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Assessing The Phillips Curve in China: An Empirical Study of Inflation and Unemployment

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Abstract: *China's inflation rate (IR) has generally remained moderately fluctuating, while the unemployment rate (UR) has shown a phased upward trend under economic transformation. Studying these two fields is conducive to the central bank's regulation and control of fiscal and monetary policies. Given China's distinct economic structure and government-controlled labor market, it remains unclear whether the classical Phillips Curve (PC) or the New Keynesian Phillips Curve (NKPC) holds in this context. The research aims to test the theoretical feasibility of applying PC models within China's economy and provide empirical insights into inflation-unemployment dynamics. To capture both short- and long-term dynamics, annual data from 1978 to 2021 was utilized and applied to the linear regression model and autoregressive distributed lag (ADL) model to test the performance of the classical PC and the NKPC in China respectively. The findings of the Johansen cointegration test indicate the independent variables—UR, gross domestic product index (GDPI), exchange rate (ER), and national savings rate (NSR)—demonstrate a long-term influence on the dependent variable IR, which supports the applicability of the PC in this context. From an academic perspective, the study enriches the literature by extending the PC framework to a developing, transitionary economy, offering a methodological reference for future research.*
Keywords: *Inflation, unemployment, China, Phillips Curve, ADL model.*

INTRODUCTION

Inflation and unemployment are fundamental global macroeconomic issues. Over the past century, scholars have focused on the unemployment rate (UR) and inflation rate (IR) as key indicators. Researchers represented by [1] and [2] conducted extensive studies on their relationship, providing theoretical support for macroeconomic policy. For social stability, all nations aim to reduce UR and stabilize IR.UR reflects the labor market; high UR indicates underutilized resources. In response, governments often lower interest rates and increase investment to stimulate growth and reduce UR. IR reflects price changes—moderate inflation signals growth, but excessive inflation increases living costs and suppresses consumption. Inflation is usually controlled via money supply adjustments.Changes in monetary conditions often influence the real economy through the original Phillips curve, which connects wage change rates and UR. [1] first identified a negative correlation between UR and wage change rate. [2] found a positive correlation between wage change rate and IR, replacing wage growth with IR, thus extending the Phillips curve to describe the IR-UR relationship. This suggests a trade-off: low unemployment with high inflation, or low inflation with high unemployment. However, this relationship varies across countries and time periods. For example, [3] argued that the Phillips curve is ineffective in the long run as UR returns to its natural level.In China, due to its economic structure, the Phillips curve's applicability is debated. This study explores China's inflation-unemployment relationship while considering other economic factors. It provides empirical evidence for both the classical Phillips curve and the New Keynesian Phillips Curve (NKPC), offering insights for China's economic policy, especially regarding inflation and unemployment.

Literature Review

The Theoretical Evolution of Phillips Curve

The Phillips curve originated from the New Zealand economist in [1], who demonstrated the negative correlation between UR and wage growth using UK data from 1861 to 1957. This was later extended to show the IR-UR correlation and became known as the Phillips Curve. [2] further developed this idea, making it a policy tool.

However, during mid-20th century stagflation in Europe, high UR and high IR coexisted, contradicting the classical

Phillips curve. In response, [4] proposed the "expectations-augmented Phillips curve", and [3] introduced the "natural unemployment rate hypothesis". Both theories suggest the Phillips curve holds only in the short run and that UR tends to its natural level over time. Later, [5] introduced the "New Keynesian Phillips Curve", incorporating price rigidity and other factors. Though controversial in the long run, the Phillips curve remains widely used.

Classical Phillips Curve

[2] extended the theory of [1] and proposed the classical Phillips curve based on IR and UR, arguing that governments can trade off between them. The model describes a static relationship:

$$\pi_t = \alpha - \beta\mu_t \quad (1)$$

where, π_t is IR, β is the adjustment coefficient, and μ_t is UR, α is the intercept. It is visualized with UR on the horizontal axis and IR on the vertical axis. Being static, it is typically analyzed using linear regression. Many studies confirm its short-term stability—for example, [6] verified it using UK data. However, most agree it is only applicable in the short term. To extend its use to long-term data, scholars introduced inflation expectations, forming the NKPC.

