Correlation Analysis of Surplus Labor Transfer and Economic Growth Based on STR Model

Zehui Yu,1 Yiming Li,2 and Liru Bai2

1School of Innovation and Entrepreneurship, Shandong Women’s University, Jinan, Shandong 250300, China
2School of Economic and Trade, Shandong Management University, Jinan, Shandong 250300, China

Correspondence should be addressed to Zehui Yu; 30061@sdwu.edu.cn

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For a long time, the research on the relationship between economic growth and the transfer of surplus labor has been the focus and hot issue of all kinds of people. As a model that can describe the nonlinear transformation between different states of variables in detail, the STR model is the Frontier and hot topic of nonlinear time series analysis. In recent years, it has been successfully applied in the fields of economy, finance, capital market, macro policy simulation, and so on. The STR model can well describe the nonlinear and nonequivalent linkage effect between economic growth and surplus labor and has significance in both practice and theory. By constructing an STR model of four variables, including the added value of rural labor transfer and the real added value of each industry, this paper conducts an empirical analysis on the extremely dynamic interaction between the transfer of rural surplus labor and various industries in China. There is an interactive effect of economic growth. The results of the study show that the relationship between human capital and economic growth in China presents a nonlinear characteristic of periodic changes, and frequently switches between linear and nonlinear relationships.

1. Introduction

Economic growth refers to the growth of the ability of a country or a region to produce goods and services, or the output of the national economy, which means the growth of the quantity and the expansion of the scale of the national economy. Economic growth is conducive to promoting social progress and has a very special significance for a country’s status and social stability. Finding the source of economic growth and taking effective measures to achieve economic growth is the goal of people’s tireless exploration, and it is also a major and difficult problem that social development and political stability must face. The reasons for economic growth, the internal mechanism, and the way to achieve economic growth have always been the core issues in the study of economic theory. With the development of social economy in the 21st century, finance has become the core of modern economy. Under the general environment that economic financialization has become an inevitable trend of economic development, it is very important to conduct in-depth research on the relationship between economic growth and financial development. The reason is that finance, as an important means of optimizing the allocation of social resources, plays an important role in leveraging the government’s macro-control and plays a central role in economic growth. But it was not until the 1950s that the research on the relationship between economic growth and financial development aroused widespread attention in the academic circles [1–7].

Over the past 40 years of reform and opening up, China’s economic development has achieved world-renowned achievements, of which the average contribution rate of human capital growth has reached 22%. However, with economic development and an increasingly aging population, China’s extensive economic growth model that relied on a large number of cheap labor for a long time in the past has become unsustainable. The new economic growth theory holds that strengthening the accumulation of human capital, improving the quality of laborers, and replacing quantitative advantages with laborers’ quality advantages are
not only conducive to promoting scientific and technological progress, but also conducive to the adjustment and upgrading of industrial structures and sustained economic growth [8–12].

Since the human capital theory put forward the proposition that “human capital is the source of modern economic growth” in the 1950s, quantitative studies on the relationship between human capital and economic growth have emerged in the theoretical circles. The main reason is that the measurement methods, research objects, sample data, model parameter estimation, and testing methods used in different research literatures are different [13–15].

The transfer of surplus labor in China’s rural areas is an inevitable process from a traditional agricultural society to a modern industrial society. At present, the transfer of China’s rural labor force has reached a certain scale, which has made an important contribution to the development of the rural economy and the improvement of farmers’ income, and at the same time has had an important positive impact on China’s economic development. According to the investigation by the Department of Industrial Policy and Regulations of the Ministry of Agriculture, the income of rural laborers going out to work has become the main source of farmers’ income. In 2000, the per capita income of farmers accounted for 86% of the increase in farmers’ income in that year; in 2002, the contribution rate of farmers’ per capita employment income to the increase in farmers’ income was 41.8%; in 2003, the contribution rate was 32.9%; in 2008, the per capita income of farmers working outside was 398 yuan, which contributed 16.6% to the increase in farmers’ income that year. Although the proportion of the primary industry in the national economy has dropped from 28.1% in 1978 to 15.2% in 2004, the absolute value of the output value of the primary industry has grown rapidly, from 1018.4100 million yuan rose to 2,076.81 billion yuan. A large number of rural laborers turned to the secondary and tertiary industries, providing sufficient cheap labor for the development of the secondary and tertiary industries. From 1978 to 2004, the proportion of agricultural labor force in social employees dropped from 70.5% to 46.9% [16–20].

