EXCHANGE RATES AND PURCHASING POWER PARITY: A Comparative Study of CIS Region Countries and Major Global Economies with a Focus on Kazakhstan

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THESIS

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Table of contents

Introduction

The relationship between exchange rates and Purchasing Power Parity (PPP) is one of the important factors to consider in international economics since it can influence trade relationships, economic policies, and global financial stability. On the other hand, PPP, a foundational theory of economics, states that in the long run, the ratio of two currencies' price levels should be reflected in the exchange rate between them (Arize et al., 2015b).

Changes in exchange rates may have a considerable effect on the economic health of a country since they can influence the competitiveness of exports, inflation, and capital flows. Consequently, it is of the utmost importance for governments, businesses, and investors to understand the behavior and determinants of exchange rates, as it has a direct impact on the cost of imports and exports (Brillembourg, 1977).

Purchasing Power Parity takes into account the relative price levels of several currencies to equalize their purchasing power. Essentially, PPP theory says that to promote equilibrium in international commerce, exchange rates should gradually alter to reflect variations in inflation rates among nations (Rogoff, 1996). Therefore, PPP is an essential metric for determining whether a currency is overvalued or undervalued, which helps with trade negotiations and economic planning

(Brillembourg, 1977). Exchange rates and PPP are especially important in the Commonwealth of Independent States (CIS), a territory comprising former Soviet republics. Since these countries have historical, cultural, and economic interactions, their financial relationships and monetary policies are intrinsically connected. Kazakhstan, as one of the CIS's largest and most active economies, is a significant focus in this regional framework.

The economic interdependence of the CIS countries is complicated, with trade, investment, and policy linkages influencing exchange rates and adherence to PPP. Factors such as similar pasts, different rates of economic growth, and distinct geopolitical circumstances all contribute to the complexities of exchange rate movements and CIS commitment to PPP.

This study aims to look into Kazakhstan's specific bilateral relationships with CIS and developed countries regarding exchange rates and PPP. This research seeks to make clear the determinants, patterns, and deviations in these economic metrics by examining exchange rate behavior and adherence to PPP principles within this regional context, essentially gaining a deeper understanding of the economic landscape.

The purpose of this research is to present a detailed examination of exchange rates and PPP, with an emphasis on Kazakhstan's interactions with other CIS nations

and major economies, to uncover the complexity and nuances of economic relationships between them and Kazakhstan.

1. Review of the Literature

1.1. PPP and LOP

Purchasing Power Parity (PPP) is a concept in economics and exchange rate regime that proposes that exchange rates between a pair of currencies are supposed to, in the long run, equalize the relative prices of a basket of goods and services in the two nations (identical goods should have an equivalent price when expressed in a common currency). Therefore, the exchange rate shall be adjusted so that the same amount of money in both nations may buy the same quantity of goods and services. There are two types of PPP: absolute and relative.

The notion of absolute purchasing power parity (APPP) posits that the exchange rate between two currencies should match the ratio of the prices of a basket of comparable products and services in the two countries. In a nutshell, the same value of money in both countries should buy the same quantity of products ◆◆◆◆◆◆* and services. If ◆◆ represents the domestic currency price level and represents the matching foreign price level, then ◆◆ represents the nominal exchange rate ◆◆ (domestic price of foreign currency), absolute PPP is calculated as follows (Taylor, 2003):

$$\text{□□}_{\text{□□}} = \text{□□}_{\text{□□}}{}^{*}/\text{□□}_{\text{□□}}$$

When changes in the purchasing parity between the two countries are equalized, relative PPP holds since the exchange rate has been modified to reflect the relative change in price levels. This means that the same amount of money in both nations may buy the same number of products and services, even if the prices of individual commodities and services have varied over time. It is possible to write it as follows (Taylor, 2003):

$$\Delta\text{□□}_{\text{□□}} = \frac{\text{□□}_{\text{□□}-1}+\Delta\text{□□}_{\text{□□}}{}^{*}}{\text{□□}_{\text{□□}-1}}{}^{*}$$

$$\text{□□}\text{□□}_{\text{□□}} - \text{□□}_{\text{□□}-1}\Delta\text{□□}_{\text{□□}}\text{□□}_{\text{□□}} - \text{□□}_{\text{□□}-1}\Delta\text{□□}_{\text{□□}}{}^{*}\text{□□}_{\text{□□}}{}^{*} - \text{□□}_{\text{□□}-1}{}^{*}$$

where $\Delta\text{□□} =$, $=$, and $=$.

Nevertheless, we will be interested in absolute purchasing power parity. The Law of One Price is a fundamental economic theory that states that similar items ought to sell for the same price when stated in a common currency, after transportation costs and other factors are taken into account. The concept of LOP is strongly tied to the concept of PPP. While PPP is concerned with the overall link between exchange rates and price levels, LOP is concerned with the price of a single identical commodity in different places. According to the LOP (Rogoff, 1996):

$$P_{i} = E \times P_{i}^{*}$$

where P_i is the domestic-currency price for product i, P_i^* is the foreign currency price, and E is the exchange rate, defined as the home-currency price of foreign currency.

Both the LOP and the PPP are founded on the assumption that arbitrage will push prices to equality. Arbitrage is the process of purchasing products in one market and selling them at a greater price in another. If the LOP fails to hold, there is an arbitrage opportunity. Because the LOP and PPP are predicated on the premise that there are no barriers to trade (such as tariffs, transportation costs, or quotas), they do not always hold precisely in practice.

1.2. PPP and Cointegration tests

Arize et al. (2015b), who conducted a study testing the presence of PPP among 116 countries, stated that if PPP remains true, a unit of currency should have the same real worth when purchasing goods and services all over the world. The authors investigate two critical characteristics of PPP. The first is symmetry, which looks into whether deviations from the theory are symmetric across countries. The second concept is proportionality, which investigates whether exchange rate variances are proportional to the degree of departure from PPP.

To evaluate the data and make conclusions regarding the behavior of exchange rates in different nations, the authors used several cointegration tests. If PPP is holding, it can provide insights into the long-term behavior of exchange rates as well as assist investment and financial decision-making. The symmetry criteria were upheld in 56% of the cases, according to the study. Meanwhile, the proportionality criteria received statistical support in 21% of cases. The paper by Kim (1990) "Purchasing Power Parity in the Long Run: A Cointegration Approach" researches the long-term relationship of Purchasing Power Parity (PPP) by analyzing the comovement of exchange rates and relative price levels in several bilateral exchanges. The study employs the cointegration technique proposed by Engle and Granger (1987) to test the existence of a long-run equilibrium relationship between exchange rates and price ratios. The analysis involves five major countries — Canada, France, Italy, Japan, and the United Kingdom — evaluating the Wholesale Price Index (WPI) and the Consumer Price Index (CPI) data over different periods.

The results of the study show that the nominal exchange rate is cointegrated with both the WPI ratio and the CPI ratio across most currencies, except for the Canadian dollar. The hypothesis that the real exchange rate follows a random walk is rejected for the majority of cases, except the Canadian dollar, yen, and pound in

combination with the CPI ratio. Moreover, estimated error correction models demonstrated significant effects of PPP deviations on exchange rates, particularly in cases where cointegration is confirmed.

1.3. PPP Puzzle

The PPP puzzle is an economic observation that real exchange rates have great persistence despite the fact that nominal exchange rates are extremely fluctuating. This means that, even while exchange rates across nations can vary drastically in the short run, the prices of goods and services in various countries tend to move relatively slowly together.

Standard economic theory suggests that real exchange rates should be mean-reverting, meaning that they should tend to return to their long-run state of equilibrium following a shock. The persistence of real exchange rates shows that some pressures are preventing them from mean-reverting. Price stickiness, non-traded goods, and exchange rate overshooting, which can contribute to real exchange rate persistence, are some of the hypotheses evolved for solving the PPP puzzle (Rogoff, 1996).

2. Data

This research investigates the relationship between exchange rates and PPP in the context of CIS countries and major global economies. For this study, we used a

dataset that includes monthly exchange rates and Consumer Price Index (CPI) metrics. The exchange rates were obtained as a foreign currency in terms of Kazakh tenge (KZT). The analysis extends across a number of countries, including Azerbaijan, Armenia, Kazakhstan, Kyrgyzstan, Moldova, Russia, and Ukraine from the CIS region. Additionally, we broadened the scope of the study to include major global economies, such as the USA, UK, and Japan. The analysis covers a period of 28 years, ranging from January 1995 to September 2023. This extensive time frame allows for a comprehensive understanding of the long-term dynamics and fluctuations in exchange rates and price levels within the specified CIS countries.

The required datasets were acquired from reputable platforms and authoritative sources, including the Bloomberg terminal, Refinitiv database, and the official websites of respective Central Banks. The International Monetary Fund (IMF) Bloomberg database is a reputable source for macroeconomic data, which offers comprehensive information on various economic indicators, including the CPI. Refinitiv also provides financial data and is another notable source of economic information, including the CPI and exchange rates.

Due to the unavailability of data on CPI levels and exchange rates of Belarus, Uzbekistan, and Tajikistan for certain periods, these CIS countries were excluded from the analysis. While acknowledging the broader scope of the CIS region, the

analysis focuses on the selected 7 countries from CIS due to data limitations.

3. Methodology

3.1. Checking time series variables for stationarity

It is important to determine the time series properties of the variables prior to conducting cointegration tests to analyze the presence of PPP among foreign countries and Kazakhstan. It is critical to determine whether the data exhibits non-stationary behavior because performing cointegration estimation on stationary data will lead to inconclusive results. The further analysis for the cointegration involves assuming the time series variables to be I(1), performing a cointegrating regression, and testing the residuals from this regressions to be I(0) (Taylor, 1988; Hendry & Jusélius, 2000).

A number of economic time series data shows non-stationary behavior due to the constantly evolving and changing nature of economies (Hendry & Jusélius, 2000). Similarly, the exchange rates and CPI ratios data is expected to exhibit non-stationarity, especially considering that the time frame includes the volatile period that occurred after the collapse of the USSR. Still, the time series variables have to be analyzed by unit root tests to check for the non-stationarity. Consequently, prior to starting our analysis for the presence of PPP, we tested the time series of exchange rates and CPI ratios for the unit root by using established

stationarity tests such as the Augmented Dickey-Fuller (ADF) test, the Phillips-Perron (PP) test, and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests.

The Augmented Dickey-Fuller test and the Phillips-Perron test are two fundamental unit root tests widely used in the field of time series analysis. Their main purpose is to determine the stationarity or nonstationarity of the data by estimating the potential unit root that denotes nonstationarity.

The ADF test is a classic approach that includes regressing a variable on its lagged values while allowing for additional lags to take into account serial correlation. It is a standard way of testing stationarity. Similarly, the Phillips-Perron (PP) test uses regression techniques but uses alternative methods to deal with the problem of serial correlation and heteroscedasticity. According to Kim (1990), the Phillips-Perron test may have an advantage over the ADF tests because it is robust to a wide range of serial correlations and time-dependent heteroscedasticity. It is important to note that these tests may produce slightly different results due to differences in methodologies for adjusting the statistical properties of the data.

Following that, we used the KPSS unit root test to examine the residuals' stationarity qualities. The null hypothesis asserts that the time series under consideration is stationary in the context of the KPSS test, whereas the alternative hypothesis asserts that there is a unit root.

In our time series analysis, employing all three ADF, PP, and KPSS tests serves a fundamental purpose. Although they have similar objectives, their technical nuances, especially in controlling serial correlation and heteroscedasticity, can lead to different results. The use of all three tests allows a more comprehensive assessment of the stationarity or non-stationarity of a time series, increasing the reliability of the unit root test results before conducting cointegration analysis. This approach allows for thorough evaluation and cross-validation, eliminating potential limitations that may occur from relying solely on a single test.

