabilities due in each future period
	Liquidity gap ratio	《G21 statistical table of liquidity term gap》	C_7	$\frac{\text{Liquidity gap in each future period}}{\text{assets due in each}} * 100\%$
	Core debt ratio	《G21 statistical table of liquidity term gap》	C_8	$\frac{\text{Core liabilities}}{\text{total liabilities}} * 100\%$
	Peer integration Ratio	《G24 table of inter-industry integration of the top 10 financial institutions》	C_9	$\frac{\text{Interbank demolition} + \text{interbank deposit} + \text{sale repurchase} + \text{principal interbank payment} + \text{issuance of interbank deposit bills} - \text{settlement interbank deposit}}{\text{total liabilities}} * 100\%$
	Top 10 peer integration ratio	《G24 table of inter-industry integration of the top 10 financial institutions》	C_{10}	For the trading opponents of the top 10 inter − industry institutions $\frac{(\text{interindustry dismantling} + \text{interindustry deposit} + \text{selling repurchase} + \text{interindustry payment by the principal} + \text{issuing interindustry certificates of deposit} - \text{settlement interindustry deposits})}{\text{total liabilities} * 100\%}$
	Top 10 deposit ratio	《G23 statement of top ten deposit customers》	C_{11}	$\frac{\text{Top 10 total deposits}}{\text{total deposits}} * 100\%$
	Overpayment ratio	《G22 liquidity ratio monitoring table》	C_{12}	$\frac{\text{Excess deposit reserve} + \text{cash deposit}}{\text{deposits}} * 100\%$
	Liquidity coverage ratio of important currencies	《G25-1 liquidity coverage ratio》	C_{13}	$\frac{\text{Qualified liquidity assets of important currencies}}{\text{cash outflow in the next 30 days}} * 100\%$
	Loan-to-deposit ratio	《G21 statistical table of liquidity term gap》	C_{14}	$\frac{\text{Loan amount}}{\text{deposit amount}} * 100\%$

Table 2: Historical information table for each phase of the full cycle of bank liquidity risk events.

Case number: i Framework name: bank liquidity risk case name
Node 1: description of regional information Composition 1: regional name Composition 2: year of occurrence Composition 3: problem description
Node 2: feature description Composition 1: cause Composition 2: process Composition 3: indicator 1 status Composition 4: indicator 2 status Composition n: indicator n status
Node 3: result set Composition 1: bank liquidity crisis in incubation period (or attack period, deterioration period, and recovery period)
Node 4: emergency countermeasures Composition 1: bank management countermeasures set Composition 2: regulatory agencies countermeasures set Composition 3: government countermeasures set

are regarded as abnormal values for interval division. Group selection is based on the distribution of a set of data and the needs of decision makers. How to consider group spacing is a very important problem. This paper considers both the distribution of normal values and the distribution of extreme values and makes every interval equal probability as possible.

The specific steps are as follows:

(1) Centralize the indicator data C_i in the historical database

$$N_{\text{cen}} = C_i \overline{-x_{\text{Ci}}} \tag{1}$$

(2) Standardize the indicator data in historical databases

$$N_{\text{nor}} = N\text{cen} - \frac{\overline{x_{\text{Ci}}}}{S_{\text{Ci}}} \tag{2}$$

(3) Normalize the indicator data in historical databases

$$N_{\text{one}} = \frac{N\text{nor} - \max\,(N\text{nor})}{\max\,(N\text{nor}) - \min\,(N\text{nor})} \tag{3}$$

(4) Calculate the overall average and standard deviation before the outliers are removed

(5) Calculate the normal interval according to the mean and standard deviation and give the abnormal interval; if $\overline{x_i} - 1.96S_i \le 0$ and $\overline{x_i} - 1.96S_i \ge 1$, there is no abnormal interval;

(6) Place the abnormal value after the abnormal interval, its normal constant is considered as the main body to calculate the average value $\overline{x_i}^*$