As for the research topic of the impact of labor transfer (see Figure 1) on economic development, a large number of economists in China have conducted research and analysis on it. The scope of analysis includes the following: collecting relevant data on the status quo of labor transfer and economic development level to analyze the correlation between the two; research is an empirical method, and the reasons for the impact on labor mobility are obtained by establishing an econometric model.

The assumptions of related theoretical models proposed by Western scholars are actually inconsistent with developing countries. Therefore, the relevant domestic theoretical research focuses on the difference of the actual situation. On the basis of learning from international theories, it is combined with the actual situation of labor transfer in China, which can be described as Chinese and Western. The research content covers a wide range, mainly including economy, technology, system, and industry, which has a great theoretical support for China’s economic development [21–24].

Based on the above analysis, it can be summarized into the following two points: (1) The research on the relationship between human capital and economic growth in foreign countries provides the theoretical basis and basic framework and especially acts as an important role in the accumulation of knowledge and the resulting economic growth. (2) Most domestic scholars use linear paradigm models such as Cobb–Douglas production function, Granger test, cointegration theory, and panel data model to analyze the contribution rate of human capital factors to economic growth and the interaction between the two. However, they did not fully integrate the reality of contemporary China and did not fully consider the general background of China’s institutional change. Their analysis assumed a linear relationship between human capital and economic growth, did not consider the possible nonlinear relationship, and adopted a linear paradigm to measure methods and models used to study, so the conclusions obtained are quite controversial. In recent years, the smooth transition (STR) model has been successfully applied to the modeling and forecasting of macroeconomic phenomena such as economic cycle research, inflation, and financial contagion. It is one of the typical tools for nonlinear relationship model analysis. The STR model is a very typical nonlinear model. The main feature of it that is different from the linear model is that it can give transition variables and thresholds and clearly describe the state transition of variables between different zones, thus reflecting the general economic implications that cannot be included in a linear model. Therefore, this paper intends to use the STR model, which can effectively deal with the structural changes of economic phenomena, to deeply analyze the complex old linear relationship between human capital and economic growth [25–27].

This paper uses the STR model to study the impact of surplus labor transfer on economic growth, explores the way that surplus labor transfer affects economic growth, and puts forward corresponding policy suggestions for steadily advancing surplus labor transfer on the premise of maintaining economic growth. Firstly, the relevant literatures are sorted out, the existing research angles and measurement models on the transfer of surplus labor are analyzed, and the possible
The faster the conversion speed of the model between the parameter of the conversion function, which represents the exogenous variable, or a time trend, variable, which can be a lagged endogenous variable, an standard STR model has the following form:

$$G(y, c; s_t) = 1 - \exp\left(-\gamma(s_t - c)^2\right), \quad y > 0. \quad (2)$$

Then the STR model at this time is embodied as the ESTR model. At this time, the conversion function G is an even function. When the switching variable takes values at point c, the converted value G is symmetrical about it, which reflects that the influence of the switching variable on the target variable is symmetrical. When the transfer function satisfies the following formula, the influence of the nonlinear part of the model gradually disappears, and only the linear influence part remains.

$$G(y, c; s_t) \rightarrow 0. \quad (3)$$

That is,

$$\begin{cases} G(y, c; s_t) \rightarrow 0, & \text{if } s_t \rightarrow c \\ G(y, c; s_t) \rightarrow 1, & \text{if } s_t \rightarrow \pm \infty \end{cases} \quad (4)$$

If the conversion function is of the form:

$$G(y, c; s_t) = \left[1 + \exp\left(-\gamma(s_t - c)\right)\right]^{-1}, \quad y > 0. \quad (5)$$

That is, the transformation function G has only one position parameter, and the corresponding model form is the LSTR model. The transformation function G increases monotonically with the change of the transformation variable s_t and satisfies the following formula:

$$\begin{cases} G(y, c; s_t) = 0.5, & \text{if } s_t = c \\ G(y, c; s_t) \rightarrow 1, & \text{if } s_t \rightarrow \infty \end{cases} \quad (6)$$

Similarly, if the conversion function is of the form:

$$G(y, c; s_t) = \left[1 + \exp\left(-\gamma(s_t - c_1)(s_t - c_2)\right)\right]^{-1}, \quad y > 0, \quad c_1 < c_2. \quad (7)$$

That is, the conversion function G contains two position parameters, at this time:

$$\begin{cases} G(y, c; s_t) = 1, & \text{if } s_t = \pm \infty \\ G(y, c; s_t) \rightarrow 0, & \text{if } y \rightarrow \infty, \quad c_1 \leq s_t \leq c_2 \end{cases} \quad (8)$$

The modeling process of the STR model roughly includes three stages: model setting, parameter estimation in the model, and model evaluation. The model setting process includes the determination of the lag order of the regression part, nonlinear testing, and pattern identification. The evaluation phase of the model includes goodness-of-fit testing and fitness testing. The modeling steps of the STR model are as follows (see Figure 2).

