



# Testing the Purchasing Power Parity Hypothesis with Tourism Price Indices for OECD Countries

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**Abstract:** *This chapter investigates the empirical validity of PPP for the group of 26 OECD economies. Four improvements are derived from the research. First, the testing strategy relies on two price indicators: the consumer price index for all items and the consumer price index for hotels and restaurants including catering and accommodation services. Second, the PPP theory is scrutinized by employing two base currencies; the US dollar and the euro. Third, the mean reversion hypothesis of OECD countries' real exchange rates is evaluated by a variety of first-generation panel unit root tests plus by the Pesaran CIPS unit root test integrating potential correlations across residuals of panel units. Fourth, the PPP model is inspected on a new data set covering the period from February 2002 to October 2022. The results reveal robust evidence of mean reversion of real exchange rates in the panel of OECD countries.*

## 1. INTRODUCTION

The theory of purchasing power parity (PPP) constitutes an indispensable part of any type of open economy model which describes price mechanisms underlying international trade flows and financial markets. The starting point of this theory is the idea that under efficient arbitrage across different markets, the price of an individual good converted to the same currency is the same in international markets. Extension of the logic of the law of one price over a homogeneous basket of goods and services results in the absolute PPP. Under the given exchange rate such a homogeneous basket of items should therefore cost the same in both countries leading to the equalization of national price levels (calculated in the same currency). Although the relative PPP allows differences between national price levels, it predicts that nominal exchange rates will systematically respond to inflation differentials between the observed economies. The PPP dictum essentially postulates that shifts in international relative prices dictate the behavior of exchange rates and that in the world of successful arbitrage as well as the high mobility of goods and services price differences are among particular competitive markets and between open economies in the long run theoretically nonexistent, empirically trivial.

The scientific literature provides a plethora of evidence about the possible factors causing at least short-run departures from PPP standards (Drissi & Boukhatem, 2020; Taylor & Taylor, 2004). The presence of menu costs, imperfect price flexibility and temporary market frictions require a certain time in the price adjustment towards PPP-determined levels. Significant transport costs, high tariffs in international trade and costly nontariff barriers are making the manifestation of the PPP mechanism even more difficult. The PPP-determined price adjustment can also be impeded due to excessive price-cost margins, the presence of differentiated and nontradable goods, extensive intra-industry trade activities, or due to the pricing to market strategies of companies (Cheung et al., 2001).

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The movement of real exchange rates towards the PPP level can also take nonlinear dynamics. Several sources of nonlinearity in real exchange rates have been identified (Taylor & Taylor, 2004; Taylor, 2006; Vo & Vo, 2020): high sunk costs of investments allow participants to enter the market only under substantial arbitrage opportunities; huge mismatch between expectations of dominant traders in foreign exchange markets and the expectations of market followers; the impact of central bank actions on market participants in circumstances of pronounced exchange rate misalignments. Above all, fundamental deviations from PPP equilibrium can be triggered by idiosyncratic productivity shocks, via the effects of government spending on relative prices and the structure of aggregate consumption, whereas demographic changes can increase the relative demand for nontradable old-age related goods and services (Abioglu & Hasanov, 2021; Groneck & Kaufmann, 2017; Taylor & Taylor, 2004).

The goal of this study is to put forward fresh evidence about the relevance of the PPP proposition in 26 members of The Organization for Economic Co-operation and Development (OECD). The group of OECD countries provides around 60% of world GDP and generates approximately 75% of world trade (U. S. Department of State, 2023). In 2019, member countries of the OECD accounted for 61% of all international travel receipts and 49 % of all international travel expenditures. In the pre-Covid-19 period, the average direct contribution of tourism to GDP in the OECD group amounted to 4.7%. Considerably above-average was 2019 the direct contribution of the tourism sector to OECD countries' GDP, for example in Spain (12.4%), Portugal, Mexico, Iceland (8% each), France (7.5%), and Greece (OECD, 2022a).

The current research on PPP for OECD economies stands out with four original contributions. First, the study relies on two categories of price indices: the consumer price index for all items and the consumer price index for hotels and restaurants including catering and accommodation services. Second, the testing procedures are performed on two base currencies; the US dollar and the euro. Third, the mean reversion hypothesis of OECD countries' real exchange rates is evaluated by a variety of first-generation panel unit root tests plus by the Pesaran CIPS unit root test integrating potential correlations across residuals of panel units. Fourth, the PPP model for the OECD club is inspected on a new data set covering the period from February 2002 to October 2022, and in addition, subsamples are created to investigate the impact of the Great Recession on PPP and to isolate the effects of Covid-19 pandemic outbreak on the observed empirical phenomenon.

The study is divided into the following seven sections. After the introduction, the relevant PPP studies for the group of OECD countries are evaluated in the second section. A description of the PPP theory and the implemented econometric strategy are presented in the third section. The definition of the available data set is given in the fourth section. Results of the empirical examination and possible extensions of the current research are elaborated in section five and section six, respectively. The fundamental conclusions of the study are summarized in the final section.

## 2. LITERATURE REVIEW

The overview of PPP studies which concentrate on the countries of the OECD group offers great heterogeneity in terms of applied methodological approaches, estimation techniques, types of data, and the period of the data observed. A large number of research papers examine the relevance of PPP conditions under the floating exchange rate regime in the post-Bretton Woods era. Coe and Serletis (2002) and Serletis and Gogas (2004) employ quarterly data for 21 OECD countries covering the period between 1973 and 1998 for three benchmark currencies: the US

dollar, the German DM mark and the Japanese yen. Serletis and Gogas (2004) found only weak evidence of PPP, whereas the research outcome in the paper written by Coe and Serletis (2002) is more encouraging. In their study the absolute PPP is rejected under the US dollar rates, some evidence about the absolute PPP is reported when the Japanese yen and the German mark are employed as base currencies. Further, Coe and Serletis (2002) confirm the existence of relative PPP irrespective of the used numeraire currency.

The behavior of exchange rates consistent with parity equilibrium conditions are scrutinized in the post-1973 period also in Narayan (2005) and Coakley et al. (2005). When applying the unit root test with structural breaks in the intercept and slope, Narayan (2005) reports only 3 valid PPP cases based on US dollar values out of 17 OECD countries, whereas for the German mark-based real exchange rates 7 PPP cases out of 17 OECD countries are revealed. Based on the finding of Coakley et al. (2005), the PPP relationship is substantially more sensitive to the selection of price index; more support for the PPP proposition is provided when the tested real exchange rates are derived from producer price indices. Regardless of the chosen panel unit root tests and numeraire currencies, on the other hand, the real exchange rates based on consumer price indices do not imitate the PPP trajectory. Kalyoncu and Kalyoncu (2008) operate with two types of real exchange rates; first, they are calculated by comparing consumer prices of 25 OECD economies with US consumer price indices, and second, they are corrected by the ratio between each OECD country's consumer price index and the consumer prices index of industrial countries. Experimenting with various country subgroups, Kalyoncu and Kalyoncu (2008) can confirm the stationarity of real exchange rates among OECD economies under both indicators of consumer price indices. Chortareas and Kapetanios (2009) analyze the relevance of PPP based on the US dollar and the German DM mark in 25 members of the OECD club over the period 1957-1998. Their estimates show that the mean reversion of real exchange rates is especially robust for US dollar rates.

