Framework Study on System Risk and Optimization of Rural Financial Market Based on ARCH Family Measurement Model

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Abstract

In the process of studying the volatility of financial market, we usually need to set the relevant variables in the assumptions and explain its objective law of development on the basis of financial theory. However, on the basis of deepening of financial theory, the law of option volatility as a constant operation also shows unreasonable circumstances. In the empirical study of China's rural financial markets, there are still many uncertainties in most financial data such as the indicators of peasant incomes, the bond market interest rates, the foreign exchange market exchange rates, the stock prices, the subsidies for agricultural credit, and the peasant saving power, resulting in irregular fluctuations in risk variance over time at the same time. Then further study of the interaction of the above financial information and the establishment of rural financial market risk management system can avoid the risk of uncertainty caused by price fluctuations. Therefore, this study proposes a systematic risk framework for rural financial markets based on the ARCH family measurement model and a reference scheme for optimizing the model in order to provide a theoretical reference for the management of rural financial markets.

Keywords: ARCH, Autoregressive Conditional Heteroskedasticity Model, Financial Market, Risk Management System, Optimization Model.

1. RESEARCH BACKGROUND

1.1 Literature review

ARCH in the Chinese literature is known as, and the English full name is autoregressive conditional heteroskedasticity model. Econometrician Robert F. Engle, as early as the 1980s, put forward the theory of autoregressive heteroskedasticity and applied it to the study of the volatility of the financial index after inflation in the United Kingdom, and achieved remarkable research results by fully analysing the probability of price volatility and its formation mechanism when financial risks occur (Xie et al., 2014). The ARCH model can simulate the variation of the volatility of the time series variables, and then objectively reflect the volatility risk encountered in the measurement financial field. Academic research on ARCH is the main expansion direction of the model and is collectively referred to as ARCH family measurement model (Jin and Cao, 2014). In 2003, Robert F. Engle won the Nobel Prize in economics in his contribution to the ARCH model field and proposed a completely new viewpoint and evidence base for the research on the ARCH family econometric models (Zeng and Xiong, 2013).

1.2 Research purposes

After conducting empirical research on most of the financial data, economist Mandelbrot argued that the random variable of financial prices tended to approach an infinite variance (Ding and Wei, 2013). In the financial risk mechanism, the distribution law of random variables shows the characteristics of "thick tail", and the variation of financial variance tends to show this phenomenon. In the changes of the financial risk equation, the change of volatility is also concentrated in a certain period of time at the same time, and the change of amplitude in other periods is small (Li et al., 2013). Therefore, the statistical based financial risk assessment mechanism obviously does not apply to the systematic model of rural financial risk, and only the law of independent covariance cannot fully describe the price law of rural financial markets. For this reason, this study proposes an optimization scheme to introduce the ARCH family econometric model through the design of the rural financial market risk system, so as to solve the practical problems with more variables of the financial risk.
2. RISK FRAMEWORK OF RURAL FINANCIAL MARKET SYSTEM BASED ON ARCH FAMILY MEASUREMENT MODEL

2.1 Advantages of ARCH family measurement model in financial risk assessment

In the financial sector, economists have adopted a research program based on the conditional heteroskedastic autoregressive model, which is also the initial model state of ARCH. After nearly 30 years of development, the ARCH family econometric models have been able to objectively reflect the changing conditions and volatility trends of financial markets in different time periods from the description of time series (Wang and Wu, 2012). Then to apply ARCH family econometric model to the risk assessment of rural financial market also possesses objective description basis of the price volatility and can fully interpret the rationality of adopting the optimization plan when adjusting the rural financial market. Therefore, this study designs the systematic risk framework of rural financial market based on the operational effect of ARCH family econometric model in assessing financial risks, as shown in Figure 1.