New Keynesian Phillips Curve

In the 1980s, the classical Phillips curve could no longer explain changes in the IR-UR relationship. Under [5], the NKPC was developed. Unlike the classical model, it considers IR as influenced by both current UR and future inflation expectations. The IR-UR correlation is significantly affected by inflation expectations. Different models reflect varying assumptions. Static expectations assume constant IR over time. Rational expectations, proposed by [7], assume that all available information is used to form optimal predictions, consistent with actual IR distributions. [8] noted rational expectations are essential for estimating inflation expectations and analyzing the IR-UR dynamic. [9] found that real-time expectations could be incorporated through survey data.

Extrapolative expectations project future IR from past trends, often linearly. [10] highlighted their strong explanatory power for inflation stickiness. [11] found that in steady states, extrapolative and rational predictors yield similar accuracy due to evolutionary dynamics. Adaptive expectations are widely used in long-term inflation studies; [12] found them better at explaining inflation expectations with memory effects.

[5] reviewed how the IR-UR relationship evolved, focusing on the NKPC under New Keynesian theory, incorporating expectations into the model. The dynamic form is:

$$\pi_t = \beta_1\pi_e + \beta_2\mu_t + \varepsilon_t \quad (2)$$

where, π_t is IR, β is the adjustment coefficient, μ_t is UR, π_e is inflation expectation, ε_t is a random shock. Unlike the classical model, the NKPC includes inflation expectations, often modeled by lagged IR terms. It reflects a dynamic, time-series relationship between IR and UR. As it involves expectations, the NKPC cannot be represented with a simple 2D curve and requires time-series models like the autoregressive distributed lag (ADL) model for analysis.

The Phillips curve theory has undergone an evolution from the classical Phillips curve to NKPC. The classic Phillips curve emphasizes the negative correlation between the unemployment rate and the inflation rate. The NKPC, on the other hand, introduced inflation expectations and emphasized the dynamic adjustment process. This paper adopts NKPC as the analytical framework to conduct a more comprehensive analysis of the feasibility of the Phillips curve in China.

DATA AND METHODOLOGY

The National Bureau of Statistics of China[1] provided the majority of the data used in this research. It is one of the most authoritative sources of official statistics. The data in the study covering the annual data from 1978 to 2021. The UR data is China's registered urban population UR, and the IR data is calculated by China's urban CPI. The ER, and the GDPI are all derived directly from the website. The NSR data are derived from CEIC Data[2], a global macroeconomic data platform for economists, policy makers, financial institutions and enterprises.

According to the definition in [13], IR refers to the increase in the money supply or the total amount of money income. [14] pointed out that inflation is related to the price of gold and is usually reflected in the fluctuations of foreign exchange rates. In the study of the Phillips curve, IR is usually taken as the dependent variable.

[1] National Bureau of Statistics of China, China Statistical Database (2024), available at https://data.stats.gov.cn/easyquery.htm?cn=C01.
[2] CEIC Data, China Gross Savings Rate (2024), available at https://www.ceicdata.com/zh-hans/indicator/china/gross-savings-rate.

UR adopts the modern definition proposed in [15], namely the proportion of the unemployed population in the labor force. The studies of [16] and [17] indicated that, in addition to the influence of natural economic factors, UR is also often affected by government policies. In the Phillips curve, UR has always been the core explanatory variable.

This study will also introduce the influence of GDPI, ER, and NSR on IR. GDPI is used to measure the relative changes in a country's economic activity level within a certain period, based on the first definition in [18]. ER reflects the amount required to purchase US dollars using other currencies and is a core variable in the international financial market. The studies of [19] and [20] indicated that future inflation expectations will affect ER fluctuations. [21] pointed out that the adjustment of IR and ER helps alleviate income inequality and reduce UR. NSR refers to the proportion of a country's total savings to its GDP. Research in [22] indicated that the higher the level of savings, the higher the long-term economic growth and the higher the IR will be.

