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Research and Enlightenment of Purchasing Power Parity Test

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Abstract: Purchasing Power Parity (PPP) is the cornerstone of many theoretical models in international finance. The PPP test is of great importance to market participants, central banks and policy makers. This paper reviews the relevant literature on the validity test of PPP in recent years: involving micro and macro directions, which are embodied in four aspects: empirical, model, exchange rate and evaluation. Although the research and application of PPP test have made great progress, there are still some problems and challenges. With the continuous development of the global economy and the improvement of data availability, the future research on PPP test will be more in-depth and comprehensive.

Keywords: Purchasing Power Parity; test; validity

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1. Introduction

Purchasing Power Parity (PPP) is an important theory in international finance. The main idea of this theory is that the price of the same commodity in two countries should be equal under the condition of no transportation costs, tariffs, or other trade barriers.

In recent years, with the acceleration of globalization and the continuous development of international trade, international economic integration has become an important trend in the economic development of various countries. In this context, the study of PPP theory can better understand the impact of international trade and investment on exchange rates, as well as the impact of exchange rate changes on international economic integration. The PPP test is of great significance for understanding the exchange rate determination mechanism and predicting exchange rate fluctuation. Through the study of PPP, we can understand the changing trend of currency value and exchange rate, and provide an important decision basis for monetary policy making. Through the analysis and prediction of exchange rate changes, we can find and deal with the possible currency crisis or financial crisis in time, and reduce the probability and impact of financial risks. In addition, studying the relationship between monetary policy and exchange rate, can provide a more scientific and reliable decision-making basis for monetary policy formulation, thus promoting the stability and development of the international financial market.

Over the past several decades, economic statistical research has paid escalating attention to testing the validity of PPP. This is because the verification of PPP's validity holds considerable significance for market participants, central banks, and policymakers. As China's market economy and exchange rate formation mechanism have been refined and the degree of opening up has been intensified, the function of PPP in China has become increasingly conspicuous, and the research on the validity of PPP has received growing emphasis.

2. Literature Review and Theoretical Basis

2.1. PPP Test Methods

Through reviewing the literature, it can be seen that the evolution of PPP validity testing methods is almost synchronized with the improvement of unit root testing methods. When new unit root testing methods appear, PPP validity testing methods will also be improved on the original basis.

2.1.1. Time Series Linear Unit Root Test the Validity of PPP

At first, the time series set by the simplest form of non-parametric linear unit root test was a first-order autoregressive process with white noise. However, due to the more complex actual situation, this assumption could not be held all the time. Therefore, Said and Dickey introduced the lag term of the test variable based on the DF test [1]. It can be approximately guaranteed that the error term is an independent uniformly distributed process, so the DF test has evolved into the ADF test. However, in the case of heteroscedasticity, the application effect of the ADF test is not good, so Phillips carried out non-parametric modification of DF statistic and proposed a new test method for detecting the presence of unit root in general time series model —— PP test [2].

2.1.2. Testing PPP Validity Under Nonlinear Problems

Some studies have shown that the time series data of the real exchange rate is nonlinear. If only the linear unit root is used to test the validity of PPP, the conclusion may be misleading. In addition, if the exchange rate has a nonlinear stationary process, the traditional linear unit root test cannot find the mean reversion of the exchange rate. Therefore, Kwiatkowski et al. and Kapetanios et al. proposed unit root tests —— KPSS tests and KSS tests that can solve nonlinear problems [3, 4].

2.1.3. Panel Data Non-Parametric Unit Root Test the Validity of PPP

Since the traditional unit root test initially used time series data instead of panel data, the null hypothesis of unit root could not be rejected due to low statistical power, so the research focus turned to panel data research, which is more likely to find support for PPP using panel data than using time series data. Breuer et al. and Wu and Lee proposed the SURADF test and SURKSS test, which can solve the panel cross-section dependence problem in the PPP test [5, 6].

2.1.4. PPP Validity Test Considering Structural Mutation Problem

However, the above standard unit root test did not consider the structural mutation problem that may exist in the data generation process of the real exchange rate. To overcome this problem, Enders et al. and Becker et al. proposed the use of the FADF test and FKPSS test [7, 8]. Because the Fourier unit root test is used, the nonlinear characteristics and structural abrupt changes of the real exchange rate data are considered.

