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Analysis of the mechanism of price and technological progress on economic fluctuations in resource-based areas: The case of Shanxi, China

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Abstract: This paper draws on the theory of the monetary economic cycle and the theory of the real economic cycle, constructs a theoretical model of economic fluctuations in resource-based regions that takes price levels and technological progress into consideration, analyzes the mechanism of the effect of price levels and technological progress on economic fluctuations in resource-based regions, and derives the key equation of the effect of the two on economic fluctuations. Then, taking Shanxi data as an example, the key equation is verified, and the Shanxi economy is analyzed through two econometric model methods, namely the time series threshold regression model and the Zou test, in two cases of static expectations and rational expectations. The necessity and path of the government's active regulation of economic transformation are proposed.

Keywords: *Economic fluctuations, Price level, Rational expectations, Static expectations, Technological progress.*

1. Introduction

After more than 40 years of reform and opening up, China's economy has developed rapidly and has become the world's second largest economy. While the economy is growing, it has also led to a significant increase in demand for resources, which has driven the development of some regions that rely on abundant natural resources. Although these resource-rich regions have achieved rapid economic development by relying on extensive resource exploitation and utilization, they have also formed a resource-dependent economy. During economic prosperity, the prices of resource products are high, and the generous returns and low investment costs attract a large number of production factors to flow into resource-based enterprises, driving the rapid development of resource-based industries and economic prosperity; during economic downturns, in response to supply chain shocks and inflation [1] commodity price fluctuations [2] and falling resource prices [3] resource-based economies have long relied on this development path, resulting in the inability or difficulty of regional industry transformation, thus triggering an economic downturn. At the same time, during the prosperity of resource-based industries, a large amount of capital flowed into resource-based enterprises, making it difficult for other industries to develop, or simply transforming and investing in the development of resource-based industries [4]. This has led to an imbalance in the local industrial structure, difficulty in developing manufacturing, and the inability to produce many non-resource products independently, which need to be imported from outside the province [5]. In addition, the long-term resource-dependent economic development model is unsustainable [6]. The first reason is that these resources are non-renewable and will cause irreversible environmental pollution during the mining process [7]. Second, economies that rely on resources for development for a long time may fall into the "resource curse", which will eventually lead to an imbalance in the industrial structure and stagnation in economic growth [8]. Resource price fluctuations cause price changes in resource-based regions, which in turn

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affect economic fluctuations in resource-based regions [9]. Therefore, resource-based regions need to transform and upgrade, change their original development model, and achieve sustainable economic development [10].

2. Hypothesis Development

The research framework of this paper is as follows:

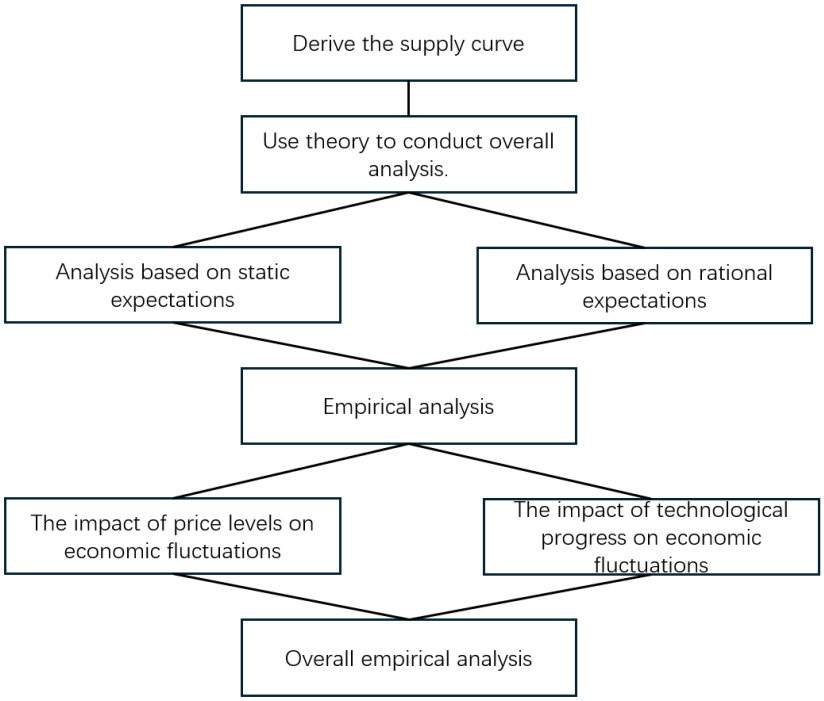

Figure 1.
The research sequence diagram of this paper.

This paper will adopt the method of quantitative analysis. At the beginning, this paper first introduces the basic concepts and related theories, and then uses the formula provided by the theory to deduce the impact of price changes and technological progress on Shanxi's economic fluctuations. At the same time, it deduces how price changes and technological progress will affect Shanxi's economic fluctuations under static expectations and rational expectations.

Next, this paper will use the collected data for empirical analysis. Through the time series threshold regression model and Zou test, we will analyze the impact of price changes and technological progress on the fluctuations of Shanxi's economy in different time periods under static expectations and rational expectations.

3. Materials and Methods

3.1. Data

The sample data range used in this article is the data of the whole country and Shanxi Province from 1984 to 2024. The basic data used in the calculations in this article come from the "China Statistical Yearbook" and the "Shanxi Province Statistical Yearbook" respectively. The selected data include: China's nominal GDP value from 1984-2024, Shanxi Province's nominal GDP value from 1984-2024, and above from 1984-2024 The GDP index with the base period of 1984-2024, the regional GDP index of Shanxi Province with the base period of 1984-2024 and the total employment number of Shanxi

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Province from 1984-2024. The growth rate of technological progress in Shanxi Province is calculated based on the nominal GDP value of Shanxi Province from 1984 to 2024 in the above data, the regional GDP index of Shanxi Province from 1984 to 2024 with the previous year as the base period, and the total number of employees in Shanxi Province from 1984 to 2024. income. The price level of China and Shanxi Province is calculated from the nominal GDP value of China and Shanxi Province from 1984 to 2024 and the GDP index of China and Shanxi Province from 1984 to 2024 as the base period.

3.2. Data Gathering and Analysis

This paper conducted an empirical study on the impact of price and technological progress on economic fluctuations in Shanxi Province [11]. First, the actual economic situation of economic fluctuations in Shanxi Province, a resource-based region, is described. The HP filter method is used to obtain the required relevant data. On the basis of the theoretical model, time series threshold regression, Chow test and OLS regression methods are further used to analyze the impact of price level changes and technological progress in different stages on economic fluctuations in Shanxi Province from the perspectives of static expectations and rational expectations.

4. Results and Discussion

4.1. Supply Curve

4.1.1. Producer Behavior

This section will analyze producer behavior and derive the aggregate supply curve based on the actual economic situation and the idea of Lucas's aggregate supply curve [12].

Assume that the total output level of an enterprise is mainly determined by two parts, namely the level of technological progress and labor. Similarly, let A_i represent the technological progress rate of enterprise i, and L_i represent the number of employees in enterprise i, then the producer behavior can be expressed as:

$$Y_i = A_i \cdot L_i$$

In the above formula, the increase in fixed assets per capita and the increase in labor productivity per capita caused by pure technological progress are unified as technological shock A.

The producer's profit is:

$$\pi_i = P_i Y_i - w_i L_i = P_i A_i L_i - w_i L_i$$

P_i represents the price of a product produced by enterprise i, and w_i is the wage level of the industry.

The formula means: the total output value that an enterprise can obtain is the output it produces multiplied by the product price, minus the cost of paying wages to workers is the enterprise's profit.

According to the principle of enterprise pursuit of profit maximization, the conditions for enterprise profit maximization are:

$$\frac{\partial \pi_i}{\partial L_i} = P_i A_i - w_i = 0$$

Then we can get:

$$w_i = P_i A_i$$

When the producer can obtain the maximum profit, the wage paid for each unit of labor is equal to the product A produced by a single labor multiplied by the price of the product.

4.1.2. Consumer Behavior

Assume that the utility function of consumer i is

$U = C_i - \frac{1}{\gamma} \cdot L_i^{\gamma}$, the function $\gamma > 1$

C_i is the consumption of consumer i. L_i is the labor provided by the consumer.

We know that people often consume a package of goods rather than a single product, so the price paid is not the price of a single product p_i, but the social average price level P, then the actual consumption expenditure of consumer i is PC_i. The consumer's budget constraint is:

$$PC_i = w_i L_i$$

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The consumer behavior model for maximizing utility is:

$\max: C_i - \frac{1}{\gamma} \cdot L_i^{\gamma}, \ \gamma > 1$

$$s.t. PC_i = w_i L_i$$

According to the budget constraint:

$$C_i = \frac{w_i}{P} L_i$$

From this, we can get the consumer utility as:

$$U = \frac{w_i}{P} L_i - \frac{1}{\gamma} L_i^{\gamma}$$

4.1.3. Balanced

Producer behavior analysis shows that: $Y_i = A_i \cdot L_i, \ w_i = P_i A_i$

Consumer behavior analysis shows that: $U = \frac{w_i}{P} L_i - \frac{1}{\gamma} L_i^{\gamma}$

Substituting the conclusion of the producer's pursuit of profit maximization behavior analysis into the consumer's pursuit of utility maximization behavior equation, we can obtain the common equilibrium condition of producer and consumer behavior [13]:

$\max: U = \frac{P_i}{P} Y_i - \frac{1}{\gamma} \left(\frac{Y_i}{A_i}\right)^{\gamma}$

The optimization condition is that the derivative about Y_i is equal to 0, which gives:

$$\frac{P_i}{P} - \frac{1}{\gamma} \gamma \left(\frac{Y_i}{A_i}\right)^{\gamma - 1} = 0$$

It can be deduced that:

$$\frac{Y_i}{A_i} = \left(\frac{P_i}{P}\right)^{\frac{1}{\gamma - 1}}$$

$$Y_i = \left(\frac{P_i}{P}\right)^{\frac{1}{\gamma - 1}} \cdot A_i$$

At this time, taking the logarithm of both sides of the equation and then taking the derivative at the same time, the growth rate of output can be expressed as:

$$\frac{\dot{Y}_i}{Y_i} = \frac{1}{\gamma - 1} \left(\frac{\dot{P}_i}{P_i} - \frac{\dot{P}}{P}\right) + \frac{\dot{A}_i}{A_i}$$

Make $y_i = \frac{\dot{Y}_i}{Y_i}, \ g_i = \frac{\dot{A}_i}{A_i}, \ p_i = \frac{\dot{P}_i}{P_i}, \ p = \frac{\dot{P}}{P}$, The output change rate can be expressed as:

$$y_i = \frac{1}{\gamma - 1} (p_i - p) + g_i$$

When enterprises in this region make production decisions, they need to rely on the information they have, but the information they have is the price of their own products and they cannot know the overall price level. Therefore, they make an expected judgment on the overall price level based on knowing the price of their own products. The formula is:

$$y_i = \frac{1}{\gamma - 1} [p_i - E(p|p_i)] g_i$$

At this time, the rate of change of output can be determined by the rate of change of the manufacturer's own price, the conditional expectation value of the rate of change of the social price level and the rate of technological progress [14].

4.2. Theoretical-Based Analysis

Assume that there are n companies in a country.

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According to the Wiener theorem: when people want to observe the random variable x but cannot observe it directly, they will use the already observed economic variable a and the relationship between a and x, a=x+z, to further observe x. That is, given the condition of a, find the mathematical expectation of x:

$$E(x|a) = \frac{\sigma^2}{\sigma_x^2 + \sigma_a^2} a$$

Assume that:$a = p_i - E(p)$， $x = p - E(p)$， $z = p_i - p$

According to Wiener's theorem:

$$E(x|a) = E[p - E(p)]p_i - E(p) = \frac{\sigma_x^2}{\sigma x^2 + \sigma_z^2} \cdot [p_i - E(p)]$$

It can be deduced that:$E\left[p_{-E(p)}|p_i\right] = \frac{\sigma_x^2}{\sigma_x^2+\sigma_2^2}[p_i - E(p)]$

$$E(p|p_i) - E(p) = \frac{\sigma_x^2}{\sigma_x^2 + \sigma_z^2}[p_i - E(p)]$$

$$E(p|p_i) = \frac{\sigma_x^2}{\sigma_x^2 + \sigma_z^2} p_i - \frac{\sigma_x^2}{\sigma_x^2 + \sigma_z^2} E(p) + E(p)$$

$=\frac{\sigma_x^2}{\sigma_x^2+\sigma_z^2} p_i + \frac{\sigma_x^2}{\sigma_x^2+\sigma_z^2} E(p)$

From this, we can estimate:

$$E(p|p_i) = \frac{\sigma_x^2}{\sigma_x^2 + \sigma_z^2} p_i + \frac{\sigma_x^2}{\sigma_x^2 + \sigma_z^2} E(p)$$

We can finally get:

$$y_i = \frac{1}{\gamma - 1}[p_i - \frac{\sigma_x^2}{\sigma_x^2 + \sigma_z^2} p_i - \left(1 - \frac{\sigma_x^2}{\sigma_x^2 + \sigma_z^2}\right) E(p)] + g_i$$

$$= \frac{1}{\gamma - 1} \cdot \frac{\sigma_x^2}{\sigma_x^2 + \sigma_z^2} \cdot [p_i - E(p)] + g_i$$

Among them, let b=$\frac{1}{\gamma-1} \cdot \frac{\sigma_x^2}{\sigma_x^2+\sigma_z^2} > 0$, then the key equation of the final output of the regional representative enterprises is:

$$y_i = b \cdot [p_i - E(p)] + g_i$$

We can get the output growth rate formula of all manufacturers in a country as follows:

$\Sigma_{y_i} = b \cdot [\sum p_i - \sum E(p)] + \sum g_i$, (i=1, 2, …, n)

Here, let y represent the growth rate of a country's total output, which is the average of the output growth rates of various manufacturers, p represents the average price level of a country, which is the average of the product price growth rates of various manufacturers, and g represent the average technological progress rate of a country. It is the average of the technological progress rates of various manufacturers. Then the output growth rate of all manufacturers in a country is obtained by the formula:

$$ny = b \cdot [np - nE(p)] + ng$$

$$y = b \cdot [p - E(p)] + g$$

(1) If it is assumed that technological progress is not taken into account, the technological progress rate g=0. The formula can be changed to:

$$y = b \cdot [p - E(p)]$$

This is equivalent to the Lucas aggregate supply curve formula in the monetary economic cycle model

From the results derived from the monetary economic cycle model, we can know that:

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$$E(p_t) = m_g + m_{t-1}$$
$$p_t = m_g + m_{t-1} + \varepsilon_t - y$$

Substituting it into the formula we get:

$$y_t = \frac{\varepsilon_t}{1+b}$$

From the formula, we can see that the fluctuation of a country's economy is mainly caused by random monetary shocks, which is completely consistent with the formula of the monetary economic cycle model. If the technological progress rate g=0, then this model degenerates into a monetary economic cycle model.