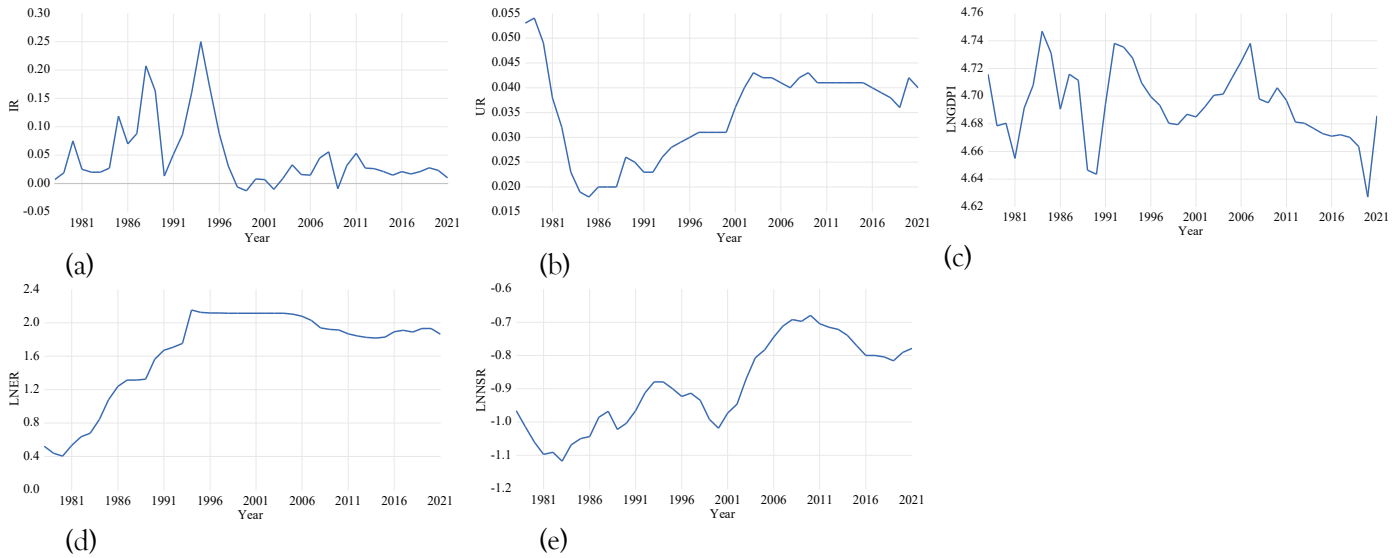

Figure 1. Time Series of $IR_{(a)}$, $UR_{(b)}$, $LNGDPI_{(c)}$, $LNER_{(d)}$, $LNNSR_{(e)}$ from 1978 to 2021

The time series graph of each variable from 1978 to 2021 are shown in Figure 1(a),(b),(c),(d),(e). Due to the large fluctuation of some data, in order to reduce heteroscedasticity and bias, the experiment originally planned to take logarithms of all variables. However, due to the negative value of IR, logarithmic processing cannot be carried out, and the research pays more attention to the direct impact of UR on IR changes. Therefore, raw values of IR and UR are used, and logarithms of the remaining variables (ER, GDPI, NSR) are denoted as LNER, LNGDPI and LNNSR to analyze their influence on the relative change of IR.

Testing the data's stationarity is an essential step in time series analysis. Non-stationary data may lead to spurious regression phenomena in regression analysis, thereby producing false statistical significance was studied by [23]. To avoid it, scholars usually use unit root tests to detect the stationarity of the data. One of the most commonly used unit root tests is the Augmented Dickey-Fuller (ADF) test, which was proposed by [24]. ADF test is applied to assess the stationarity of the variables. If the data pass the stationarity test, the variables are directly used to construct the model.

However, if the variables unable to pass the ADF test, differencing data is performed to achieve the stationarity of variables. If all variables are verified to be first-difference stationary, to determine if these variables have a stable, long-term linear relationship, the Johansen cointegration test proposed by [25] is employed. In the Johansen cointegration test, the trace test assesses the overall significance of multiple potential cointegration relationships, while the maximum eigenvalue test focuses on the strongest individual cointegration relationship at each step. If cointegration is identified, the original data can be used for model construction, and avoiding the problem of spurious regression. Otherwise, the differenced data will be constructed model.

In this study, a linear regression model was used to test the applicability of the classical Phillips Curve. The classical Phillips curve describes the negative correlation between the Inflation Rate and the Unemployment Rate, expressed as:

$$IR_t = \beta_0 + \beta_1 UR_t + \varepsilon_t \quad (3)$$

where, IR_t is the inflation rate, and UR_t is the actual unemployment rate, β_0 is the intercept term, β_1 is the regression

coefficient of the UR, which should theoretically be negative, ε_t is the random shock term.

ADL model is an econometric model for analyzing the dynamic relationships between time series variables, which was first proposed and applied by [26]. The model can consider the influence of the lag term of the dependent variable and the current value and the lag value of multiple explanatory variables on the current dependent variable. In the NKPC theory mentioned above, compared with the classical Phillips curve theory, NKPC needs to consider the influence of inflation expectation term when selecting the model, while Adaptive inflation expectation is predicted by the past value of inflation rate, which is exactly consistent with the dependent variable lag term of ADL model. This is also the reason why most researchers like to use ADL model to implement NKPC.

