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Dynamic Analysis of Influencing Factors and Forecast of Development Trend of "Disappearance of Rural Primary Schools"

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Abstract

A time series model was used to screen the causes of changes in the number of rural elementary schools from 1996 to 2019 related to schools, classes, and students in rural, township, and urban areas, as well as the birth rate, population growth rate, and urbanization rate, and a VAR model was developed with five strong influencing factors of rural classes, students, urban schools, classes, and growth rate of students in schools and changes in rural schools. The variance decomposition of the model shows that the continuous reduction of rural classes (student attrition) and the growth of urban students (rural students' rural-urban mobility) are the main reasons for the disappearance of rural elementary schools, while the policy of "removing and merging schools" does not have a long-term impact on the disappearance of rural schools and does not accelerate the disappearance of rural elementary school.

Keywords

VAR, Primary School, School Closure and Merger

1. Introduction

In recent years, people in China have often returned to their hometowns and exclaimed, "The elementary school I went to has disappeared"! The rural elementary schools are disappearing which is a common phenomenon in the development of China's current basic education, the Ministry of Education issued a "Ten Years of Rural Education Layout Adjustment Evaluation Report" shows that China's rural elementary school disappeared an average of 63 per day during the 10 years from 2000 to 2010 (Jin & Wang, 2013). If this time is stretched out, there were still 1.057 million rural elementary schools in China in 1975, and only 86 thousand were left in 2019, nearly 1 million elementary schools disappeared in China's countryside in more than 40 years, and this phenomenon is continuing. There are currently 691,500 villages in China, meaning that there is only one elementary school in every eight villages on average. In 2001, the State Council issued the "State Council Decision on the Reform and Development of Basic Education", which formally launched the "School Closure and Merger" activity, an education policy based on the national level. Since the implementation of this policy, 45 rural elementary schools have disappeared every day, continuing the downward trend in the number of elementary schools in China.

The phenomenon of the elimination of rural elementary schools is a microcosm of our social, demographic, and educational development, and the reasons for this may come from several sources. After the reform and opening up, a large number of rural people began to flock to the cities to work, and some of them began to stay in the cities to buy their own homes, this trend is becoming more and more rapid, as a result, China's urbanization process is gradually accelerating, and the proportion of the population in the countryside is decreasing. Coupled with the fact that the fertility rate in China has also been declining year by year, the population in the countryside has become smaller and smaller, and the number of school-age elementary school students has also fallen off a cliff. In such a background, the national and local government's "School Closure and Merger" action began to gradually promote (Zhou & Cui, 2022). Since the introduction of the national regulations, many scholars have begun to study the impact of this policy and reflection, such as Cai and Kong (2014) pointed out that the "School Closure and Merger" movement has not narrowed the education gap, but rather increased the inequality of education, and also accelerated the development of the education system. Sun and Zheng (2021) used quantitative analysis to prove that the abolition of schools is good for some schools, which makes some schools bigger and bigger, and the bigger the school, the easier it is to fight for educational resources. Liang and Wang (2020) used a double difference model to study "merging schools" and "school closure" separately and pointed out in the results that "school closure" hurt the enrollment rate of some children's elementary schools, while "merging schools" has facilitated the probability of access to upper secondary education in rural elementary schools.

At present, most of the available literature on the reduction of rural elementary schools focuses on the impact and countermeasures of the initiative of "School Closure and Merger" (Liu et al., 2010; Rao & Ye, 2016; Jiang, 2020), and few people dig deeper to find out the real causes of the reduction of the number of rural elementary school and whether the policy of "School Closure and Merger" has accelerated the process of the disappearance of agricultural primary schools. Based on this, this paper starts from the causes of the disappearance of rural elementary schools and uses the dynamic time series analysis model to analyze and study the real causes of the disappearance of rural elementary schools and the impact of the policy of "School Closure and Merger" on the change of the number of rural elementary school.

2. Methodology

In general, there are many reasons for the disappearance of a primary school. This study selected rural schools, classes, students, town schools, classes, students, urban schools, classes, students, and birth rate rates, urbanization rates, population growth rates, etc. The first nine indicators are all closely related to school survival, while the last three reflect demographic changes.

2.1. Impact Factor Analysis Based on VAR Model

Multiple regression analysis is one of the most classic models to analyze the causal relationship between the explanatory variables and the explanatory variables, but there is a basic premise of multiple regression analysis that the data must obey the normal distribution, that is to say, the data must be in the steady state, otherwise, it is easy to lead to the phenomenon of pseudo-regression (Shumway & Stoffer, 2000). Among the multivariate time series models, the vector autoregressive model (VAR) is another model that can be used to explain the causal relationship between variables, VAR model is a kind of non-structural system of equations model, which is often used to predict the relationship between several related time series and the effect of perturbations on the other series of the system. The VAR model is a multivariate generalization of the AR model, and the explanatory variables are called exogenous variables in the model established. Exogenous variables are not obvious and each of them can be used as endogenous variables to construct the model. Using the number of rural elementary schools as an exogenous variable, and then using the number of rural elementary schools and all the rest of the indicators as endogenous variables, a general model for predicting the number of elementary schools based on vector autoregression can be constructed:

$$Y_t = f\left(A_0 X_t^i, A_1 X_{t-1}^i, \cdots, A_1 X_{t-p}^i\right), \quad i = 1, 2, \cdots, 12;\ p = 0, 1, \cdots, \tag{1}$$

where Y_t is the number of rural primary schools in t-th period, X_{t-p}^i is the value of $(t-p)$-th period of the factor i, p is the number of lag period, and A is the coefficient matrix.