3.2. PPP tests

To analyze the long-run relationship between exchange rate dynamics and PPP theory, we tested the presence of PPP in three different levels of strictness:

3.2.1. Strict model

We tested for cointegration between exchange rates and relative price ratios of Kazakhstan to other countries to identify whether PPP holds or not. The existence of cointegration is often interpreted as the evidence of PPP (Taylor, 1988). However, we should keep in mind that the existence of cointegration does not necessarily mean the existence of PPP. The evidence of PPP would be the cointegrating relationship with the coefficient of 1. This is what we assume in our strict model. We assume that the coefficient of price levels of Kazakhstan (������)$_{��}$

and foreign countries ($\ast$) are equal to 1 but with opposite signs. The model is described as follows:

$$\varepsilon_t = s_t - (p_t - p_t^*) \quad (1)$$

where s_t is the nominal exchange rate (the tenge price of a foreign currency), p_t is the Kazakh CPI, and p_t^* is a foreign CPI. All of these variables are in logarithms. We estimated ε_t as demonstrated in the equation (1), and tested it for unit roots by using Augmented Dickey-Fuller, Phillips-Perron, and Kwiatkowski-Phillips-Schmidt-Shin tests. This form of testing for Purchasing Power Parity was expected to allow for less instances of cointegration between the analyzed countries. Taylor's 2003 study used similar testing procedures to investigate the validity of Purchasing Power Parity (PPP) as a long-term economic phenomenon. The traditional technique to studying PPP involves empirical examination of the real exchange rate, indicated as ε_t , with the expectation that $\varepsilon_t \varepsilon_t$ should ideally remain equally equal to zero under PPP principles. In general, the assumption holds that any variations in the real exchange rate are indicative of

deviations from the PPP-determined equilibrium.

3.2.2. Moderate model

The less strict form of the PPP test involves assuming that coefficients of the

$$\text{﷼﷼﷼﷼﷼﷼}_{\text{﷼﷼}}) \ \text{﷼﷼﷼﷼﷼﷼}_{\text{﷼﷼}}^{*}$$

price levels of Kazakhstan (﷼﷼﷼﷼﷼﷼ and other countries ( ) are equal to each other with opposite signs, but not necessarily equal to 1. In this model, we need to estimate the regression of exchange rates on the relative price ratios first, then save the residuals, and test the residuals for stationarity. As Henry and Jusélius (2000) stated, we can conclude that there is an actual causal link between I(1) series only if the residuals of this regression are stationary. Taylor (1988) also argues that we can state to have found cointegration and, subsequently, the long-run PPP only if we can reject the hypothesis that the cointegrating residuals are I(1). Consequently, if the residuals are stationary, then PPP holds. The estimated regression is in the following form:

$$\text{﷼﷼}_{\text{﷼﷼}} = \alpha + \beta \ \text{﷼﷼﷼﷼}^{\text{﷼﷼}}{}_{\text{﷼﷼}} \qquad \text{﷼﷼﷼﷼﷼﷼ (2)}$$

$$\text{﷼﷼}_{\text{﷼﷼}^{*}} + \varepsilon_{\text{﷼﷼}}$$

where ﷼﷼﷼﷼﷼﷼ is the exchange rate which represents the tenge price of foreign
﷼﷼

currency, and ﷼﷼﷼﷼-is the ratio of Kazakh CPI to a foreign CPI. We expected this
﷼﷼﷼﷼

$$\frac{P}{P^*}$$

PPP test to detect more cointegrating relationships between countries. Arize, Malindretos, and Ghosh (2015) cite Taylor's (1988) analogous equation in their study. This weaker variant of PPP limits the changes of exchange rates and national price levels while acknowledging that variables other than the two prices might influence the PPP connection.

Additionally, it is important to consider that when conducting non-stationarity tests on the residuals of the regression, the critical values of ADF, PP, KPSS tests become invalid. That is why in our moderate model, where we estimate the regression first, we need to adjust critical values for the tests. For the ADF and PP tests, the adjusted critical values are already known; they are the same as the critical values used for the Engle-Granger test. In this case, the new critical values are -3.928, -3.354, and -3.057 at 1%, 5% and 10% significance levels, respectively. However, the critical values for KPSS tests are still not valid, but we cannot calculate adjusted critical values. What we did instead is taking critical values corresponding to the highest significance level, i.e. we took critical values for 10% significance level rather than for 1% significance level because we are aware that now the KPSS test may be slightly biased towards stationarity since we are testing the residuals of the regression, not the time series itself. The fact that we are

using residuals means that our test statistics are lower than it would otherwise be.

3.2.3. Flexible model

The least strict form of testing for PPP involves allowing the coefficient of

$$\text{□□}\text{□□□□□□□}\text{□□}^*$$

price levels (□□□□□□ and) to differ, but to have opposite signs. In this model, we employ a multiple regression with two different coefficients for price levels.

$$\text{□□} = \alpha + \beta_1\text{□□□□□□□}\text{□□} + \beta_2\text{□□□□□□□}\text{□□}^* + \varepsilon_{\text{□□}}$$

□□□□□□ (3)

We run the regression, get the coefficients, save the residuals, and then again apply ADF, PP, and KPSS tests to check for stationarity in these residuals. If they are stationary, then there is a cointegration, and PPP holds for a given foreign country and Kazakhstan.

3.3. Fully Modified Least Squares cointegrating regression

The next step in our analysis was to conduct the Fully Modified Ordinary Least Squares cointegration regression, which was developed by Phillips and Hansen in 1990. When confronted with challenges, such as the nonstationarity or unit root properties inherent in the underlying regressors, this method has been used as an effective alternate approach to produce unbiased estimates of long-run

connections (Arize et al., 2015). This allows us to obtain reliable and unbiased estimates of long-run correlations, even in situations where traditional least squares methods may fail due to the nonstationary nature of the variables. In comparison to OLS, the FMOLS estimator eliminates asymptotic bias and improves efficiency by adjusting for both long-term serial correlation in the error term and endogeneity in the variables (Kheifets & Phillips, 2023). The FMOLS methodology is acknowledged for its empirical accuracy since it allows for the accurate capturing of underlying economic links in nonstationary time series data. This method has been frequently used in economic research, including studies on inflation, exchange rates, and economic growth. With its robustness, FMOLS may allow for a more comprehensive study of long-term relationships in the context of nonstationary data. The model is specified as following:

$$\text{[illegible]} = \alpha + \beta \text{[illegible]} \quad \text{[illegible]} \quad (4)$$

- where [illegible] represents the natural logarithm of the tenge price of a foreign currency;
- [illegible]-represents the natural logarithm of the ratio of Kazakh CPI to a foreign CPI;
- [illegible] is a dummy variable for the Russian crisis, taking the value 1 until 99

the end of 1999 and 0 from 2000 onward;

● ⬚ is a dummy variable for the exchange rate regime shift, taking the 15 value 1 from 2000 to 2015 and 0 otherwise.

This CPI ratio may effectively represent a measure of relative pricing levels between Kazakhstan and the selected reference nations in this context. Subsequently, our regressand consisted of the reference countries' exchange rates for the Kazakhstani Tenge (KZT). We were able to analyze the interaction between changes in relative pricing levels, as captured by the CPI ratio, and the associated changes in exchange rates using this analytical methodology, assuming that there is cointegration between CPIs and exchange rates. This approach helps to understand the significance of the impact of regressor to regressand by p-values and coefficients. Augustine, Malindretos, Ghosh (2015) research acknowledges their methodological approach, citing the fully-modified least squares (FMLS) method pioneered by Phillips and Hansen (1990). This method is highlighted as an alternate model used explicitly in their investigation, and it serves as a significant tool for obtaining unbiased estimates of the long-run connection.

3.4. The Error Correction Model

In choosing our econometric model, we also considered the Error Correction Model (ECM) framework. The ECM methodology is parametric in nature and has

proved its effectiveness in various empirical applications (Phillips & Hansen, 1990). The ECM is a well-established methodology that is especially appropriate for modeling and clarifying the short-term and long-term dynamics among variables, particularly in the setting of cointegration. Our model has been carefully designed to include the following critical components. First one is the dependent variable in our model is the change in exchange rates relative to the KZT. This variable measures short-term swings in exchange rates, indicating month-over-month changes in foreign currency relative to the KZT. As the regressors we took into account change in CPI ratio, two dummy variables indicating the December 1999 and August 2015, two interaction terms with dummy variables and non-linear error-correction term. The ECM formula is written as follows:

$$\begin{aligned}
\Delta\text{[illegible]}_{t} &= \alpha_0 + \alpha_1 \Delta\text{[illegible]}_{t-1} \\
&\quad + \alpha_2 \text{[illegible]}_{99} \Delta\text{[illegible]}_{t-1} \\
&\quad + \alpha_3 \text{[illegible]}_{15} \Delta\text{[illegible]}_{t-1} \\
&\quad + \delta \left(\text{[illegible]}_{t-1} - \beta\text{[illegible]}_{t-1}\right. \\
&\quad \left. + \alpha_{99} \text{[illegible]}_{99} + \alpha_{15} \text{[illegible]}_{15} + \text{[illegible]}_{t}\right) \\
&\quad + \text{[illegible]}_{t-1} \qquad (5)
\end{aligned}$$

Because of insignificance of two interaction terms we excluded them from ECM and developed the following model:

$$\begin{aligned}
\Delta\text{[illegible]}_{t} &= \alpha_0 + \alpha_1 \Delta\text{[illegible]}_{t-1} \\
&\quad + \text{[illegible]}_{t-1} + \delta \left(\text{[illegible]}_{t-1} - \beta\text{[illegible]}_{t-1}\right. \\
&\quad \left. + \alpha_{99} \text{[illegible]}_{99} + \alpha_{15} \text{[illegible]}_{15} + \text{[illegible]}_{t}\right) \\
&\quad + \text{[illegible]}_{t-1}
\end{aligned}$$

Nonlinear error correction models (NECMs) are econometric models that may capture nonlinear correlations between economic variables. NECMs are a subset of linear error correction models (ECMs), which are used to simulate the long-run equilibrium interactions among cointegrated variables (Junttila & Korhonen, 2011).

NECMs have the advantage of being able to record more intricate interactions between variables than ECMs. This is because NECMs allow for nonlinearity in variable adjustment dynamics as well as long-run equilibrium relationships. As a result, NECMs are better suited to modeling real-world economic data, which frequently exhibits nonlinear behavior. NECMs, for example, have been used to demonstrate that exchange rates can exhibit threshold effects, which means that the connection between currency rates and their monetary fundamentals can change depending on the variables' values (Junttila & Korhonen, 2011).