Cerrato and Sarantis (2008) applied a variety of panel cointegration tests for 20 OECD countries between 1973 and 2000. The authors found significant cointegration between the US dollar-based nominal exchange rates and domestic and foreign prices thereby corroborating the weak version of PPP, although the joint symmetry and proportionality conditions (strong form of PPP) could not be validated for the complete set of OECD economies. Using the KPSS cointegration test with multiple structural breaks Narayan et al. (2009) confirmed a significant cointegration relationship between nominal exchange rates and relative prices for all OECD countries in the sample. In addition, among a range of econometric approaches, Ramajo and Ferré (2010) utilized various individual and panel cointegration tests. The derived results support the weak version of the PPP-determined relationship between nominal exchange rates and domestic and foreign prices, and even some evidence in favor of the strong version of PPP is obtained.

The issue of nonlinearity in the dynamics of PPP-driven real exchange rates in the OECD group is addressed among others by Ramajo and Ferré (2010), Christopoulos and León-Ledesma (2010) and Omay et al. (2020). Christopoulos and León-Ledesma (2010) specify structural breaks and nonlinear adjustment of US dollar-based real exchange rates with the ESTAR model for the quarterly time sample 1974-2006. The review of results shows that they can reject the nonstationarity in the observed real exchange rates for 14 countries out of 15 OECD economies. Evidence about the stationarity of real exchange rates for OECD countries is also presented by Ramajo and Ferré (2010) with a combination of various individual and panel unit root tests incorporating nonlinear adjustment processes. Omay et al. (2020) developed a new testing procedure that considers both temporary breaks in data series and nonlinear re-adjustment towards PPP-determined levels,

thereby avoiding the problem with the Fourier series that is not consistent with any exchange rate theory. Instead, they apply an exponential smooth transition function to specify the deterministic component of the series, simultaneously studying both symmetric and asymmetric ESTAR-type nonlinearities (Omay et al., 2020, 3489). With this testing strategy, the quoted authors verified 16 PPP cases among 26 real exchange rate series of OECD countries.

In the context of the global economy, in the world of increasing specialization and dispersed trade flows countries have many important trading partners, therefore the trade-weighted multilateral and effective real exchange rates could capture more precisely the degree of a country's international competitiveness. Studies analyzing PPP on real effective exchange rates of the OECD group include Aslan and Korap (2009); Cuestas and Regis (2013); Bahmani-Oskooee et al. (2014); Jiang et al. (2015) and Xie et al. (2021). Holmes et al. (2012) operated with trade-weighted multilateral real exchange rates in a panel of 26 OECD economies. The panel stationarity of related real exchange rates is established after the authors identify relevant structural breaks and cross-sectional dependencies in the data. On the whole empirical results found in Aslan and Korap (2009); Cuestas and Regis (2013), and Bahmani-Oskooee et al. (2014) are in favor of the PPP model at least for the group of OECD economies. Similarly, the hypothesis of PPP-determined real effective exchange rates holds for half of the sample of 34 OECD countries examined by Jiang et al. (2015). Xie et al. (2021) employ a range of advanced unit root tests on monthly real effective exchange rates of 23 OECD economies plus the members of the euro area for the period 1994-2019. In the quoted paper the researchers analyze four types of exchange rate specifications: standard PPP, trend PPP, qualified PPP and trend qualified PPP. Except for Ireland, at least one of the four types of PPP is substantiated for all of the economies studied by Xie et al. (2021). The validity of trend PPP in the data sample is verified by the majority of empirical tests. Xie et al. (2021) emphasize that more types of PPP are empirically accepted for economies with smaller GDP and that the government debt to GDP has a negative effect on the relevance of the PPP hypothesis.

The possibility that various shocks impact the dynamics of real exchange rates at different time intervals can be modeled by quantile unit root tests. Thus, Bahmani-Oskooee and Ranjbar (2016) adopt a quantile stationarity test on the sample of 23 OECD countries and detect 16 economies with mean reversion in their real effective exchange rates. Bahmani-Oskooee and Wu (2018) extend the quantile unit root testing procedure with specifications of sharp shifts and smooth breaks. Such an upgraded quantile unit root test is used on the real effective exchange rate series of 34 OECD countries over the period 1994-2016. The published results show that 18 countries' real effective exchange rates follow a mean reverting process consistent with the PPP proposition and the calculated half-life of the real effective exchange rate takes 7-18 months (Bahmani-Oskooee & Wu, 2018, p, 2633).

### 3. THE PPP HYPOTHESIS AND PRESENTATION OF ECONOMETRIC METHODOLOGY

The purchasing power parity (PPP) can be empirically expressed as (Froot & Rogoff, 1995):

$$e_t = \alpha_0 + \alpha_1 p_t + \alpha_2 p_t^* + \zeta_t \quad (1)$$

where  $e_t$  denotes the nominal exchange rates defined as the price of foreign currency in the units of domestic currency;  $p_t$  marks domestic price index and  $p_t^*$  foreign price index. The error term  $\zeta_t$  illustrates deviations from PPP. All variables are expressed in logarithms.

In this paper, we estimate the characteristics of real exchange rates in line with the strict version of PPP in Equation 1, where  $\alpha_0 = 0$ ,  $\alpha_1 = 1$  and  $\alpha_2 = -1$ . The nominal exchange rates should adjust in such a way as to eliminate the changes in relative prices. Therefore, the real exchange rates should be constant over the long-run and their time series are expected to be stationary, with no unit roots (Parikh & Wakerly, 2000).

In search of evidence in favor of PPP, this paper applies panel unit root tests. As described in Bekő and Boršič (2018) the model takes into account the following first-order autoregressive (AR(1)) process for panel data:

$$y_{i,t} = \rho_i y_{i,t-1} + X_{i,t} \delta_i + \varepsilon_{i,t} \quad (2)$$

where  $i$  represents  $N$  cross-section units observed over periods  $t = 1, 2, \dots, T_i$ ,  $X_{i,t}$  are exogenous variables in the model (any fixed effects or individual trends),  $\rho_i$  are autoregressive coefficients, while errors ( $\varepsilon_{i,t}$ ) are assumed as a mutually independent idiosyncratic disturbance. When the absolute value of  $\rho_i$  is less than 1,  $y_i$  is weakly stationary. When the absolute value of  $\rho_i$  is 1,  $y_i$  contains a unit root.