Before doing the VAR model usually need to test the smoothness of the data indicators, otherwise, it is easy to lead to a pseudo-regression model of vector autoregression, if the time-series data do not meet the smoothness conditions, to build the VAR model, it is either to differentiate the data until smooth or need to test the cointegration between the variables, and if there is a cointegration relationship, then you can also build the VAR model. The general VAR model can be built as:

$$Y_t = a_1 Y_{t-1} + \cdots + a_p Y_{t-p} + b_{i0} X_t^i + b_{i1} X_{t-1}^i + \cdots + b_{ir} X_{t-r}^i + \varepsilon_t,\ t = 1, 2, \cdots, n \tag{2}$$

Here Y_t is regarded as an exogenous variable, that is, the explanatory variable, and X_t^i is the *i*-th endogenous variable, b_{it} is the corresponding coefficient, p and r are the numbers of lags of exogenous and endogenous variables, respectively, and ε_t is the random error.

To find out the reasons for the gradual "Disappearance" (shrinkage) of rural primary schools, it is necessary to explore which factors are related to the reduction of the number of rural primary schools, The VAR analysis includes the following steps: 1) stability test, the number of schools, classes and the number of students in school, with the decrease of our country's birth population and the increase of urbanization rate, there will always be a certain trend, to verify which factors are related to these trends, first of all, we need to do the stationarity test for these trends, the commonly used stationarity test method is ADF test; 2) co-integration analysis, if the endogenous variables of predicting the number of rural schools meet the requirement of stationary, VAR model can be established directly. If the series is a trend series, it is necessary to further test whether there is a co-integration relationship in the time series system; 3) Percy Grainger causality test, Percy Grainger causality test is to test whether there is a real causal relationship between endogenous and exogenous variables, it is the important guarantee to avoid the model falling into regression, and also the premise to analyze the impact of endogenous variables on the number of rural primary schools; 4) VAR model fitting to establish the Vector autoregression between the number of rural primary schools and other factors, which can be used to explain the causes and predict the follow-up problems; 5) stability test to judge the rationality of the model; 6) impulse effect analysis, which is mainly used to analyze the impact of a change in a cause on the number of rural primary schools; 7) variance decomposition, which is used to analyze the contribution of the main factors affecting rural primary schools, we can further analyze the main and secondary causes; 8) model prediction, using VAR model to predict the future changes in the number of rural primary schools trend.

2.2. Analysis of Policy Interventions

Time series data are often easily disturbed by external factors, such as the promulgation of a policy or the implementation of a measure will cause great fluctuations in the development trend of the original time series data, such as shopping malls, promotional activities will make the day's turnover far more than other points in time, the implementation of real estate restrictions on the implementation of the provisions of the real estate transactions will result in a sharp decline in the number of transactions.

"School Closure and Merger" is an important initiative enacted by China in 2001, and the extent to which the implementation of this policy has had an impact on the reduction of rural schools is another focus of this study. Intervention analysis can be found in Box and Diao's study, in which they introduced the policy as a dummy variable into an ARIMAX model.

Note that the policy variable for "School Closure and Merger" takes the values of 0 and 1 before and after implementation, respectively, *i.e.*:

$$X_t^Z = \begin{cases} 0 & t < 2001 \\ 1 & t \ge 2001 \end{cases} \tag{3}$$

Then ARIMAX can be modeled with the policy dummy variable as the input variable and the number of rural elementary schools as the output variable:

$$Y_t = \frac{\omega}{1-\delta B} X_t^Z, \tag{4}$$

where ω and δ are the parameters to be estimated in the model, $\delta = 0$ means that the impact of the intervention will only exist for a period of time, and $\delta = 1$ means that the intervention will exist for a long period of time. Finally, the results of the model can be used to study the impact of the policy of "School Closure and Merger" on changes in the number of rural elementary schools.

3. Empirical Analysis

The data used in this study are macro-level data from the China Education Statistical Yearbook and the China Statistical Yearbook from 1997 to 2020, of which the China Education Statistical Yearbook contains nine indicators: the number of elementary schools in rural (X_1), the number of classes in rural (X_2), the number of students enrolled in rural primary schools (X_3); the number of elementary schools in urban (X_4), the number of classes in urban (X_5), the number of students in urban (X_6), the number of elementary school in townships (X_7), the number of classes in townships (X_8), number of students in townships (X_9). Where the urbanization rate (%) (X_{10}), the birth rate (‰) (X_{11}), and the number of births (X_{12}) are collected from the China Statistical Yearbook. Of the 12 indicators, the number of rural classes is the explanatory variable, and the rest are explanatory variables. In addition, "School Closure and Merger" (is used as a separate policy factor in the subsequent intervention analysis. For subsequent time-series modeling, it is assumed that all data were collected on the first day of the year.