![Figure 1. Rural Financial Market System Risk Framework Based on ARCH Family Measurement Model](image)

2.2 Operating mechanism of systematic risk framework in rural financial markets

In this framework, the financial risk early warning system is the application target of the system. During its preliminary preparation stage, risk information needs to be collected, and the relevant content of the risk signal sources have to be analogized, including the risk type, risk characteristic and risk structure. In the actual evaluation of the rural financial risk mechanism, the ARCH family econometric model needs to objectively describe the sources of risk (Yao and Guo, 2012). Based on this, an early warning system for risk is established, consisting of five functional modules: signal acquisition, signal processing, early warning structure, organization setting and staffing. Firstly, the financial risk information from different intervals and time periods are mainly collected in signal acquisition, and then the operation result of the ARCH family econometric model is taken as the update...
direction. Based on the clear definition of the risk type and risk structure, the ARCH family econometric model is used to process the signal source and bring it into the early warning structure to evaluate the risk content. Finally, through organizational setup and staffing, management decisions are made against such risks. When early warning information is obtained, financial programs can be adjusted in time or supplementary funds can be used to reduce the risk of financial risks.

After establishing the risk early warning system, long-term maintenance is needed. The maintenance of the functional module needs to include four aspects of workflow. First, the timely collection of feedback information in rural financial markets is used to understand the current financial model fitness assessment. Second, taking the database of risk information as the core, and the risk factors in different periods and stages are summarized. Thirdly, by continuously improving the management system and reducing the implementation bias in risk management assessment, it is possible to ensure effective docking of information processing and implementation (Zhuang and Hao, 2012). Finally, on the part of expanding and improving the financial information tools, we design the evaluation of the prognosis of risk management and the evaluation of the effect of resource allocation, and then continue to propose the improvement direction and adjustment mode of the system to achieve a better operation status of the risk assessment system. The above steps to complete the operation is based on whether the relationship between the return and risk management can achieve the desired effect. If earnings continue to fall below the return indicators that can be provided by risk indicators, it does not mean that the system is completely in balance. Assuming investors do not receive the expected benefits in the long-term investment, it is bound to convert the investment method, and such a conversion process may be the individual behaviour of the system that can’t be foreseen. Therefore, when designing the system risk framework of rural financial market, we need to further study the operating mode of the system and the balance between return and risk in order to achieve the operational effect of optimizing the theoretical framework.

3. ARCH AUTOREGRESSIVE CONDITIONAL HETEROSKEDASTICITY FUNCTION MODEL

3.1 Linear law of ARCH model

Robert F. Engle, based on statistical econometrics in the design of the ARCH model, introduced conditional heteroskedasticity to analyse the changing patterns of economic fluctuations (Tang and Xu, 2011). The definition of conditional variance is \( \sigma^2 \), and \( q \) represents the linear law of square of lag perturbation \( \{ \varepsilon_{t-1}^2, \varepsilon_{t-2}^2, K \varepsilon_{t-q}^2 \} \). Its definition model is:

\[
Y_t = \mu_t + \varepsilon_t
\]

\[
\varepsilon_t = \varepsilon_t + \sigma_t
\]

\[
\sigma_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 = \alpha_0 + \alpha(L)\varepsilon_t^2
\]

In this formula, \( \alpha(L) \) represents the polynomial of the lag operator, and \( \sigma^2 \) can represent the variance of \( \varepsilon_t \) and therefore \( \varepsilon_t \) can also be computed as a known set of information. On the basis of guaranteeing the variance of conditions \( \sigma_i^2 \geq 0 \), further non-negative constraints need to be proposed: \( \alpha_0 > 0, \alpha_i > 0 \) and \( i = 1, 2, \ldots, K \). At the same time, the stability of the second order of \( \{ Y_t \} \) improves the precision of the calculation. The eigenvalues of polynomial \( 1 - \alpha(L) \) represents the unit vectors and meet the above corresponding conditions, so as to describe the operating conditions of the ARCH model and show the operation of the ARCH model (Hui and Zhu, 2010). However, the conditions for compliance of \( \varepsilon_t \) can also be fulfilled under their constraints. Taking \( V_t = \varepsilon^2 - \sigma^2 = (\varepsilon_t^2 - 1)\sigma^2 \) as an example, there is no correlation between their sequences \( \{ V_t \} \) and non-constraint conditions. Therefore, the variance of random disturbance can be expressed as:

\[
\varepsilon^2 = V_t + \sigma^2 = \alpha_0 + \alpha(L)\varepsilon_t^2 + V_t
\]