(2) The real business cycle theory holds that monetary factors are exogenously determined by the monetary authorities and have no real impact on economic fluctuations. Therefore, if it is assumed that the money supply can be anticipated by the public, that is, p-E(p)=0 then formula becomes: y=g

It can be seen from the formula that economic fluctuations are mainly caused by technological progress. At this time, the formula is equivalent to the formula in the actual economic cycle model, and the model in this paper degenerates into the actual economic cycle model.

The above article analyzes the mechanism of price and technological progress on general economic fluctuations, which is similar to the monetary economic cycle model and the actual economic cycle model. Next, we will analyze the mechanism of price and technological progress on economic fluctuations in resource-based regions in detail based on the particularity of resource-based regions [15].

4.3. Analysis Based on Static Expectations

When studying a region or province, the economic situation is very different. Regions or provinces do not have their own independent currencies. The total output of the region is determined by the enterprises in the region based on the price situation to determine whether the market has excess demand for the products they produce, and whether to expand production [16]. Even when the national monetary authorities publicly announce the monetary supply, the national average price level is expected by the public, but if the regional output price level is higher than the national average price level, it also means that there is excess demand for regional output, and regional enterprises will also expand production, causing regional economic fluctuations. Resource-based regions are greatly affected by resource prices, and in many cases, they will deviate from the national average price level to a large extent. Output price fluctuations in resource-based regions often cause economic fluctuations. The specific situation is analyzed as follows.

4.3.1. Output Formula for Resource-Based Regions

Assume that there are m enterprises in a resource-based region, m<<n.

The output growth rate formula of all manufacturers in the resource-based region is:

$$\sum y_i = b \cdot [\sum p_i - \sum E(p|p_i)] + \sum g_i, \quad (i=1, 1, ...,m)$$

Here, let y_x represent the growth rate of total output in resource-based regions, which is the average of the output growth rates of various manufacturers, p_x represents the rate of change of the average price level in resource-based regions, which is the average of the rate of change of product prices of various manufacturers, and g_x represents the average rate of technological progress in the resource-based region. It is the average of the technological progress rates of various manufacturers. Then the output growth rate formula of all manufacturers in resource-based regions is:

$$my_x = b \cdot [mp_x - mE(p|p_x)] + mg_x$$
$$y_x = b \cdot [p_x - E(p|p_x)] + g_x$$

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From the above results, the output growth rate level of resource-based regions is affected by the difference between the price change rate of this resource-based region and the conditional expected price, i.e. $E(p|p_x)$, and the rate of technological progress.

For economic actors, whether they can get accurate expected prices is the key to corporate production decisions. China's market economy is still imperfect, and enterprises are born out of the planned economy, especially many enterprises in resource-based regions such as Shanxi. Based on the national monetary policy and their own price-level information conditions, there is still a process of improvement in their expectations of the country's overall price level. The expected level does not reach rational expectations, so this article discusses the original static expectations and advanced rational expectations [17].

When the expected price of the actor is predicted completely according to the price of the previous period, the actor adopts a static expectation; but if the actor not only considers the price changes of the previous period when making decisions, but also makes reasonable predictions based on the information he has obtained, then the decision-making expectations of the economic actor are more inclined to rational expectations. Based on these two possible expectations, we will reduce the output of resource-based regions in the two cases.

4.3.2. Function Analysis

The adjustment of an enterprise's output is often related to the expectations of the enterprise's actors. When economic actors can correctly predict the trend of economic development, they can adjust production in time to increase or decrease output to gain profits or reduce losses. Under static expectations, the enterprise's expectations for prices are completely based on the actual price observed in the previous period as the current forecast price. Because the forecast price is the price of the previous period, the price change rate is 0. At this time, the enterprise's expected $E(p|p_x)$, in this case, the enterprise's output will be:

$$y_x = b \cdot (p_x - 0) + g_x = b \cdot p_x + g_x$$

At this time, the output of resource-based regions will depend entirely on the fluctuation of price levels in resource-based regions and will not be affected by fluctuations in the overall national price level.

When considering economic fluctuations, the technological progress rate g_x is affected by both the trend term g_x^0 and the fluctuation term $\widetilde{g_x}$, so the total output growth rate of the region can also be expressed as:

$$y_x = b \cdot p_x + g_x^0 + \widetilde{g_x}$$

We define $y_x = \widetilde{y_x} + y_x^0$, where $\widetilde{y_x}$ is the fluctuation term of y_x, and y_x^0 is the trend term of y_x. The trend term y_x^0 of y_x represents the normal growth rate of the economy, which is mainly brought about by long-term per capita capital growth and pure technological progress, so$y_x^0 \approx g^0$,

$$y_x = b \cdot p_x + y_x^0 + \widetilde{g_x}$$
$$y_x - y_x^0 = b \cdot p_x + \widetilde{g_x}$$
$$\widetilde{y_x} = b \cdot p_x + \widetilde{g_x}$$

From the formula results, the rate of change of price levels in resource-based regions and the fluctuation of technological progress are two key factors that cause economic fluctuations in the region. On the one hand, when the price level in resource-based regions rises positively, it means that the economic development expectations of resource-based regions are better, which will bring a positive impact on the economy of resource-based regions. On the contrary, when the price level in resource-based regions changes negatively, the market outlook is not optimistic, and local enterprises will reduce

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production to avoid losses, which will have a negative impact on local economic fluctuations. On the other hand, the fluctuation of technological progress has a direct impact on resource-based regions. When $\widetilde{g_x}>0$, it means the emergence of new technologies. New technologies will drive new demands, improve labor productivity, increase corporate profits while reducing corporate costs, and companies will expand production, thereby bringing positive economic fluctuations. On the contrary, when $\widetilde{g_x}<0$, it means that the technology used by manufacturers is already backward. Instead of creating new demands, it will increase the cost of expanding production for enterprises, make transformation and upgrading difficult, and ultimately weaken the competitiveness of enterprises and eventually exit the market. The consequence of this economic fluctuation will be economic stagnation or even recession [18].

From the above analysis, we can see that once technological progress occurs, it will directly affect the economy and will be less affected by the outside world. Since the price level will be affected by various factors when observing and expecting information, if the coefficient b has a greater impact, then its impact on the price will be greater, and vice versa. When prices and technological progress increase at the same time, the economy may fluctuate greatly and enter a boom. On the contrary, if both decline at the same time, it means that the economy will fall into depression and economic growth will stagnate.

4.4. Analysis Based on Rational Expectations

Under rational expectations, regional enterprises anticipate the national overall price level based on information released by the national monetary authorities and their own prices. If the monetary authorities do not have unexpected money supply, the rational expectation of regional enterprises is $E(p|p_x)=p_z$, where p_z is the real rate of change of the national overall price level. The national overall price level is what the enterprises expect [19].

Currently, the regional output is:

$$y_x = b\cdot(p_x-p_z)+g_x$$
$$y_x = b\cdot(p_x-p_z)+g_x^0+\widetilde{g_x}$$
$$\widetilde{y_x} = b\cdot(p_x-p_z)\widetilde{+g_x}$$

From the formula results, under rational expectations, the two key factors that cause economic fluctuations in the region are the gap between the growth rate of price levels in resource-based regions and the national level and the fluctuation of technological progress. On the one hand, the expectations of enterprises in resource-based regions will not only consider the production price of their own products, but also the price level of the entire society. When the rate of change of price levels in resource-based regions, p_x, is higher than the rate of change of national price levels, p_z, it means that the economic development expectations of resource-based regions are better, which will have a positive effect on the economy of resource-based regions. On the contrary, when the rate of change of price levels in resource-based regions, p_x, is lower than the rate of change of national price levels, p_z, it means that the local economy is too depressed, the consumption capacity is insufficient, and the market prospects are not optimistic. Local enterprises will reduce production to avoid losses, which will have a negative effect on local economic fluctuations. On the other hand, it can also be seen that the fluctuation of technological progress directly impacts resource-based regions. When $\widetilde{g_x}>0$, it has a positive effect on economic fluctuations. On the contrary, when $\widetilde{g_x}<0$, it has a negative effect on economic fluctuations. Compared with price levels, technological progress, as the most direct factor affecting economic fluctuations, means that if there is technological progress, it can bring about obvious economic fluctuations. The price level in resource-based areas will also be affected by coefficient b. If the price level and technological progress increase at the same time, it means that the economy of this resource-based area will grow rapidly and present a prosperous scene. On the contrary, if the price level decreases and the technological level also declines, the economy will gradually stagnate.

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When enterprises in resource-based regions make production decisions, their expected results have a significant impact on economic fluctuations. Whether under static expectations or rational expectations, prices are affected by the accuracy of enterprise expectations and are constrained by the ratio b. Technological progress has a more direct impact on economic fluctuations. Once an enterprise obtains new technology, it can immediately put it into production and create new value. The direction of the impact of technological progress on economic fluctuations depends on the technology itself. If technology can create new demand and improve enterprise production efficiency, then the enterprise will choose to expand production, which will have a positive impact on economic fluctuations. On the contrary, if this technology is not suitable for development, no longer generates new demand, and promotes the improvement of enterprise productivity, then this technology will be backward. Sticking to this production technology will only put enterprises in trouble, ultimately affecting economic development and bringing negative economic fluctuations.

4.5. The Impact of Price Levels In Shanxi Province on Economic Fluctuations

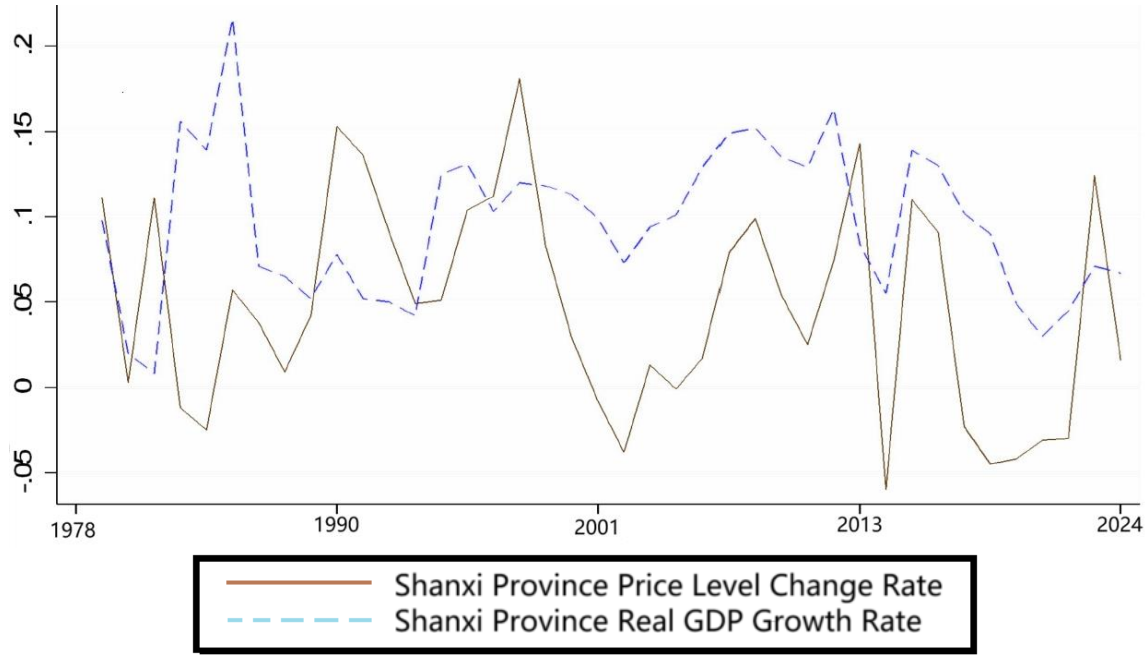

Figure 2.
Shanxi Province price level change rate and Shanxi Province real GDP growth rate chart.

Comparing the changes in Shanxi's price level and economic growth rate, we find that the coordination between price changes and economic changes may be staged. According to Figure 2, the trends between price level changes and economic fluctuations are roughly similar. When prices are high, the economic growth rate will also be faster. When prices are low, the economic growth rate slows down. The changes in some time periods are different, but overall, the trend of price fluctuations and economic changes is almost completely consistent [20].