Because the above data units are not unified, to eliminate the dimensional effect between the data, the ratio of the data is processed. Taking the number of rural primary schools as an example, the new variable is remodeled as:

$$RX_{1t} = \frac{X_{1t} - X_{1(t-1)}}{X_{1(t-1)}}, \tag{5}$$

where RX_{1t} represents the growth rate of rural primary schools, X_{1t} is the number of rural primary schools in the current year, and $X_{1(t-1)}$ is the number of rural primary schools in the previous year. If the indicator is positive, it indicates that the number of rural primary schools has increased, and if negative, it indicates that the number of rural primary schools has decreased. By this analogy, we can get another 10 new indexes, such as the growth rate of rural class

(RX_2), the growth rate of rural school students (RX_3), the growth rate of urban primary school students (RX_4), the growth rate of urban class students (RX_5), the growth rate of urban school students (RX_6), the growth rate of urban school students ($RX_{2=7}$), the growth rate of urban school classes (RX_8), the growth rate of urban school students (RX_9), the growth rate of population (RX_{12}), etc., the urbanization rate (X_{10}) and the birth rate (X_{11}) are not dimensional indicators and therefore should not be dealt with. Figure 1 shows the change of 12 new indicators.

As can be seen from Figure 1, the number of rural schools, classes, and the overall number of students are negative growth, which shows that the scale of rural education is declining year by year. Urban schools, classes, and the number of students in school after 2007 to positive growth-based, which proves the urban school size is increasing. The number of classes and students in the township schools showed negative growth before 2014 and positive growth after that, indicating that the number of the township schools is decreasing, but the scale of the schools is increasing year by year, but the growth rate of school-running scale in the urban area is lower than that in urban area. In 2001, all the indicators except the urbanization rate were negative, which showed that all the education indicators had declined significantly in that year, which was the first year of the implementation of the policy of "Withdrawing points and combining schools". Then in 2011, rural schools, classes, and students dropped significantly, and urban and township-related indicators have increased significantly.

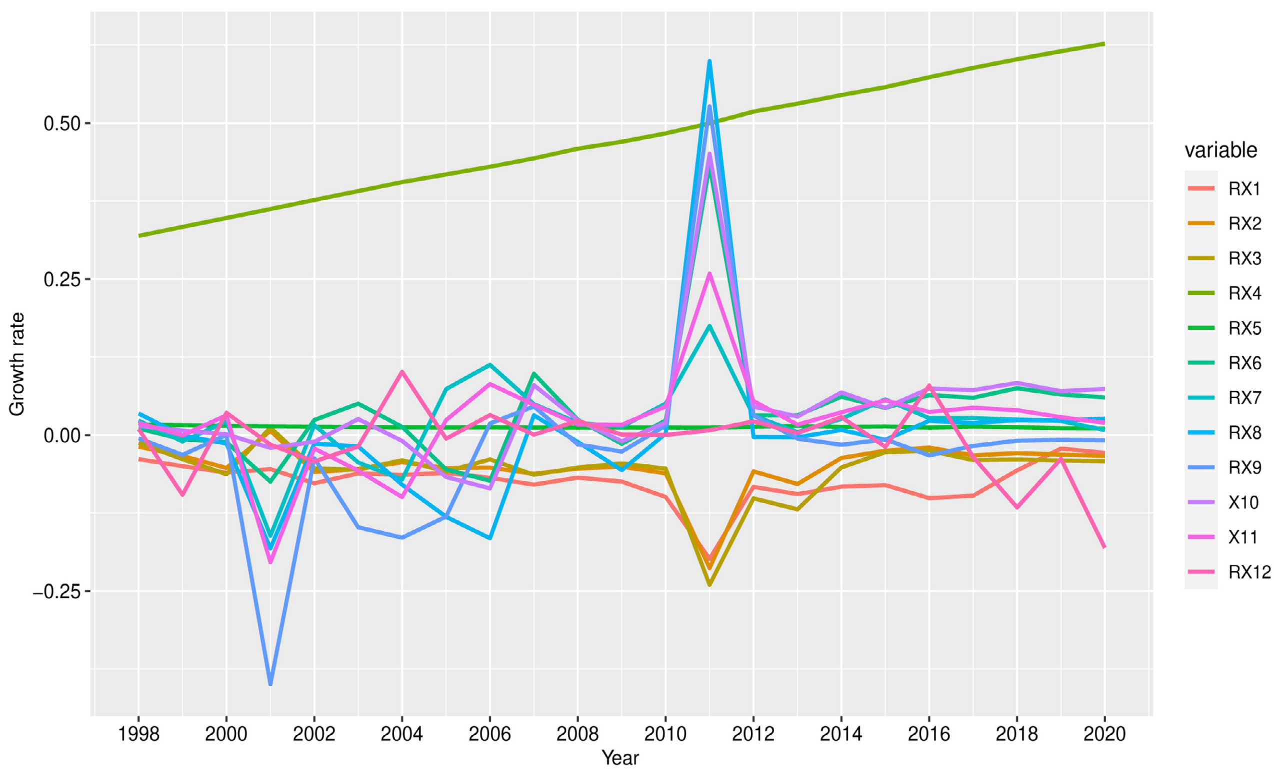

Figure 1. Trends in indicators.