Step1. Data preprocessing is done. The STR model is generally suitable for stationary time series and cannot be applied to nonstationary time series. Therefore, the stationarity of the sequence needs to be checked before establishing the model. The preprocessing process such as difference transforms the data into a stationary time series, and then
the Granger causality analysis cannot be performed to determine whether it is a one-way causal relationship or a two-way causality and specify who is the independent variable and who is the dependent variable.

Step 2. Determine the lag order of the regression part. Build the regression model:

\[ y_t = a_0 + a_1 y_{t-1} + a_2 y_{t-2} + \cdots + a_k y_{t-k} + b_1 x_{t-1} + b_2 x_{t-2} + \cdots + b_k x_{t-k} + \varepsilon_t, \]  

(9)

where \( k1 \) and \( k2 \) is the order and \( \varepsilon_t \) is the residual. The lag order is determined by computing the LB statistic and the likelihood ratio LR statistic of the residual sequence \( \{\varepsilon\} \). The expression of the LB statistic (also called the \( Q \) statistic) is as follows:

\[ Q_{LB} = N (N+2) \sum_{k=1}^{p} \frac{(\rho_k)^2}{N-k} \]  

(10)

If the above formula satisfies formula (11), it means that the lag order is \( p \).

\[ Q_{LB} \geq \chi^2 (p). \]  

(11)

The expression for the LR statistic is

\[ LR = -2 \left[ \log L(\hat{\beta}, \hat{\sigma}^2) - \log L(\bar{\beta}, \bar{\sigma}^2) \right], \]  

(12)

where \( \log L \) is the maximum value of the log-likelihood function of the restricted model and the nonrestricted model.

Step 3. Nonlinear test is done, that is, the choice of linear model and nonlinear STR model. The original hypothesis of the nonlinear test is that there is a linear relationship between the explained variable \( y \) and the explanatory variable \( x \), that is, the model is a linear model, and the nonlinear STR model is used as the model for its alternative hypothesis.

Step 4. Pattern recognition is the selection of conversion function. After passing the nonlinear test, pattern recognition was performed, and a choice was made between the LSTR model and the ESTR model.

Step 5. Estimation of the STR model parameters is done. The methods of parameter estimation mainly include the Gauss–Newton iteration method, simulated annealing method, and grid search method. The specific parameter estimation problem will be described in detail in the third chapter.

Step 6. Evaluation and adaptability test of the STR model is done. The evaluation of the model is mainly done by comparing the AIC value, SC value, and DW value of the model: the adaptability test of the model is to test whether \( \{\varepsilon\} \) is a random sequence according to the sample autocorrelation coefficient of the residual sequence \( \{\varepsilon\} \).

According to the construction steps of the STR model, the problems that need to be solved in the empirical research of the STR model are mainly summarized as follows: stationarity test, Granger causality test, nonlinear test, determination of lag order, determination of transfer function selection, and parameter estimation of the model.

3. Empirical Analysis

There are many factors that affect labor transfer, as follows.

3.1. Expected Income Gap. The driving force of labor migration to cities lies in the income gap between urban and rural areas. When the income gap between urban and rural areas is small enough to be equal to the cost of migration, rural labor will be more inclined to migrate nearby. Compared with the cost of migration to big cities (discrimination in employment, unbalanced education, high cost of living), the urban-rural income gap is not that huge. The farmer’s union considers various factors to determine its own place of employment. The increase in wages in this province will speed up the pace of labor returning to the province for development. There is a cost to living long term in the city. Under the influence of inflationary pressure, the rise of urban prices in recent years has generally been greater than that of wages, which makes urban life more difficult and the cost of living increases. At the same time, the transfer locations of rural surplus labor are generally concentrated in the developed eastern coastal areas, where wages are difficult to afford high housing prices, and the rural transfer population does not have a strong sense of belonging. The transfer of rural surplus labor has made important contributions to the primary, secondary, and tertiary industries and played an important role in China’s rapid economic growth. The cost of living in the city is also reflected in the cost of education. Many children of migrant workers cannot enjoy formal education in local public schools, which creates inequality in education. All of the above reasons are likely to form the flow of labor to the hometown for development. The predicted value is shown in Figure 3.