4. Results and Discussion

4.1. Analysis for the CIS region

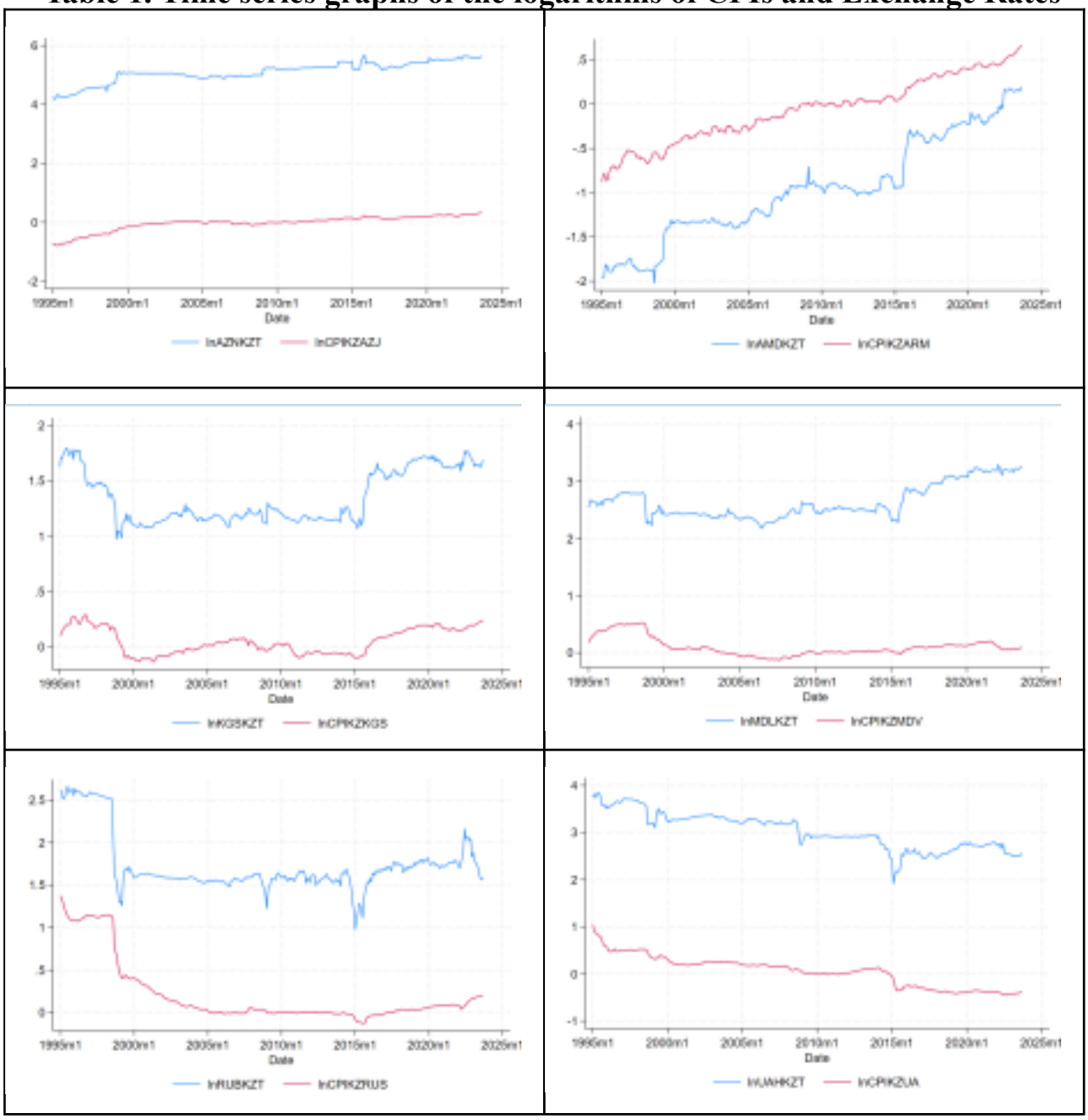
The first part of our analysis is focused on the relationship between exchange rates and relative price ratios in the CIS region.

4.1.1 Stationarity test results

The graphs of the time series variables for exchange rates and relative price

ratios for Azerbaijan, Armenia, Kyrgyzstan, Moldova, Russia, and Ukraine relative to Kazakhstan are illustrated in Table 1.

Table 1. Time series graphs of the logarithms of CPIs and Exchange Rates



The time series variables were tested for stationarity using ADF, PP, and

KPSS tests. The results are presented in Table 2.

Table 2. Testing Logarithmic Exchange Rates and CPI ratios for (non-)stationarity for the period of 1995-2023

Variables	Level First Difference			2nd difference
	ADF	PP	KPSS ADF PP KPSS	KPSS
AZN/KZT	-2.252	-1.979	13.5*** -13.12*** -18.89*** 0.087	
AMD/KZT	-0.263	-0.221	15.9*** -12.34*** -18.68*** 0.0597	
KGS/KZT	-1.378	-1.263	5.38*** -12.22*** -19.97*** 0.352*	
MDL/KZT	-0.683	-0.644	9.07*** -12.77*** -17.31*** 0.174	
RUB/KZT	-2.832*	-2.705*	4.41*** -10.89*** -14.47*** 0.178	
UAH/KZT	-1.927	-1.770	14.9*** -13.02*** -17.41*** 0.0386	
CPIKZ/AZJ	-3.979***	-3.436**	12.6*** -11.15*** -13.78*** 0.743***	0.0237
CPIKZ/ARM	-0.699	-1.048	16.6*** -12.64*** -12.67*** 0.089	
CPIKZ/KGS	-1.178	-0.662	2.87*** -10.78*** -11.69*** 0.383*	
CPIKZ/MDV	-1.556	-0.949	5.13*** -9.275*** -9.827*** 0.302	
CPIKZ/RUS	-3.545***	-4.554***	9.14*** -8.501*** -11.55*** 1.8***	0.00704
CPIKZ/UA	-2.077	-3.793***	15.5*** -9.569*** -10.98*** 0.599**	0.0502

*** p<0.01, ** p<0.05, * p<0.1

It is important to consider that null hypotheses are different for ADF & PP tests and KPSS test: for ADF and PP tests, the null hypothesis is that there is a unit

root, meaning that the series is non-stationary, while for the KPSS test, the null is that the series is stationary. According to the results, exchange rates are all non-stationary. Only RUB/KZT was identified as stationary at a 10% significance level in ADF and PP tests, while the KPSS test showed that it is non-stationary.

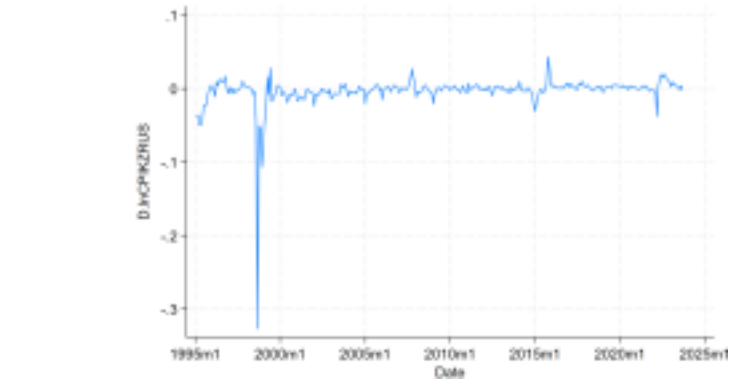
Regarding CPI ratios, there are conflicting results for the ratio of the CPI of Kazakhstan to the CPIs of Azerbaijan and Russia: ADF and PP tests show that these time series variables are stationary at a 5% significance level, while the KPSS test shows non-stationarity at 1% significance level. Additionally, ADF and KPSS tests find the ratio of Kazakhstani CPI on Ukrainian CPIs to be non-stationary, while PP tests show that it is stationary.

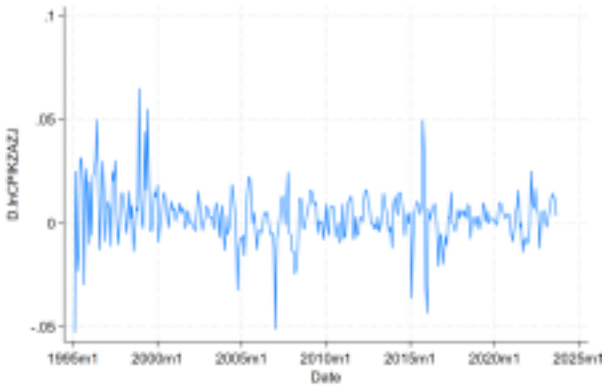
These conflicting results may indicate that unit root tests have some limitations and are not always correct. These tests can be easily affected by the period or number of observations while the bigger picture may be different from the results shown by these tests. There is always the possibility of Type 1 error of rejecting a null hypothesis that is actually true. Therefore, considering that price levels are prone to change constantly, we decided to treat these few variables for which the results of unit root tests were conflicting as non-stationary.

To make sure that the order of differencing is the same among the variables, we conducted ADF, PP, and KPSS tests on the first differences of each of the

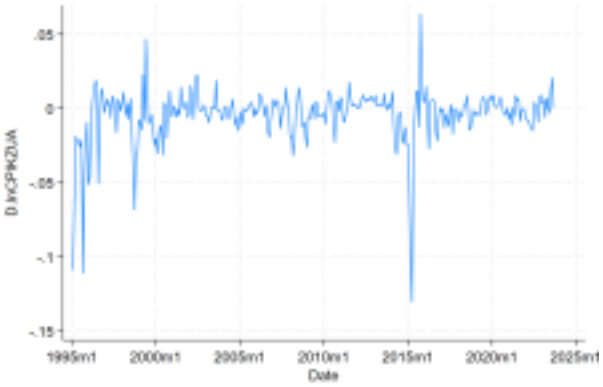
variables. ADF and PP tests show that the first differences of all of the variables are stationary, meaning that they are all integrated of order I(1). However, KPSS results for the difference in relative prices of Kazakhstan to Azerbaijan, Kyrgyzstan, Russia, and Ukraine contrast the results of ADF and PP tests, showing non-stationarity. Nevertheless, since the other two tests showed a highly significant rejection of the null of non-stationarity, we are inclined to conclude that all of the variables are integrated of order I(1). The time series graphs of the first differences of logarithmic CPIs and exchange rates that have contradictory results are demonstrated in Table 3. It can be seen that there are some spikes that are associated with the Russian default crisis in 1998-1998 and exchange rates regime shift in 2015. Table 2 also shows that there are spikes in the time series graphs of the logarithms of CPI ratios and Exchange Rates associated with these events.

Table 3. Time series graphs of the first differences of logarithmic CPIs and Exchange Rates of Azerbaijan, Russia and Ukraine





Azerbaijan **Russia**



Ukraine

Considering the time series graphs of the variables, we decided to test the stationarity of our data taking into account the breakpoints in 1998-1999 and in

2015 in order to address the problem of contradictory results for the stationarity of the variables and their order of integration. To do that, we divided our data into three periods: from 1995 to 2000, from 2000 to 2015, and from 2015 to 2023, and conducted ADF, PP, and KPSS tests on each of the periods. The results are shown in Table 4, Table 5, and Table 6.

Table 4. Testing Logarithmic Exchange Rates and CPI ratios for (non-)stationarity for the period of 1995 - 1999

Variables	Level		First Difference	
	ADF	PP KPSS	ADF PP	KPSS
AZN/KZT	-0.180	0.021 2.66***	-6.013*** -7.923***	0.125
AMD/KZT	0.162	0.130 1.33***	-5.278*** -8.095***	0.274
KGS/KZT	-0.490	-0.429 2.75***	-5.390*** -8.723***	0.123
MDL/KZT	-1.630	-1.721 .794***	-5.282*** -7.435***	0.135
RUB/KZT	-0.951	-0.547 2.09***	-4.435*** -4.798***	0.147
UAH/KZT CPIKZ/AZJ CPIKZ/ARM	-1.713 -0.135 -1.488	-1.497 1.54*** 0.463 2.95*** -1.888 1.83***	-5.121*** -6.792*** -5.437*** -7.845*** -5.082*** -5.026***	0.0578 0.125 0.145
CPIKZ/KGS	-0.147 -0.512	0.594 1.84*** -0.672 .714**	-4.448*** -4.593*** -3.115** -3.210**	0.773*** **

CPIKZ/MDV				1.45***

CPIKZ/RUS	-0.351	-0.110 2.06***	-3.648*** -5.118***	0.235
CPIKZ/UA	-2.299*	-4.521*** 2.03***	-4.327*** -5.321***	0.54**

*** p<0.01, ** p<0.05, * p<0.1

For the period of 1995-1999, all of the variables except for the CPI ratio of Kazakhstan to Ukraine were confirmed to be non-stationary by all of the three tests. For CPI ratio of Kazakhstan to Ukraine, ADF and KPSS tests indicate non-stationarity at 5% significance level, while Phillips-Perron test shows stationarity. For the first differences, ADF and PP tests show stationarity in all of the variables, indicating that all exchange rates and CPI ratios are integrated of order 1. However, the KPSS test shows non-stationarity for the ratios of Kazakh CPI to the Kyrgyz, Russian, and Ukrainian CPIs.