3.1. Analysis of Factors Influencing Changes in the Number of Rural Elementary Schools

3.1.1. Stability Test

By using R 4.2.1 software, the data of rural primary schools and the data of 11 potential influencing factors were read in the past years. From the stability test, if a 95% significance level is set, in the original variables, the growth rate of the number of rural schools, the class of rural schools, the growth rate of rural students, the urbanization rate, the birth rate and the population growth rate are unstable, and the other variables are stable. And all the sequences are stable after the first order difference, in **Table 1**, "d_{RX_1}" or "d_{X_1}" means that the variable has been processed the first order difference.

3.1.2. Co-Integration Test

As there are 6 trend series in the original variables, to analyze whether these variables can establish a non-stationary VAR model, the following cointegration test of the series, the test results are shown in **Table 2**. If the cointegration of the series is judged at the level of $\alpha = 0.05$, it can be seen that when $r \le 3$, the test result is 34.63 < 34.91, which means that these variables contain 2 cointegrating vectors, thus the VAR model can be established.

3.1.3. Granger Causality Test

Because there are two pairs of cointegrating vectors in the series, which means that there are at least two sets of causal models between the series, to further determine the factors related to the number of rural elementary schools, to avoid the model falling into a pseudo-regression, the following endogenous variables affecting the number of rural elementary school with which to do the Granger causality test, the results of the test are shown in **Table 3**. From **Table 3**, we can

Table 1. Stability test.

Variable	ADF	p	Result	Variable	ADF	p	Result
RX_1	−1.2267	0.87	unstable	RX_7	−2.3238	0.45	stable
d_{RX_1}	−3.5881	0.05	stable	d_{RX_7}	−4.5948	0.01	stable
RX_2	−1.8021	0.64	unstable	RX_8	−2.3315	0.45	stable
d_{RX_2}	−3.3637	0.08	stable	d_{RX_8}	−4.4529	0.01	stable
RX_3	−1.9292	0.60	unstable	RX_9	−2.2236	0.49	stable
d_{RX_3}	−3.069	0.17	stable	d_{RX_9}	−4.7546	0.01	stable
RX_4	−2.5593	0.36	stable	X_{10}	−2.0480	0.55	unstable
d_{RX_4}	−4.2060	0.02	stable	$d_{X_{10}}$	−3.6179	0.04	stable
RX_5	−2.5862	0.35	stable	X_{11}	−1.8929	0.61	stable
d_{RX_5}	−4.3983	0.01	stable	$d_{X_{11}}$	−1.4557	0.78	unstable
RX_6	−2.8101	0.26	stable	RX_{12}	−0.0331	0.99	unstable
d_{RX_6}	−4.8942	0.01	stable	$d_{RX_{12}}$	−3.6340	0.04	stable

Table 2. Co-integration test.

Number of cointegration vectors	vaule	$\alpha = 0.1$	$\alpha = 0.05$	$\alpha = 0.01$
$r \le 5$	4.87	7.52	9.24	12.97
$r \le 4$	16.31	17.85	19.96	24.60
$r \le 3$	34.63	32.00	34.91	41.07
$r \le 2$	59.23	49.65	53.12	60.16
$r \le 1$	105.66	71.86	76.07	84.45
$r \le 0$	188.67	97.18	102.14	111.01

Table 3. Granger causality test for quantitative factors of rural primary schools.

factors	F value	p value	factors	F value	p value
RX_2	4.2132	0.033	RX_8	0.7983	0.617
RX_3	4.0104	0.038	RX_9	0.1305	0.879
RX_4	3.8725	0.042	X_{10}	0.2889	0.753
RX_5	3.9375	0.041	X_{11}	0.8664	0.439
RX_6	4.1752	0.035	RX_{12}	0.9742	0.3988
RX_7	0.2318	0.810			

see that there is a Granger causality with the number of rural elementary schools between the only five factors: the growth rate of rural school classes, the growth rate of rural school students, the growth rate of urban school numbers, the growth rate of urban school classes, and the growth rate of urban school students. It is curious that the birth rate and urbanization rate, two indicators directly linked to the rural population, do not have a direct causal relationship with the number of rural elementary schools. A detailed analysis can be understood, the birth rate and the natural population growth rate reflect the development trend of the national population, whether it is urban or rural, the population growth rate is slowing down, compared to the urban population in the countryside is more moderate slowdown trend, and the birth rate There is a serious lag between the birth rate and the number of primary school-age students, and the model takes into account a combination of factors and chooses a 2-period lag model (with the lowest AIC value), so the causal relationship between the birth rate and the number of schools in the countryside will not be obvious. The increase in the urbanization rate reflects more of a process of integration of adults from rural to urban areas, and although there are children of school age who move with their parents to urban areas, the proportion is very small, so the change in the urbanization rate on the number of rural elementary school is also not obvious.