(7) Consider the distribution ratio to determine the number of bank liquidity risk cases r before $\overline{x_i}^*$ and the number of bank liquidity risk cases q after $\overline{x_i}^*$ according to the distribution of normal values above and below; and calculate the distribution ratio $Q_{\text{ahead}} = r/(r+q)$ of the normal value on $\overline{x_i}^*$, and calculate the ratio $Q_{\text{behind}} = q/(r+q)$ of the lower distribution

(8) Use the resulting Q_{ahead}和Q_{behind} to determine the number of $\text{Count}_{\text{ahead}}$ and $\text{Count}_{\text{behind}}$ in the front and back intervals of the principal data in $\overline{x_i}^*$; this paper selects the interval of 10, then

$$\begin{aligned} \text{Count}_{\text{ahead}} &= \left[\frac{r}{r+q}\right] \times \left(10 - \text{Num}_{\text{exp}}\right) \\ \text{Count}_{\text{behind}} &= \left[\frac{q}{r+q}\right] \times \left(10 - \text{Num}_{\text{exp}}\right) \end{aligned} \tag{4}$$

(9) Determine the anterior group G_{Sahead} and the posterior group distance G_{Sbehind}, where

$$\begin{aligned} \text{Gs}_{\text{ahead}} &= \frac{\left[\overline{\text{x}_\text{i}}^* - \max\,\left(0, \overline{\text{x}_\text{i}} - 1.96\text{S}_\text{i}\right)\right]}{\text{Count}_{\text{ahead}}} \\ \text{Gs}_{\text{ahead}} &= \frac{\left[\min\,\left(\overline{\text{x}_\text{i}} + 1.96\text{S}_\text{i}, 1\right) - \overline{\text{x}_\text{i}}^*\right]}{\text{Count}_{\text{ahead}}} \end{aligned} \tag{5}$$

According to the above steps, Table 3 divides the interval into the following four situations:

After obtaining the interval divided by each indicator, this paper finds the corresponding interval for the current indicator of the bank liquidity risk event and then finds out the interval where the indicator is at the stage involved in the whole liquidity risk. In Table 4, "√" indicates the stage involved in the current indicator in the whole bank liquidity risk event.

Finally, calculate the repetitive degree R_i, and select the stage with repetitive degree $R_i > \theta$, where θ is given by the decision maker.

4.2. Similarity Calculation. By calculating the similarity between the current bank liquidity risk index vector and the historical bank liquidity risk vector, represent the similarity between the different stages of the historical bank

Table 3: Types of interval division.

Types of interval division
(1) The pre- and postabnormal value intervals exist
$[0, \overline{x_i} - 1.96S_i)$, $[\overline{x_i} - 1.96S_i, \overline{x_i} - 1.96S_i + GS_{ahead})$, … $[\overline{x_i} + 1.96S_i, 1]$
(2) Only the preabnormal value intervals exist
$[0, \overline{x_i} - 1.96S_i)$, $[\overline{x_i} - 1.96S_i, \overline{x_i} - 1.96S_i + GS_{ahead})$, … ,$[(\overline{x_i} - 1.96S_i + GS_{ahead} \times Count_{ahead}) + GS_{behind} \times (Count_{ahead} - 1), 1]$
(3) Only the post-abnormal value intervals exist
$[0, GS_{ahead}]$,$[GS_{ahead}, 2GS_{ahead}]$, …,$[GS_{ahead} \times Count_{ahead} + GS_{behind}, GS_{ahead} \times Count_{ahead} + GS_{behind} \times (Count_{behind} - 1)$, $[GS_{ahead} \times Count_{ahead} + GS_{behind} \times (Count_{behind} - 1), \overline{x_i} + 1.96S_i)$, $[\overline{x_i} + 1.96S_i, 1]$
(4) There is no interval of abnormal value
$[0, GS_{ahead}]$,$[GS_{ahead}, 2GS_{ahead}]$, …, $[GS_{ahead} \times Count_{ahead} + GS_{behind} \times (Count_{behind} - 1), 1]$

Table 4: Intervals of indicators and phases of liquidity risk.