Table 5. Testing Logarithmic Exchange Rates and CPI ratios for (non-)stationarity for the period of 2000-2015

Variables	**Level First Difference**				
	ADF	**PP KPSS ADF PP**			**KPSS**
AZN/KZT	-1.363	-1.401 5.97*** -9.242*** -14.039***			0.0913
AMD/KZT	-1.112	-1.209 7.97*** -10.676*** -16.077***			0.0778

KGS/KZT	-3.607***	-3.883** .778*** -10.065*** -15.445***	0.0492
MDL/KZT	-2.155	-2.095 2.4*** -9.501*** -12.945***	0.102
RUB/KZT	-1.811	-1.530 1.26*** -8.200*** -11.704***	0.168

UAH/KZT 0.702 0.737 6.86*** -9.366*** -13.178*** 0.317 **CPIKZ/AZJ** -1.967 -1.286 4.69*** -7.452*** -8.007*** 0.124

CPIKZ/ARM	-1.500	-1.456 9.01*** -9.588*** -9.643***	0.0717
CPIKZ/KGS	-1.987	-1.576 1.92*** -8.703*** -9.601***	0.268
CPIKZ/MDV	-2.211	-2.328 2.13*** -8.283*** -8.658***	0.485**
CPIKZ/RUS	-3.112**	-4.570*** 5.95*** -5.930*** -6.531***	1.22
CPIKZ/UA	-0.326	1.763 6.21*** -6.860*** -6.583***	0.352*

*** p<0.01, ** p<0.05, * p<0.1

For the period of 2000-2015, three tests have corresponding results of non-stationarity for almost all of the time series. The exceptions are KGS/KZT exchange rate and the Kazakh and Russian CPI ratio, where ADF and PP tests show stationarity at 5% significance level, while the KPSS test shows non-stationarity. Additionally, the first difference of the CPI ratio of Kazakhstan to Moldova is stationary according to ADF and PP tests, but non-stationary according to the KPSS at 5% significance level.

Table 6. Testing Logarithmic Exchange Rates and CPI ratios for

(non-)stationarity for the period of 2015-2023

Variables	Level First Difference		
	ADF	PP KPSS ADF PP	KPSS
AZN/KZT	-1.189	-1.372 3.24*** -8.070*** -12.0***	0.0891
AMD/KZT	-0.826	-1.711 4.26*** -6.375*** -9.819***	0.114
KGS/KZT	-3.712***	-4.524*** 2.31*** -5.230*** -11.681***	0.372*
MDL/KZT	-2.464	-3.041** 4.36*** -6.903*** -9.124***	0.25
RUB/KZT	-2.801*	-3.432** 1.74*** -6.035*** -10.52***	0.394*
UAH/KZT	-1.621	-2.553 1.4*** -8.138*** -12.28***	0.223
CPIKZ/AZJ	-0.863	-0.312 3.78*** -8.845*** -6.477***	0.13
CPIKZ/ARM	-1.178	-1.093 4.46*** -6.639*** -6.237***	0.183
CPIKZ/KGS	-4.385***	-4.572*** 3.26*** -6.582*** -6.124***	0.755***
CPIKZ/MDV	-3.171**	-2.899** 1.09*** -4.970*** -5.494***	0.678**
CPIKZ/RUS	-1.812	-1.738 4.25*** -6.354*** -5.645***	0.201
CPIKZ/UA	-1.263	-1.173 3.24*** -7.824*** -7.762***	0.126

*** p<0.01, ** p<0.05, * p<0.1

For the period of 2015-2023, there are contradictory results for the exchange rate of Kyrgyz som to Kazakh tenge, where ADF and PP tests indicate stationarity, while the KPSS test shows non-stationarity. Additionally, for the exchange rates of the Moldovan leu and Russian rouble to Kazakh tenge, ADF and KPSS tests show

non-stationarity, while the PP test indicates stationarity at a 5% significance level.

The relative CPI ratios of Azerbaijan, Armenia, Russia, and Ukraine seem to be non-stationary according to 3 tests, and by testing the first difference the relative CPI ratios become stationary according to three tests. However, we have contradictory results in Kyrgyzstan and Moldova, where ADF and Phillips-Perron tests show stationarity, while the KPSS test results indicate stationarity.

Again, these contradictions show that none of these tests is perfect. Even though there are some contradictions in the unit root tests, we are still inclined to not assume stationarity in the levels. We tested the series for the whole period and found contradictions in the results of ADF, PP, and KPSS for some of the variables. We tried to resolve them by looking into the sub-periods, as the graphs of the variables seem to distinguish three sub-periods in the level of the variables, so the stationarity issues may be different in the sub-periods and in the whole period. However, we still found some contradictions, so it did not resolve the issue of contradicting results. We conclude that the overwhelming evidence suggests that the variables are not stationary. There are some cases where they might look stationary, but it is much safer to allow for non-stationarity than to assume stationarity. If we assume stationarity when it is not there, then the inference of the following analysis will be meaningless. When we allow for non-stationarity and difference the series in

case of possible stationarity there might be a possibility of introducing a serial correlation or moving average residuals, but still it would not be as dangerous as a spurious regression problem that comes from mistakenly assuming stationarity (Hendry & Jusélius, 2000). In the spurious regression, conventionally-calculated critical values are incorrect and R-squared does not indicate the goodness-of-fit, making further analysis nonsensical (Hendry & Jusélius, 2000). That is why we are inclined to assume non-stationarity in the series that have contradictory results of ADF, PP, and KPSS tests. There is no variable that was unanimously found to be stationary by all three tests.

Regarding the contradiction in the order of integration, it is possible that there is a non-constancy in the variance since all of these tests assume constant variances. There are different levels of sensitivity of these tests on the non-constancy of variances.

Those cases where there is a hesitancy to find the stationarity of first differences, there is a disagreement with the PPP and LOP, since it suggests that the ratio of the prices evolves at another level of integration than the exchange rate. On the other hand, in spite of unfavorable tests on the order of integration, when the ECM is used to estimate the exchange rate and how it adapts to the price ratio, it usually works better. Moreover, the overwhelming evidence still shows that the

variables are integrated of order 1 as both ADF and PP tests suggest the rejection of the null of non-stationarity of the first difference at the 1% significance level, Therefore, we decided to assume that the order of integration of all of the variables is I(1).

This allows us to move to the next part of our analysis, where we estimate the cointegration among the exchange rates and relative price levels. ***4.1.2. Results of PPP tests***

4.1.2.1. Strict model

The results for the strict model are demonstrated in Table 7.

Table 7. Strict model results for the CIS region

c	**Level**		
Test - statistics (p-values)	**ADF**	**PP**	**KPSS**
AZJ	-2.761* (0.0641)	-2.818* (0.0557)	8.71***
ARM	-1.315 (0.6223)	-1.251 (0.6512)	12.5***
KGS	-2.449 (0.1283)	-2.326 (0.1639)	6.27***
MDV	-0.492 (0.8936)	-0.538 (0.8844)	13.8***
RUS	-3.251** (0.0172)	-3.093** (0.0271)	8.24***
UA	-3.356** (0.0126)	-3.583*** (0.0061)	3.16***

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

According to the strict model of testing for PPP among CIS countries and Kazakhstan, ADF and PP tests indicated that PPP holds for Azerbaijan, Russia, and Ukraine relative to Kazakhstan. For Armenia, Kyrgyzstan, and Moldova, there was no evidence of PPP relative to Kazakhstan. However, the results of the KPSS test differ from the results of ADF and PP tests, indicating that there is no PPP in any of the countries. Such a contradiction may be explained by the vulnerability of the KPSS test to type I error, which is also called a rejection error (Kagalwala, 2022). The fact that the KPSS test is nonparametric contributes to its high type I error probability. This implies it makes no assumptions about the distribution of the data, which makes it more vulnerable to noise and outliers. As a result, even if the data is close to being stationary, the KPSS test is more likely to reject the null hypothesis when it is not strongly stationary. Another explanation for the KPSS test's high type I error rate is that it is not flexible to alternative hypothesis misspecification. The KPSS test compares the null hypothesis of stationarity to the alternative hypothesis of a unit root. If the actual alternative hypothesis is not a unit root, but rather some other sort of non-stationarity, the KPSS test may reject the null hypothesis even if it is true. Thus, it is critical to understand the test's limits and to use it in conjunction

with other tests, such as the ADF or PP tests. This reduces the possibility of making type I mistakes and ensures that you draw solid conclusions regarding the stationarity of the data.

Such results that indicate PPP holding for some countries but not for others may be explained by the effect of various economic factors. One of the possible reasons for obtaining such results can be the level of economic integration. Countries that are more economically integrated with Kazakhstan may demonstrate a stronger commitment to PPP. This integration may take place in terms of economic policies, trade relations, or historical connections. According to Tica and Soric (2012), the performance of international market mechanisms and the convergence of real exchange rates can be enhanced by economic cooperation and trade. The economies of Russia and Kazakhstan are known to be closely linked because of a vast border and long-standing historical ties. The presence of PPP among Kazakhstan and Azerbaijan might be explained by the fact that both countries share economic characteristics such as abundant natural resources, such as gas and oil, limited economic diversification, and a political landscape which is dominated by strong autocratic presidentialism and neopatrimonial structures (Franke et al., 2009). These economic and political factors, along with post-Soviet legacies like low political engagement in society and a hierarchical population

orientation, contribute to a distinctive post-Soviet form of rentierism in Kazakhstan and Azerbaijan, which in turn, may lead to higher level of economic integration and adherence to PPP. It was not expected, however, that this model would show the absence of PPP between Kazakhstan and Kyrgyzstan, although these two countries border and actively trade with each other.

Nevertheless, since this is the strictest model, it is not surprising that it failed to find PPP between Kazakhstan and a number of other CIS countries. We expect further less strict models for PPP to indicate cointegrating relationships between exchange rates and CPI ratios for more countries.

4.1.2.2. Moderate model

Table 8. Moderate model test results for the CIS region

Variables	**Level**		
Test - statistics (p-values)	**ADF**	**PP**	**KPSS**
AZJ	-3.433** (0.0099)	-3.557** (0.0066)	2.41***
ARM	-4.018*** (0.0013)	-4.178*** (0.0007)	1.32***
KGS	-3.364** (0.0123)	-3.199* (0.0201)	4.78***
MDV	-0.530 (0.8861)	-0.562 (0.8793)	12.6***
RUS	-3.546** (0.0069)	-3.272* (0.0162)	3.84***

UA	-3.541** (0.0070)	-3.879** (0.0022)	1.68***

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

According to the results of this moderate strictness model, ADF and PP tests show that PPP holds for Azerbaijan, Armenia, Kyrgyzstan, Russia, and Ukraine relative to Kazakhstan. Again, ADF and PP tests contradict KPSS tests, where KPSS suggests non-stationarity of residuals and absence of cointegration and PPP for all of the countries. However, it was explained before that the KPSS test may have some limitations. Thus, we are inclined to draw conclusions relying on the overall picture of the results of all three tests. Since both ADF and PP tests show cointegration in the exchange rates and relative price ratios in the mentioned countries, we are inclined to conclude that PPP holds in these countries relative to Kazakhstan.