3.1.4. VAR Modeling and Cause Analysis

In Granger causality analysis, it has been known that changes in the number of rural schools are mainly affected by the growth rate of rural school classes, the growth rate of rural school students, the growth rate of the number of urban schools, the growth rate of urban school classes, the growth rate of urban school students, five factors, therefore, these five factors are selected to sequence with the growth rate of rural schools according to the formula (2) and get the regression equation as:

$$\begin{aligned} RX_{1,t} = {} & 1.315RX_{1,t-1} - 0.641RX_{2,t-1} - 0.584RX_{3,t-1} + 0.499RX_{6,t-1} \\ & - 0.824RX_{8,t-1} + 0.568X_{10,t} - 0.533RX_{2,t-2} + 1.252RX_{2,t-2} \\ & - 0.014RX_{3,t-2} - 0.096RX_{6,t-2} + 0.305RX_{8,t-2} - 0.130X_{10,t-2} \\ & - 0.004t - 0.055 \end{aligned} \tag{6}$$

where $RX_{i,t}$ denotes the growth rate of variable X_i at moment *t*.

From the fitted model above, it can be seen that the growth rate of rural elementary schools is strongly influenced by the rural classes with a lag of 2 periods and the growth rate of rural schools in the previous year. To further analyze the influence of each factor on the changes in rural elementary schools, the model was further subjected to impulse analysis and variance decomposition, and the graphs obtained for the impulse analysis are shown in Figure 2, and the graphs for the variance decomposition are shown in Figure 3.

The red dashed line in Figure 2 is the 95% confidence interval, and the impulse results show that the decline in rural elementary school classes brings a

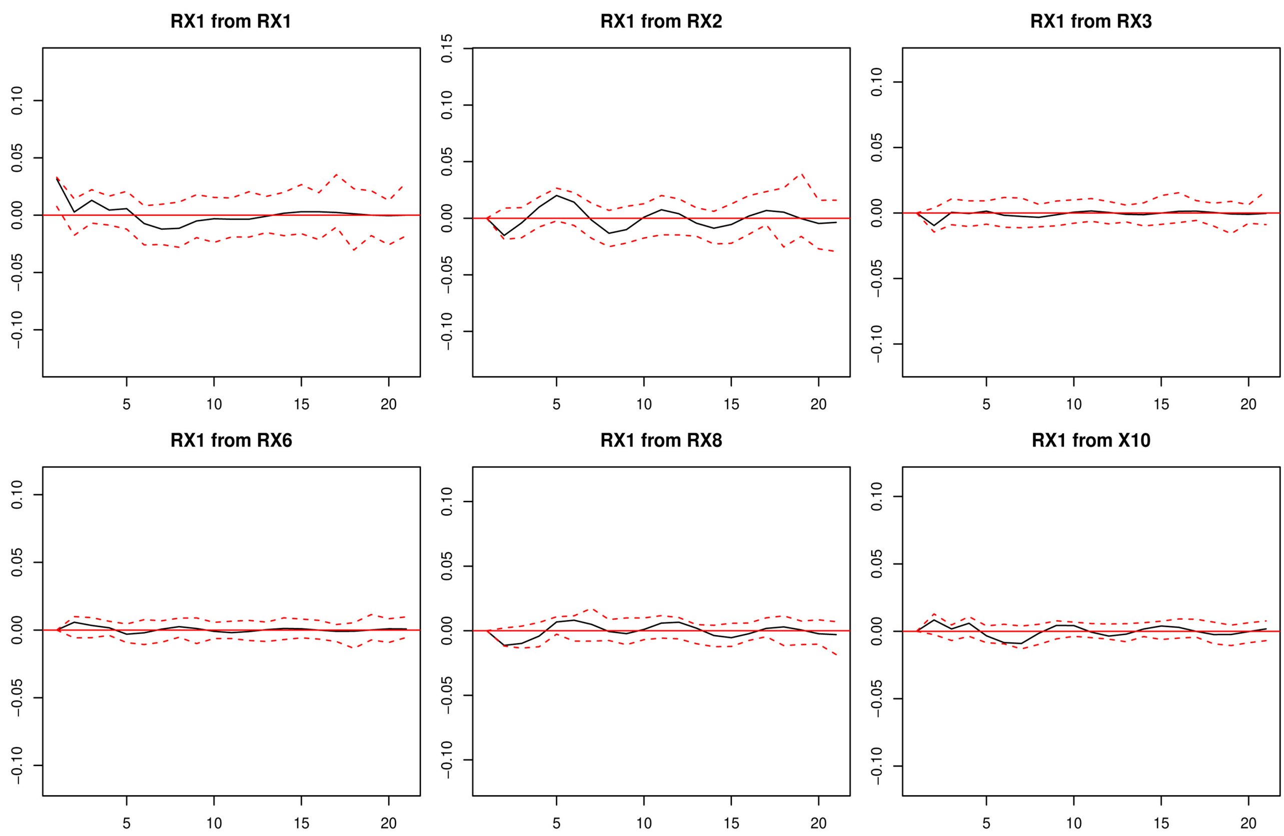

Figure 2. The pulse analysis of each factor to the rural primary school number.