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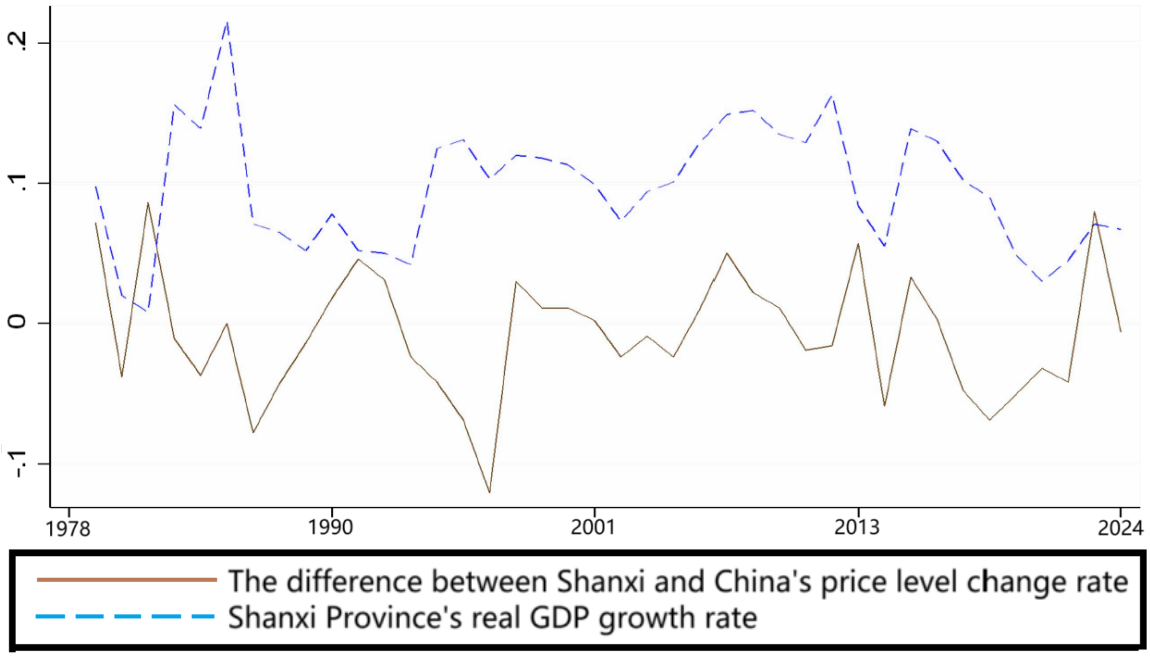

Figure 3.
The difference between the price level change rate of Shanxi Province and China and the real GDP growth rate of Shanxi Province.

Comparing the difference between the price level in Shanxi Province and the national price level with the changes in the economic growth rate in Shanxi Province, it is found that there are phases in the trend of price changes and economic changes before and after 1994, that is, the impact of price factors on the economy is different before and after 1994. According to Figure 3, before 1994, the trend between the difference in price change rate and economic fluctuations was roughly similar, but the changes in some time periods were different. After 1994, the difference in price change rate and the trend of economic changes were almost completely consistent. When the difference in price changes is higher, the economic growth rate will also be faster. When the difference in price changes is lower, the economic growth rate will slow down.

The monetary economic cycle theory and the real economic cycle theory believe that price changes will only have an impact on the economy when people unexpectedly experience sudden price changes due to an increase in money supply. If people can expect that the price increase is caused by an increase in money supply, then changes in nominal quantity will not have an impact on the economy. In the long run, it is impossible for the price fluctuations caused by an increase in money supply to be unexpected by the actors for a long time, so price fluctuations will not cause economic fluctuations in a long-term consistency, and the price change trend cannot be consistent with the actual economic fluctuations. If the actors tend to have static expectations, they tend to focus on considering the changes in regional price levels, as shown in Figure 2. It can be seen that price changes in Shanxi Province have been consistent with economic fluctuations for a long time, which is contrary to the traditional economic fluctuation theory we know. From the perspective of the difference in the rate of change of regional and national price levels, it is more inclined to rational expectations. From Figure 3, it can be seen that the price change rate difference was not completely consistent with the economic fluctuations before 1994, but only after 1994 did the trend become consistent. From the empirical facts of price changes and economic fluctuations in Shanxi Province, it can be seen that changes in Shanxi's price levels will greatly affect economic fluctuations.

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4.6. The Impact of Technological Progress In Shanxi Province on Economic Fluctuations

Technological progress will lead to changes in labor productivity in the economy, promote the improvement of labor productivity and increase output, and then bring about economic fluctuations. Since the technological progress in this article not only includes the improvement of pure technology represented by total factor productivity, but also partly comes from the increase in per capita labor productivity caused by capital expansion, this article uses labor productivity to reflect technological progress, and the change rate of per capita labor productivity to reflect the rate of technological progress [21].

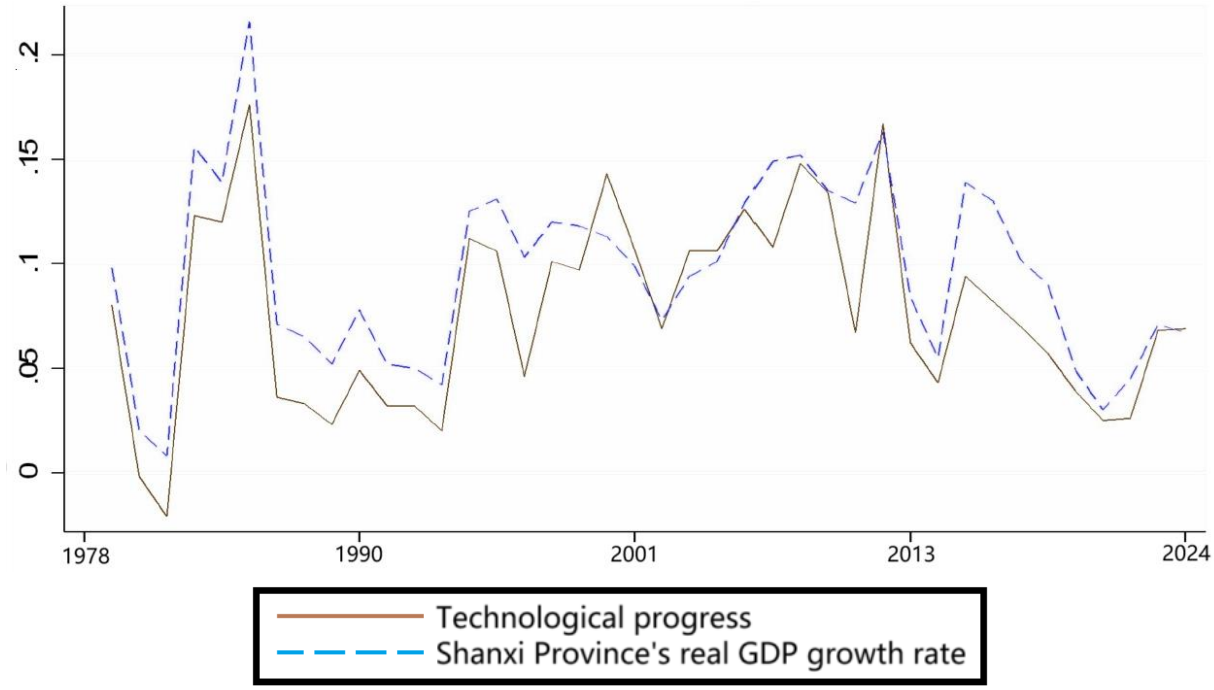

Figure 4.
Technological progress rate and the growth rate of real GDP in Shanxi Province.

The real economic cycle theory believes that economic fluctuations are caused by changes in the actual economic factor technology. When new technology first appears, it will lead to a positive change in the economy. As the role of technology in driving the economy weakens, the economy returns to its original stable state. Therefore, the fluctuations of technological progress are basically consistent with economic fluctuations. That is, technological progress brings positive economic fluctuations, and the weakening of technology weakens the impact on the economy, and economic fluctuations gradually return to stability. From Figure 4, it can be found that the trend of changes in the real economy is basically consistent with the changes in per capita labor productivity. The changes in per capita labor productivity represent the changes in the technological level of the entire society to a certain extent. When the growth rate of per capita labor productivity is high, it indicates that the economic growth rate is fast. When the growth rate of labor productivity is slow, the economic growth rate will also slow down. This change is completely consistent with the discussion of the real economic cycle theory on the role of technological progress in economic fluctuations.

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4.7. Overall Empirical Analysis

4.7.1. Econometric Model Setting

Let p_s represent the rate of change of the price level in Shanxi Province; let $p_c = p_s - p_z$ represent the difference between the rate of change of the price level in Shanxi Province and the rate of change of the national price level. Using $\tilde{g}_s$ to represent the fluctuation of technological progress in Shanxi Province, two econometric models are constructed:

Under static expectations:

$$\widetilde{y_{st}} = a_1 + b_1 p_{st} + \beta_1 \cdot \tilde{g}_{St} + \varepsilon_{1t} \quad (1)$$

Under rational expectations:

$$\widetilde{y_{st}} = a_2 + b_2 p_{ct} + \beta_2 \cdot \tilde{g}_{St} + \varepsilon_{2t} \quad (2)$$

Among them, b_1、b_2 and β_1、β_2 are the coefficients of the variables in the two formulas, a_1、a_2 are the constant term of the two formulas, and ε_1、ε_2 are the random disturbance term, and satisfies white noise.

4.7.2. The Fluctuation Term of the Real GDP Growth Rate in Shanxi Province

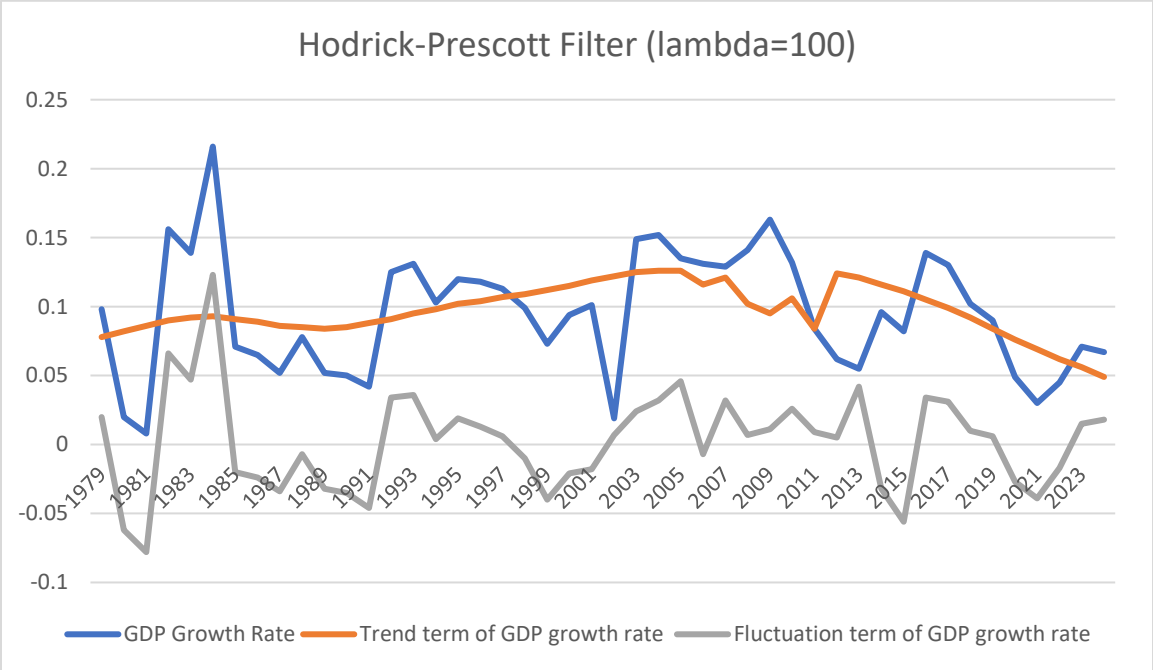

Figure 5.
HP filter value chart of Shanxi Province GDP growth rate.

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Table 1.
Trend and fluctuation items of Shanxi Province's real GDP growth rate.

Year	GDP Growth Rate	Trend term of GDP growth rate	Fluctuation term of GDP growth rate yx
1979	0.098	0.078	0.0200
1980	0.020	0.082	-0.062
1981	0.008	0.086	-0.078
1982	0.156	0.090	0.066
1983	0.139	0.092	0.047
1984	0.216	0.093	0.123
1985	0.071	0.091	-0.020
1986	0.065	0.089	-0.024
1987	0.052	0.086	-0.034
1988	0.078	0.085	-0.007
1989	0.052	0.084	-0.032
1990	0.050	0.085	-0.035
1991	0.042	0.088	-0.046
1992	0.125	0.091	0.034
1993	0.131	0.095	0.036
1994	0.103	0.098	0.004
1995	0.120	0.102	0.019
1996	0.118	0.104	0.013
1997	0.113	0.107	0.006
1998	0.099	0.109	-0.010
1999	0.073	0.112	-0.040
2000	0.094	0.115	-.021
2001	0.101	0.119	-0.018
2002	0.019	0.122	0.007
2003	0.149	0.125	0.024
2004	0.152	0.126	0.032
2005	0.135	0.126	0.046
2006	0.131	0.116	-0.007
2007	0.129	0.121	0.032
2008	0.141	0.102	0.007
2009	0.163	0.095	0.011
2010	0.132	0.106	0.026
2011	0.084	0.084	0.009
2012	0.062	0.124	0.005
2013	0.055	0.121	0.042
2014	0.096	0.116	-0.032
2015	0.082	0.111	-0.056
2016	0.139	0.105	0.034
2017	0.130	0.099	0.031
2018	0.102	0.092	0.010
2019	0.090	0.084	0.006
2020	0.049	0.076	-0.027
2021	0.030	0.069	-0.039
2022	0.045	0.062	-0.017
2023	0.071	0.056	0.015
2024	0.067	0.049	0.018

Source: The data in this table are calculated based on the relevant measurement results. All data in the table are rounded to three decimal places unless necessary.

From Figure 5 and Table 1, we can see that from the overall situation, the growth rate of Shanxi Province's GDP is basically above 5%, but after 2005, its overall upward trend has been declining year by year.