Phase	Indicator1	Indicator 2	Indicator 3	Indicator 4	…	Indicator n
Incubation period	×	√	√	×	×	√
Attack period	×	×	√	×	√	×
Deterioration period	×	×	×	√	×	√
Recovery period	√	√	×	×	√	×

Table 5: Liquidity risk state of A commercial bank in 2020.

C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
1.01	0.98	1.12	0.22	0.99	23865.85	0.05	0.52	0.09	0.57	0.23	0.17	0.97	0.82

Table 6: Interval division of bank liquidity risk indicators.

Indicator	Interval division
C_1	[0,0.042) [0.042,0.116) [0.116,0.174) [0.174,0.232)[0.232,0.29)[0.29,0.347) [0.347,0.51) [0.51,0.673) [0.673,0.836) [0.836,1]
C_2	[0,0.066) [0.066,0.132) [0.132,0.198) [0.198,0.264)[0.264,0.33)[0.33,0.496) [0.496,0.662) [0.662,0.828) [0.828,0.993) [0.993,1]
C_3	[0,0.029) [0.029,0.058) [0.058,0.087) [0.087,0.116)[0.116,0.145)[0.145,0.176) [0.176,0.383) [0.383,0.59) [0.59,0.798) [0.798,1]
C_4	[0,0.037) [0.037,0.074) [0.074,0.011 1) [0.111,0.148) [0.148,0.185)[0.185,0.222) [0.222,0.459) [0.459,0.696) [0.696,0.932) [0.932,1]
C_5	[0,0.042) [0.042,0.084) [0.084,0.126) [0.126,0.168) [0.168,0.21)[0.21,0.249) [0.249,0.408) [0.408,0.567) [0.567,0.726) [0.726,1]
C_6	[0,0.063) [0.063,0.126) [0.126,0.189) [0.189,0.252) [0.252,0.315)[0.315,0.38) [0.38,0.535) [0.535,0.69) [0.69,0.845) [0.845,1]
C_7	[0,0.021) [0.021,0.042) [0.042,0.063) [0.063,0.084) [0.084,0.105)[0.105,0.128) [0.128,0.368) [0.368,0.608) [0.608,0.849) [0.849,1]
C_8	[0,0.052) [0.052,0.135) [0.135,0.342) [0.342,0.369)[0.369,0.48)[0.48,0.526) [0.526,0.598) [0.598,0.673) [0.673,0.921) [0.921,1]
C_9	[0,0.128) [0.128,0.251) [0.251,0.362) [0.362,0.395)[0.395,0.41)[0.41,0.483) [0.483,0.522) [0.522,0.619) [0.619,0.81) [0.81,1]
C_{10}	[0,0.012) [0.012,0.025) [0.025,0.036) [0.0362,0.112)[0.112,0.213)[0.213,0.29) [0.29,0.354) [0.354,0.527) [0.527,0.928) [0.928,1]
C_{11}	[0,0.106) [0.106,0.212) [0.212,0.31) [0.318,0.425) [0.425,0.431)[0.431,0.538) [0.538,0.653) [0.653,0.66) [0.66,0.784) [0.784,1]
C_{12}	[0,0.402) [0.402,0.442) [0.442,0.506) [0.506,0.608) [0.608,0.71)[0.71,0.812) [0.812,0.836) [0.836,0.86) [0.86,0.984) [0.984,1]
C_{13}	[0,0.506) [0.506,0.513) [0.513,0.619) [0.619,0.626)[0.626,0.733)[0.733,0.749) [0.749,0.866) [0.866,0.882) [0.882,0.893) [0.893,1]
C_{14}	[0,0.006) [0.006,0.012) [0.012,0.118) [0.118,0.225) [0.225,0.331)[0.431,0.538) [0.538,0.653) [0.653,0.76) [0.76,0.884) [0.884,1]

liquidity risk event and the current bank liquidity risk event.