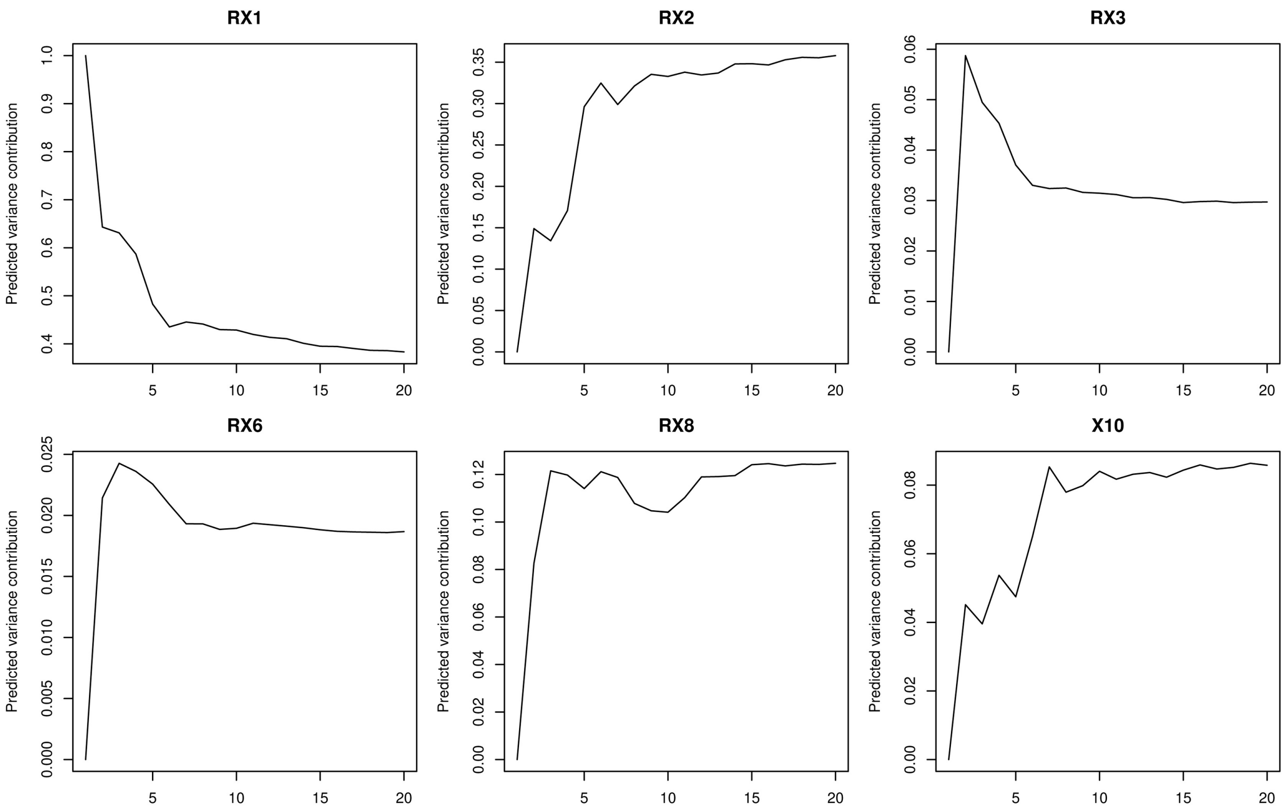

Figure 3. Variance decomposition.

shock to the number of schools in the school in the short term, followed by a rapid plateau, and the impulse effects of the rest of the variables are relatively smooth. Further, the variance decomposition of **Figure 3** can be found in the rural primary class growth rate on the school growth rate of the change in the long term after the stability of about 35%, the number of elementary schools in the urban area on the impact of the long term after the stability of about 12%, the growth rate of the number of elementary school in the countryside of the impact of the late rapid decline in the stabilization of the number of 40%, the rest of the factors of the growth rate of the elementary school growth rate are relatively small between 2% - 8%.

The large graph in the upper half of **Figure 4** shows the effect of VAR fitting for the change in the growth rate of the number of rural elementary schools, and the two small graphs in the lower half show the autocorrelation and partial autocorrelation graphs of the fitted residuals. From the point of view of the real value and the predicted value of the fitted equation, the two fit well, and the established model can correctly reflect the trend of the growth of the number of elementary schools in the countryside, and the autocorrelation and partial autocorrelation plots of the residuals show that the residuals of the fitted residuals are a white noise sequence, indicating that the fitting effect is good.