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4.7.3. The Difference Between the Price Level Change Rate In Shanxi Province and the National Price Level Change Rate

We know that the GDP conversion index can represent the overall price level of a country or region, and its calculation formula is GDP conversion index=nominal GDP/real GDP. The rate of change of the GDP conversion index can reflect the changes in the price level in this region, and because in mathematical economics, the rate of change of the quotient of two variables is equal to the difference between the rates of change of two variables, therefore:

Change rate of price level=Change rate of nominal GDP - Change rate of real GDP

And: the rate of change in nominal GDP=current nominal GDP/previous nominal GDP -1, the rate of change in real GDP=(GDP index based on the previous year -100)/100.

Therefore, the rate of change in price can be rephrased as:

Change rate of price level

= Change rate of nominal GDP - change rate of real GDP

= [(Current nominal GDP/Previous nominal GDP) -1] [(GDP index based on the previous year -100)/100]

= (Current nominal GDP/Previous nominal GDP) * 100- GDP index based on years or more

The specific calculation formula for the change rate of price levels in Shanxi Province and China can be obtained as follows: the change rate of GDP price level in Shanxi Province=(nominal GDP of Shanxi Province in the current period/nominal GDP of Shanxi Province in the previous period) * 100- the GDP index of Shanxi Province based on the previous year. Using the same method, calculate the rate of change in China's price level: the rate of change in China's price level=(China's nominal GDP for the current period/China's nominal GDP for the previous period) * 100- the Gross Domestic Product Index based on the previous year [22].

By calculating the change rates of price levels in Shanxi and the whole country separately and obtaining the deviation difference p_c between the change rates of price levels in Shanxi Province and China.

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Table 2.
The rate of change of price level p_x, p_z and the deviation difference p_c of the price change rate.

Year	Shanxi price level change rate p_x	China price level change rate p_z	Deviation difference of price level change rate p_c
1978	-0.007	0.015	-0.002
1979	0.111	0.039	0.072
1980	0.003	0.041	-0.038
1981	0.111	0.025	0.086
1982	-0.012	-0.001	-0.011
1983	-0.025	0.013	-0.038
1984	0.057	0.057	0.000
1985	0.038	0.116	-0.078
1986	0.009	0.051	-0.043
1987	0.042	0.056	-0.014
1988	0.153	0.135	0.018
1989	0.136	0.090	0.046
1990	0.091	0.060	0.031
1991	0.049	0.073	-0.024
1992	0.051	0.094	-0.042
1993	0.104	0.173	-0.069
1994	0.112	0.233	-0.121
1995	0.181	0.151	0.030
1996	0.083	0.072	0.011
1997	0.029	0.018	0.011
1998	-0.008	-0.009	0.002
1999	-0.038	-0.014	-0.024
2000	0.013	0.022	-0.009
2001	-0.001	0.023	-0.024
2002	0.017	0.007	0.010
2003	0.079	0.029	0.050
2004	0.099	0.077	0.022
2005	0.054	0.043	0.011
2006	0.036	0.002	0.032
2007	0.008	0.038	-0.030
2008	0.103	0.009	0.094
2009	0.007	0.102	-0.095
2010	0.121	0.053	0.068
2011	0.052	0.066	-0.014
2012	0.025	0.044	-0.019
2013	0.074	0.089	-0.016
2014	0.143	0.085	0.057
2015	-0.060	-0.001	-0.059
2016	0.110	0.077	0.033
2017	0.091	0.089	0.003
2018	-0.023	0.025	-0.048
2019	-0.045	0.024	-0.069
2020	-0.042	0.009	-0.051
2021	-0.031	0.001	-0.032
2022	-0.030	0.012	-0.042
2023	0.124	0.044	0.080
2024	0.016	0.022	-0.006

Source: The data in this table are calculated and collated based on relevant measurement results.

By calculating the change rates of Shanxi and national price levels respectively, the deviation difference p_c between the change rates of Shanxi and China's price levels is obtained Table 2 shows the calculation results.

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4.7.4. Fluctuation Term of Shanxi Province's Technological Progress Rate

This paper uses the growth rate of per capita labor productivity as the calculation indicator of technological progress rate.

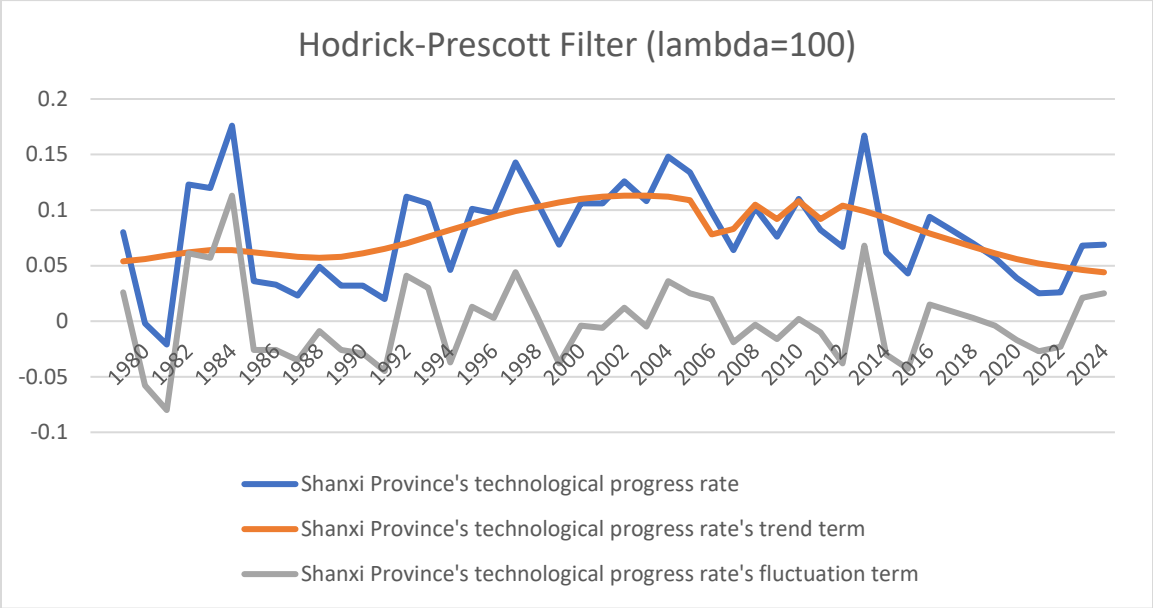

Figure 6.
HP filter value diagram of Shanxi Province's technological progress rate.

Table 3.
Trend and fluctuation items of Shanxi Province's technological progress rate.

Year	Shanxi Province's technological progress rate	Shanxi Province's technological progress rate's trend term	Shanxi Province's technological progress rate's fluctuation term ***gs***
1979	0.080	0.054	0.026
1980	-0.002	0.056	-0.058
1981	-0.021	0.059	-0.080
1982	0.123	0.062	0.061
1983	0.120	0.064	0.057
1984	0.176	0.064	0.113
1985	0.036	0.062	-0.026
1986	0.033	0.060	-0.026
1987	0.023	0.058	-0.035
1988	0.049	0.057	-0.009
1989	0.032	0.058	-0.026
1990	0.032	0.061	-0.029
1991	0.020	0.065	-0.045
1992	0.112	0.070	0.041
1993	0.106	0.076	0.030
1994	0.046	0.082	-0.037
1995	0.101	0.088	0.013
1996	0.097	0.094	0.003
1997	0.143	0.099	0.044
1998	0.107	0.103	0.004
1999	0.069	0.107	-0.038
2000	0.106	0.110	-0.004
2001	0.106	0.112	-0.006

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2002	0.126	0.113	0.012
2003	0.108	0.113	-0.005
2004	0.148	0.112	0.036
2005	0.134	0.109	0.025
2006	0.098	0.078	0.020
2007	0.064	0.083	-0.019
2008	0.102	0.105	-0.003
2009	0.076	0.092	-0.016
2010	0.110	0.108	0.002
2011	0.082	0.092	-0.010
2012	0.067	0.104	-0.038
2013	0.167	0.099	0.068
2014	0.062	0.093	-0.030
2015	0.043	0.086	-0.043
2016	0.094	0.079	0.015
2017	0.082	0.073	0.009
2018	0.070	0.067	0.003
2019	0.057	0.061	-0.004
2020	0.039	0.056	-0.017
2021	0.025	0.052	-0.027
2022	0.026	0.049	-0.023
2023	0.068	0.046	0.021
2024	0.069	0.044	0.025

Source: The data in this table are calculated based on relevant data.

4.7.5. Empirical Analysis Method

4.7.5.1. Time Series Threshold Regression Model

The time series threshold regression model is a nonlinear time series model originally proposed by Tong [23]. The main idea is to use time series data to construct a regression model and then identify the corresponding threshold values to analyze the relationship between economic variables before and after the threshold values. Afterwards, Hansen [24] improved it and proposed a multiple threshold regression model. Based on the reference of two scholars, this article constructs a basic threshold regression model:

$$y_t = \begin{cases} a_1 + \beta_1 x_t^1 + \beta_2 x_t^2 + \varepsilon_{1t}, t \le T \\ a_2 + \phi_1 x_t^1 + \phi_2 x_t^2 + \varepsilon_{2t,t} > T \end{cases}$$

Among them, y_t is the dependent variable, x_t^1 and x_t^2 are explanatory variables, t is the set threshold variable, and T is the threshold value. Since the effects of price and technological progress on economic fluctuations studied in this article may vary in direction and magnitude at different times, the threshold variable set in this article is time t. Using this model, the optimal time threshold is identified, and the relationship between variables before and after different times is observed.

4.7.5.2. Chow Test

The Chow test is a quantitative method used to measure whether there are structural changes in time series data. It was first proposed by Chinese economist Zou Zhizhuang in 1960.

Assuming the existence of a set of time series data $\{x_i\}(i = 1,2,\cdots,n)$, and setting its data model as:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \varepsilon$$

Assuming that the residual ε follows an independent and identically distributed normal distribution with unknown variance, the basic principle of the model is to divide the data into two stages based on its characteristics and determine whether the coefficients of the model in the two stages are equal. If the

coefficients are equal, there is no structural change; if they are not equal, there is a structural change between the two. This method can effectively verify whether there are structural changes in time series at different stages, in order to provide more reasonable explanations for different times. The purpose of using the Chow test method in this article is to further verify whether there are structural changes in the relationship between price changes, technological progress, and economic fluctuations at different stages.

4.7.5.3. Empirical Analysis Based on Static Expectations

Next, this paper starts from the perspective of static expectations and only considers the impact of price fluctuations in Shanxi Province on economic fluctuations in Shanxi Province. It conducts time series threshold regression analysis on the variables of Shanxi Province GDP fluctuation term$\widetilde{y_s}$, Shanxi price level change rate $p_s$and Shanxi Province technological progress fluctuation term$\widetilde{g_s}$.

Table 4.
Stability test results.

	Variable	Test Statistic	Key Value of the Test			P Value
			1% Level	5% Level	10% Level	
ADF test	ys	-4.637	-3.662	-2.964	-2.614	0.000
	ps	-3.397	-3.662	-2.964	-2.614	0.000
	gs	-4.983	-3.662	-2.964	-2.614	0.000
PP test	ys	-4.795	-3.655	-2.961	-2.613	0.000
	ps	-4.697	-3.655	-2.961	-2.613	0.000
	gs	-5.631	-3.655	-2.961	-2.613	0.000

Source: The data in this table are compiled based on the measurement results.

4.7.5.4. Stationarity Test

In empirical regression analysis, if the variables are not stable, it will affect the empirical results. Therefore, this paper uses the ADF test and PP test to test the stability of the required data [25].
As shown in Table 4, the results of the two stationary tests show that all variables are stationary at the 5% significance level, so regression analysis can be performed on the data.

4.7.5.5. Empirical Analysis - Time Series Threshold Regression

Time series threshold regression analysis is performed on the variables of Shanxi Province GDP fluctuation term $\widetilde{y_s}$, Shanxi price level change rate p_s and Shanxi Province technological progress fluctuation term $\widetilde{g_s}$:
Model settings:

$$y_t = \begin{cases} a_1 + \beta_1 p_{st}^1 + \beta_2 \tilde{g}_{st}^2 + \varepsilon_{1t}, t \le T \\ a_2 + \phi_1 p_{st}^1 + \phi_2 \tilde{g}_{st}^2 + \varepsilon_{2t,t} > T \end{cases}$$

Table 5.
Time series threshold regression results.

ys	Regime1	Regime2
Threshold Estimate	q<=1993	q>1993
Intercept	-0.001	-0.005
ps	0.007	0.143
gs	1.022	0.553
Sum of Squared Errors	0.0004	0.005
R-squared	0.989	0.669

Source: The data in this table are compiled based on the measurement results.

As shown in Table 5 above, the best result with 1993 as the threshold is: from 1978 to 1993, the effect of price on economic fluctuations is positive (0.007), and the effect of technological progress on economic fluctuations is positive (1.022); from 1994 to 2024, the effect of price on economic fluctuations is positive (0.143), and the effect of

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technological progress on economic fluctuations is positive (0.553). Comparing the two stages, after 1994, the effect of price shocks has increased, and the effect of technological progress has weakened.