The panel unit root tests in this empirical study belong to the first and the second generation of panel unit root tests. The first generation of panel unit root tests assumes cross-section independence, while the second generation of panel unit root tests assumes cross-sectional dependence. Furthermore, the first-generation unit root tests differ in two assumptions about the  $\rho_i$  in panel unit root tests. Im et al. (2003), Fisher ADF and Fisher PP (Choi, 2001; Maddala & Wu, 1999) procedures deal with individual unit root processes, where  $\rho_i$  vary across cross-sections. While, Levin et al. (2002) and Breitung (2000) approaches consider common unit root processes, with common autoregressive coefficients across cross-sections ( $\rho_i = \rho$ ) for all  $i$ . According to Bekő and Boršič (2020), the preceding subchapters denote the specific characteristics of the first-generation panel unit root tests applied in this research.

### 3.1. Im, Pesaran and Shin Test

Im et al. (2003) take into account individual unit root processes and calculate individual ADF regression for each cross-section:

$$\Delta y_{i,t} = \alpha y_{i,t-1} + \sum_{j=1}^{p_i} \beta_{i,j} \Delta y_{i,t-j} + X'_{i,t} \delta + \varepsilon_{i,t} \quad (3)$$

where the null hypothesis is

$$H_0 : \alpha_i = 0, \text{ for all } i \quad (4)$$

while the alternative hypothesis is defined as:

$$H_1 : \begin{cases} \alpha_i = 0 & \text{for } i = 1, 2, \dots, N_1 \\ \alpha_i < 0 & \text{for } i = N_1 + 1, \dots, N \end{cases} \quad (5)$$

$\bar{t}$  stands for the average of the t-statistics for  $\alpha_i$  from individual ADF regressions:

$$\bar{t} = \frac{1}{N} \sum_{i=1}^N t_i \quad (6)$$

Im et al. (2003) standardize the  $\bar{t}$ -statistic and prove that the new statistic W is asymptotically normally distributed.

### 3.2. Fisher ADF and Fisher PP Tests

Taking into account the results of Fisher (1932), Maddala and Wu (1999) and Choi (2001) developed tests that integrate the individual p-values.  $\pi_i$  denotes the p-value from individual unit root test for cross-section  $i$ . According to Hurlin (2010) the corresponding p-values are uniform  $[0, 1]$  variables. Maddala and Wu (1999) define their statistic as

$$\chi^2 = -2 \sum_{i=1}^N \log(\pi_i) \quad (7)$$

and prove that it has an asymptotic  $\chi^2$ -distribution with  $2N$  degrees of freedom. Choi (2001) defines a similar Z statistic:

$$Z = - \frac{\sum_{i=1}^N \log(\pi_i) + N}{\sqrt{N}} \quad (8)$$

The null and alternative hypotheses are the same as for the Im, Pesaran and Shin test above (Equations 4 and 5). Under the null hypothesis, Z-statistic is normally distributed.

### 3.3. Levin, Lin and Chu test, and Breitung Test

Levin et al. (2002) test takes into account the following ADF specification:

$$\Delta y_{i,t} = \alpha y_{i,t-1} + \sum_{j=1}^{p_i} \beta_{i,j} \Delta y_{i,t-j} + X'_{i,t} \delta + \varepsilon_{i,t} \quad (9)$$

where a common  $\alpha = \rho - 1$  is assumed, while the lag order for difference terms ( $p_i$ ) varies across cross-sections. The null hypothesis ( $H_0: \alpha = 0$ ) implies that there is a unit root. While the alternative hypothesis ( $H_1: \alpha < 0$ ) implies stationarity. In Levin et al. (2002) approach the first step requires an assessment of auxiliary regressions of  $\Delta y_{i,t}$  and  $y_{i,t}$  on lagged terms  $\Delta y_{i,t-j}$  and exogenous variables  $X_{it}$ . Residuals (denoted by  $\tilde{\cdot}$ ) are used as proxies for  $\Delta y_{i,t}$  and  $y_{i,t}$ . In the next step,  $\alpha$  is calculated from the pooled equation:

$$\Delta \tilde{y}_{i,t} = \alpha \tilde{y}_{i,t-1} + \eta_{i,t} \quad (10)$$

Since the standard t-statistic for testing the hypothesis  $\hat{\alpha} = 0$  diverges to negative infinity, Levin et al. (2002) derive the modified  $t$  statistics ( $t^*$  in Equation 11) and show that it is asymptotically normally distributed.

$$t^* = \frac{1}{\sigma^*} \left( t - NT \cdot \hat{S}_N \hat{\sigma}^{-2} \hat{\sigma}_\alpha \mu^* \right) \quad (11)$$

where

$\mu^*$  and  $\sigma^*$  are adjustment terms for the mean and standard deviation calculated by Levin et al. (2002),

$\hat{\sigma}_\alpha^2$  is the standard error of  $\hat{\alpha}$ ,

$\hat{\sigma}^2$  is the estimated variance of the residuals from equation (10) and

$\hat{S}_N$  denotes the average of individual ratios of long-run to short-run standard deviations.

$\hat{S}_N$  is estimated with kernel-based techniques. According to Levin et al. (2002) we applied Bartlett kernel, Parzen kernel and quadratic spectral kernel. To check the robustness of the results we also considered regression (9) augmented with individual linear deterministic trends. The number of lags in each cross-section ADF regression ( $p_i$ ) was selected by the Schwarz information criterion.

The Breitung test is similar to Levin, Lin and Chu test. It estimates auxiliary regressions of  $\Delta y_{i,t}$  and  $y_{i,t}$  on lagged terms  $\Delta y_{i,t-j}$  only, while proxies are transformed and detrended ( $\Delta y_{it}^*$ ). Panel proxy equation is used to estimate the persistence parameter  $\alpha$ :

$$\Delta y_{it}^* = \alpha y_{it-1}^* + v_{it} \quad (12)$$

According to Breitung (2000) under the null hypothesis, the estimate of the persistence parameter  $\alpha$  is asymptotically normally distributed.

### 3.4. Cross-section Dependence Test

In order to place ground for the second generation panel unit root test, we conducted a battery of cross-section dependence tests. The results of Breuch-Pagan LM test, Pesaran scaled LM test, Baltago, Feng and Kao bias-corrected LM test and Pesaran CD tests are presented in Table 15.