The ADL (*p, q*) model in general form can be expressed as:

$$Y_t = \alpha + \sum_{i=1}^{p} \beta_i Y_{t-i} + \sum_{j=0}^{q} \gamma_j X_{t-j} + \varepsilon_t \quad (4)$$

where, Y_t is dependent variable, X_t is explanatory variable, Y_{t-i} is lag term of dependent variable, and p is the maximum lag order of the dependent variable, q is the maximum lag order of the explanatory variable, β_i and γ_j are the coefficients of the dependent and explanatory variables, respectively.

In this study, only the influence of the current value of the explanatory variable will be considered, that is, q=0. The best lag order p of the dependent variable (IR) will be determined by the Akaike information criterion (AIC) value of the model. A reasonable order of ADL model was established by observing AC and PAC charts of IR data, and then the model with the lowest AIC value was selected as the final ADL model of the experiment:

$$IR_t = C + \sum_{i=1}^{p} \beta_i IR_{t-i} + \gamma_0 UR_t + \gamma_1 LNGDPI_t + \gamma_2 LNER_t + \gamma_3 LNNSR_t + \varepsilon_t \quad (5)$$

where, IR_t is the inflation rate at time t, UR_t is UR at time t, $LNGDPI_t$ is the logarithmic transformed GDPI at time t, $LNER_t$ is the logarithmic transformed USD ER at time t, $LNNSR_t$ is the logarithmic transformed NSR at time t, IR_{t-i} is the i^{th}-order lag term for IR, β_i and γ_j are the coefficients. ε_t is the random shock term. This study will evaluate whether it conforms to the expectations of economic theory through the signs and significance levels of the regression coefficients of each variable. And compare the overall goodness of fit of the model (R^2 and adjusted R^2) to judge the advantages and disadvantages of the classical Phillips curve and NKPC.

results

Before building a linear model to implement the classical Phillips curve and build an ADL model to implement NKPC, the stationarity and avoid spurious regression need to be verified by using ADF test and Johansen cointegration test. ADF test which was performed on IR, UR, LNGDPI, LNER and LNNSR variables are shown in Table 1:

Table 1. Augmented Dickey-Fuller Test

	With no intercept and no trend		With intercept		With trend and intercept	
Variables	**Level I (0)**	**First Difference I (1)**	**Level I (0)**	**First Difference I (1)**	**Level I (0)**	**First Difference I (1)**
IR	-1.0460	-5.4515***	-1.5172	-5.3751***	-3.7924**	-5.3608***
UR	-1.0924	-3.6970***	-1.9895	-3.6857***	-3.3524*	-3.9271**
LNGDPI	-0.2055	-5.7566***	-3.8575***	-5.6702***	-4.1470**	-5.5866***
LNER	1.2610	-4.2340***	-2.6335*	-4.5952***	-0.7718	-5.7107***
LNNSR	-1.0204	-3.9325***	-1.4915	-3.9868***	-2.5979	-3.9286**

* indicates significance at the 10% level. ** indicates significance at the 5% level. *** indicates significance at the 1% level.

This shows that to build a model, the research needs to carry out first-order difference on the data to avoid spurious regression, but this will destroy the original relationship between the data, which is not conducive to the subsequent analysis. Therefore, the research decides to examine the variables using the Johansen cointegration test, provided that the first-order difference of each variable is stable. The Johansen cointegration test results are evaluated using two criteria: Trace statistics and Max-eigenvalue statistics. The following is the detailed analysis of the test results.

Table 2. Unrestricted Cointegration Rank Test (Trace)

Hypothesized Number of Cointegrating Equation(s)	Trace Statistic	0.05 Critical Value	Prob. Critical Value
None**	98.5465	69.8189	0.0001
At most 1	47.2014	47.8561	0.0575
At most 2	27.9380	29.7971	0.0807

** denotes rejection of the hypothesis at the 5% level.

Table 3. Unrestricted Cointegration Rank Test (Max-eigenvalue)

Hypothesized Number of Cointegrating Equation(s)	Max-eigen Statistic	0.05 Critical Value	Prob. Critical Value
None**	51.3451	33.8769	0.0002
At most 1	19.2634	27.5843	0.3944
At most 2	15.2357	21.1316	0.2727