PPP does not hold only between Moldova and Kazakhstan according to all three tests. Nevertheless, it is important to consider that we allowed the coefficients of the price levels to not equal 1, and in this case the coefficients of price ratios of Kazakhstan to Armenia, Kyrgyzstan, and Moldova considerably deviate from one,

the coefficients of β_{UA}-is equal to 1.53, 1.77, and 0.66 respectively. Thus, it may

be the case that even though there is a cointegration between exchange rates and price ratios of Kazakhstan with Armenia and Kyrgyzstan, this may not necessarily mean that there is PPP.

4.1.2.3. Flexible model

Table 9. Flexible model results for the CIS region

Variables	Level		
Test - statistics (p-values)	**ADF**	**PP**	**KPSS**
AZJ	-3.956** (0.0017)	-4.114** (0.0009)	0.607**
ARM	-4.624*** (0.0001)	-4.601*** (0.0001)	1.18***
KGS	-4.193*** (0.0007)	-3.859** (0.0024)	1.17***
MDV	-4.207** (0.0006)	-4.014** (0.0013)	1.22***
RUS	-3.758* (0.0034)	-3.474* (0.0087)	0.35*
UA	-3.633* (0.0052)	-3.791** (0.0030)	1.04***

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In the flexible model, ADF and PP tests indicate the presence of PPP between Kazakhstan and Russia at 10% significance level; between Kazakhstan and

Azerbaijan, Moldova, and Ukraine at 5% significance level; and between Kazakhstan and Armenia at 1% significance level. We still have contradictory results of the KPSS test that shows non-stationarity of the residuals. As was explained previously, this might be related to the higher probability of rejection error associated with the KPSS test. Therefore, we should use it in conjunction with other tests to decrease the possibility of making type I mistakes. In this case, we are inclined to trust ADF and PP test results, and these tests show some adherence to PPP between Kazakhstan and all other analyzed CIS countries.

4.1.3. The FMOLS cointegrating regression results

The fully modified least squares regression is a type of cointegrating regression. It allows us to interpret the coefficients of the cointegrating relationship between exchange rates and relative price ratios.

Although it might be nonsensical to conduct cointegrating regression analysis on the series that are not cointegrated, we still conducted FMOLS regression on all of the countries, since we cannot be entirely sure if there is no cointegration among some series. Cointegration tests are not powerful enough to always identify the cointegration relationship. This is why we assume that there is a cointegration and conduct the cointegrating regression for all of the countries.

The results of the FMOLS regression are presented in the table above. The

intercepts are all significant at 1% significance level for all of the countries, and the coefficients of the relative price ratios are also significant at 1% significance level for all of the countries except for Moldova. The coefficients for the CPI ratios are all positive and around 1 for Azerbaijan, Russia, and Ukraine, meaning that 1% increase in ratio of Kazakh CPI on CPIs of these countries is associated with roughly 1% rise in the exchange rates relative to Kazakh Tenge. These results seem to support our results for the strict model of PPP test, where the same three countries were identified to have PPP with Kazakhstan. The coefficients for the CPI ratios for Armenia and Kyrgyzstan are also positive, but are notably higher than 1, which may suggest that the relationship between exchange rates and relative price ratios is not proportional, and that even though there is a cointegration, there is not necessarily evidence of strong adherence to PPP.

FMOLS test emerges as a useful tool in our analytical framework, revealing insight into the complicated structure of the long-run relationship between the explained and explanatory variables over a long time horizon. Within this context, we arrive at a significant discovery that the CPI ratio of Kazakhstan and Moldova, when used as an independent variable, is incapable of explaining variations in the Moldovan Leu to Kazakhstani Tenge exchange rate (MDL/KZT). This discovery represents a notable detail in the dynamics of Kazakhstan-Moldova exchange rate

relations. This result also may indicate the possibility of unknown factors or complexities governing this particular exchange rate relationship.

$$\text{[illegible]}_{\text{[illegible]}} = \alpha + \beta \text{[illegible]}^{\text{[illegible]}}_{\text{[illegible]}} \text{[illegible]}^{\text{[illegible]}}_{\text{[illegible]}^{*}} + \varepsilon_{\text{[illegible]}}$$

Table 10. The FMOLS results for the CIS region

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	lnAZNKZT	lnAMDKZT	lnKGSKZT	lnMDLKZT	lnRUBKZT	lnUAHKZT
lnCPIKZAZJ	1.379***					
	(0.113)					
lnCPIKZARM		1.551***				
		(0.058)				
lnCPIKZKGS			1.902***			
			(0.220)			
lnCPIKZMDV				0.642		
				(0.533)		
lnCPIKZRUS					0.898***	
					(0.071)	
lnCPIKZUA						1.187***
						(0.117)
Constant	5.122***	-0.883***	1.244***	2.586***	1.578***	2.988***
	(0.028)	(0.022)	(0.027)	(0.101)	(0.030)	(0.037)
Observations	344	344	344	344	344	344
R-squared	0.873	0.944	0.486	0.103	0.775	0.859

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The FMOLS regression above does not account for the potential breaks in our data that were identified during testing our time series for unit roots. These breakpoints include the Russian default crisis in 1998-1999 and exchange rate regime shift in 2015. After involving two dummies in 1999 and 2015 coefficients of relative price ratios became significant at 1% significance level in all countries, including Moldova that was insignificant before inclusion of dummies. Dummies

are also significant for all of the countries except for Azerbaijan. Now, the relative price ratio coefficients are all positive and around 1 for Armenia, Kyrgyzstan, Moldova, and Russia, and around 1.5 for Azerbaijan and Ukraine. These results may suggest that there is a positive relationship between the fluctuations of exchange rate and relative price ratios for all countries, and that for Azerbaijan and Ukraine this relationship is higher.

Table 11. The FMOLS results for the CIS region with dummies

$$\text{[illegible]}_{it} = \alpha + \beta_1 \text{[illegible]}^{it}_{it} \text{[illegible]}_{it^*} + \beta_{99} D99_{99} + \beta_{15} D15_{15} + \varepsilon_{it}$$

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	lnAZNKZT	lnAMDKZT	lnKGSKZT	lnMDLKZT	lnRUBKZT	lnUAHKZT
lnCPIKZAZJ	1.551***					
	(0.265)					
D99	0.142	-0.324***	-0.127***	-0.726***	-0.432***	-0.515***
	(0.195)	(0.089)	(0.038)	(0.115)	(0.115)	
D15	-0.047	-0.249***	-0.274***	-0.537***	-0.153***	-0.357***
	(0.113)	(0.049)	(0.042)	(0.061)	(0.039)	
lnCPIKZARM	1.269***					
	(0.081)					
lnCPIKZKGS	0.992***					
	(0.174)					
lnCPIKZMDV	0.967***					
	(0.322)					
lnCPIKZRUS	1.135***					
	(0.112)					
lnCPIKZUA	1.641***					
	(0.208)					
Constant	5.134***	-0.706***	1.465***	2.983***	1.677***	3.251***
	(0.070)	(0.038)	(0.034)	(0.054)	(0.032)	(0.087)
Observations	344	344	344	344	344	344
R-squared	0.896	0.949	0.776	0.584	0.574	0.388

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

4.1.4. The Error Correction Model results

We introduce another ECM where the EC mechanism is always present, but we also allow the long run relationship to shift. The model is specified as following:

$$\Delta\text{[illegible]}_{\text{[illegible]}} = \alpha_0 + \alpha_1 \Delta\text{[illegible]}^{\text{[illegible]}}_{\text{[illegible]}} \text{[illegible]}_{\text{[illegible]}^*} + \alpha_2 \text{[illegible]}_{99} \Delta\text{[illegible]}^{\text{[illegible]}}_{\text{[illegible]}} \text{[illegible]}_{\text{[illegible]}^*} + \alpha_3 \text{[illegible]}_{15} \Delta\text{[illegible]}^{\text{[illegible]}}_{\text{[illegible]}} \text{[illegible]}_{\text{[illegible]}^*} + \delta \left(\text{[illegible]}_{\text{[illegible]}-1} - \beta\text{[illegible]}^{\text{[illegible]}}_{\text{[illegible]}} \text{[illegible]}_{\text{[illegible]}-1} \right.$$

$$\left. {}_{*}\text{[illegible]} \right) + \alpha_{99} \text{[illegible]}_{99} + \alpha_{15} \text{[illegible]}_{15} + \text{[illegible]}_{\text{[illegible]}} \text{[illegible]}_{\text{[illegible]}-1}$$

where

- α_1 is how change in CPI ratio affects the change in exchange rate;
- α_2 is interaction term between a dummy for the Russian default crisis and change in the relative price ratio;
- α_3 is interaction term between a dummy for the exchange rate regime shift and change in the relative price ratio;
- δ is an error correction speed;
- β is a long-run effect of the price ratios on the exchange rates;
- α_0 is intercept;
- α_{99} is a dummy variable coefficient;
- α_{15} is a dummy variable coefficient.

Table 12. The ECM results for the CIS region with dummies and interactions

Variables	Dependent variables					
	Δln(AZN/ KZT)	Δln(AMD/ KZT)	Δln(KGS/ KZT)	Δln(MDL/ KZT)	Δln(RUB/ KZT)	Δln(UAH/ KZT)
α_1	1.511*** (0.386)	0.579* (0.335)	0.320 (0.442)	-0.325 (0.422)	0.823 (0.656)	-0.397 (0.539)
α_2	-0.946** (0.472)	-0.482 (0.387)	0.694 (0.507)	2.076*** (0.485)	0.797 (0.666)	1.101* (0.609)
α_3	-0.264 (0.495)	-0.077 (0.379)	-0.102 (0.511)	1.135** (0.541)	1.377 (0.866)	0.732 (0.607)
δ	-0.084*** (0.022)	-0.087*** (0.024)	-0.095*** (0.024)	-0.114*** (0.019)	-0.129*** (0.024)	-0.053** (0.024)
β	1.379*** (0.290)	1.025*** (0.184)	0.070 (0.383)	0.084 (0.313)	0.854*** (0.152)	1.691*** (0.552)
α_0	0.438*** (0.113)	-0.044** (0.018)	0.157***	0.357***		0.176** (0.077)

			0.220*** (0.036) (0.055) (0.040)	
α_{99}	0.010 (0.019)	-0.045** (0.019)	-0.025*** -0.058*** -0.020	-0.032 (0.028)
α_{15}	-0.008 (0.007)	-0.040*** (0.011)	(0.007) (0.017) (0.022)	-0.028 (0.017)
$\hat{\sigma}^2$	0.120	0.074	-0.047***	0.032
Root MSE	.041492	.039222	-0.079*** -0.021*** (0.009) (0.011) (0.007) 0.110 0.230 0.294 .0347814 .0384283 .0500107	.0550101

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results of this ECM model are presented in Table 12. The change in CPI ratio affects the change in exchange rate positively in case of Azerbaijan at 1% significance level and in Armenia at 10% significance level.

δ is significant in all of the countries, and can be interpreted as the error correction speed coefficient or speed of adjustment towards equilibrium. A negative δ indicates that the error term tends to adjust towards its long-run equilibrium, and the speed of adjustment is influenced by the difference between the lagged error

term and the expected value based on the lagged price ratio. δ should be negative to make sense. In all of the cases, it is negative indicating the percentage by which the error is compensated.

β is also significant in the majority of countries such as Azerbaijan, Armenia, Russia, and Ukraine at a 1% significance level. α_2 is significant in Moldova, Azerbaijan, Ukraine at 1%, 5%, 10% respectively showing the additional effect of change in CPI ratio to change in exchange rates in the period before 2000. α_3 is significant at the 5% significance level in Moldova showing the additional positive effect of change in CPI ratio between 2000 and July 2015 to change in exchange rate.