### 3.5. Pesaran CIPS Test

The framework for Pesaran (2007) Cross-sectionally augmented IPS (CIPS) test is an integrated panel data model, which can be formally expressed as:

$$Y_{i,t} = D_{it} + u_{it} \quad (13)$$

where  $D_{it}$  are the model deterministic dynamics and  $u_{it}$  are the innovations. The first generation panel unit root tests described above all assume that  $u_{it}$  are independent across cross sections ( $i$ ). To take into account the cross sectional dependence  $u_{it}$  is structured as follows:

$$u_{it} = \lambda_i' F_t + v_{it} \quad (14)$$

where  $\lambda_i$  presents a vector of cross section specific factors,  $v_{it}$  denotes a multivariate idiosyncratic component, which is cross sectionally independent, while  $F_t$  accounts for all inter cross sectional dependence and is a vector of  $r$  common factors generated by a multivariate noise process  $\eta_t$

$$(1-L) F_t = C(L) \eta_t \quad (15)$$

where  $L$  is lag operator. Thus, the integrated panel model assuming cross sectional dependence can be written as:

$$Y_{i,t} = D_{it} + \lambda_i' F_t + v_{it} \quad (16)$$

The Pesaran CIPS test considers cross-sectional dependency by restricting model (16) to a single stationary common factor ( $r=1, F_t=I(0)$ ). Thus, model 16 becomes a simple heterogeneous

dynamic linear model. Rewriting it in ADF form, Pesaran derives the null hypothesis for the unit root and for  $N$  sufficiently large also derives a proxy for the common factor  $F_t$ :

$$\bar{Y}_t = \frac{1}{N} \sum_{s=1}^N Y_{st} \quad (17)$$

Using these proxies Pesaran obtains the cross-sectionally augmented ADF (CADF) equation:

$$\Delta Y_{it} = \mu_i + \gamma_i t + \rho_i Y_{it-1} + \sum_{k=1}^p \varphi_{ik} \Delta Y_{it-k} + \alpha_i \bar{Y}_{it-1} + \sum_{k=1}^p \beta_{ik} \Delta \bar{Y}_{it-k} + \varepsilon_{it} \quad (18)$$

If  $\tau_i^{CADF}$  is t-statistics related to traditional ADF test, the panel unit root test is a pooled version of individual CADF statistics, namely cross-sectionally augmented (CIPS) statistics:

$$\tau_i^{CIPS} = \frac{1}{N} \sum_{i=1}^N \tau_i^{CADF} \quad (19)$$

A truncated CIPS accounts for the influence of extreme outcomes if  $T$  is sufficiently small. CIPS and truncated CIPS critical values have been derived by Pesaran (2007) since the two test statistics do not have standard limiting distribution.

#### 4. DESCRIPTION OF DATA

The preceding empirical tests are based on monthly data covering the period from February 2002 to October 2022 for 26 OECD countries, including Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Korea, Latvia, Lithuania, Luxembourg, Norway, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom. Thus, the panel dataset consists of 26 cross-sections and 249-period observations, resulting in a total of 6474 observations.

The consumer price indices (CPI, previous month=100) and the monthly averages of nominal exchange rates with reference currencies of euro (EUR) and US dollar (USD) were gathered from [IMF International Financial Statistics \(2022\)](#). In pursuance of applying empirical investigation for the tourism sector, data for CPI for hotels and restaurants (CPI C11) were assembled from [OECD \(2022b\)](#) database for most of the observed countries, except Euroarea ([Eurostat, 2022](#)), Finland ([Statistics Finland, 2022](#)), Hungary ([Hungarian Central Statistical Office, 2022](#)), Spain ([Instituto Nacional de Estadística \(2022\)](#)), Switzerland ([Federal Statistical Office, 2022](#)) and USA ([U.S. Bureau of Labour Statistics, 2022](#)). Utilized CPI C11 data for the USA were calculated as a geometric average of data series CPI for “Food away from home” (BLS series code: CUUR0000SEFV), and data series CPI for “Lodging away from home” (BLS series code: CUUR0000SEHB).

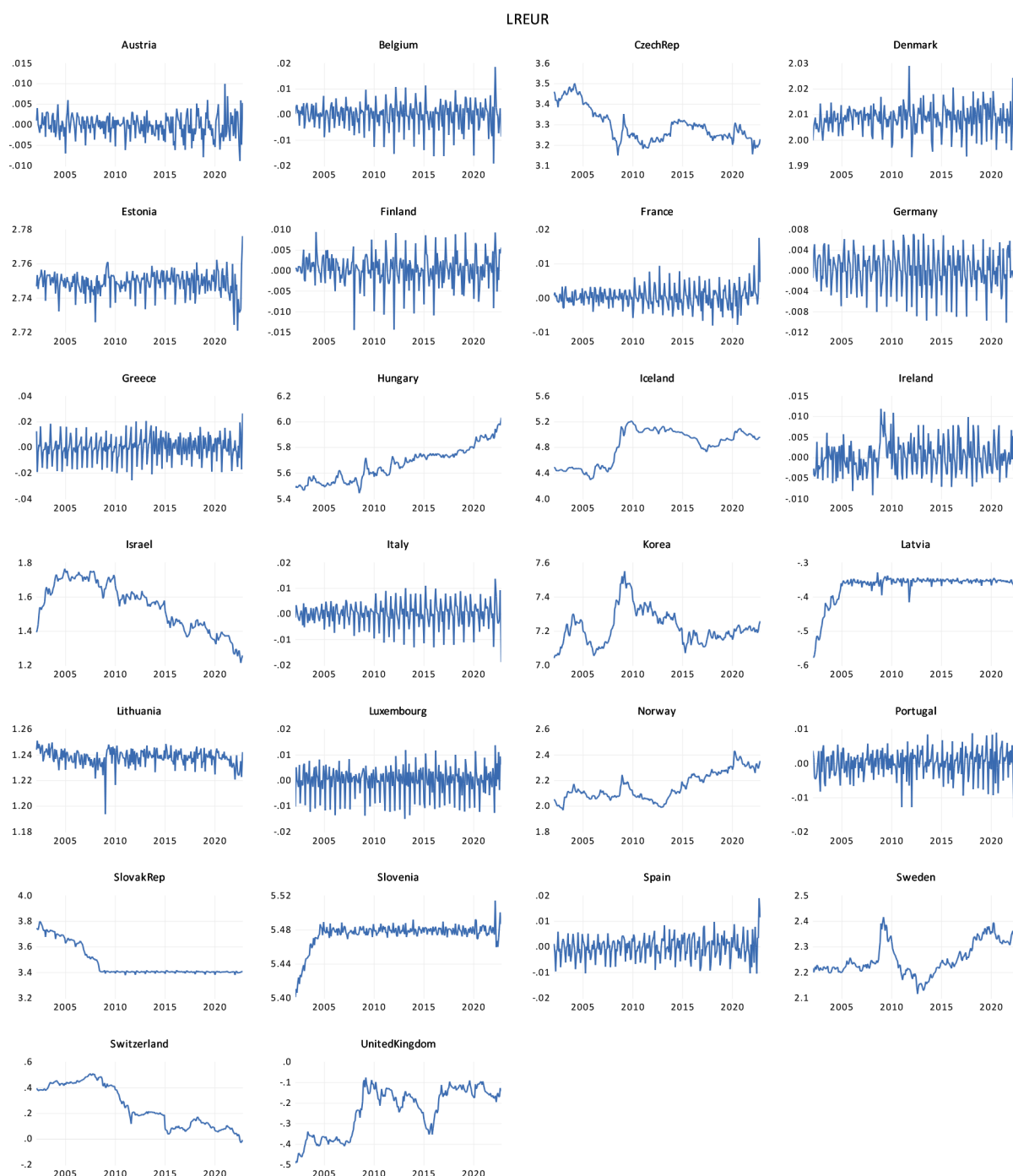
The first step in testing the strict version of PPP requires the calculation of real exchange rates:

$$RER = NER \frac{P^*}{P} \quad (20)$$

where RER stands for real exchange rate, NER is abbreviation for nominal exchange rate defined as a price of foreign currency in units of domestic currency,  $P^*$  is a foreign price index and  $P$  is a domestic price index. There are four sets of real exchange rates used in the empirical analysis.