** denotes rejection of the hypothesis at the 5% level.

The Johansen cointegration test results in Table 2 and Table 3 both show that there is a cointegration relationship between variables in the system at the 5% significance level, indicating that although the variables themselves may be non-stationary, their linear combinations are stable, with long-term equilibrium relations and stable residuals, and there is no spurious regression problem in the model, so the original data can be used for regression analysis. This research will first focus on building a linear regression model to achieve the classical Phillips curve.

$$IR_t = 0.158 - 3.139UR_t + \varepsilon_t \quad (6)$$

where IR_t is the inflation rate at time t, and UR_t is the actual unemployment rate at time t, ε_t is the random shock term. The plots of classical Phillips curve and linear regression model are shown in Figure 2, It can be intuitively seen that there is a negative correlation between IR and UR, which satisfies the classical Phillips curve theory.

Table 4 shows that UR has a significant negative effect on IR, and the regression coefficient is -3.139, and both the UR and intercept terms pass the significance test of 1%. However, the lower R^2 and adjusted R^2 of the model indicate that although the classical Phillips curve can reflect the negative correlation between IR and UR, its explanatory power is limited and it is difficult to effectively predict IR.

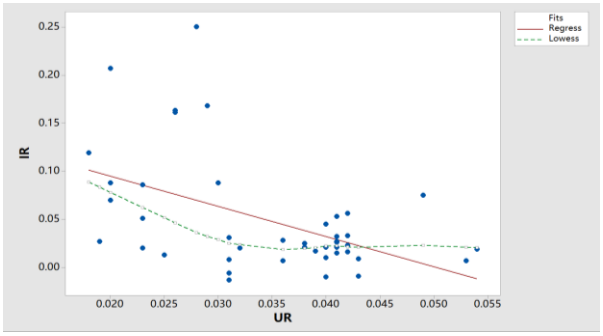

Figure 2. Classical Phillips Curve and Linear Regression Model

Table 4. Estimation Results of The Classical Phillips Curve

Variable	Coefficient	Standard Error	t-Statistic	P-value
Intercept	0.158***	0.0311	5.07	0.000
UR	-3.139***	0.865	-3.63	0.001

*** indicates significance at the 1% level.

In order to determine the order of the lag terms of the ADL model, it is necessary to observe the ACF and PACF graphs of IR data first, through which it is known that the IR data is significantly affected by the first five orders. In order to find out the optimal lag order of IR in the ADL model, it can be seen that the AIC value of the ADL model from the first order lag terms to the sixth order lag terms is compared. With the increase of the number of maximum lag terms, AIC value showed a trend of decreasing first and then increasing, and ADL (5,0,0,0,0) has the lowest AIC value (-3.6759),

which indicates that this model is the best among all candidate models, that is, while ensuring a good degree of fit, Over-complication is avoided. Therefore, this study chooses 5 as the maximum number of lag terms for IR in the ADL model, and the results of ADL (5,0,0,0,0) model is as follow:

$$\begin{aligned} IR_t = &-2.410+0.930IR_{t-1}-0.551IR_{t-2}+0.470IR_{t-3}-0.512IR_{t-4}+0.410IR_{t-5} \\ &-1.578UR_t+0.566LNGDPI_t-0.032LNER_t+0.138LNNSR_t+\varepsilon_t \end{aligned} \quad (7)$$

where IR_t is the inflation rate at time t, UR_t is the actual unemployment rate at time t, $LNGDPI_t$ is the logarithmic transformed gross domestic product index at time t, $LNER_t$ is the logarithmic transformed USD ER at time t, $LNNSR_t$ is the logarithmic transformed national savings rate at time t, IR_{t-i} is the i^{th}-order lag term for inflation rate, ε_t is the random shock term. Although NKPC is called a "curve", it is often impossible to draw a true curve in empirical research, mainly because it is a dynamic time series relationship in nature. Rather than a simple static function.

Table 5. Estimation Results of the NKPC

Variable	Coefficient	Standard Error	t-Statistic	P-value
Intercept	-2.410**	1.090	-2.22	0.034
UR_t	-1.578*	0.889	-1.77	0.085
$LNGDPI_t$	0.566**	0.224	2.52	0.016
$LNER_t$	-0.032*	0.017	-1.88	0.068
$LNNSR_t$	0.138*	0.077	1.79	0.082
IR_{t-1}	0.930***	0.136	6.86	0.000
IR_{t-2}	-0.551***	0.176	-3.13	0.004
IR_{t-3}	0.470**	0.185	2.54	0.016
IR_{t-4}	-0.512***	0.176	-2.91	0.006
IR_{t-5}	0.410***	0.148	2.78	0.009

* indicates significance at the 10% level. ** indicates significance at the 5% level. *** indicates significance at the 1% level.