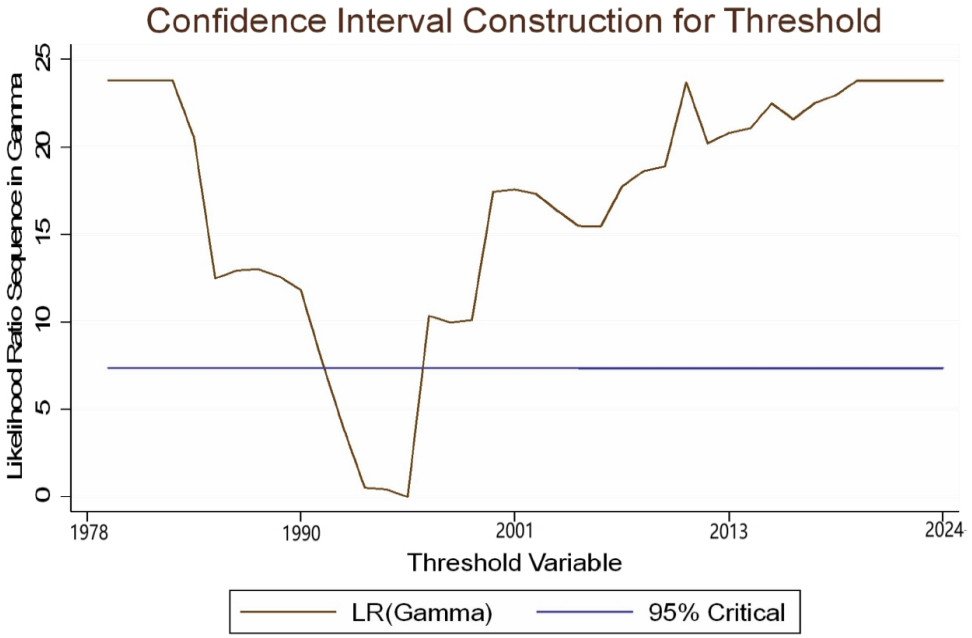

Figure 7.
Time series threshold regression results.

It can be seen from the threshold regression results Figure 7 that there may be more than one threshold value. Therefore, we use the threshold value of 1993 as the stage point and use the staged threshold regression method to conduct further analysis.

Stage 1: 1979-1993

The threshold regression results are as follows:

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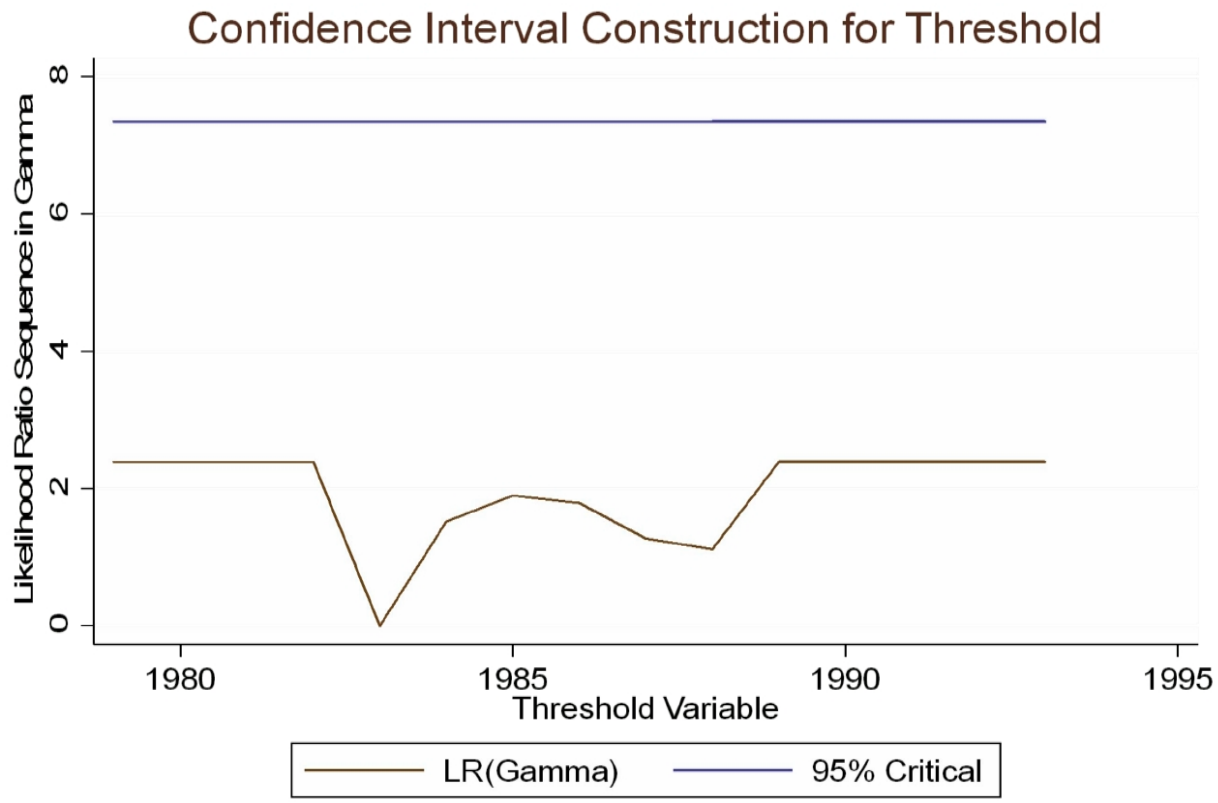

Figure 8.
Time series threshold regression results.

From Figure 8 above we can see that there may be multiple threshold values in this stage. To further confirm, the threshold value is determined by using staged threshold regression, and the threshold regression results are sorted out to obtain the following table**:**

Table 6.
Time series threshold regression results.

Threshold Estimate	1979-7983	1984-1987	1988-1993
Intercept	-0.003	-0.003	-0.006
ps	0.004	0.210	0.039
gs	0.983	1.006	1.034
Sum of Squared Errors	0.000	0.000	0.000
R-squared	0.992	0.998	0.982

Source: The data in this table are compiled based on the measurement results.

Table 6 Results show that there were two threshold values before 1993, which divided the economy into three stages. From 1978 to 1983, the effect of price on economic fluctuations was positive (0.004), and the effect coefficient of technological progress on economic fluctuations was positive (0.983); from 1984 to 1987, the effect of price on economic fluctuations was positive (0.210), and the effect coefficient of technological progress on economic fluctuations was positive (1.006); from 1988 to 1993, the effect of price on economic fluctuations decreased, but was still positive (0.039), and the effect coefficient of technological progress on economic fluctuations was positive (1.034). In short, in the period from 1979 to 1993, the effect of price on economic fluctuations first increased and then decreased, while the effect of technological progress has been increasing.
Stage 2: 1994-2024

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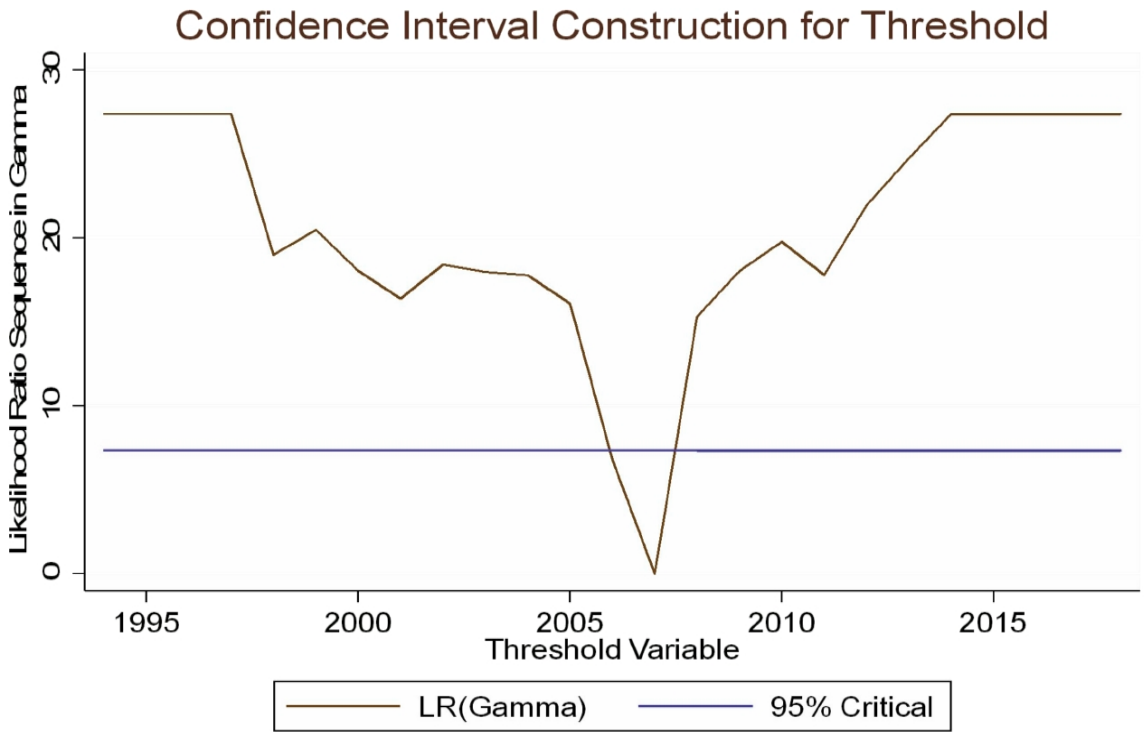

Figure 9.
Time series threshold regression results.

From Figure 9 we can see that there is a very obvious threshold value between 1994 and 2024. In 2007, the staged threshold regression results are summarized in the following table:

Table 7.
Time series threshold regression results.

ys	Regime1	Regime2
Threshold Estimate	q<=2007	q>2007
Intercept	-0.008	-0.002
ps	0.218	0.033
gs	0.331	1.186
Sum of Squared Errors	0.002	0.001
R-squared	0.729	0.872

Source: The data in this table are compiled based on the measurement results.

From the results of different stages, from 1994 to 2007, the effect of price on economic fluctuations was positive (0.218), and the effect coefficient of technological progress on economic fluctuations was positive (0.331). From 2007 to 2024, the effect of price on economic fluctuations was positive (0.033); the effect coefficient of technological progress on economic fluctuations was positive (1.186), which was significantly enhanced.
Empirical analysis - Chow test
The following further uses the Chow test method to judge structural changes.

Table 8.
Chow test results from 1979 to 2024.

Ho: no Structural Change		
Cut-off point (>=)	**Chow Test**	**p value**
1979	0.23	0.637
1980	0.22	0.803
1981	0.33	0.807
1982	0.64	0.595
1983	0.56	0.647
1984	2.20	0.106
1985	2.10	0.119
1986	2.08	0.121
1987	2.18	0.109
1988	2.36	0.89
1989	3.40	0.029
1990	4.53	0.009
1991	5.70	0.003
1992	5.73	0.003
1993	5.89	0.002
1994	2.72	0.060
1995	2.81	0.054
1996	2.78	0.056
1997	1.14	0.346
1998	1.12	0.356
1999	1.17	0.337
2000	1.36	0.272
2001	1.54	0.222
2002	1.52	0.221
2003	1.08	0.371
2004	0.91	0.445
2005	0.86	0.470
2006	0.37	0.564
2007	0.24	0.665
2008	0.65	0.872
2009	0.17	0.643
2010	0.46	0.549
2011	0.55	0.711
2012	0.02	0.996
2013	0.62	0.608
2014	0.51	0.678
2015	0.46	0.710
2016	0.22	0.883
2017	0.37	0.772
2018	0.22	0.884
2019	0.14	0.937
2020	0.11	0.952
2021	0.22	0.885
2022	0.17	0.843
2023	0.03	0.866

Source: The data in this table are compiled based on the measurement results.

According to the Chow test results in Table 8, we can see that the result in 1993 is the best, and the null hypothesis is rejected at the 5% significance level, indicating that there are structural changes in the period around

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1993. This test result verifies the result of the time series threshold regression. The following uses OLS regression to analyze the effects of these two influencing factors on economic fluctuations in different time periods.

Table 9.
OLS regression results.

	$\widetilde{y_s}$,	**Coef.**	**Std. Err**	**t value**	**p value**
1979-1993	Constant term	-0.001	0.003	-0.32	0.753
	p_s	0.007	0.030	0.24	0.814
	$\widetilde{g_s}$	1.022	0.035	28.98	0.000
1994-2024	Constant term	-0.005	0.003	-1.61	0.122
	p_s	0.143	0.060	2.39	0.026
	$\widetilde{g_s}$	0.553	0.138	4.02	0.001

Source: The data in this table are compiled based on the measurement results.

The overall regression results in Table 9 show that at a significant level of 5%, during the period of 1979-1993, the changes in Shanxi's price level did not have a significant impact on the economic fluctuations in Shanxi, while the role of technological progress was significantly positive. From 1994 to 2024, the role of prices on economic fluctuations increased significantly and was significantly positive. Although the role of technological progress was still significantly positive, its impact coefficient decreased significantly compared with the role in the previous period, which is consistent with the results of threshold regression. Next, the results of staged structural changes are further analyzed using the Chow test.

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Table 10.
Chow test results for 1979 to 1993 and 1994 to 2024.

Ho: no Structural Change			
stage	**Cut-off point**	**Chow Test**	**p value**
1979-1993 (>=)	1979	1.36	0.268
	1980	0.65	0.541
	1981	0.51	0.688
	1982	0.13	0.943
	1983	0.81	0.519
	1984	0.25	0.858
	1985	0.14	0.936
	1986	0.17	0.915
	1987	0.33	0.803
	1988	0.38	0.768
	1989	0.29	0.834
	1990	0.70	0.576
	1991	1.16	0.352
	1992	0.89	0.366
1994-2018 (>=)	1994	1.04	1.320
	1995	0.60	0.559
	1996	0.42	0.740
	1997	1.01	0.409
	1998	1.06	0.390
	1999	0.84	0.487
	2000	1.20	0.337
	2001	1.46	0.256
	2002	1.14	0.357
	2003	1.21	0.333
	2004	1.24	0.323
	2005	1.551	0.244
	2006	1.36	0.194
	2007	0.95	0.103
	2008	1.27	0.95
	2009	1.33	0.162
	2010	1.23	0.203
	2011	1.98	0.102
	2012	3.34	0.038
	2013	5.55	0.007
	2014	1.64	0.213
	2015	1.20	0.336
	2016	0.94	0.439
	2017	1.24	0.324
	2018	0.5	0.593
	2019	0.30	0.826
	2020	0.27	0.848
	2021	0.23	0.875
	2022	0.29	0.754
	2023	0.23	0.634

Source: The data in this table are compiled based on the measurement results.