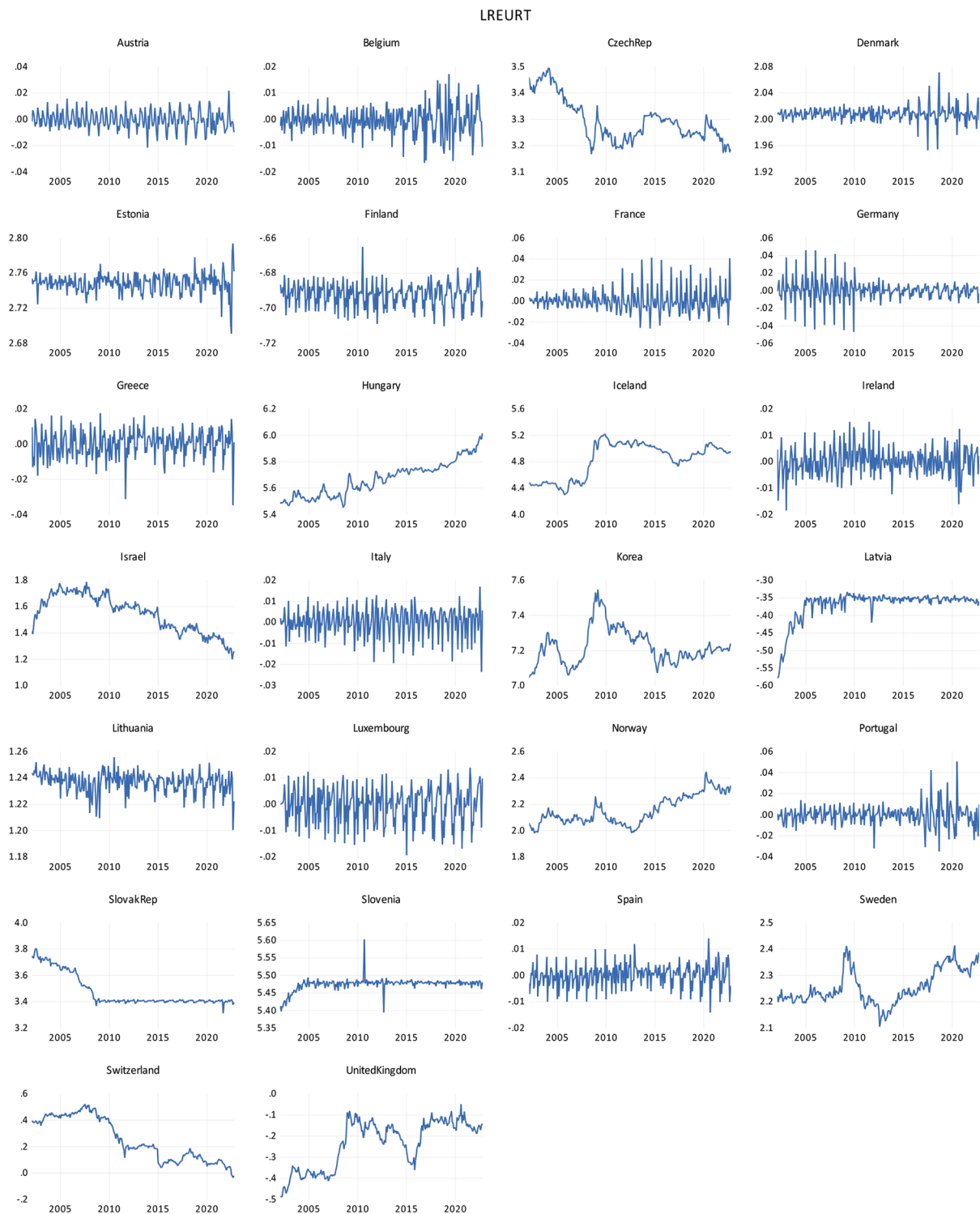
Namely, the real exchange rates are calculated by two reference currencies (EUR and USD) and by using two different price deflators: CPI for the whole economy (CPI All items) and CPI for hotels and restaurants including catering and accommodation services (CPI C11 Hotels and restaurants).

The empirical analysis is generated by using logarithmic values of individual real exchange rates. Thus, the logarithms of real exchange rates based on CPI All items are presented in Figures 1 and 2, while Figures 3 and 4 display the logarithms of real exchange rates when CPI for tourism services was taken into account.