Table 5 shows the overall significance of the model is strong, and most variables pass the 5% or 10% T-test. There is a significant negative correlation between UR and IR, and both LNGDPI and LNNSR have a positive and significant impact on IR. Although LNER deviates from the traditional theory, it also shows a marginal effect on restraining inflation. In addition, the lag term of IR is generally significant, indicating that inflation has obvious viscous and autoregressive characteristics, verifying the ability of NKPC model to explain short-term dynamic adjustment.

In ADL model, the value of R^2 is 0.7281, meaning that the model can explain 72.81% of the change in IR. In actual research, when the value of R^2 is greater than 0.6, the model is considered to have good explanatory ability. To address potential overfitting from excessive independent variables, the adjusted R^2, which penalizes the inclusion of unnecessary variables, is considered. For this model, the adjusted R^2 is 0.6562, showing the model still explains 65.62% of IR changes while accounting for variable complexity. Although adjusted R^2 is lower than R^2, both indicate strong model fit.

DISCUSSION

Through empirical analysis, regression model and time series analysis, this study deeply discusses the relationship between IR and UR with China's data:

To analyze the correlation between the IR and the UR in China, this study verifies the significant negative correlation between the IR and the UR based on the results of the classical Phillips curve linear regression model. This result is in line with the classical Phillips curve theory, which states that decreasing IR results from increased UR, and rising IR leads to falling UR. The strength of this relationship is different in different social contexts, and this dynamic relationship also reflects the development of China's economic structure.

To verify the applicability of classical Phillips curve in China, this study analyzed the results of the linear regression model, and both the intercept term and the estimated coefficient of UR passed the *t*-test at the significance level of 1%, indicating that the classical Phillips curve has certain applicability in China. In a follow-up experiment, it is found that the lag term of the IR is also significant in the model, further reflecting the viscous characteristics of inflation, which is in line with the theoretical framework of the NKPC. Overall, the empirical results support the applicability of Phillips curve in China.

In terms of evaluating other economic factors affecting the relationship between IR and UR, this study introduced other

important economic variables, such as LNGDPI, LNER and LNNSR, and found through the analysis of the ADL model results of the NKPC. LNGDPI: The coefficient is significantly positive, indicating that economic growth has an impact that drives inflation, reflecting the existence of demand-led inflation. LNER: The coefficient is negative, although the significance is weak, indicating that the RMB/USD ER change has a small impact on imported inflation, but it may indirectly affect the price level by affecting the export level. LNNSR: The coefficient is positive, indicating that the increase in the NSR is positively correlated with the IR, which may push up the price level through the investment channel. These results reveal that the connection between inflation and unemployment is not a single linear mechanism, but is influenced by multiple economic factors.

CONCLUSION:

Considering the research findings above, this study makes the following recommendations for China's economic policy. Balancing unemployment and inflation targets should combine the applicability of Phillips curve when adjusting UR and IR. To achieve the policy goal of controlling inflation level and reducing UR, we should not only pay attention to the changes in economic transition but also pay attention to the impact of social background on the economy. Paying attention to the coordination effect of economic growth and inflation, by reasonable fiscal policy, ensure the moderation of inflation in stimulating economic growth, at the same time prevent because the economy is overheating and inflation risk. Considering that the ER influences China's inflation more indirectly, maintaining a sound ER remains the key to controlling inflation. The structure of savings should be optimized. High NSR may cause inflationary pressure while promoting investment. Policy formulation should focus on promoting the transformation of savings at all levels into effective investment and stimulating consumer demand.

Future studies can select data over a longer time range or introduce more frequent data (such as quarterly or monthly data) to improve the accuracy of model estimates. It is necessary to consider that frequent changes in monthly data may introduce more potential impact shocks, making the model more meaningful. Future researchers could further consider other factors that influence inflation, such as energy prices, international trade shocks, and labor productivity. At the same time, the correlation between the IR and UR in China can be compared with other countries, which can be divided into two camps: socialist countries and capitalist countries. Comparisons in specific socioeconomic contexts can enhance the different explanatory capabilities of Phillips curve under different economic systems, thus providing broader empirical support for global economic policies.

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