The dummy for the Russian default crisis, α_{99}, is significant for Armenia, Kyrgyzstan and Moldova at 1% significance level showing the additional negative effect of the change in exchange rate before 2000. The dummy for the shift in the exchange rate regime, α_{15}, is significant for Russia, Armenia, Kyrgyzstan and Moldova at 1% significance level showing the additional negative effect of the change in exchange rate during 2000 - July 2015. Due to its geographical distance from the other sample nations, establishing purchasing power parity (PPP) with Moldova might be difficult.

The intercept, α_0, which indicates the expected change in exchange rate when

all other variables are zero, is significant for all of the countries. It is also positive everywhere except for Armenia.

Since α and are insignificant for most of the countries, we questioned the $_2\alpha_3$ relevance of the interaction terms with dummy variables in this ECM model. In order to check their relevance, we performed a joint test of the significance of the coefficients associated with the interactions. This test assesses whether a group of coefficients is jointly equal to zero. The null hypothesis for this test is that all coefficients associated with the interactions are equal to zero, which means that the interactions do not significantly affect the dependent variable, while the alternative hypothesis is that at least one of the coefficients associated with the interaction terms is not equal to zero. The test statistic of a joint test of significance is calculated based on the difference between the restricted (null hypothesis) and unrestricted (alternative hypothesis) models. The null hypothesis is rejected, if the test statistic is beyond a critical value, which demonstrates that at least one of the coefficients of interaction terms is significantly different from zero. The test results show that the interactions with dummies do not significantly affect the ECMs for the majority of the countries, the only exception being Moldova. Therefore, we modified the ECM model by removing these interaction variables to improve the

efficiency of our statistical model. This decision is motivated by the desire to preserve degrees of freedom. By eliminating unnecessary interaction terms, we optimize the model without endangering its explanatory power. This not only helps in the interpretation of the remaining significant factors, but also contributes to the reliability and generalizability of our results. The model is specified in the following equation:

$$\Delta\text{[illegible]}_{\text{[illegible]}} = \alpha_0 + \alpha_1 \Delta\text{[illegible]}^{\text{[illegible]}}_{\text{[illegible]}} \text{[illegible]}^{\text{[illegible]}}_{\text{[illegible]}^*} + \delta\,(\text{[illegible]}_{\text{[illegible]}-1} - \beta\text{[illegible]}^{\text{[illegible]}}_{\text{[illegible]}-1} {}_*) + \alpha_{99}\text{[illegible]}_{99} + \alpha_{15}\text{[illegible]}_{15} + \text{[illegible]}_{\text{[illegible]}} \text{[illegible]}_{\text{[illegible]}-1}$$

The results of this ECM without interaction terms are demonstrated in Table 13.

Table 13. The ECM results for the CIS region without interactions for dummies

Coefficients	**Dependent variables**					
	Δln(AZN/ KZT)	Δln(AMD/ KZT)	Δln(KGS/ KZT)	Δln(MDL/ KZT)	Δln(RUB/ KZT)	Δln(UAH/ KZT)

α_1	0.999***	0.358***				0.388*
	(0.185)		0.600***			(0.205)
				1.130***		
δ	-0.081***				1.602***	-0.047**
	(0.022)	(0.130)				(0.024)
			(0.171)			
				(0.181)		
					(0.144)	
		-0.089***				
			-0.080***			
				-0.103***		
					-0.123***	
		(0.024)				
			(0.023)			
				(0.0189)		
					(0.022)	

β	1.339***	1.028***				1.489**
	0.304		0.003			(0.586)
				0.075		
					0.817***	
		(0.179)				
			(0.469)			
				(0.354)		
					(0.155)	
α_0	0.421***	-0.044**				0.153**
	(0.113)		0.133***			(0.076)
				0.322***		
					0.207***	
		(0.018)				
			(0.034)			
				(0.055)		
					(0.038)	
α_{99}	0.003	-0.049***				-0.025
	(0.018)		-0.023***			(0.027)
				-0.052***		
					-0.013	
		0.018				
			(0.007)			
				(0.017)		
					(0.021)	

α_{15}	-0.009 (0.007)	-0.041*** -0.040*** -0.071*** -0.019*** (0.011) (0.009) (0.011) (0.007)	-0.021 (0.016)
R^2	0.1076	0.0660 0.0950 0.1849 0.2885	0.0217

Root MSE .0416694 .0392668 .0349607 .0394315 .0500506 .0551256

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results of the ECM without interaction terms for dummies show that the model works very well for the majority of the countries. The coefficient of the change in the relative price ratios, α_1, is significant and positive for all of the countries, indicating the positive relationship between changes in exchange rates and in price ratios.

The error correction speed, δ, is always significant and negative, which indicates that the specified error correction term works well in this model. It measures the speed at which deviations from the long-run equilibrium are corrected. It suggests that the error is compensated by around 8% for Azerbaijan and Kyrgyzstan, around 10% for Armenia, Moldova and Russia, and nearly 5% for Ukraine.

The β is significant and around 1 for Azerbaijan, Armenia, Russia, and Ukraine, meaning that there is indeed a long-run effect of the price ratios on the exchange rates. This means that the given ECM model works well for these four countries, and shows strong evidence of the presence of PPP between these countries and Kazakhstan. However, for Kyrgyzstan and Moldova β is very low and insignificant, which may indicate that the specified ECM model does not explain the long-run relationship between the price ratios and the exchange rates for these two countries.

The intercept, α_0, is always significant, and it is also positive for all of the countries except Armenia. Dummies for the Russian default crisis and the exchange rate regime shift are significant for the majority of countries.

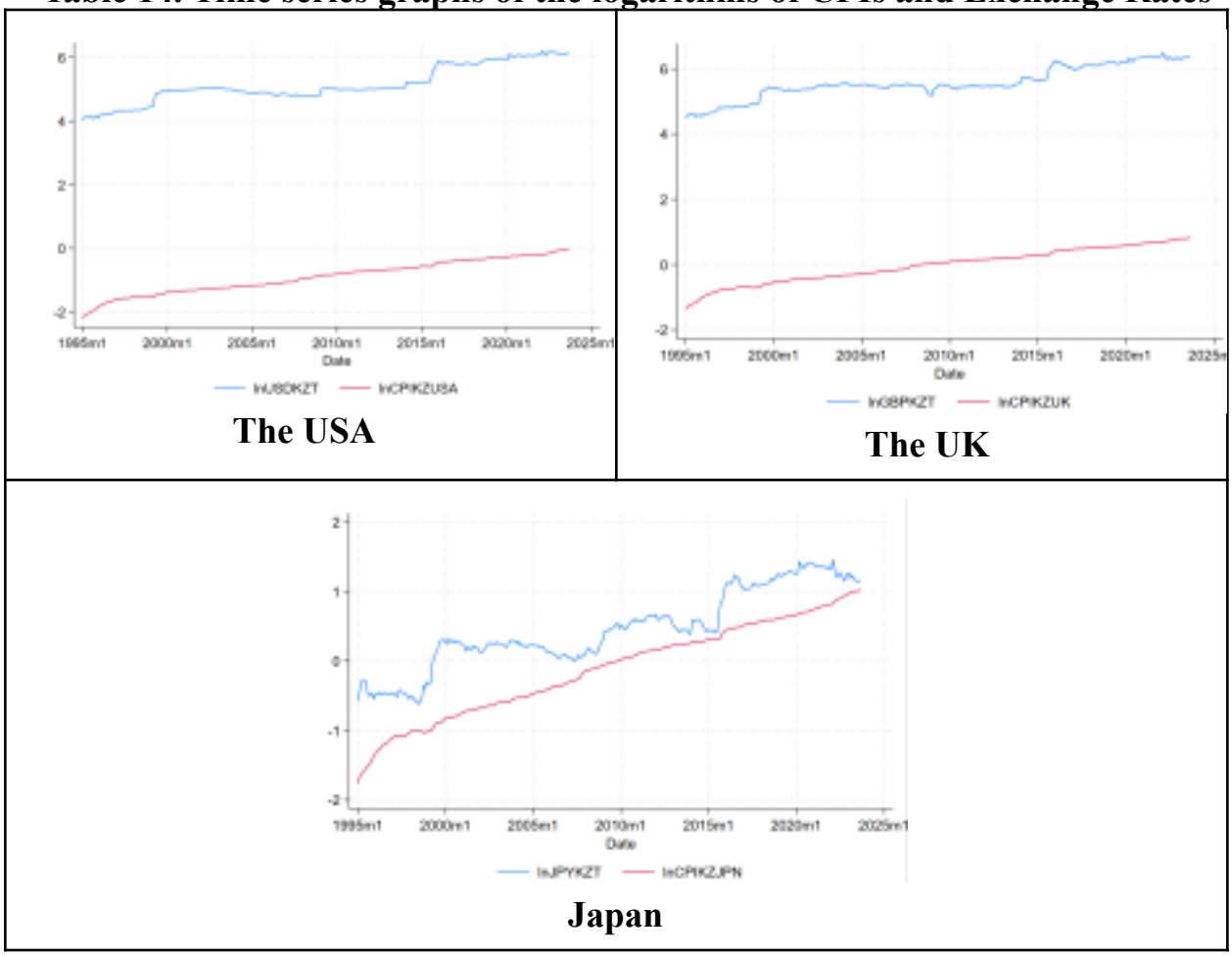
Overall, the results of this ECM show that for Azerbaijan, Armenia, Russia, and Ukraine, we do find a relatively strong tendency for PPP to occur, but for Kyrgyzstan and Moldova we do not find any evidence of PPP.

4.2. Analysis for the global economies: the USA, UK, and Japan The second part of our analysis is focused on the evaluation of PPP among the major global economies and Kazakhstan. We chose the USA, the UK, and Japan for this analysis. European countries were not chosen due to the difficulty of obtaining a reliable CPI that encompasses all of the countries that use euro as a currency.

4.2.1. Stationarity test results

The graphs of the time series variables for exchange rates and relative price ratios for the USA, the UK, and Japan relative to Kazakhstan are illustrated in Table 14.

Table 14. Time series graphs of the logarithms of CPIs and Exchange Rates



The USA

The UK

Japan

Although the graphs demonstrate a non-stationary pattern in the time series, we still need to test variables for stationarity using ADF, PP, and KPSS tests. The results are presented in Table 15.

Table 15. Testing Logarithmic Exchange Rates and CPI ratios for (non-)stationarity

Variables	Level		First Difference				2nd
	ADF	PP	KPSS	ADF	PP	KPSS	KPSS
USD/KZT	-0.670 (0.8544)	-0.869 (0.7980)	14.3***	-11.533*** (0.0000)	-15.211*** (0.0000)	.134	
GBP/KZT	-1.352 (0.6049)	-1.568 (0.4998)	14.2***	-12.333*** (0.0000)	-16.819*** (0.0000)	.116	
JPY/KZT	-1.170 (0.6864)	-1.359 (0.6020)	15***	-11.929*** (0.0000)	-15.584*** (0.0000)	.0825	
CPIKZ/USA	-2.347 (0.1573)	-4.834*** (0.0000)	16.9***	-8.887*** (0.0000)	-10.979*** (0.0000)	1.43***	0.0556
CPIKZ/UK	-3.200** (0.0200)	-5.545*** (0.0000)	16.8***	-8.751*** (0.0000)	-10.791*** (0.0000)	1.8***	0.0538
CPIKZ/JPN	-2.538 (0.1064)	-4.851*** (0.0000)	17***	-9.152*** (0.0000	-10.359*** (0.0000)	1.59***	0.0582

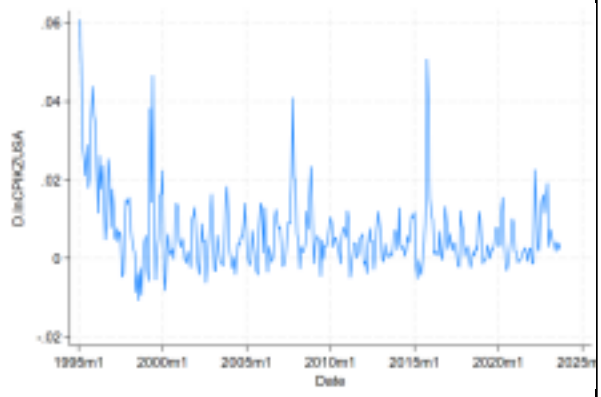
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

According to the results of the unit root tests, the exchange rates for the developed countries all are found to be non-stationary. However, there are contradictory results for the CPI ratios. While ADF and KPSS tests show non-stationarity of the data, PP tests seem to find stationarity in these ratios.