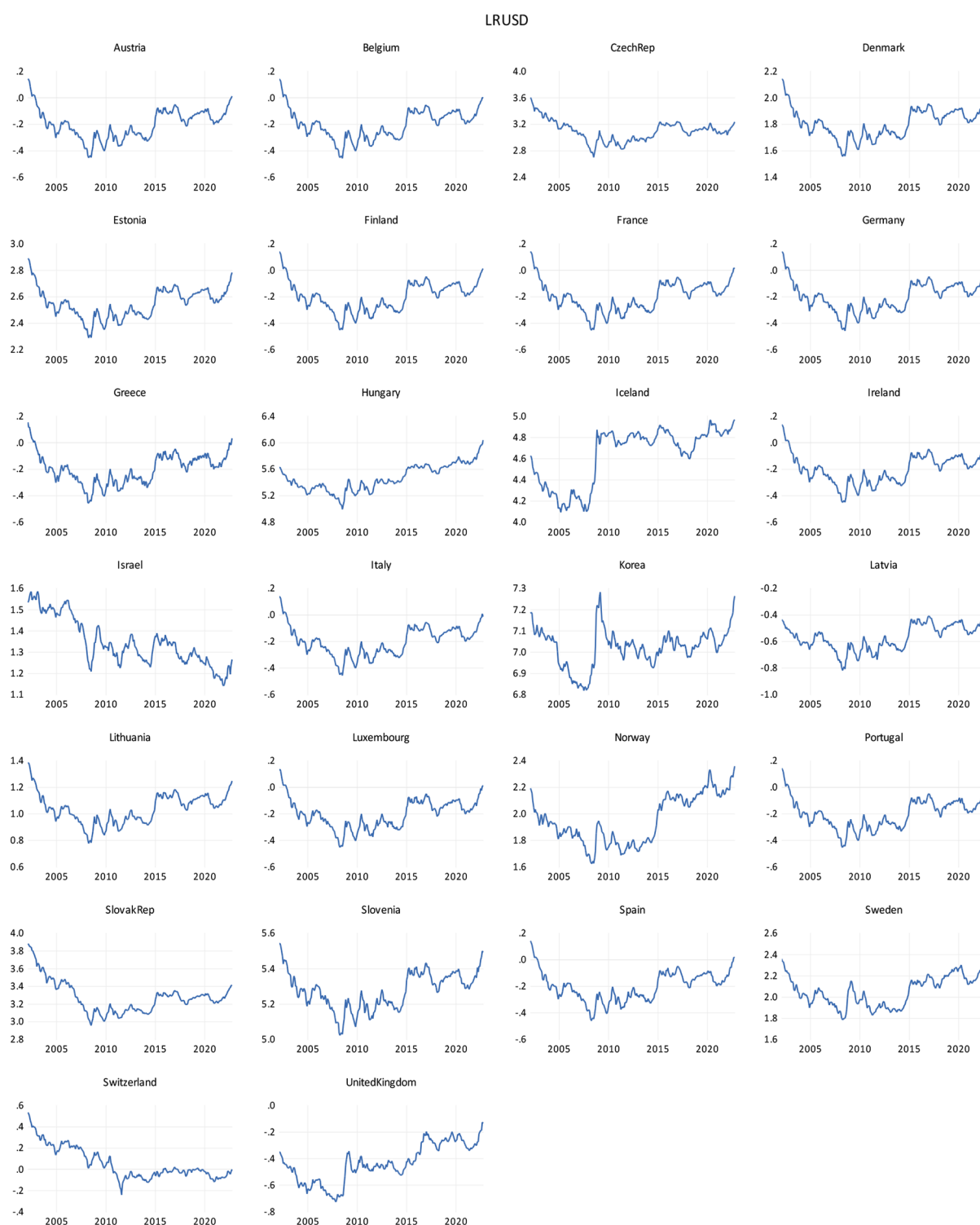
**Figure 1.** Logarithms of real exchange rates of selected OECD countries, reference currency EUR and CPI (All items) deflator

Source: Authors' compilation based on IMF (2022) and Eurostat (2022) data



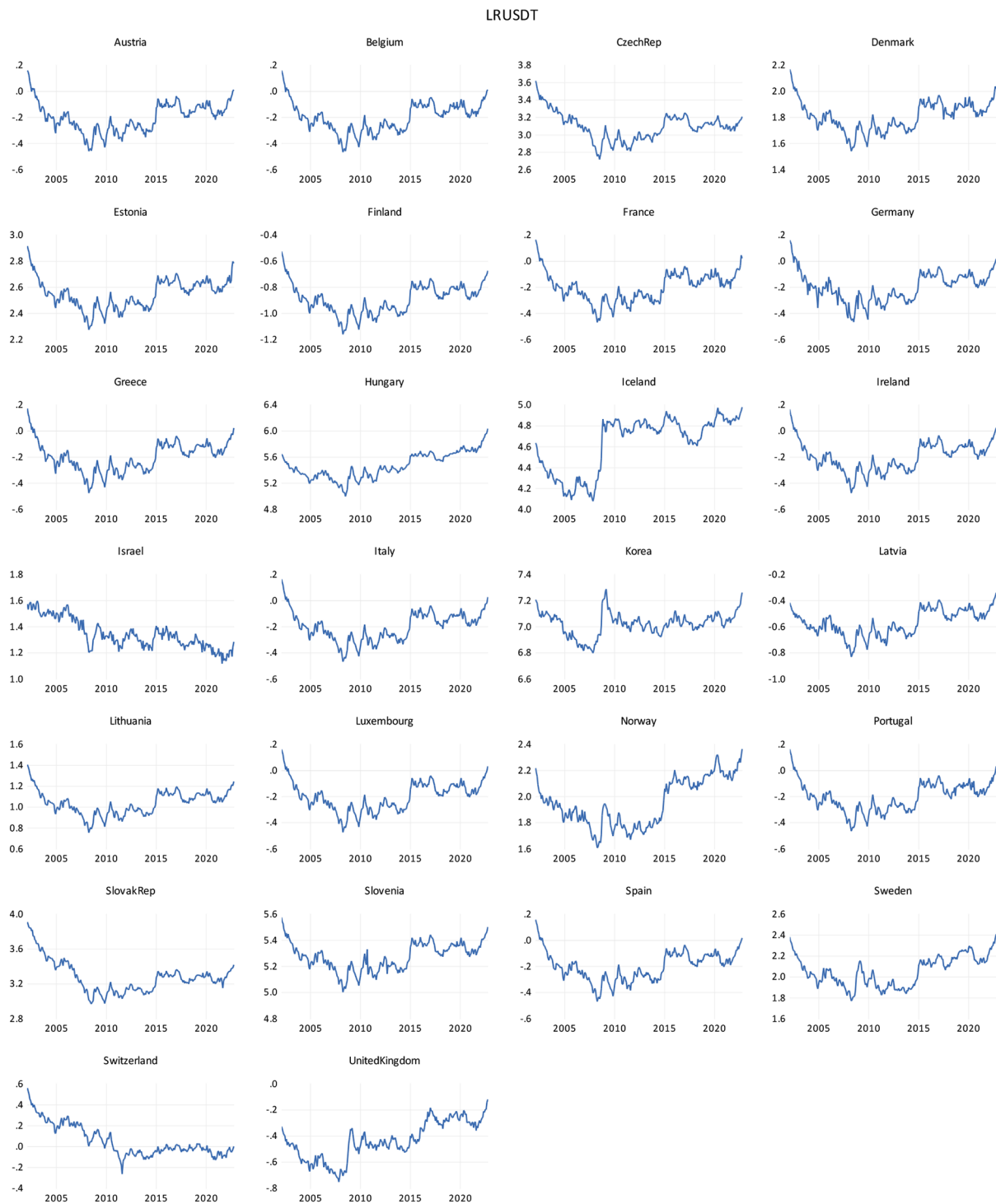
**Figure 2.** Logarithms of real exchange rates of selected OECD countries, reference currency EUR and CP11 (Hotels and restaurants) deflator

**Source:** Authors' compilation based on IMF (2022), OECD (2022b), Eurostat (2022), Statistics Finland (2022), Hungarian Central Statistical Office (2022), Instituto Nacional de Estadística (2022), and Federal Statistical Office (2022) data



**Figure 3.** Logarithms of real exchange rates of selected OECD countries, reference currency USD and CPI (All items) deflator

**Source:** Authors' compilation based on IMF (2022) and U.S. Bureau of Labour Statistics (2022) data



**Figure 4.** Logarithms of real exchange rates of selected OECD countries, reference currency USD and CP11 (Hotels and restaurants) deflator

**Source:** Authors' compilation based on IMF (2022), OECD (2022b), Eurostat (2022), Statistics Finland (2022), Hungarian Central Statistical Office (2022), Instituto Nacional de Estadística (2022), Federal Statistical Office (2022) and U.S. Bureau of Labour Statistics (2022) data

The empirical study was divided into four parts for both deflators. First, we analyzed the whole observed period (February 2002-October 2022) with 6474 observations. Second, we took into account the pre-pandemic period by shortening the sample to February 2020, resulting in 5642 observations. Third, we considered the pre-economic crisis period ranging from February 2002

to December 2007 including 1846 observations. And fourth, we studied the post-economic crisis period covering data from July 2009 to October 2022, consisting of 4160 observations. The **NBER (2012)** methodology for defining the US business cycles was applied to settle the subperiods. The following chapter presents the results of individual panel unit root tests for all four periods. The first set of tables examines the PPP concept for the whole economy based on CPI (All items) deflator, while the second set of tables reveals the evidence of PPP for the tourism sector based on the CPI for hotels and restaurants.