3.2. Household Registration System Constraints. In China, there is a special household registration system that separates urban and rural areas. This system coexists in the process of rural labor transfer. The existence of the
household registration system has led to a series of problems such as urban and rural employment discrimination, social security system inequality, and education inequity. However, with the introduction of various policies, the household registration wall tends to soften, changing from the previous “hard wall” to a “soft wall.” It is embodied in the previous restrictions on labor and the transfer of the population to the current free movement of the population. And employment policies, medical care, social security, and education all have a rhythm that tends to be fair. At present, the reform of the household registration system is still incomplete, and the return of the labor force within the province is also an inevitable under the development of the system. At the same time, with the rapid development of China’s economy, a large number of employment opportunities and space have been created for the transfer of rural labor force.

3.3. Factors of Industrial Transfer. Unemployment brought about by industrial transfer prompts laborers to return to their hometowns for employment. At the same time, the return of laborers to their hometowns will also promote the upgrading of the industrial structure and economic growth in the province and county. It can be said that there is a mutual influence and mutual promotion relationship between industrial transfer and labor force transfer.

3.4. Family Factors. The reasons for returning due to family are concentrated in two aspects: one is that unmarried laborers return to their hometowns to get married and stay in their hometowns, which will make the rural laborers go back to their hometowns; The decision-making of the migrant labor force and the family relationship maintained by family affection have a subtle influence on us. Therefore, it can be said that the family aspect is a major determinant of the return of rural surplus labor.

3.5. The Role of Government. Policy orientation is an important factor influencing the trend change in the transfer of rural surplus labor. There are countless entrepreneurial industrial parks and industrial parks in various places, more employment opportunities, and wages have also increased to a certain extent. Only a good policy environment can support the return of rural surplus labor to employment in the province, and only a policy of returning home to start a business that is good at guiding can better promote entrepreneurship, so as to solve the employment problem of the returning labor force. The predicted value is shown in Figure 4.

The coefficient of the labor transfer rate is 0.532357, which means that, holding other explanatory variables constant, for each percentage point of labor from the agricultural sector to the nonagricultural sector (due to the logarithmic form used in the regression), the annual growth rate of per capita GDP will be an increase of 0.532357 percentage points indicates that the transfer allocation effect of labor has a significant impact on economic growth. The Solow model needs to be analyzed here. According to the STR model, when the input of labor increases, it can prevent the economic growth caused by the increase in capital output rate. It is difficult to maintain the stage of economic growth. By extending the STR model, it can be obtained that the trend of employment growth rate and economic growth rate is consistent in theory, that is to say, in theory, employment will also maintain a corresponding increase in the process of economic growth. The labor transfer rate is calculated by dividing the total number of employment in the secondary and tertiary industries by the total number of employees. It can be concluded that a large amount of labor was transferred from the agricultural sector every year, and the overall average annual employment growth in Shandong Province was positive, indicating that other industrial sectors in Shandong Province absorbed these workers from the agricultural sector. Labor transferred from the agricultural sector. At the same time, the average annual employment growth rates of the secondary and tertiary industries are both positive and faster than the province’s average annual employment growth rate, revealing that the labor force transferred from the agricultural sector is likely to be absorbed by the secondary and tertiary industries. However, it can be seen that the real GDP of Shandong Province cannot be used as an explanatory variable for the labor transfer rate. The labor transfer rate is a value obtained by dividing the number of employees in the secondary and tertiary industries by the total number of employees. From the perspective of industrial economy from the point of view, the labor productivity of the secondary and tertiary industries is higher than that of the primary industry. At the same time, in the secondary and tertiary industries, technology is an indispensable factor of production in the process of economic production. The output value growth of the tertiary industry has made a huge contribution. Taking the secondary industry as an example, in the era of modernization and industrialization, many production processes have replaced labor with machinery. Workers do not use manual labor to produce but operate machines to produce. Labor needs to have certain knowledge and skills to control this. It can be seen that the quality requirements of the labor force in the secondary and tertiary industries are higher than those in the primary industry, and most of the rural labor force transferred from the primary industry does not have this quality. It is difficult for the labor force to enter the
industries that make a huge contribution to GDP, so GDP cannot be used as an explanatory variable for the change of labor transfer rate. The normalized frequency is shown in Figure 5.