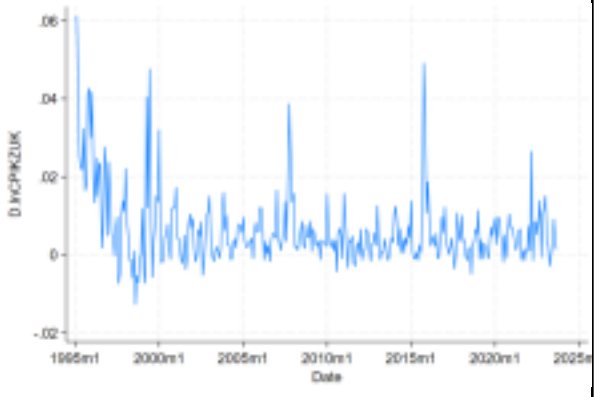
Regarding the first differences, all exchange rates are found to be I(1), but there are again contradictory results for the first differences of the CPI ratios. While ADF and PP tests find the ratios to be I(1) with at 1% significance level, KPSS test shows non-stationarity of the first differences. The time series graph of the first differences of CPIs are shown in Table 16.

Similar to the analysis for the CIS region, we decided to break the dataset into three sub-periods in order to address the contradictions in the unit root test results.

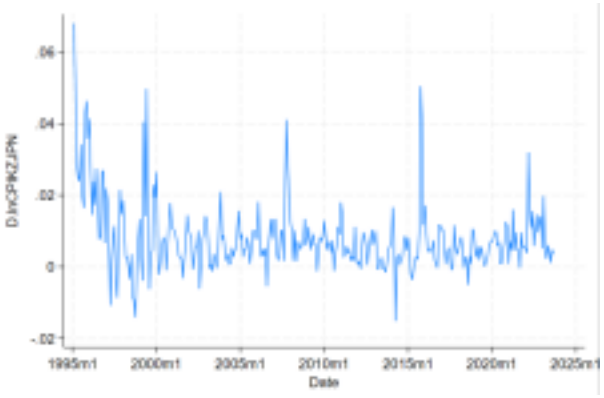
Table 16. Time series graphs of the first differences of logarithmic CPIs that have contradictory unit root test results



The USA



The UK



Japan

Table 17. Testing Logarithmic Exchange Rates and CPI ratios for (non-)stationarity for the period of 1995-1999

Variables	Level First Difference			
	ADF	PP	KPSS ADF PP	KPSS
USD/KZT	0.456 (0.9835)	0.439 (0.9829)	2.34*** -4.501*** -6.093*** (0.0002) (0.0000)	.224
GBP/KZT	0.308 (0.9777)	0.225 (0.9736)	2.48*** -5.232*** -6.318*** (0.0000) (0.0000)	.166

JPY/KZT	0.346 (0.9793)	0.539 (0.9860)	1.22*** -4.454*** (0.0002) -6.075*** (0.0000)	.389*
CPIKZ/USA	-2.866* (0.0494)	-6.120*** (0.0000)	2.62*** -3.448** (0.0094) -5.321*** (0.0000)	1.41
CPIKZ/UK	-3.068** (0.0290)	-5.693*** (0.0000)	2.62*** -3.661*** (0.0047) -4.658*** (0.0001)	1.33
CPIKZ/JPN	-2.594 (0.0942)	-5.417*** (0.0000)	2.66*** -3.752*** (0.0034) -4.486*** (0.0002)	1.25

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

For the period of 1995-1999, the tests for unit root show that the exchange rate time series for all of the countries are I(1). For the CPI ratios, there are still contradictions between the tests in the stationarity of levels, but the contradictions in the first differences are resolved as all three tests show that the first differences of the CPI ratios are stationary.

Table 18. Testing Logarithmic Exchange Rates and CPI ratios for (non-)stationarity for the period of 2000 - 2015

Variables	**Level First Difference**		
	ADF	**PP KPSS ADF PP**	**KPSS**

USD/KZT	-0.405 (0.9093)	-0.468 (0.8981)	2.94*** (0.0000)	-9.148*** -12.748*** (0.0000)	.262
GBP/KZT	-1.959 (0.3046)	-1.929 (0.3184)	2.34*** (0.0000)	-9.103*** -13.461*** (0.0000)	.0675
JPY/KZT	-1.216 (0.6665)	-1.173 (0.6852)	5.33*** (0.0000)	-8.958*** -12.866*** (0.0000)	.13
CPIKZ/USA	-0.473 (0.8973)	-0.107 (0.9488)	9.46*** (0.0000)	-8.012*** -6.583*** (0.0000)	.172
CPIKZ/UK	-0.959 (0.7678)	-0.927 (0.7790)	9.45*** (0.0000)	-7.068*** -8.125*** (0.0000)	.242
CPIKZ/JPN	-1.170 (0.6862)	-1.420 (0.5727)	9.49*** (0.0000)	-7.541*** -7.686 *** (0.0000)	.452

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

For the period of 2000-2015, all three tests unanimously find non-stationarity in the levels for all variables and suggest stationarity in the first differences of the variables.

Table 19. Testing Logarithmic Exchange Rates and CPI ratios for (non-)stationarity for the period of 2015-2023

Variables	Level	First Difference		
	ADF	PP KPSS ADF	PP	KPSS
USD/KZT	-1.983 (0.2941)	-2.920** (0.0430)	4.53*** -6.893*** (0.0000)	-9.386*** (0.0000)	.163
GBP/KZT	-1.728 (0.4165)	-2.325 3.98*** -7.925*** (0.1640) (0.0000)		-10.310*** (0.0000)	.0808
JPY/KZT	-3.107** (0.0261)	-4.045*** (0.0012)	2.58*** -7.373*** (0.0000)	-9.127*** (0.0000)	.435*
CPIKZ/USA	-1.229 (0.6608)	-1.648 (0.4582)	4.66*** -8.084*** (0.0000)	-7.762*** (0.0000)	.286
CPIKZ/UK	-1.571 (0.4981)	-1.985 (0.2930)	4.79*** -6.533*** (0.0000)	-6.074*** (0.0000)	.315
CPIKZ/JPN	-0.703 (0.8459)	-0.756	4.75*** -6.592***	-5.777*** (0.0000)	.266

		(0.8318) (0.0000)		

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Regarding the period of 2015-2023, there are no contradictions between the stationarity tests for the CPI ratios: all CPI ratios are found to be non-stationary in the levels, and their first differences are found to be stationary, meaning that the data is I(1). However, there are some contradictions between ADF, PP and KPSS tests in checking for the stationarity of USD/KZT and JPY/KZT. Still, the first differences of these exchange rates are reported to be stationary at 5% significance level by all three tests.

For the reasons similar to the reasons discussed in the analysis for the CIS region, we are inclined to assume that the time series variables are I(1). For reasons analogous to those discussed in the analysis for the CIS region, we are inclined to assume that the time series variables for major economies are I(1). In our previous analysis for the CIS region, we considered the evidence suggesting that the variables are not stationary. Underlining the importance of

avoiding the assumption of stationarity when it is not present, we emphasized the risks associated with spurious regression problems. Mistakenly assuming stationarity can lead to incorrect critical values, make R-squared values

meaningless, and result in nonsensical subsequent analyses (Hendry & Jusélius, 2000). To mitigate this risk, we decided to allow for non-stationarity in cases where ADF, PP, and KPSS tests yielded contradictory results. It is important to note that no variable demonstrated unanimous stationarity across all three tests.

Additionally, regarding the I(1) vs I(2) contradiction, despite hesitancy in finding the stationarity of first differences, we recognized that employing the Error Correction Model (ECM) often yielded more favorable results when estimating the exchange rate's adaptation to the price ratio. Also, taking into account that the ADF and PP tests show that the first differences of the series are stationary at 1% significance level, we decided to assume that the order of difference is I(1).

Given this preliminary analysis, we extend our assumption of nonstationarity to time series variables for major economies. This cautious approach is necessary for preserving the integrity of our subsequent analyses, particularly those that include cointegration tests and examination of purchasing power parity (PPP).

4.2.2. Results of PPP tests

4.2.2.1. Strict model

Table 20. Strict model results for the developed countries

Variables	**Level**		
Test - statistics (p-values)	**ADF**	**PP**	**KPSS**

USA	-1.680	-1.506	2.39***
UK	-2.272	-2.158	3.97***
JPN	-2.398	-2.121	6.42***

*** p<0.01, ** p<0.05, * p<0.1

4.2.2.2. Moderate model

Table 21. Moderate model results for the developed countries

Variables	**Level**		
Test - statistics (p-values)	ADF	PP	KPSS
USA	-1.790	-1.619	2.37***
UK	-2.187	-2.084	1.73***
JPN	-2.502	-2.215	1.17***

*** p<0.01, ** p<0.05, * p<0.1

4.2.2.3. Flexible Model

Table 22. Flexible model results for the developed countries

Variables	**Level**		
Test - statistics (p-values)	ADF	PP	KPSS
USA	-2.149	-2.024	2.36***

UK	-2.282	-2.182	1.92***
JPN	-2.393	-2.042	0.661**

*** p<0.01, ** p<0.05, * p<0.1

The non-stationarity of the Zt and residual series indicates that there is no cointegration between Kazakhstan and developed countries, as evidenced by the results of all three tests. Importantly, the results of the ADF, PP, and KPSS tests are consistent and support each other, in contrast to the inconsistencies reported in the CIS region.

Empirical studies using all three levels of strictness of testing for PPP fail to find evidence of cointegration, meaning that Kazakhstan and developed countries do not have purchasing power parity (PPP). This lack of PPP can be attributable to issues such as insufficient trading volumes, trade barriers (including great distances and expensive customs charges), insufficient commercial agreements, and differences in exchange rate regimes. Notably, Japan has a fixed exchange rate regime that is controlled by its central bank. Furthermore, Kazakhstan's financial markets are underdeveloped, limiting arbitrage opportunities. Moreover, Kazakhstan's export portfolio consists mostly of raw materials such as oil, gas, and metals, whereas industrialized countries sell finished goods and services. These

variables all contribute to Kazakhstan's departure from PPP with industrialized economies.

4.2.3. The FMOLS cointegrating regression results

The FMOLS test can be unnecessary as it already assumes that there is cointegration between regressor (CPI ratio) and regressand (exchange rate), which was not proved in the tests descriptive above. Nevertheless, in the FMOLS cointegration regression dummies and CPI ratios for all countries are significant at a 1% significance level.