From the results in Table 10, we can see that: between 1979 and 1993, the Chow test results all accepted the null hypothesis, indicating that there was no structural change. However, the Chow test results of the threshold point 2007 between 1994 and 2024 rejected the null hypothesis at a significance level of 5%, which means that there was a significant structural change around 2007, which is consistent with the threshold regression results. We continue to use OLS regression to simply analyze the relationship between the variables in these stages with significant structural changes, also using the OLS regression model.

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Table 11.
OLS regression results for 1994 to 2007and 2008 to 2024.

	Variable	Coef.	Std. Err	t value	p value
1994-2007	Constant term	-0.008	0.004	-1.89	0.085
	p_s	0.218	0.067	3.26	0.008
	$\widetilde{g_s}$	0.331	0.114	2.91	0.014
2008-2024	Constant term	0.002	0.004	0.39	0.705
	p_s	0.033	0.044	0.73	0.485
	$\widetilde{g_s}$	1.186	0.162	7.30	0.000

Source: The data in this table are compiled based on the measurement results.

From Table 11, we can see that at the 5% significance level, the impact of prices on economic fluctuations was significant before 2007, while technological progress was not significant. After 2007, the role of technological progress began to increase, while the role of prices began to weaken, which is completely consistent with the results of threshold regression.

4.7.6. Empirical Analysis Based on Rational Expectations

For enterprises with rational expectations, they often combine various production and price experiences when conducting production analysis and consider changes in the overall market and changes in regional market price levels at the same time. Based on this, this chapter first conducts a time series threshold regression analysis on the variables of Shanxi Province's GDP volatility$\widetilde{\boldsymbol{y_s}}$, Shanxi's price level change rate deviation difference p_c and Shanxi Province's technological progress volatility $\widetilde{g_s}$. Considering the price level deviation difference p_c between Shanxi and the whole country is exactly the economic behavior of enterprises under rational expectations.

4.7.6.1. Stationarity Test

The ADF test and PP test are used to test the stability of the price level change rate deviation p_c between Shanxi and the whole country.

Table 12.
Stationarity test results.

	variable	Test Statistic	Key value of the test			p value
			1% level	5% level	10% level	
ADF test	p_c	-3.474	-3.662	-2.964	-2.614	0.002
PP test	p_c	-5.836	-3.655	-2.941	-2.613	0.000

Source: The data in this table are compiled based on the measurement results.

The results of both stationary tests show that the variables are stationary at the 5% significance level, the regression analysis can be performed on the data.

4.7.6.2. Empirical Analysis - Time Series Threshold Regression

Time series threshold regression analysis is performed on the variables of Shanxi Province GDP fluctuation term $\widetilde{\boldsymbol{y_s}}$, Shanxi price level change rate $\boldsymbol{p_s}$ and Shanxi Province technological progress fluctuation term $\widetilde{\boldsymbol{g_s}}$:

Model settings:

$$y_t = \begin{cases} a_1 + \beta_1 p_{st}^1 + \beta_2 \tilde{g}_{st}^2 + \varepsilon_{1t}, t \le T \\ a_2 + \phi_1 p_{st}^1 + \phi_2 \tilde{g}_{st}^2 + \varepsilon_{2t,t} > T \end{cases}$$

Table 13.
Time series threshold regression results.

y_s	Regime1	Regime2
Threshold Estimate	q<=1994	q>1994
Intercept	0.000	-0.001
p_s	-0.119	0.123
$\widetilde{g_s}$	0.975	0.678
Sum of Squared Errors	0.001	0.006
R-squared	0.965	0.631

Source: The data in this table are compiled based on the measurement results.

As shown in the Table 13, the best result with 1994 as the threshold is: from 1978 to 1994, the effect of price on economic fluctuations is negative (-0.119), and the effect of technological progress on economic fluctuations is positive (0.975); from 1994 to 2024, the effect of price on economic fluctuations is positive (0.123), and the effect of technological progress on economic fluctuations is positive (0.678). Before 1994, the effect of price on economic fluctuations was negative, and the effect of technological progress on economic fluctuations was positive; after 1994, both price and technological progress had positive effects. However, the effect of price has increased, and the effect of technological progress has weakened.
The threshold regression results are as follows:

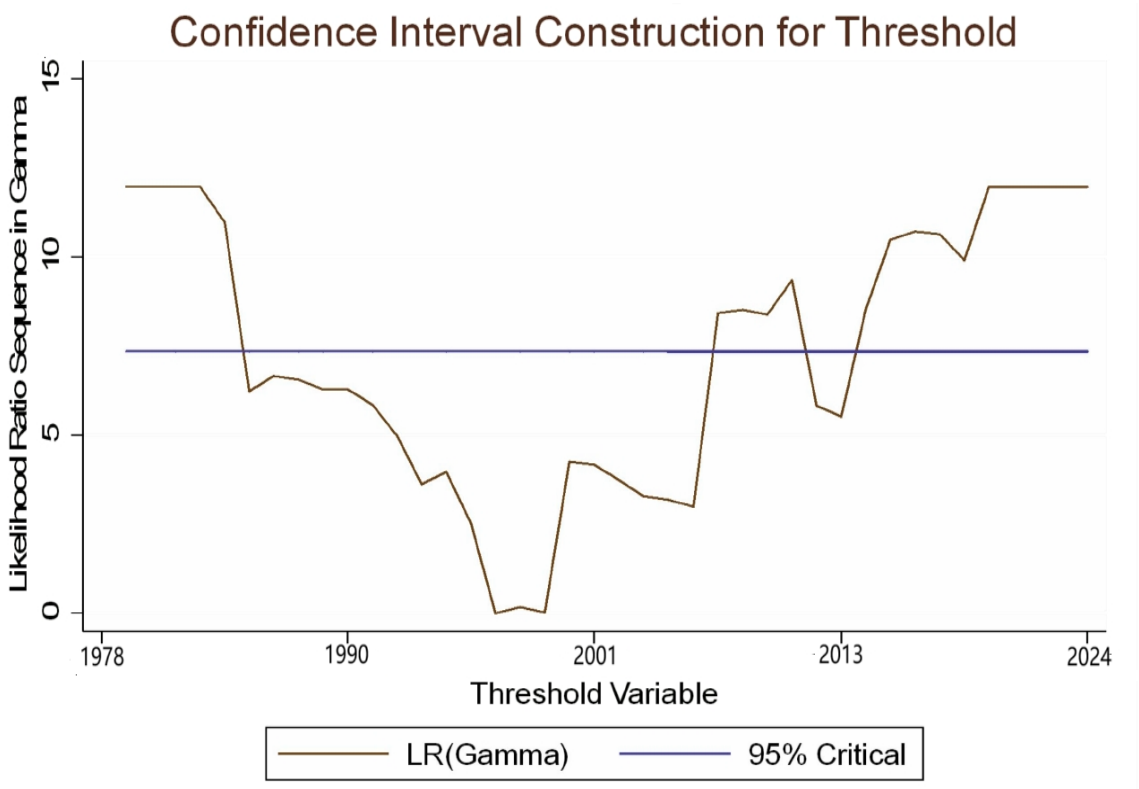

Figure 10.
Time series threshold regression results.

The threshold regression results shown in Figure 10 show that there may be threshold values between 1980-1994 and 1994-2010. Therefore, we divide the time series into two stages, 1979-1994 and

1995-2024. Then we perform threshold regression on the two stages of 1979-1994 and 1995-2024 respectively:
Stage 1: 1979-1994
The threshold regression results are as follows:

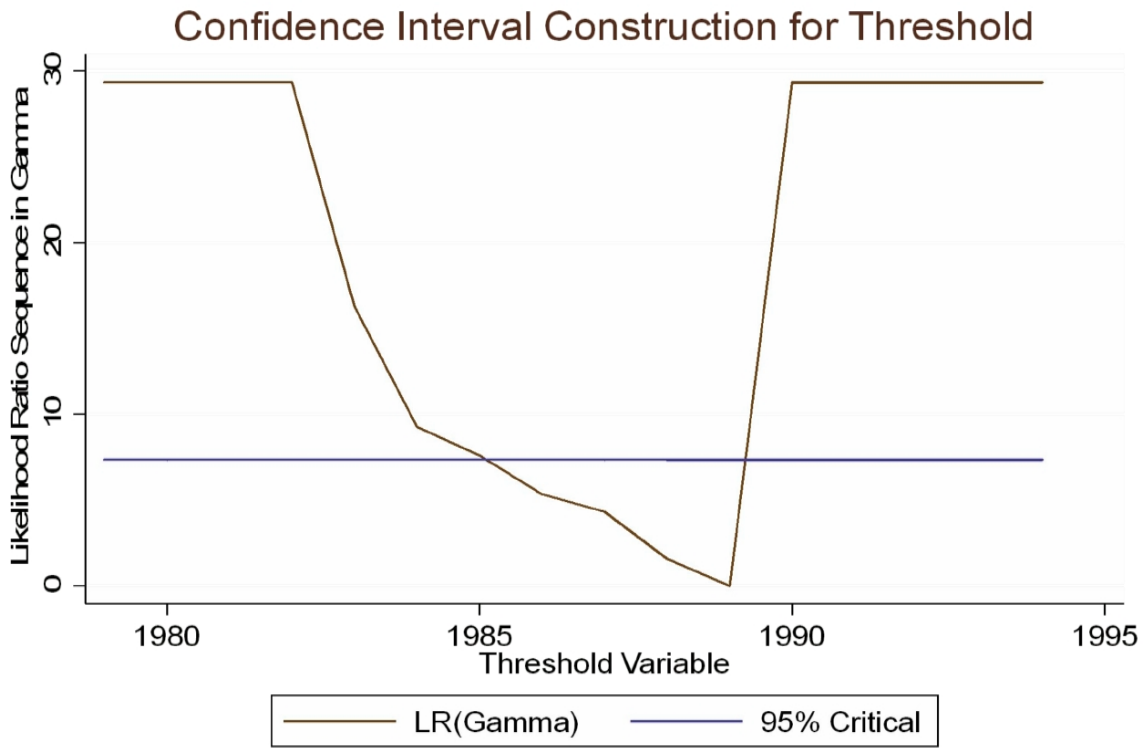

Figure 11.
Time series threshold regression results.

The threshold regression results can be summarized into the following table:

Table 14.
Time series threshold regression results.

y_s	**Regime1**	**Regime2**
Threshold Estimate	q<=1989	q>1989
Intercept	0.0002	-0.009
p_s	-0.021	-0.314
$\widetilde{g_s}$	1.018	0.778
Sum of Squared Errors	0.000	0.000
R-squared	0.990	0.975

Source: The data in this table are compiled based on the measurement results.

According to the results in Figure 11 and Table 14, there was a threshold before 1994, in 1989, the economy was divided into two stages. From 1978 to 1989, the effect of prices on economic fluctuations was negative (-0.021), and the effect coefficient of technological progress on economic fluctuations was positive (1.018); from 1990 to 1994, the effect of prices on economic fluctuations was negative (-0.314), and the effect coefficient of technological progress on economic fluctuations was positive (0.778). After 1989, although the impact of prices on economic changes was negative, the impact of prices on the

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economy became stronger and stronger. The effect of technological progress on the economy was positive throughout the stage, but the effect coefficient was gradually weakening.

Stage 2: 1995-2024

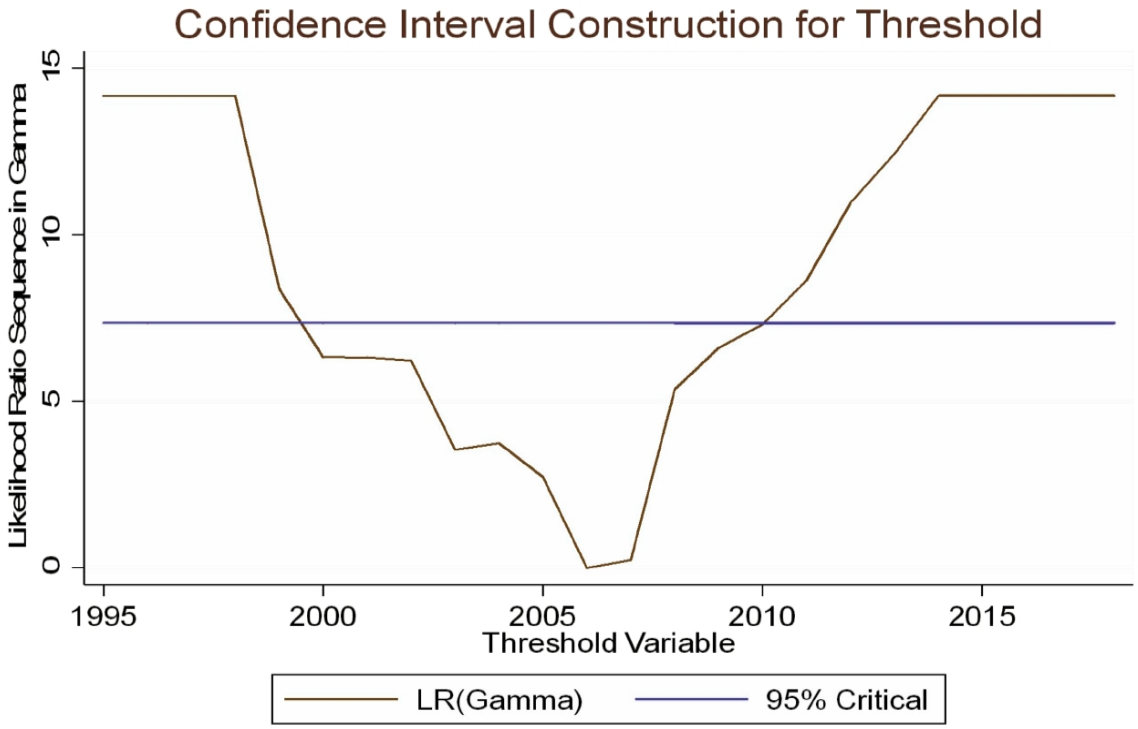

Figure 12.
Time series threshold regression results.