It can be seen that the computing power of the regression equation itself can reflect a certain linear law and provide extremely powerful computational power for economic research with the particularly proposed research ability of practical data (Liu and Shi, 2017). However, there are some drawbacks based on the linear law: on the one hand, the fitting effect of the linear law on the empirical data does not meet the specific requirements of the order \( q \), so after expanding the research variables, it is not possible to directly summarize the common problems of linear law. On the other hand, when the returns of rural financial markets are negatively correlated with the future expectation, they will also generate a higher ratio of assets to liabilities from the leverage effect, thus pushing up the risk value.
of the economic activity. It can also prove that the linear rule represents only the influence of new information and does not make a complete trend judgment on the reflection of new information.

3.2 Relationship between return and risk balance in ARCH-M model

The ARCH-M model is a comprehensive measurement of changes in financial risk at random times. In the case of close relationship between risk and return, based on the evolution of investment psychology, it is clear that the expected return is relatively high when the risk is high. Conversely, when the financial risk is low, the rate of return does not meet the client's expectations (Cao and Wang, 2017). So in the assessment of financial risk, it is also needed to calculate the formation of risk compensation conditions on the basis of increasing the risk return rate of its variables. The research on the internal relations based on such benefits and risks is the ARCH-M model's expansion direction in the ARCH model family, namely: ARCH in mean model.

Setting $X_t$ as the average return, $Y_t$ as excess returns, $\varepsilon_t$ as random disturbance items, and the ARCH-M model calculation process is as follows:

$$Y_t = X_t + \varepsilon_t$$

$$X_t = X_t \delta + \beta \sigma^2$$

$$\sigma^2 = \vartheta_0 + \vartheta_1 \sum_{i=1}^{q} \omega_i \varepsilon_{t-i}^2 \quad (7)$$

In this formula $i, j$ can be seen as a collection of known financial information, and $X_t$ represents additional variables, $\delta$ represents the threshold of vector parameters.

4. TO OPTIMIZE RISK ASSESSMENT FRAMEWORK FOR RURAL FINANCIAL MARKETS WITH ARCH MODEL

4.1 GARCH evolution model

The rural financial market in our country also needs the cooperation of the national monetary policy in its innovation direction. Earlier, the relevant study on interest rate floating of Rural Credit Cooperatives in Cangnan County, Zhejiang Province found that although the interest rate floating transformation in the local financial markets played a positive effect, for financial institutions, farmers and small businesses, the credit behaviour itself has not reached the expected value. Such limitations may have some inherent connection with the local financial environment and the notion of thinking. At the same time, if the current monetary policy cannot meet the basic motive force that supports the construction and loan of peasants, it will not be able to confirm the strength and driving effect of its policy orientation (Chen and He, 2016). Therefore, in the process of studying the rural financial market, if only the original ARCH model is used as the assessment condition, the relative evaluation base and the parametric criteria cannot directly meet the expected development conditions. Therefore, China adopted the agricultural subsidy policy in the later period. However, on the combined effect of the Agricultural Bank of China and the local government, it is necessary to decentralize the specific amount of subsidies on the basis of credit supplementation. However, such an approach is also likely to cause unfavourable constraints on the decline of loan recovery rates. Therefore, it is necessary to attach more superior constraints on the basis of the ARCH model. Based on the ARCH model, some researches focus on the generalized autoregressive conditions, get the model demand of expanding the direction, and create a definition model GARCH similar to ARCH, whose operation flow is as follows:

$$Y_t = \mu_t + \varepsilon_t$$

$$\sigma^2 = \vartheta_0 + \sum_{i=1}^{q} \vartheta_i \varepsilon_{t-i}^2 + \sum_{i=1}^{q} \eta_i \sigma_{t-i}^2 \quad (9)$$