Through the results of regression analysis, the per capita human capital stock is $-3.106124$, which is the only coefficient with a negative value among all the independent variables in the linear regression analysis. This shows that human capital in Shandong Province is negatively correlated with economic growth in Shandong Province. This is diametrically opposed to popular scholars’ notions. Nowadays, people generally realize that increasing investment in human capital has a positive effect on economic growth. While accumulating material capital, economically developed countries also pay attention to people’s health through investment in education. Health status, accumulated a lot of human capital for the country. Through education, ordinary people can become skilled labor, can use and operate complex labor tools, and create new ideas and methods that can improve production efficiency in economic production activities. Although countries with relatively backward economies may have a large number of laborers, the proportion of such skilled laborers is still very small. The lack of skilled laborers has become an obstacle to the economic development of these underdeveloped countries. Extending the Solow model, the "savings" in it are not only used to invest in material capital, but also part of it is used to invest in education, which has been discussed above for the improvement of the quality of the labor force. In theory, material capital should have the phenomenon of diminishing returns to scale, but by observing the economic growth of various countries, it is found that capital does not have the phenomenon of diminishing returns to scale that should have occurred. They are unified as capital for analysis, so there is a phenomenon that the marginal rate of return of capital will be roughly constant. It can be seen that human capital has a positive effect on economic growth. Figure 6 shows the probability plot.

However, the phenomenon that the coefficient of human capital stock is negative in the regression model can be...
explained from the perspective of the distribution of educational resources in Shandong Province. In the third chapter, this thesis has described the educational situation in Shandong Province. The distribution of educational resources in Shandong is unreasonable. The number of agricultural population in the three regions of the east, the middle and the west is the largest in the western region of Shandong, which means that the western region of Shandong is in need of The regions with the largest number of transferred labor force, but their educational resources, taking the number of schools with professional skills and the number of teaching staff as an example, ranked the last in three regions. Moreover, there is not only the problem of regional imbalance in the distribution of educational resources, but also the problem of imbalance between rural and urban areas, and the problem of imbalance between demand and supply of education. Therefore, labor activities in rural areas have more opportunities to increase human capital stock than the labor force with hukou in the city is much smaller. Moreover, the income obtained by the labor force working in the agricultural sector is often only enough to support the needs of family life. The amount to be paid for human capital investment is a considerable burden for these people, and some families cannot even afford this expenditure. Therefore, some rural laborers will enter the labor market after receiving primary education, and the labor quality of these laborers transferred from rural to urban areas does not meet the requirements of the labor force needed in the urban secondary and tertiary industries. In this situation of unbalanced distribution of labor resources, the labor force with household registration in the city has greatly improved the opportunity to improve labor skills under the condition of relatively abundant educational resources, and become the skilled labor force needed by the secondary and tertiary industries. The welcome of the secondary and tertiary industries, which crowds out the employment opportunities of the labor force transferred from the countryside. Therefore, when other independent variables remain constant, for every one percentage point increase in human capital stock, the evaluation is shown in Figure 7, meanwhile the amplitude is compared in Figure 8.

4. Conclusion
From the above analysis, it can be concluded that the rapid development of the primary industry has played an
important role in the transfer of rural surplus labor, but there is no complete surplus labor in rural China, and the transfer of rural labor has little contribution to the primary industry; both the impulse response and forecast variance decomposition show that the secondary industry has played an important role in the transfer of rural labor; the transfer of rural labor has provided a large number of cheap labor for the development of the tertiary industry and has made an important contribution to the tertiary industry. It also played a huge role in the process of accelerating the transfer of rural labor force and made an important contribution to promoting the transfer of rural labor force.

Based on the above analysis, we can see that there is a good interaction effect between rural labor transfer and economic growth, especially the tertiary industry. Therefore, more transfer opportunities should be provided for the rural labor force in an all-round way and help the rural labor force have more employment opportunities. From the perspective of industry, it is necessary to vigorously develop the labor-intensive tertiary industry and expand the employment channels for the rural labor force. The tertiary industry includes labor-intensive industries such as retail, transportation, tourism, catering services, finance, and real estate, and it has the strongest ability to absorb labor. It is necessary to increase capital investment in the tertiary industry, give various preferential policies to enterprises belonging to the tertiary industry, and guide the rural labor force to transfer to the tertiary industry through the support of capital, technology, and services. From the perspective of laborers, it is necessary to increase investment in rural vocational education and training to improve the labor skills of rural laborers. First, on the basis of the implementation of the nine-year compulsory education system, vocational and technical education should be strengthened. Develop public vocational and technical schools and encourage the development of legal private vocational and technical schools, while reducing the cost of people's vocational and technical education, so as to attract more people, especially those with lower living standards, to study in vocational and technical schools. Second, carry out rural labor transfer employment training. A transfer employment training model combining government-led and market-led should be established, and the government, enterprises, and rural labor force should be mobilized to actively participate in the transfer employment training system.

In this paper, only the parameter measurement of the STR model is discussed in depth, and the unit root test and pattern recognition in the model need to be further studied.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no known conflicts of interest or personal relationships that could have appeared to influence the work reported in this paper.

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