2.2. PPP Theory

The theory of PPP is a significant concept in the field of international economics that examines currency exchange rates. According to this theory, the exchange rate between two countries' currencies is determined by the ratio of their respective price levels. When there is a decrease in the domestic purchasing power of a currency, indicated by an increase in the domestic price level, it results in an equivalent depreciation of the currency in foreign exchange markets. Conversely, an increase in purchasing power leads to a corresponding appreciation of the currency.

The law of one price serves as the foundational principle in the development of PPP. It posits that, within a free competitive market devoid of transportation costs and official

trade barriers like tariffs, identical goods should be priced equivalently in the same currency across different countries.

However, due to the psychological factors of buyers and sellers, time differences, information asymmetry ,and the Barca effect, the law of one price only reflects the price and exchange rate of certain trade goods, so Cassel proposed to replace commodity prices with price levels. absolute PPP states that the ratio of the purchasing power of two countries is the exchange rate of the two countries. Purchasing power is determined by the goods and services that money can buy. The premise of this theory includes: in an idealized foreign trade market, any identical commodity sold in any country and eventually purchased with the same currency, the amount of money needed to pay is the same. In addition to this, a new assumption has been developed to give equal weight to various tradable goods in the price indices of both countries.

The theory of absolute PPP encompasses a static mechanism. Based on this premise, the dynamic relationship between price fluctuations and exchange rate movements in both countries gives rise to the theory of relative PPP. Relative PPP posits that the percentage change in the exchange rate between two currencies over any given period will be equal to the percentage difference in the change in domestic price levels between these two countries during that same period. Relative PPP reflects the correlation between changes in price levels and exchange rates, while maintaining constant domestic and foreign purchasing power for each currency.

3. Research Status of PPP Test

According to the statistical analysis conducted by Alsmadi, et al. [9], a total of 1003 authors have published articles on Public-Private Partnerships (PPP) between 1935 and 2021. Among these papers, the most frequently cited works were Rogoff's study in 1996 and Pedroni's research in 2001. Notably, the United States has been at the forefront of testing PPP validity with a significant contribution of 248 articles.

3.1. Demonstration and Application

3.1.1. Empirical Analysis of PPP Test

This includes conducting empirical analysis and testing of PPP using various data and models to determine whether it holds.

Bošnjak et al. tested Croatia's PPP theory through unit-roots of different norms and quantile autoregressive methods [10]. The results do not support the validity of Croatia's PPP theory. Given that no empirical PPP studies have been conducted in GIIPS countries (Greece, Italy, Ireland, Portugal, and Spain). Nazlioglu et al. pioneered the use of unit-root methods different from structural breakthroughs and nonlinearities for PPP testing [11]. Research shows that PPP works in GIIPS countries. It is important to consider structural breakthroughs and nonlinearities in the real exchange rate.

3.1.2. Application of PPP in Practice

This includes exploring the application of PPP in exchange rate policy-making, international trade, international investment, etc., to understand its real value and role.

The PPP of BRICS countries (Brazil, Russia, India, China, and South Africa) was examined by Gövdeli et al. using a Fourier perspective-based time series analysis [12]. The findings of the study unveil the presence of a co-integration relationship among the BRICS nations.

Kuncoro et al. used an autoregressive distributed lag model to verify the validity of the PPP assumptions for Indonesia and the Philippines from 2005 to 2021 [13]. The study found strong long-term PPP relationships, but not significant short-term PPP relationships. At the same time, it is found that the relative price has more impact on the appreciation of the Indonesian exchange rate than the depreciation. In the Philippines, the relative

PPP held for both currency depreciation and appreciation, while the impact of central bank intervention was not statistically significant.

The prospects for monetary union in the East African Community were assessed by Caporale et al. through an examination of generalised PPP (G-PPP) and business cycle synchronicity [14]. This study employed univariate fractional integration analysis, fractional bivariate cointegration test, and fractional cointegration vector autoregression (FCVAR) methods. The findings provide support for the existence of broad PPP and indicate that a monetary union is feasible.

3.1.3. The Relationship Between PPP and Other Economic Indicators

This includes exploring the relationship between PPP and other economic indicators such as inflation rate, interest rate, etc., to understand their mutual influence and role.

The study conducted by Pour et al. constructs a model to analyze the deviation from equilibrium between exchange rates and PPP [15]. This model is empirically tested using annual panel data encompassing 34 countries with floating exchange rate regimes from 2000 to 2020. The findings reveal that stronger national currencies relative to the euro are associated with higher per capita GDP, interest rates, investment freedom, urbanization rates, and terms of trade; as well as lower inflation.