Table 15.
Time series threshold regression results.

y_s	**Regime1**	**Regime2**
Threshold Estimate	q<=2006	q>2006
Intercept	-0.003	0.000
p_s	-0.663	0.046
$\widetilde{g_s}$	0.121	0.918
Sum of Squared Errors	0.001	0.002
R-squared	0.694	0.812

Source: The data in this table are compiled based on the measurement results.

From a stage-by-stage perspective, from 1995 to 2006, the effect of price on economic fluctuations was positive (0.663), and the effect coefficient of technological progress on economic fluctuations was positive (0.121); from 2007 to 2024, the effect of price on economic fluctuations was still positive (0.046) but significantly reduced, and the effect coefficient of technological progress on economic fluctuations was positive (0.918), which was significantly enhanced. The threshold result diagram in Figure 12 above shows that there may be multiple threshold values after 1994. Therefore, taking 1994 as the boundary, we focus on analyzing the impact of price and technological progress on economic fluctuations at different stages during the period of 1995-2024.

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Table 16.
Time series threshold regression results

Threshold Estimate	1995-2001	2002-2006	2007-2011	2012-2018
Intercept	-0.007	0.010	-0.0004	-0.004
p_s	0.806	0.301	0.222	-0.121
$\widetilde{g_s}$	0.199	0.043	0.907	1.180
Sum of Squared Errors	0.000	0.000	0.001	0.000
R-squared	0.878	0.654	0.844	0.883

Source: The data in this table are compiled based on the measurement results.

The results in Table 16 show that after 1994, there are three thresholds, namely 2001, 2006 and 2011, which divide the economy into four stages. From 1995 to 2001, the effect of price on economic fluctuations is positive (0.806), and the coefficient of technological progress on economic fluctuations is positive (0.199); from 2002 to 2006, the effect of price on economic fluctuations is positive (0.301), and the coefficient of technological progress on economic fluctuations is positive (0.043); from 2007 to 2011, the effect of price on economic fluctuations is positive (0.222), and the coefficient of technological progress on economic fluctuations is positive (0.907); from 2012 to 2024, the effect of price on economic fluctuations turns negative (-0.121), and the coefficient of technological progress on economic fluctuations is positive (1.180). After segmenting the period from 1995 to 2024, it was found that the impact of prices on economic changes was positive from 1995 to 2011, and the impact of prices on the economy weakened after 2012 compared with before 2012. The impact of technological progress on the economy was positive throughout the period from 1995 to 2024, and the impact coefficient gradually became stronger after 2012 compared with before 2012.

4.7.6.3. Empirical Analysis - Chow Test

Through threshold regression, we found the best time segmentation point. To further test whether there is a structural change before and after the threshold value in the above time series threshold, we use the Chow test method to conduct an overall analysis.

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Table 17.
Chow test results from 1979 to 2024.

Ho: no Structural Change		
Cut-off point (>=)	**Chow Test**	**p value**
1979	0.00	0.986
1980	0.24	0.787
1981	0.16	0.924
1982	0.23	0.876
1983	0.19	0.906
1984	1.16	0.339
1985	1.07	0.376
1986	1.09	0.367
1987	1.15	0.343
1988	1.15	0.343
1989	1.25	0.308
1990	1.45	0.247
1991	1.77	0.171
1992	1.69	0.188
1993	2.05	0.126
1994	2.73	0.059
1995	2.68	0.063
1996	2.72	0.060
1997	1.62	0.203
1998	0.64	0.199
1999	1.74	0.177
2000	1.86	0.156
2001	1.88	0.152
2002	1.93	0.143
2003	0.69	0.565
2004	0.67	0.576
2005	0.70	0.560
2006	0.87	0.601
2007	0.62	0.522
2008	0.34	0.633
2009	0.56	0.624
2010	0.63	0.347
2011	0.49	0.565
2012	0.50	0.683
2013	1.25	0.306
2014	1.32	0.283
2015	0.67	0.577
2016	0.28	0.840
2017	0.23	0.971
2018	0.25	0.861
2019	0.39	0.760
2020	0.15	0.932
2021	0.04	0.991
2022	0..04	0.951
2023	0.09	0.766

Source: The data in this table are compiled based on the measurement results.

Comparison in Table 17 shows all the results of the Chow test, it is found that the result with 1994 as the threshold value is closest to the 10% significance level, indicating that there may be structural changes in the previous and next time periods. The results of the Chow test further verify the results of the time series threshold regression. In different time periods, price changes and technological progress have different effects on economic fluctuations. The following uses OLS regression to analyze the effects

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of these two factors on economic fluctuations in different time periods. According to the results of the model formula we set, OLS regression analysis is performed.

Table 18.
OLS regression results for 1979-1994 and 1995-2024.

	Variable	Coef.	Std.Err	T Value	P Value
1979-1994	Constant term	0.0004	0.002	0.21	0.839
	p_s	-0.119	0.073	-1.62	0.129
	$\widetilde{g_s}$	0.975	0.062	15.68	0.000
1995-2024	Constant term	-0.001	0.004	-0.17	0.868
	p_s	0.124	0.096	1.29	0.211
	$\widetilde{g_s}$	0.678	0.141	4.81	0.000

Source: The data in this table are compiled based on the measurement results.

The results in Table 18 show that during the period of 1979-1995, the difference between the price level of Shanxi Province and the national price level had a negative impact on economic fluctuations, and technological progress had a positive impact on economic fluctuations, which is consistent with the results of threshold regression. The regression results also show that before 1994, the effect of price changes on the economy of Shanxi Province was not significant, while compared with prices, the role of technological progress in promoting Shanxi Province was more obvious. After 1994, the impact of prices on the economy turned from negative to positive. Although the role of technological progress was positive, it was lower than before, which was also consistent with the results of threshold regression. The overall Chow test results are consistent with the threshold regression results, and the staged Chow test will be further conducted next.

Table 19.
Chow test results from 1979 to 1994.

Ho: no Structural Change			
stage	**Cut-off point**	**Chow Test**	**p value**
1979-1994 (>=)	1979	0.09	0.775
	1980	0.60	0.565
	1981	0.88	0.482
	1982	0.74	0.553
	1983	1.39	0.301
	1984	2.77	0.097
	1985	3.23	0.069
	1986	3.97	0.042
	1987	4.34	0.033
	1988	5.60	0.016
	1989	6.53	0.010
	1990	9.99	0.002
	1991	10.00	0.002
	1992	13.18	0.001
	1993	26.58	0.000

Source: The data in this table are compiled based on the measurement results.

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Table 20.
Chow test results from 1995 to 2024.

Ho: no Structural Change			
Stage	**Cut-Off Point**	**Chow Test**	**P Value**
1995-2024 (>=)	1995	0.10	0.903
	1996	0.20	0.897
	1997	1.00	0.415
	1998	1.08	0.383
	1999	1.19	0.341
	2000	1.73	0.196
	2001	1.73	0.196
	2002	1.76	0.190
	2003	2.62	0.083
	2004	2.55	0.088
	2005	2.91	0.063
	2006	2.76	0.022
	2007	2.25	0.026
	2008	1.96	0.136
	2009	2.78	0.095
	2010	2.04	0.137
	2011	3.12	0.121
	2012	4.28	0.053
	2013	3.97	0.102
	2014	2.02	0.147
	2015	1.65	0.213
	2016	1.46	0.258
	2017	1.13	0.364
	2018	0.61	0.620
	2019	0.31	0.815
	2020	0.25	0.863
	2021	0.14	0.935
	2022	0.17	0.844
	2023	0.02	0.884

Source: The data in this table are compiled based on the measurement results.

From the Chow test results between 1979 and 1994 in Table 19, we can see that there were obvious structural changes after 1987. The threshold regression results for the period 1979-1994 show that 1989 is the threshold value, and the results in the above table also verify that there were indeed structural changes around 1989, but the most obvious structural change was in 1993.

According to the threshold results obtained by threshold regression in Table 20, there is one threshold cutoff point before 1994 and three cutoff points after 1994. From the results in the table above, at the 5% significance level, the Chow test results show that the result at the cutoff point in 2006 is the smallest, which means that there is the most obvious structural change around 2006.

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Table 21.
Chow test results from 1995-2006.

Ho: no Structural Change			
stage	**Cut-off point**	**Chow Test**	**p value**
1995-2006 (>=)	1995	0.00	0.982
	1996	0.20	0.821
	1997	0.14	0.930
	1998	0.09	0.964
	1999	1.11	0.417
	2000	3.34	0.097
	2001	3.80	0.077
	2002	4.62	0.062
	2003	5.42	0.038
	2004	8.01	0.016
	2005	18.30	0.003

Source: The data in this table are compiled based on the measurement results.

As can be seen from Table 21, the best structural dividing point between 1995 and 2006 is 2005, which is inconsistent with the result of 2001, the dividing point of the time series threshold regression. Therefore, 2001 is no longer considered as the dividing point in the following stage analysis.

Table 22.
Chow test results from 2007-2024.

Ho: no Structural Change			
stage	**Cut-off point**	**Chow Test**	**p value**
2007-2024 (>=)	2007	5.86	0.042
	2008	2.79	0.128
	2009	1.68	0.269
	2010	0.87	0.505
	2011	0.65	0.497
	2012	0.32	0.432
	2013	0.44	0.312
	2014	0.63	0.567
	2015	0.51	0.441
	2016	0.63	0.423
	2017	0.35	0.505
	2018	0.28	0.620
	2019	0.19	0.788
	2020	0.20	0.838
	2021	0.25	0.898
	2022	0.08	0.891
	2023	0.12	0.784

Source: The data in this table are compiled based on the measurement results.

The results in Table 22 show that at the 5% significance level, the best structural point is 2007, and the results after 2007 show that there is no structural change, which is inconsistent with the result of the threshold value point in 2011 in the threshold regression results, so the 2011 dividing point is eliminated.

In summary, the overall time system is divided by 1989 and 2006 before and after 1994, respectively. Before 1994, it can be divided into two stages: 1979-1989 and 1990-1994. After 1994, it can be divided into two stages: 1995-2006 and 2007-2024. The OLS regression is used to simply analyze the relationship between the variables in these stages, and the OLS regression model is also used.

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Table 23.
OLS regression results for different stages.

	variable	Coef.	Std.Err	t value	p value
1979-1989	Constant term	0.000	0.002	0.10	0.925
	p_s	-0.021	0.037	-0.56	0.594
	$\widetilde{g_s}$	1.018	0.043	23.73	0.000
1990-0994	Constant term	-0.009	0.006	-1.62	0.246
	p_s	0.315	0.077	-4.10	0.055
	$\widetilde{g_s}$	0.778	0.093	8.39	0.014
1995-2006	Constant term	-0.003	0.004	-0.62	0.552
	p_s	0.663	0.113	5.86	0.000
	$\widetilde{g_s}$	0.119	0.198	0.60	0.563
2007-2025	Constant term	-0.0004	0.004	-0.10	0.924
	p_s	0.046	0.081	0.57	0.582
	$\widetilde{g_s}$	0.918	0.181	5.06	0.001

Source: The data in this table are compiled based on the measurement results.

The results of the phased regression from 1979 to 2024 show that there was no significant correlation between prices and economic fluctuations before 1994, which is the same as the overall regression results. The role of technology also shows that the impact of technology is gradually weakening with the development of the economy, which is basically consistent with the results of the phased threshold regression. During the period 1995-2006, the role of prices was significantly enhanced compared with the previous period, and there was a significant correlation between prices and economic fluctuations, and its effect on the economy was more significant than the effect of technological progress on economic fluctuations. However, after 2007, the role of prices was significantly weakened, while the impact of technological progress on economic fluctuations was significantly enhanced. The phased change results from 1995 to 2024 are completely consistent with the phased change results of the threshold regression.

From the overall OLS regression results, the change in the deviation difference between Shanxi Province and China's price level changes does not have a great impact on economic fluctuations, mainly driven by technological progress. The phased results also show that, except for the period of 1995-2006, the impact of technological progress on economic fluctuations is significantly higher than the impact of prices on economic fluctuations.

Table 24.
Comparison of empirical test results.

Stage	Static expectations		Rational expectations	
	Stage1 1979-1993	Stage2 1994-2024	Stage1 1979-1994	Stage2 1995-2024
The impact of prices on economic fluctuations	Positive (0.007) Not significant	Positive (0.143) Significant	Negative (-0.119) Not significant	Positive (0.124) Not significant
The impact of technological progress on economic fluctuations	Positive (1.022) Significant	Positive (0.553) Significant	Positive (0.975) Significant	Positive (0.678) Significant

Source: The data in this table are compiled based on the measurement results.

4.7.7. Analysis of Empirical Results —— Comparison Between Static Expectations and Rational Expectations and Determination of Economic Stages

Next, based on the above empirical results, all the conclusions obtained above are sorted out, and the reasons for this phenomenon are further analyzed [26].

Comparing the results of the impact of prices and technological progress on economic fluctuations under static expectations and rational expectations in Table 24, we can see that under static expectations, the impact of prices on economic fluctuations before 1993 was not significant, mainly due to technological progress; after 1993, prices as the main factor had a significant effect on economic

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fluctuations, and the impact coefficient increased significantly. The impact of technological progress on economic fluctuations is still significantly positive, and the impact coefficient has decreased. Under rational expectations, the impact of prices on economic fluctuations in the period around 1994 was not significant, mainly due to technological progress. The comparison results mean that when enterprises conduct decision-making analysis under rational expectations, they can make more rational judgments on prices and will be less affected by price fluctuations, that is, the economic fluctuations in Shanxi Province will not be significantly affected by prices. However, through static expectations, enterprises will be more affected by prices.