$$\mathrm{Sim}(Z^*, Z_i) = \exp\left[\frac{-\left|C^{*j} - C_{ij}\right|}{d_j^{\max} - d_j^{\min}}\right], \tag{6}$$

where

$$\begin{aligned} d_j^{\max} &= \max\left\{C^{*j}, \max\left\{C_{ij} \mid i \in M, j \in N\right\}\right\}, \\ d_j^{\min} &= \min\left\{C^{*j}, \min\left\{C_{ij} \mid i \in M, j \in N\right\}\right\}, \\ Sim(Z^*, Z_i) &= \sum_{j\in N} w_j \bullet Sim(Z^*, Z_i), i \in M, j \in N, \end{aligned} \tag{7}$$

where $w_j$is determined by entropy weight method.

By setting a threshold λ, if $\lambda = \tau \cdot \max\left(\mathrm{Sim}(Z^*, Z_i)\right\}$, select the eligible historical bank liquidity risk event stage.

5. Example Description

This paper takes A commercial bank as an example to illustrate, and its various indicators are shown in Table 5.

5.1. Establishing the Historical Gene Database of Bank Liquidity Risk Events. According to the organization framework of bank liquidity risk events described above, construct the information of each stage of the obtained historical bank liquidity risk cases into a historical case gene database.

5.2. Dividing Bank Liquidity Risk Index Interval. This article is based on 10 groups of division criteria, and according to the obtained bank liquidity risk index data, 14 bank liquidity risk index intervals are divided, and the results are shown in Table 6.

After getting the interval of bank liquidity risk index, find the interval of A commercial bank liquidity risk events, as shown in Table 7; secondly, find out the stages involved in the entire liquidity risk in the interval where the indicator is located, as shown in Table 8. Finally, calculate the repetition R_i of the stage involved, and select the stage where $R_i > 5$, as shown in Table 9.

It can be seen from Table 8 that among the 14 indicators of the liquidity risk of A commercial bank, there are 7 in the attack stage and deterioration stage, 5 in the incubation stage, and 2 in the recovery stage. It can be seen that most indicators of A commercial bank indicate that it is currently in the period of liquidity risk attack or deterioration.

5.3. Similarity Calculation. Some $\mathrm{Sim}(Z^*, Z_i)$ values are shown in Table 9, assuming τ=0.90, $\lambda = 0.71$, and the eligible case is Z_9.

According to the screening results, all the index data selected from the historical gene database are consistent with the current liquidity risk events of A commercial bank as far as possible and provide more accurate reference for emergency decision-making, as shown in Table 10.

Table 7: Interval distribution of liquidity risk index of A commercial bank.

Indicator	Value	Interval
C_1	0.21	4
C_2	0.18	3
C_3	0.32	7
C_4	0.57	8
C_5	0.69	9
C_6	0.11	2
C_7	0.58	8
C_8	0.02	1
C_9	0.31	3
C_{10}	0.28	6
C_{11}	0.17	2
C_{12}	0.19	1
C_{13}	0.65	5
C_{14}	0.47	6

Table 8: The phase involved in the interval of the indicator.

Phase	Incubation period	Attack period	Deterioration period	Recovery period
C_1	×	√	√	×
C_2	×	×	√	×
C_3	×	×	√	×
C_4	√	×	×	×
C_5	√	√	×	×
C_6	×	√	√	×
C_7	√	×	×	√
C_8	×	√	√	×
C_9	×	×	√	×
C_{10}	√	√	×	×
C_{11}	×	√	√	×
C_{12}	×	√	×	×
C_{13}	×	×	×	√
C_{14}	√	×	×	×

To sum up, first of all, establish historical gene database which includes a bank liquidity risk event complete cycle of all stages, and specifically list detailed indicators of each stage of data and the corresponding emergency measures. Secondly, carry out interval division for the numerical distribution of indicators after data processing, so as to better distinguish normal values and abnormal values, and make the screening of emergency security plans more targeted. Then, find the interval of the current index according to the divided interval and the stage involved, and calculate the repeatability of the stage involved. Finally, calculate the comprehensive similarity to obtain the reference of the current emergency security plan for bank liquidity risk events.