Dudzich used the panel regression tool to analyze the reasons why the nominal exchange rate deviates from the absolute PPP in transition economies [16]. Parity exchange rates based on tradable commodity prices only were calculated for 20 transition economies.

3.2. Model Selection and Comparison

This includes exploring the application and comparison of different models such as time series models, panel data models, etc. in PPP tests to determine the most suitable model.

The majority of early PPP research focused on utilizing standard cointegration methods, assuming the presence of a unit root in the observed series. However, this assumption may not always hold, particularly for series with short-term dynamics. In 2023, Olaniran and Ismail developed a fractional cointegration panel method to test absolute PPP models, which is considered one of the most effective approaches for comparing the values of two or more currencies [17].

Uğur and Alper analyzed the PPP hypothesis for 38 OECD member countries from January 1994 to September 2021 [18]. This study is among the first to incorporate structural change and nonlinearity into the unit-root testing framework while covering all OECD nations. The traditional unit root tests such as ADF, KPSS, and Fourier KPSS were employed in this research; however, their findings contradict the validity of the PPP hypothesis. Omay and Ucar studied the validity of PPP in 34 countries [19]. They propose a new unit root test method for heterogeneous panels dependent on cross-section.

3.3. Exchange Rate and Policy

Formulation and implementation of exchange rate policy. This includes exploring how to formulate and implement effective exchange rate policies to maintain economic stability and development.

Peru, as a small and open economy heavily reliant on trade with its partners, is susceptible to external influences that can impact its exchange rate, such as the 2008 financial crisis and the 2006 interest rate shock. Laurente Blanco et al. examined the validity of PPP between Peru and the United States from 2000 to 2019 by comparing absolute PPP and relative PPP functional equations [20]. The findings indicate that the PPP hypothesis does not hold.

Liu et al. employed the panel KSS unit root test, Fourier function, and sequential panel selection method (SPSM) to examine the PPP between China and Belt and Road

(B&R) countries [21]. The findings indicate that PPP can determine the equilibrium exchange rate, while arbitrage does not yield abnormal gains from Commodity Exchange in most OBOR countries.

3.4. Comparison and Evaluation

3.4.1. Comparison of PPP in Different Countries or Regions

This includes comparing PPP levels in different countries or regions to understand their differences and why.

The theory of PPP was assessed in various integration organizations, including the North American Free Trade Agreement (NAFTA), the South American Common Market (MERCOSUR), the European Union 15 (EU15), and selected member states of the Organization for Economic Cooperation and Development (OECD) from 1960 to 2019, utilizing fractional unit root analysis and Fourier function [22]. This study employed both fractional frequency Fourier ADF and traditional ADF tests. The findings validate the validity of PPP theory within integration organizations, except MERCOSUR.

The purchasing power parities of 28 OECD countries from 1960 to 2021 were examined by Boundi-Chraki et al. [23]. They employed three methodologies: the traditional time series unit root test, panel unit root test, and nonlinear unit root test based on OLS and GLS detrending. The findings indicate that even when considering the nonlinear adjustment, the PPP hypothesis is not supported.

The study conducted by Doğanlar et al. employed a conventional nonlinear Fourier quantile unit root test to examine the long-term validity of PPP across three categories of market economies: developed markets, emerging markets, and frontier markets [24]. The analysis encompassed 45 countries comprising 10 developed nations, 20 developing nations, and 15 frontier market economies. The findings indicate that PPP holds in eight developed countries, eleven emerging countries, and seven frontier market economies.

3.4.2. Comparison and Evaluation of Different Exchange Rate Systems

This includes comparing and evaluating the advantages and disadvantages of different exchange rate regimes and their application effects to determine the most appropriate exchange rate regime.

Erdoğmuş investigated the establishment of absolute PPP between the Turkish lira and the British pound from March 2001 to November 2020, utilizing both traditional unit root tests that do not account for structural breaks and those that do [25]. The findings indicate a lack of support for absolute PPP between the two currencies.

Ali et al. used ESTAR and LSTAR models to study the long-term purchasing power parities of Pakistan's three main trading partners [26]. The results show that these sequences follow nonlinear exchange rates. Long-term PPP between Pakistan and China was established. So trade would be more profitable if exchange rates moved about major trading partners, not just the dollar.

3.4.3. Comparison and Evaluation of PPP in Different Periods

This involves comparing and assessing the level and performance of PPP over different periods to understand its changes and trends.