Combining the empirical results and the economic development of Shanxi Province, we found that the trend of economic fluctuations in Shanxi Province and the trend of price change rate in Shanxi Province have been basically consistent for a long time. When prices rise, the economy is high, and when prices fall, the economy will also fall. From the empirical analysis results table, we can see that in the latter stage of rational expectations, the impact of prices on economic fluctuations is not significant, which is inconsistent with the actual empirical facts in Shanxi Province. However, under the static expectations, the effect of prices on economic fluctuations in Shanxi Province in the latter stage is significant, which is completely consistent with the empirical facts. It can be seen that the forecasts of Shanxi enterprises seem to be more inclined to static expectations rather than rational expectations.

In the empirical analysis of static expectations, we used the time series threshold regression and Chow test to determine the stage. Observations found that the threshold regression results were different from the Chow test results. In the threshold regression, there were two thresholds in 1983 and 1987 in the period of 1979-1993, but the Chow test results showed that there was no significant structural change point. Therefore, there was a conflict between the two test results in the period of 1979-1993. However, according to the analysis of the actual economic situation, since China was mainly based on a planned economy before 1993 and the market economy was not yet perfect, the impact of prices on economic fluctuations was relatively small. Therefore, based on the actual situation, we divide this period into one stage. In the empirical results from 1994 to 2024, the analysis results of threshold regression and Chow test are completely consistent, with 2007 as the dividing point, dividing this period into two stages.

Thus, through the above analysis, we can divide the overall stage into three stages: 1979-1993, 1994-2007, and 2008-2024. The following is an analysis of the impact of prices and technological progress on economic fluctuations in different stages:

Table 25.
Empirical test results of static expectations for different stages

Stage	Static expectations		
	Stage1 1979-1993	**Stage2 1994-2007**	**Stage3 2008-2024**
The impact of prices on economic fluctuations	Positive (0.007) Not significant	Positive (0.218) Significant	Positive (0.033) Not significant
The impact of technological progress on economic fluctuations	Positive (1.022) Significant	Positive (0.331) Significant	Positive (1.196) Significant

Source: The data in this table are compiled based on the measurement results.

As can be seen from Table 25, prices and technological progress in different periods have different effects on economic fluctuations in Shanxi Province. In terms of price levels, the biggest special feature of resource-based regions is resource prices. Since the industrial system of a region is composed of different industries in the region, there is a certain correlation between them. Therefore, changes in one industry will affect other industries or all industries in the entire region. As the dominant industry in resource-based regions, resource-based industries can almost affect all enterprises in the entire resource-based region through various transmission mechanisms. Therefore, when resource-based industries change, other industries will change. Resource prices are the main factor affecting resource-based

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enterprises. Once prices change, it will inevitably cause changes in product prices of resource-based industries and then affect changes in product prices of other industries. This means that when the prices of major resources in resource-based regions fluctuate, the price level of the entire resource-based region changes.

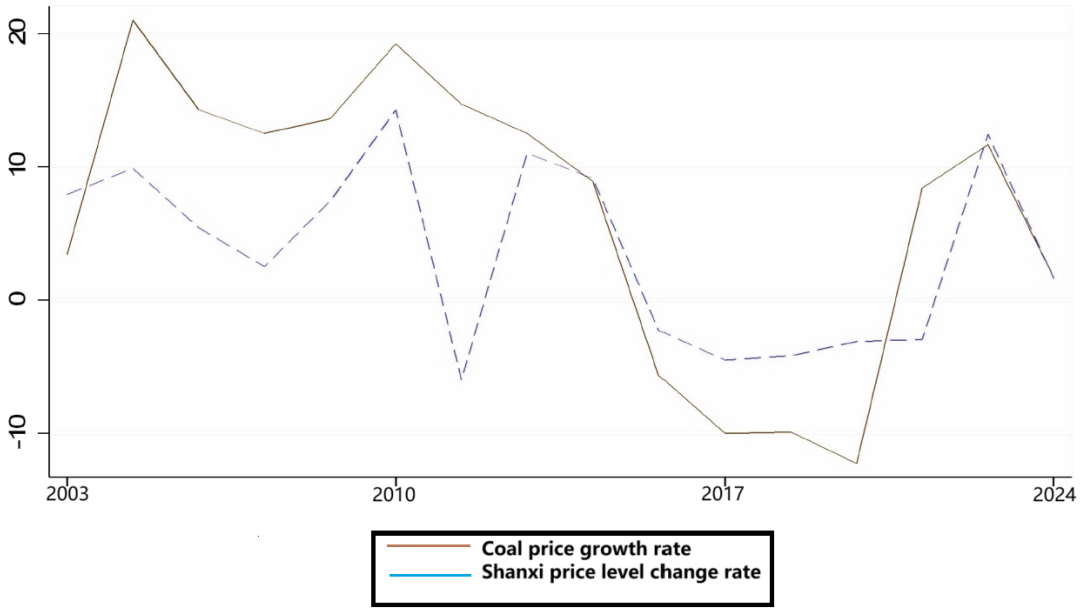

Figure 13.
Coal price change rate and Shanxi price level change rate chart.

As can be seen from Figure 13, the change in the price level of Shanxi Province is basically consistent with the change trend of coal prices. When the coal price rises, the price level of Shanxi Province will also rise; conversely, when the price falls, the price level of Shanxi Province will also fall. This shows that the fluctuation of coal prices has a great impact on the fluctuation of the price level of Shanxi Province. Therefore, when we focus on analyzing the impact of prices and technological progress at different stages on economic fluctuations in Shanxi Province under the static expectation, we must analyze the situation of the coal industry.

Empirical Results Analysis —— Phased Empirical Results Analysis of the Impact of Prices and Technological Progress on Economic Fluctuations

(1) Phase 1, 1979-1993: The impact of price on economic fluctuations was relatively weak, and technological progress played a major role.

In 1978, the Third Plenary Session of the 11th Central Committee was held, proposing to shift the focus of work to economic construction. In order to alleviate the shortage of coal supply during the rapid development of the national economy, the Party Group of the Ministry of Coal Industry held an enlarged meeting in 1979 and proposed to make the rapid expansion of coal production and meeting the needs of economic development the primary goal of coal industry development. In 1979, the Shanxi Provincial Party Committee and the Provincial Revolutionary Committee formally submitted a report entitled "Report on Building Shanxi into a National Coal Energy Base" to the Party Central Committee and the State Council. In 1980, the state responded by supporting Shanxi to strengthen its energy base and support the development of the coal industry, and the Shanxi coal industry began to develop rapidly. In 1982, the government issued the "Interim Price Management Regulations", which stipulated that "state pricing is the main situation" and coal prices are basically controlled by the state. In 1983, the state required that management policies be relaxed on the premise of ensuring safe production and

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encouraging the masses to raise funds to run mines. Before 1984, my country's coal price level has always maintained the government's minimum pricing, and coal is regarded as a means of production rather than a commodity. The role of the market is completely ignored, and the government mainly regulates it. After 1984, in order to improve the large-scale losses in the coal industry, the regulation began to loosen, and a combination of regulation and release was implemented, and price fluctuations were not very obvious. The "Price Management Regulations" of 1987 stipulates that "the state adopts the principle of combining direct management and indirect control for price management", and coal prices are still state-set. During the period from 1979 to 1993, prices were mainly regulated by the state, so they would not change much, and the impact on the economy was relatively small. Therefore, there is no significant correlation between price fluctuations and economic fluctuations. From 1979 to 1993, the country was in the stage of economic takeoff due to reform and opening up. In order to promote the development of the coal industry, the Ministry of Coal Industry successively formulated a series of policies to promote technological progress in the coal industry, such as "Quality Standards for Coal Mining Faces" and "Technical Policies for the Coal Industry". Shanxi Province also responded to the call of the reform policy and actively introduced foreign-funded enterprises to focus on the development of the coal industry. The "Interim Regulations of the Shanxi Provincial People's Government on Further Accelerating the Development of Local Coal in Our Province" issued in 1984 proposed "whoever invests, whoever benefits", encouraging investment and introducing capital and technology. In 1998, Shanxi Province began to implement resource integration, actively adjusted the industrial structure, changed the development ideas of the coal industry, and improved the technical level of the coal industry. It formulated the policy of "mining to support the mine, phased transformation, from small to large, and gradually improving", which promoted the improvement of the production technology level of state-owned coal mines and played a positive role in promoting economic development.

Before 1993, the price level was basically controlled by the state, and the overall price level did not fluctuate greatly. As the national coal supply base, Shanxi Province has not experienced major fluctuations due to the long-term state control of coal prices. Since the development of the coal industry requires the establishment of factories and the introduction of technical talents and advanced equipment, it has greatly promoted the development of Shanxi Province's technical level. Therefore, this stage shows that the role of technological progress is significant, while the role of price is very small.

4.8. Implications

Based on the theory of monetary economic cycle and the theory of real economic cycle, this paper mainly analyzes the economic fluctuations in Shanxi Province and studies the mechanism of price and technological progress on economic fluctuations in resource-based regions. It is found that in theory, the impact of technological progress on economic fluctuations in resource-based regions is greater than that of price. However, due to the high degree of dependence on resources in resource-based regions, they pay more attention to the changes in price factors and ignore the role of technological progress. As a result, resource-based regions pay too much attention to price factors in the process of economic development, while the level of technological progress gradually declines, which eventually leads to the solidification of production models and backward production methods, and the transformation and upgrading are stuck in a quagmire and difficult to extricate themselves.

5. Conclusion

Based on existing theories, this paper conducts an in-depth study and analysis on the impact of prices and technological progress on economic fluctuations in resource-based regions. Combining the monetary economic cycle theory and the real economic cycle theory, this paper analyzes the impact of prices and technological progress on economic fluctuations through theoretical derivation, time series threshold regression and Chou test. The main conclusions are as follows:

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(1) Theoretical model analysis finds that price shocks and technological progress are important factors leading to economic fluctuations in resource-based regions. Since resource-based regions have long relied on an industrial system dominated by resource-based industries, the overall price level of the region is greatly affected by the special factor of resource prices. When resource prices fluctuate, the overall price level of resource-based regions will also fluctuate significantly, resulting in a deviation between the price level of resource-based regions and the overall price level of the country. When this price level deviation is positive, it represents an excess demand for products in resource-based regions, which will lead to enterprises in the region expanding production; conversely, when the price deviation is negative, it will lead to enterprises in resource-based regions reducing production, which will then cause shocks and lead to regional economic fluctuations. This conclusion is contrary to the monetary economic cycle. The effect of price deviation on the economy is affected by the expectation tendency of enterprises. When enterprise expectations are more inclined to static expectations, economic fluctuations are completely affected by fluctuations in regional price levels. When enterprise decisions are more inclined to rational expectations, economic fluctuations are affected by changes in the difference between the price level in resource-based regions and the overall price level in the country. Technological progress will have a direct impact on economic fluctuations in resource-based regions, which is consistent with the actual economic cycle theory.

(2) The final results of the empirical analysis of Shanxi's economy show that the fluctuations in Shanxi's economy are more in line with the assumption of static expectations. The empirical results show that: from 1978 to 1993, due to the dominant economic policy of planned economy, the role of price was significantly weaker, while the role of technological progress was more obvious. From 1994 to 2007, with the establishment of the market economy system, the price factor continued to strengthen and became the dominant factor, while the impact of technological progress on economic fluctuations was weaker. At this time, Shanxi's economic growth was more dependent on the rise in resource prices. After the 2008 financial crisis, coal prices fell and resource-based economic advantages weakened. In order to seek new economic growth points, Shanxi's economy began to transform. With the elimination of overcapacity and supply-side reform, the impact of prices on Shanxi's economic fluctuations has been greatly reduced. The government and enterprises attach importance to technological innovation, making technological progress the main factor causing economic fluctuations and promoting economic growth.

(3) Based on theoretical and empirical analysis, under the market economy, resource-based regions have long relied on rising resource prices for economic development, and the industrial structure tends to be solidified, resulting in market failure. When resource prices are high, enterprises enter resource-based industries for profit, invest in extensive expansion, ignore technological progress and are unwilling to transform. When the economy falls into depression, resource prices fall, demand decreases, and corporate profits fall into difficulties, but they are difficult to transform due to lack of funds and backward technology. It shows that corporate development is more dependent on price changes rather than technological progress, which leads to the solidification of industrial structure and backward technological progress in resource-based regions. Market failure occurs, and the government needs to take the initiative to adjust. In a market economy, changes in resource prices will make it easier for enterprises to focus their forecasts on changes in resource prices, which will make enterprises in resource-based regions more inclined to static expectations when making expected decisions, making the impact of prices in resource-based regions on economic fluctuations stronger.

(4) Based on the conclusions of previous literature research, this paper draws on traditional economic theory to build a model that combines price levels with technological progress for analysis, and verifies it with empirical evidence, and finally draws corresponding conclusions. Combined with the actual experience of Shanxi, this paper puts forward several policy suggestions for the economic transformation and development of resource-based regions, especially Shanxi. However, since the empirical information and data obtained in the research process are mostly collected from existing literature and existing data, and the practical investigation of Shanxi's economy is still insufficient, the

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policy suggestions in this paper may be insufficient in operability or feasibility. In addition, for the impact of economic fluctuations in Shanxi Province, it is also possible to study the "institutional dividend" and "institutional defects" from the perspective of reflecting the process of the impact of institutional changes on productivity. In future research, we will further deepen practice and combine more actual situations for more in-depth analysis and research. In addition, resource-based regions may prosper because of their resources or be trapped by them. Although this article demonstrates the impact of price and technological progress on resource-based regions, there is still a long way to go for resource-based regions to achieve transformation and development. Further exploring the impact relationship between resource price fluctuations and technological fluctuations is also an important direction for future research.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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