## 5. EMPIRICAL RESULTS

Results of first-generation panel unit root tests taking into account the individual unit root process (Im, Pesaran and Shin test, Fisher ADF tests and Fisher PP tests) are presented first, followed by the results of the two-panel unit root tests of the first-generation (Levin, Lin and Chu test, and Breitung test), which consider common unit root process. All tests that belong to the first generation assume no cross-section dependence, while the second generation panel unit root tests assume that there is dependency across cross-sections. That is why the results of the first-generation tests are followed by the results of the cross-section dependence test and then the outcomes of the Pesaran CIPS test are displayed.

### 5.1. Results Derived from the Consumer Price Index for All Items

Table 1 presents the results of Im, Pesaran, Shin test when CPI for all items was taken into account. The results for EUR present straightforward support for the validity of PPP, since all real exchange rates panels are stationary, as the null hypothesis of unit root can be strongly rejected for all versions of the test, regardless of information criteria for lag selection and taking into account individual effects alone or together with an individual linear trend. The same results apply to all four periods under investigation.

Also, results for USD are similarly strongly supporting the PPP theory for the whole sample, for the pre-pandemic period and the pre-crisis period. While in the post-Great Recession period, the evidence in favor of PPP depends on whether individual trends are taken into account. When only individual effects are considered the PPP theory cannot be confirmed. Including individual effects and individual trends Im, Pesaran and Shin test strongly confirms the validity of PPP.

**Table 1.** Results of Im, Pesaran and Shin test, CPI (All items) deflator

Sample	Reference currency	Schwarz information criterion		Akaike information criterion		Hannan-Quinn information criterion	
		Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends
		W-stat (p-value) [no. of lags]	W-stat (p-value) [no. of lags]	W-stat (p-value) [no. of lags]	W-stat (p-value) [no. of lags]	W-stat (p-value) [no. of lags]	W-stat (p-value) [no. of lags]
2002M2-2022M10	EUR	-5.78014 (0.0000) [0-13]	-6.07918 (0.0000) [0-13]	-5.24698 (0.0000) [0-15]	-5.36721 (0.0000) [0-15]	-5.33729 (0.0000) [0-14]	-5.19043 (0.0000) [0-14]
	USD	-4.74517 (0.0000) [0-7]	-6.35259 (0.0000) [0-7]	-4.19008 (0.0000) [1-15]	-5.78950 (0.0000) [1-15]	-4.51504 (0.0000) [0-13]	-6.20566 (0.0000) [0-13]

2002M2- 2020M2	EUR	-6.84502 (0.0000) [0-13]	-6.88171 (0.0000) [0-13]	-5.68557 (0.0000) [0-14]	5.56488 (0.0000) [0-14]	-6.27352 (0.0000) [0-14]	-5.88820 (0.0000) [0-14]
	USD	-6.62722 (0.0000) [0-7]	-5.99606 (0.0000) [0-7]	-5.72964 (0.0000) [0-14]	-5.25286 (0.0000) [1-14]	-6.25777 (0.0000) [0-13]	5.75651 (0.0000) [0-13]
2002M2- 2007M12	EUR	-10.3098 (0.0000) [0-11]	-11.7987 (0.0000) [0-11]	-5.04674 (0.0000) [0-11]	-5.65684 (0.0000) [0-11]	-7.53462 (0.0000) [0-11]	-5.73629 (0.0000) [0-11]
	USD	-2.63621 (0.0042) [0-2]	-2.79200 (0.0026) [0-1]	-3.11910 (0.0009) [0-4]	-3.59317 (0.0002) [0-4]	-2.76575 (0.0028) [0-2]	-3.41163 (0.0003) [0-4]
2009M7- 2022M10	EUR	-5.09361 (0.0000) [0-13]	-5.10935 (0.0000) [0-12]	-3.51309 (0.0002) [0-13]	-3.16001 (0.0008) [0-13]	-4.09549 (0.0000) [0-13]	-4.01587 (0.0000) [0-13]
	USD	1.82794 (0.9662) [0-7]	-2.84118 (0.0022) [0-7]	0.73293 (0.7682) [0-13]	-5.03570 (0.0000) [0-13]	1.15103 (08751) [0-7]	-3.81023 (0.0001) [0-7]

Source: Authors' calculations

Table 2. Results of Fisher ADF tests (Maddala and Wu  $\chi^2$  statistic), CPI (All items) deflator

Sample	Reference currency	Schwarz information criterion		Akaike information criterion		Hannan-Quinn information criterion	
		Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends
		$\chi^2$ (p-value) [no. of lags]	$\chi^2$ (p-value) [no. of lags]	$\chi^2$ (p-value) [no. of lags]	$\chi^2$ (p-value) [no. of lags]	$\chi^2$ (p-value) [no. of lags]	$\chi^2$ (p-value) [no. of lags]
2002M2- 2022M10	EUR	202.502 (0.0000) [0-13]	191.605 (0.0000) [0-13]	179.419 (0.0000) [0-15]	161.641 (0.0000) [0-15]	180.951 (0.0000) [0-14]	159.273 (0.0000) [0-14]
	USD	111.485 (0.0000) [0-7]	123.604 (0.0000) [0-7]	103.407 (0.0000) [1-15]	114.435 (0.0000) [1-15]	107.689 (0.0000) [0-13]	121.008 (0.0000) [0-13]
2002M2- 2020M2	EUR	189.863 (0.0000) [0-13]	179.082 (0.0000) [0-13]	150.872 (0.0000) [0-14]	132.592 (0.0000) [0-14]	167.222 (0.0000) [0-14]	145.652 (0.0000) [0-14]
	USD	140.138 (0.0000) [0-7]	117.321 (0.0000) [0-7]	125.549 (0.0000) [0-14]	105.621 (0.0000) [1-14]	133.274 (0.0000) [0-13]	113.148 (0.0000) [0-13]
2002M2- 2007M12	EUR	233.374 (0.0000) [0-11]	264.123 (0.0000) [0-11]	148.543 (0.0000) [0-11]	136.544 (0.0000) [0-11]	191.175 (0.0000) [0-11]	149.282 (0.0000) [0-11]
	USD	72.2410 (0.0331) [0-1]	72.2625 (0.0330) [0-1]	78.2212 (0.0108) [0-4]	80.8290 (0.0064) [0-4]	74.1377 (0.0024) [0-2]	77.9812 (0.0113) [0-4]
2009M7- 2022M10	EUR	189.578 (0.0000) [0-13]	170.243 (0.0000) [0-12]	130.397 (0.0000) [0-13]	108.543 (0.0000) [0-13]	1347.867 (0.0000) [0-13]	113.756 (0.0000) [0-13]
	USD	29.3628 (0.9952) [0-7]	71.9742 (0.0347) [0-7]	37.6908 (0.9319) [0-13]	102.062 (0.0000) [0-13]	34.1233 (0.9738) [0-7]	83.3177 (0.0038) [0-7]