In this model, we can provide the operational direction of market parameters and make it possible to clearly plan the enforceable effect of measures in close proximity to the real environment in rural markets. If sustainable financial services for low-income population are the ultimate goal of microfinance, most of the current microfinance projects in rural financial markets in our country are still in their infancy and a series of obstacles are still there before achieving sustainable development, which needs a lot of policy reform and system innovation.
Therefore, the use of GARCH model has not led to the improvement or promotion of the financial market environment, but in this way, it can support the calculation results to show the present situation of rural financial market development (Zhang and Wang, 2016). Taking the government’s restrictions on microfinance projects as an example, when obligatory deposits are absorbed, they can be motivated by voluntary savings that bar their reference to variables as a driving force and interest rate limits can be given. Then within its limits, the central bank may also approve the standardization of microfinance so as to reduce the operational risk of private loans, maximize the controllability of the risk mechanism and supervise and manage the sustainable development of microfinance.

4.2 Stochastic volatility model

The stochastic volatility model is optimized mode of operation based on the ABCH. In the financial markets, agricultural financial products are affected by the diffusion of pricing. The price volatility variables can be transformed into volatility operation modes and described through the Wiener process, and the evolution mechanism of the financial volatility model from its model is proposed. The computing model is:

\[ Y_t = \varepsilon_t e^{\frac{k_t}{2}} \]

\[ k_t = \vartheta + \eta h_{t-1} + \beta_t \]

In this formula, \( \varepsilon_t \) and \( h_t \) are the relatively independent intervals, and \( \vartheta \) and \( \beta \) can be set as constants, \( \eta \) represents the persistence parameter, and then the impact mechanism of the current financial volatility is reflected, and \( h_t \) can serve as the evaluation condition to expand the calculation process of ARMA. From the analysis of the expansion mode of its operation model, \( \varepsilon_t \) does not obey the requirement of ecological distribution, but it can express the development mechanism of expanding the model from the distribution of different time periods (Chen and Guo, 2013). Therefore, the stochastic volatility model can be expected to assess the relationship between the volatility and returns of rural financial markets, so as to achieve a clear method and form of investment direction and investment ratio adjustment.

4.3 Optimization model of risk assessment framework of rural financial markets

By analysing the GARCH evolutionary model and the stochastic volatility model, it can be clarified that the dynamic development of the financial market has not been universally affected by macroeconomic policies. On the contrary, it is easier to form other constraints in the short-term band, or stimulate conditions. Therefore, based on the GARCH evolution model and the stochastic volatility model, this study designs an optimization model of the risk assessment framework in rural financial markets as is shown in Figure 2.

![Figure 2. Optimization Model of Risk Assessment Framework in Rural Financial Markets](image)

First of all, based on the GARCH evolution model, we put forward risk management decision-making, risk factor analysis and risk mechanism operation. Secondly, the relevant rules of risk management evaluation are proposed...
by stochastic volatility model. Finally, through the three evaluation contents of internal control management operation, credit risk assessment and negative asset liquidity assessment, we provide the quantitative standard of stochastic volatility model for the comprehensive assessment. Then in the above three steps of the operation flow, it is equivalent to optimize the theoretical framework of traditional risk warning, and the risk sources and conditions can be objectively assessed according to the impact mechanism of rural financial markets so as to provide more rigorous theoretical support of data information for risk prevention and control.

5. CONCLUSION

The hypothesis that the volatility is constant is not suitable for the actual distribution of financial time series. The ARCH family model and its extended form can well model the changing characteristics of volatility. The system of risk early warning for rural financial markets designed in this study is an early warning system set up on the basis of integrating the pricing types of derivatives in rural financial markets. Having clarified the impact mechanism of price volatility on product pricing and risk management, we can determine the optimal direction of risk early warning system. On the one hand, the efficiency and effectiveness of risk model are improved by GARCH evolution model; on the other hand, the potential risk type is calculated by stochastic volatility mode, so as to assess the source of risk as soon as possible and propose a more targeted risk management mechanism in order to promote the steady operation of rural financial markets and achieve the expected development results.

REFERENCES