3.1.5. Model Fitting Effects and Predictions

Figure 5 shows the predicted growth rate of rural elementary schools based on

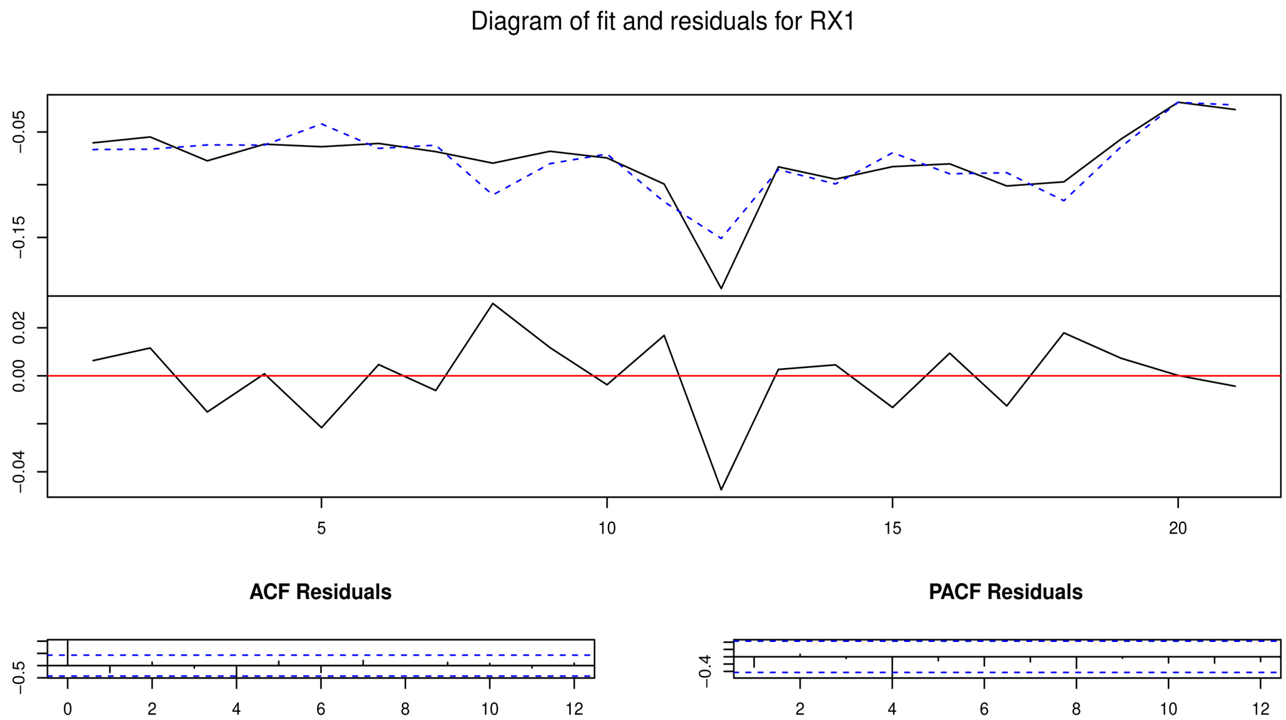

Figure 4. Model fitting.