Table 9: $\mathrm{Sim}(Z^*, Z_i)$ value.

$\mathrm{Sim}(Z^*, Z_1)$	$\mathrm{Sim}(Z^*, Z_3)$	$\mathrm{Sim}(Z^*, Z_9)$	$\mathrm{Sim}(Z^*, Z_{12})$	$\mathrm{Sim}(Z^*, Z_{17})$
0.721	0.675	0.789	0.771	0.782

Table 10: Reference emergency measure table of historical bank liquidity risk events.

Emergency measures
1. Identify viable and legitimate financing channels and the possibility of regulatory approval of waiver of statutory requirements for temporary liquidity
2. Close monitoring of withdrawals and overdraft accounts
3. Regulators take over and orderly dispose of bonds
4. Press conferences to stabilize market expectations
5. Debt recognition and transfer of deposit insurance funds
6. Comprehensive liquidation
7. Initiation of restructuring
8. Bankruptcy liquidation

6. Conclusion

In the external environment of economic downturn and epidemic, the probability of financial emergencies will also increase. Considering the vigorous development IoT finance innovation and the lack of risk prevention and control, it is of great significance for maintaining financial and social stability to construct an emergency response system for commercial banks that adapts to China's national conditions, especially for the management system of bank liquidity risk emergency security plan under the IoT finance mode. Based on the bank perspective, this paper starts from the actual implementation IoT finance, analyzes the liquidity risk of banks under the IoT model, and uses the case-based reasoning technology to construct the intelligent generation model of bank liquidity risk emergency plan. Taking commercial bank A as the research sample, according to the stage involved in the liquidity risk index, the alertness of liquidity risk of commercial bank A is judged by the repeatability, and the emergency response plan is screened from the historical gene database. This paper provides a reference for banks to effectively deal with liquidity risks under IoT finance. Specifically, according to the characteristics of IoT financial risks, combined with the genetic structure, the historical gene database of bank liquidity risk emergency plan is constructed, which stores specific case information and data, makes effective use of historical data, and intelligently selects alternative decision-making schemes from historical cases of similar bank liquidity risk, so as to provide decision support for current bank liquidity risk target cases. It provides a scientific basis for the government and banks to formulate and resolve financial emergencies caused by liquidity risk for emergency plan management.

The intelligent generation of emergency security plans for bank liquidity risk events is a complex and arduous interdisciplinary system engineering. Combined with the research results, research status, and future development trend of this paper, the management of emergency security plans for bank liquidity risk events should be further studied and discussed from the following aspects. (1) In this paper, when analyzing the management of emergency security plans for bank liquidity risk events, there is a lack of specific positioning of bank liquidity risk sources combined with upstream and downstream industry factors, which is the deficiency of this paper. (2) This paper only studies the case selection, case representation, case retrieval, and case reuse in the generation of bank liquidity risk emergency security plan but ignores case update. (3) In terms of measuring the liquidity risk of banks, this paper draws more on previous research conclusions. In order to achieve research breakthroughs in contingency plans, it is necessary to focus more on the unique risk factors at this stage, such as credit and operational risks caused by IoT finance. (4) The innovation IoT finance model intensifies many risks faced by banks. This paper only focuses on the liquidity risk of many risks and further studies on credit risk, market risk, and operational risk that can be carried out in the future. (5) This paper can further use of deep learning techniques that can be considered to improve the accuracy of case retrieval and case reuse.

Data Availability

Data is confidential.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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