Table 23. The FMOLS results for the developed countries with dummies

	(1)	(2)	(3)
VARIABLES	lnUSDKZT	lnGBPKZT	lnJPYKZT
lnCPIKZUSA	0.302***		
	(0.110)		
D99	-1.212***	-1.067***	-0.911***
	(0.166)	(0.151)	(0.179)
D15	-0.812***	-0.593***	-0.557***
	(0.094)	(0.083)	(0.099)
lnCPIKZUK	0.251***		
	(0.097)		
lnCPIKZJPN	0.384***		
	(0.088)		
Constant	6.076***	6.098***	0.968***
	(0.055)	(0.070)	(0.077)
Observations	344	344	344
R-squared	0.685	0.741	0.770

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.2.4. The Error Correction Model results

For the major economies, we used the same ECM that was specified for the CIS region countries. Dummies for the Russian crisis and exchange rate regime shift seemed to be noteworthy in this case, too. This is because the analysis is based on the exchange rates and price ratios relative to Kazakhstan, which was considerably affected by both of these events.

$$\Delta\text{[illegible]} = \alpha_0 + \alpha_1 \Delta\text{[illegible]} + \alpha_2 \text{[illegible]} \Delta\text{[illegible]} + \alpha_3 \text{[illegible]} \Delta\text{[illegible]} + \delta\,(\text{[illegible]} - \beta\text{[illegible]} + \alpha_{99}\text{[illegible]} + \alpha_{15}\text{[illegible]} + \text{[illegible]}$$

Table 24. The ECM results for major economies with dummies and interactions

Variables	Dependent variables
	Δln(USD/KZT) Δln(GBP/KZT) Δln(JPY/KZT)
α_1	0.410 0.631 -0.536
α_2	0.273 -0.021 1.234*
α_3	-0.466 -0.631 0.298
δ	-0.043*** -0.047*** -0.057***
β	0.494** 0.381* 0.342**

α_0	0.271*** 0.284*** 0.066***
α_{99}	-0.041** -0.036 -0.061***
α_{15}	-0.033*** -0.025* -0.042***

R^2 0.0595 0.0361 0.0375 n > 248 Root MSE .0330697 .0390659 .044396 ***

p<0.01, ** p<0.05, * p<0.1

In the ECM model δ is significant at a 1% significance level in all of the countries as the error correction speed coefficient or speed of adjustment towards equilibrium. A negative δ indicates that the error term tends to adjust towards its long-run equilibrium, and the speed of adjustment is influenced by the difference between the lagged error term and the expected value based on the lagged price ratio.

β is also significant in the USA and Japan at a 5% significance level and the UK at 10%. α indicates the positive effect of change in CPI ratio on change in 2 exchange rate before 2000 is significant at 10% significance level for Japan. α is 99 significant for the USA and Japan at 5% and 1% significance level showing the additional negative effect of the change in exchange rate before 2000. α is 15 significant for the USA, Japan at 1% significance level and for the UK at 10% significance level, showing the additional negative effect of the change in exchange

rate during 2000 - 2015. Due to its geographical distance from the other sample nations, establishing PPP with developed countries might be difficult.

α is significant for all countries and indicates the expected change in 0 exchange rate when all other variables are zero.

Since α and are insignificant for most of the countries, we questioned the $_2\alpha_3$ relevance of the interaction terms with dummy variables in this ECM model and had the same intuition as in the CIS countries. A joint test of the significance of the coefficients associated with the interactions showed that the interaction terms for dummies are not necessary for the model, so we excluded them from the model. The new ECM is specified in the following equation:

$$\Delta\text{[illegible]}_{\text{[illegible]}} = \alpha_0 + \alpha_1\Delta\text{[illegible]}^{\text{[illegible]}}_{\text{[illegible]}} \text{[illegible]}_{\text{[illegible]}^*} + \delta\,(\text{[illegible]}_{\text{[illegible]}-1} - \beta\text{[illegible]}^{\text{[illegible]}}_{\text{[illegible]}-1} {}_*) + \alpha_{99}\text{[illegible]}_{99} + \alpha_{15}\text{[illegible]}_{15} + \text{[illegible]}_{\text{[illegible]}} \text{[illegible]}_{\text{[illegible]}-1}$$

Table 25. The ECM results for major economies without interactions for dummies

Coefficients	**Dependent variables**	
	Δln(USD/KZT)	Δln(GBP/KZT) Δln(JPY/KZT)
α_1	0.473**	0.463* 0.230
δ	-0.043***	-0.049*** -0.050***

β	0.454**	0.372* 0.318*
α_0	0.265***	0.298*** 0.056***
α_{99}	-0.039**	-0.037* -0.045**
α_{15}	-0.035***	-0.029** -0.037***
R^2	0.0584	0.0384 0.0314
Root MSE	.0330885	.0390193 .0445371

*** p<0.01, ** p<0.05, * p<0.1

α_1 is significant for the USA and in the UK at 5% and 10% significance level respectively and demonstrates the positive effect of change in CPI ratio to change in exchange rate. δ is significant and negative for all of the countries, and can be interpreted as the error correction speed coefficient or speed of adjustment towards equilibrium. It is equal to 4%-5% for all three countries, which indicates the percentage by which the error is compensated. Intercept is also significant for all countries at a 1% significance level indicating the positive effect assuming other variables are constant. α and α_{99} are significant for all countries at least a 10% α_{15} significance level indicating additional negative effects of the periods before 2000 and August 2015 respectively. β is also significant in the USA at a 5% significance

level and in the UK and Japan at 10% indicating the positive long-run effect of the price ratios on the exchange rates.

Overall, these ECM results indicate that there is very weak evidence in favor of PPP to occur between the selected developed countries and Kazakhstan. Moreover, considering that the coefficients of β - which indicates a long-run effect of the changes in price ratio on the changes in exchange rate - are considerably below 1, we even can claim that there is no PPP between the USA, UK, and Japan relative to Kazakhstan.

The significant difference in inflation between Kazakhstan and Japan needs a corresponding adjustment in the currency rate. Also, the Japanese Central Bank's regulation of the Japanese yen blocks the holding of PPP conditions. Trade obstacles, particularly those linked to distance, limit the fulfillment of PPP requirements. Significant to mention, that oil and gas are important commodities traded between Kazakhstan and developed economies. However, in Kazakhstan, shifts in oil prices do not effectively represent inflation.

Conclusion

Our study shows that in former Soviet Union countries, PPP has a pretty strong tendency to hold. However, the evidence for PPP in Kyrgyzstan and Moldova is less compelling. Notably, the major economies, including the USA, the UK, and

Japan, show very weak signs of PPP adherence.

There are several trade treaties between Kazakhstan and post-Soviet Union countries, notably the Agreement on a CIS Free Trade Zone and the Treaty on the Eurasian Economic Union, which may explain the adherence to PPP between Kazakhstan and some post-Soviet countries. The failure to find PPP between Moldova and Kazakhstan can be explained by the far location and less amount of trade. However, it is surprising that the ECM did not provide evidence of PPP between Kazakhstan and Kyrgyzstan, although these are neighboring countries which trade a lot. Further research is needed to identify why there is no adherence to PPP between these countries.

There are a number of economic treaties and agreements between CIS countries that facilitate the economic integration and trade between these countries, which may contribute to the adherence of PPP among this region. The Treaty on the Eurasian Economic Union also provides favorable conditions for trade, such as tariff preferences, seasonal customs duties, a Single Customs Tariff, tariff benefits, tariff quota.

Additionally, the agreement on a free trade zone in the CIS is to improve the efficiency of trade through the abolition of quantitative restrictions in mutual trade, freedom of transit, non-application of customs duties on exports and imports, except

for goods that are different in each country. In Kazakhstan, for example, duties are applied to Ukraine on sugar and vodka. This agreement may facilitate the adherence to the PPP among CIS countries.

Another aspect of this agreement is the absence of obstacles to the collection of payments in the amount of domestic taxes of countries in respect of imported goods or fees based on the cost of services rendered.

However, for goods exported from the Republic of Kazakhstan to the Kyrgyz Republic and the Republic of Tajikistan, the application of customs duties may be regulated differently; multilateral and/or bilateral agreements, which may potentially contribute to the problem of identifying PPP between Kazakhstan and Kyrgyzstan. Kazakhstan also has duties on goods exported from the territory of the Republic of Kazakhstan outside the customs territory of the Customs Union, which apply to raw materials of animal and vegetable origin, metals, and energy sources (liquid fuels and gases).

For the major economies, however, the PPP seems not to hold relative to Kazakhstan. This can be explained by the fact that all three countries - the USA, the UK, and Japan - are located far from Kazakhstan. Consequently, Kazakhstan does not trade with these countries as frequently and on a large scale as with CIS countries. Deviations from PPP provide arbitrage opportunities. Due to trade

limitations, exchange rates may not be free to float, affecting the Law of One Price and the PPP relationship. Price variations are linked to factors such as customs processing fees and cross-border levies.

References

Arize, A. C., Malindretos, J., & Ghosh, D. K. (2015). Purchasing power parity-symmetry and proportionality: Evidence from 116 countries. *International Review of Economics & Finance*, *37*, 69–85. https://doi.org/10.1016/j.iref.2014.11.014

Brillembourg, A. (1977). Purchasing Power Parity and the Balance of Payments: Some Empirical Evidence (Parite des pouvoirs d'achat et balance des paiements: Resultats empiriques) (Paridad del poder adquisitivo y balanza de pagos: Algunas pruebas empiricas). *Staf Papers*, *24*(1), 77. https://doi.org/10.2307/3866537

Franke, A., Gawrich, A., & Alakbarov, G. (2009). Kazakhstan and Azerbaijan as Post-Soviet Rentier States: Resource Incomes and Autocracy as a Double "Curse" in Post-Soviet Regimes. *EUROPE-ASIA STUDIES*, *61*(1), 109–140. https://doi.org/10.1080/09668130802532977

Hadri, K., & Rao, Y. (2009). KPSS test and model misspecifications. Applied Economics Letters, 16(12), 1187–1190.

https://doi.org/10.1080/13504850701367239

Hendry, D. F., & Jusélius, K. (2000). Explaining Cointegration Analysis: Part 1. *The Energy Journal*, *21*(1). https://doi.org/10.5547/issn0195-6574-ej-vol21-no1-1

Junttila, J., & Korhonen, M. (2011). Nonlinearity and time-variation in the monetary model of exchange rates. *Journal of Macroeconomics*, *33*(2), 288–302. https://doi.org/10.1016/j.jmacro.2010.10.001

Kagalwala, A. (2022). kpsstest: A command that implements the Kwiatkowski, Phillips, Schmidt, and Shin test with sample-specific critical values and reports p-values. *The Stata Journal*, *22*(2), 269–292. https://doi.org/10.1177/1536867x221106371

Kheifets, I., & Phillips, P. C. (2023). Fully modified least squares cointegrating parameter estimation in multicointegrated systems. *Journal of Econometrics*, *232*(2), 300–319. https://doi.org/10.1016/j.jeconom.2021.07.002

Phillips, P. C. (1995). Fully modified least squares and vector autoregression. *Econometrica*, *63*(5), 1023. https://doi.org/10.2307/2171721

Phillips, P. C., & Hansen, B. E. (1990). Statistical Inference in Instrumental Variables Regression with I(1) Processes. *The Review of Economic Studies*, *57*(1), 99. https://doi.org/10.2307/2297545

Rogoff, K. (1995). The purchasing power parity puzzle. *Journal of Economic Literature*, *34*(2), 647–668. https://www.jstor.org/stable/2729217 StataCorp. (2021). Stata Data Management Reference Manual. *Stata Press, 17, 1695.* https://www.stata.com/manuals13/rnl.pdf

Taylor, M. P. (1988). An empirical examination of long-run purchasing power parity using cointegration techniques. *Applied Economics*, *20*(10), 1369–1381. https://doi.org/10.1080/00036848800000107

Taylor, M. P. (2003). Purchasing power parity. *Review of International Economics*, *11*(3), 436–452. https://doi.org/10.1111/1467-9396.00394

Tica, J., & Sorić, P. (2012). ECONOMIC INTEGRATIONS AND PURCHASING POWER PARITY ASSUMPTION. Economic research-Ekonomska Istraživanja, 4–20. https://hrcak.srce.hr/file/118960