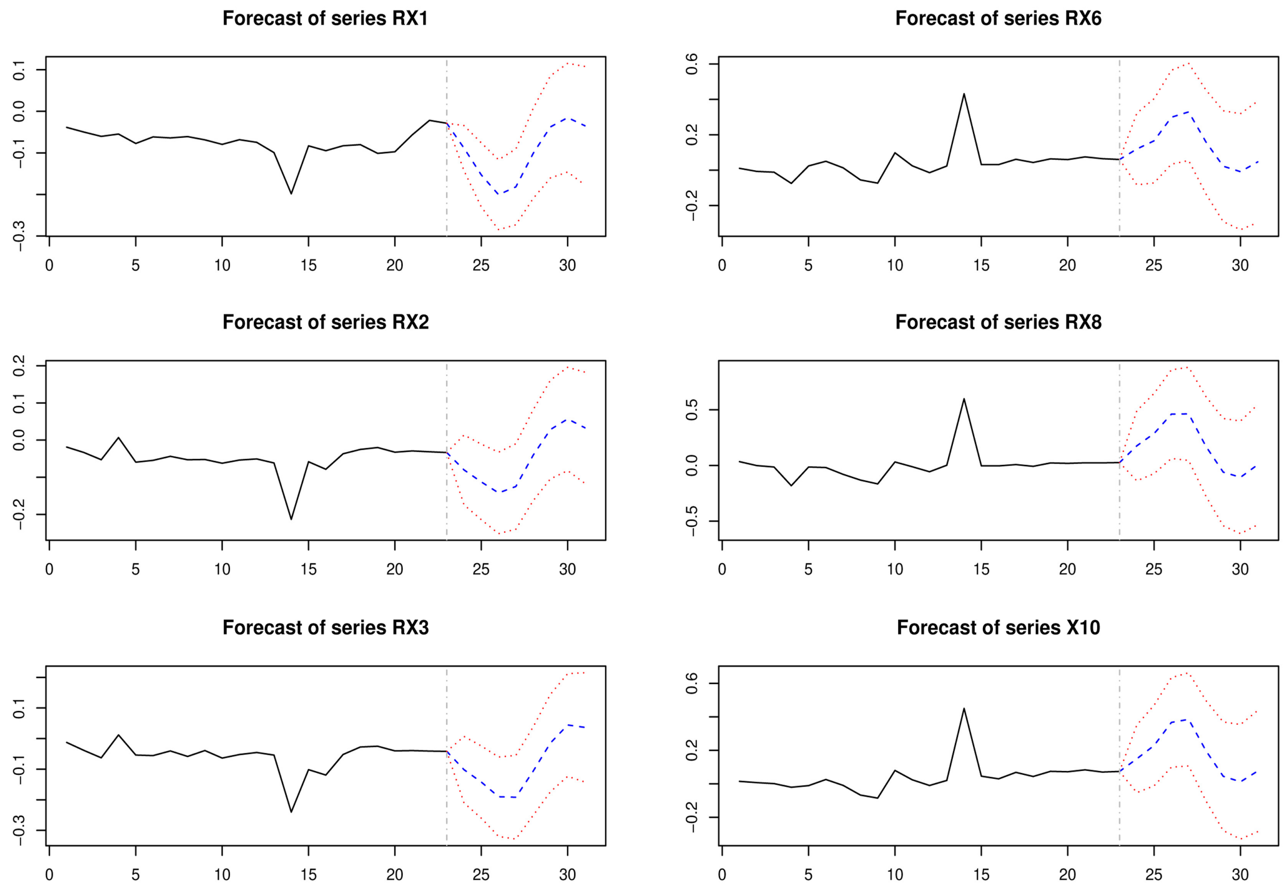

Figure 5. Model fitting.

the established VAR model, which shows that the growth of the number of rural elementary schools, the number of classes, and the number of students in the next five years are negative, that is, the number of rural elementary school, classes, and students will continue to decline over the next five years, and the downward trend will be further accentuated in the next three years, and then the decline rate will gradually slow down, and the number of urban elementary school, classes, and students will continue to grow accordingly, with the growth rate gradually slowing down with a three-year lag.

3.2. Intervention Analysis

From the test of time series in Table 1, we know that the growth rate of rural primary schools is a non-stationary series, which needs do the first-order difference to reach the requirement of stability, therefore, the Arima model of d_{RX_1} and the variable X_{13} is established for policy intervention analysis. The process can be fitted by the ARIMAX () function of R software by using the TSA package, and we got the result:

$$D(Y_t) = 0.0039 X_t^Z. \tag{7}$$

Comparing the results in Equations (5) and (4), it can be obtained that $\omega = 0.0039$, $\delta = 0$, which indicates that the implementation of the policy of “School Closure and Merger” has only one year’s impact on the change in the number of rural elementary school, but does not have a long-term impact on the change in the number of rural elementary school.

Further reviewing the background of the implementation of the policy, we can see that between the implementation of the policy, the number of rural elementary schools in China has been declining, and the data show that the number of rural elementary schools decreased from 1,057,000 in 1975 to 440,000 in 2000, i.e., 617,000 rural primary schools disappeared in the 25 years before the implementation of the policy. That is to say, in the 25 years before the implementation of the policy, 617,000 rural elementary schools disappeared, while 354,000 rural elementary schools disappeared during the period of 2001-2020 after the implementation of the policy, which is even slower than the rate before the implementation of the policy. Combined with the results of the intervention model, we can basically determine that the policy is more like a policy to follow the trend, and its implementation has not accelerated the speed of the disappearance of rural elementary schools in China.

4. Conclusion

At present, China is on the fast track of urbanization, which results in a decreasing rural population and a rising urban population, and in such an environment the lack of rural students is the essential factor in the decline and demise of rural schools. In 2001, the policy of “withdrawing and integrating schools” was regarded as the main reason for the disappearance of elementary school in many literatures, but the analysis of the results in this article shows that instead of saying that the policy of "School Closure and Merger" is the main reason for the gradual disappearance of elementary school in the countryside, it is more like a product of the trend of the times. With the economic and social development and the change of urban and rural personnel structure, the further reduction and demise of rural schools is inevitable. The decline of rural schools is in fact a microcosm of the decline of rural education. Since the main theme of the demise of rural elementary school will not change in the near future, we should think about how to improve the existing teaching environment and quality, as well as what kind of education is needed in modern villages. The exodus of rural students has greatly increased the cost of education for rural students, which is still essentially the embodiment of the uneven development of education, only to retain rural students, rural schools will not be in the development trend of the times towards extinction.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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