To ascertain the long-term stability of the real exchange rate across various periods, Vo et al. employed unit root testing and wavelet transform techniques to examine the persistence of PPP over different time spans [27]. The study utilizes monthly data on the Consumer Price Index (CPI) and nominal exchange rates for six ASEAN countries spanning from 1998 to 2019. The findings indicate that employing wavelet analysis to detrend can serve as a reliable predictor of future changes in the real exchange rate, while short-term fluctuations in the exchange rate may be attributed to arbitrage activities.

In general, research on PPP tests involves micro and macro directions, which are embodied in four aspects: empirical, model, exchange rate, and evaluation. These studies

contribute to a deeper understanding of the validity and applicability of the PPP theory, and provide valuable references for policy making.

4. Problems in PPP Test

Although PPP theory has important theoretical significance and application value, there are still many challenges in practice. Future research needs to address issues such as data quality and sample size, as well as consider other factors that influence exchange rate fluctuations. In addition, it is necessary to further explore the theoretical basis and empirical testing methods of PPP.

4.1. Data Quality

Data is the basis of PPP research. In the actual research, there are still some problems in the quality and reliability of data. For example, price data can be biased because there may be differences in how different countries collect and report price data. In addition, there may be problems with time lag and incomplete data. In the process of testing the validity of PPP, most of the data used are the real exchange rate adjusted by the consumer price index (CPI), but the existing CPI is not perfect. There is room for improvement in CPI data collection methods, CPI calculation methods, CPI weight setting methods, CPI seasonal adjustment methods, CPI quality change adjustment methods, and CPI data release.

4.2. In the Selection of Relevant Price Indices

In the process of the PPP validity test, the choice of price index will also affect the result. The most commonly used PPP validity test is the CPI, but research shows that the PPI is also valid [28]. Therefore, in the subsequent empirical research, we can choose to use the production price index as a new Angle to study. At the same time, the research results of the two price indexes can also be compared and analyzed.

4.3. Multi-Factor Influence

Some studies suggest that PPP may not hold in reality, as exchange rate fluctuations can be influenced by many factors, including structural changes in the economy, policy interventions, and imperfect competition in the market. In addition, sample size and processing complexity in empirical research also need to be considered. For example, the calculation of PPP can be affected by price distortions and incomplete information.

5. Conclusion and Enlightenment

With the continuous development of the global economy and the improvement of data availability, future research on PPP tests will be more in-depth and comprehensive. Based on the above research status, the following suggestions are put forward:

5.1. Theoretical Model Research

Research on PPP test in China first needs to deeply explore and improve the theoretical model. This includes a more detailed analysis of the assumptions of PPP theory, examining their applicability and limitations in real economic circumstances. At the same time, it is necessary to explore and develop more complex and realistic theoretical models of exchange rate determination to explain and predict exchange rate changes more accurately.

5.2. Policy Application and Effect Evaluation

Policy application and effect evaluation are the practical application values of PPP research. Chinese scholars need to pay attention to the application of monetary policy and exchange rate policy in practice, and evaluate its effect and impact. At the same time, it is

necessary to study how to use the theory of PPP to guide policy formulation and practice, to provide a scientific basis for improving the internal and external balance of Chinese economy.

5.3. International Comparison and Reference

International comparison and reference is an important way to improve the research level of PPP in China. Chinese scholars need to pay attention to the latest progress and dynamics of the international research on PPP, and learn from its successful experience and practices. At the same time, it is necessary to strengthen exchanges and cooperation with international scholars to jointly promote the in-depth development of PPP research.

5.4. Interdisciplinary Research

Interdisciplinary research is one of the trends of current academic research. Chinese scholars should pay attention to the application of interdisciplinary research in PPP, and try to introduce theories and methods from other disciplines into PPP research. This includes the cross-integration with statistics, mathematics, economics, finance, and other related disciplines to expand the field and vision of PPP research. Through interdisciplinary research, it can promote the innovation and development of PPP theory, and provide more ideas and methods for solving practical economic problems.

Although there are still some problems and challenges in the current research and application of PPP, with the improvement of data quality and model methods, as well as the deepening of globalization and the continuous development of international trade, the application scope and accuracy of PPP will be further improved, and its research prospects are very broad. For developing countries such as China, studying the applicability and practical significance of the PPP theory, as well as how to use this theory to guide the reform of the exchange rate system and monetary policy will also become one of the key directions of future research.

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