Source: Authors' calculations

Since Fisher ADF tests provide two test statistics, the estimated Maddala and Wu  $\chi^2$  statistics are presented in Table 2 and the estimated Choi Z statistics are displayed in Table 3. Both statistics enable similar conclusions as Im, Pesaran, and Shin test above. Since in all cases, the null hypothesis of a unit root can be strongly rejected, there is strong support for the PPP

theory in the case of the EUR reference currency. Similarly, the strong evidence in favor of PPP is documented in the whole period, pre-pandemic and pre-crisis periods when USD is used as reference currency. For the post-crisis period, the results depend on deterministic parameters. When taking into account individual effects and individual linear trends, the estimated test statistics strongly reject the null hypothesis and confirm the stationarity of the real exchange rates panel based on USD. But when only individual effects are considered the PPP cannot be confirmed.

Also, the Fisher PP test derives two test statistics. Table 4 presents the estimated Maddala and Wu  $\chi^2$  statistics and Table 5 demonstrates the estimated Choi Z statistics. For the whole period and the pre-pandemic period the PPP is strongly supported for real exchange rate panels based on EUR and USD reference currency. PPP is strongly confirmed also for EUR as a reference currency for pre- and post-crisis periods. In the pre-Great Recession period, there is evidence in favor of PPP for USD as a reference currency only when individual effects and individual trends are included in test specifications. However, in the post-crisis period, only one out of six versions of test specifications confirms the PPP for USD-based real exchange rates.

**Table 3.** Results of Fisher ADF tests (Choi Z statistic), CPI (All items) deflator

Sample	Reference currency	Schwarz information criterion		Akaike information criterion		Hannan-Quinn information criterion	
		Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends
		Z (p-value) [no. of lags]	Z (p-value) [no. of lags]	Z (p-value) [no. of lags]	Z (p-value) [no. of lags]	Z (p-value) [no. of lags]	Z (p-value) [no. of lags]
2002M2- 2022M10	EUR	-5.66171 (0.0000) [0-13]	-5.56139 (0.0000) [0-13]	-5.27360 (0.0000) [0-15]	-4.91066 (0.0000) [0-15]	-5.33896 (0.0000) [0-14]	-4.82349 (0.0000) [0-14]
	USD	-4.97738 (0.0000) [0-7]	-6.55241 (0.0000) [0-7]	-4.33927 (0.0000) [1-15]	-5.90280 (0.0000) [1-15]	-4.70607 (0.0000) [0-13]	-6.37866 (0.0000) [0-13]
2002M2- 2020M2	EUR	-6.73052 (0.0000) [0-13]	-6.38078 (0.0000) [0-13]	-5.71559 (0.0000) [0-14]	-5.25665 (0.0000) [0-14]	-6.26080 (0.0000) [0-14]	-5.52731 (0.0000) [0-14]
	USD	-6.92172 (0.0000) [0-7]	-6.18613 (0.0000) [0-7]	-5.92363 (0.0000) [0-14]	-5.33194 (0.0000) [1-14]	-6.51742 (0.0000) [0-13]	-5.92322 (0.0000) [0-13]
2002M2- 2007M12	EUR	-7.90642 (0.0000) [0-11]	-8.55379 (0.0000) [0-11]	-4.37430 (0.0000) [0-11]	-4.61720 (0.0000) [0-11]	-6.42010 (0.0000) [0-11]	-4.52622 (0.0000) [0-11]
	USD	-2.69767 (0.0331) [0-2]	-2.88208 (0.0020) [0-1]	-3.13628 (0.0009) [0-4]	-3.71273 (0.0001) [0-4]	-2.81992 (0.0024) [0-2]	-3.54171 (0.0002) [0-4]
2009M7- 2022M10	EUR	-4.81655 (0.0000) [0-13]	-4.51182 (0.0000) [0-12]	-3.58572 (0.0002) [0-13]	-2.90504 (0.0018) [0-13]	-4.15672 (0.0000) [0-13]	-3.84135 (0.0001) [0-13]
	USD	2.03444 (0.9790) [0-7]	-2.92754 (0.0017) [0-7]	1.04427 (0.8518) [0-13]	-5.01966 (0.0000) [0-13]	1.36921 (0.9145) [0-7]	-3.87837 (0.0001) [0-7]

Source: Authors' calculations

The results of the Levin, Lin and Chu test presented in Table 6 show that the PPP is valid for EUR-based real exchange rates only for the pre-crisis period when all test specifications

strongly reject the null hypothesis of unit root. Similarly, strong support for PPP yields in the whole period, the pre-pandemic and pre-crisis period for USD-based real exchange rates. In the post-crisis period, there is no evidence for the validity of PPP regardless of reference currency and regardless of test specifications.

Table 7 displays the results of the Breitung test, which provide no support for PPP in the whole period and the pre-pandemic period neither for EUR nor USD as reference currency no matter what test specification is chosen. When the economic crisis is taken into account, the results show that before the crisis and after the crisis PPP could be confirmed for real exchange rates based on USD, while it cannot be confirmed for real exchange rates based on EUR. Some weak evidence in favor of PPP is provided for EUR-based real exchange rates in the pre-Great Recession period when lag selection is based on the Schwartz information criterion.

**Table 4.** Results of Fisher PP tests (Maddala and Wu  $\chi^2$  statistic), CPI (All items) deflator

Sample	Reference currency	Bartlett kernel		Parzen kernel		Quadratic spectral kernel	
		Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends
		$\chi^2$ (p-value)	$\chi^2$ (p-value)	$\chi^2$ (p-value)	$\chi^2$ (p-value)	$\chi^2$ (p-value)	$\chi^2$ (p-value)
2002M2-2022M10	EUR	1675.23 (0.0000)	1642.14 (0.0000)	1652.27 (0.0000)	1619.03 (0.0000)	1652.51 (0.0000)	1626.86 (0.0000)
	USD	117.185 (0.0000)	113.878 (0.0000)	120.271 (0.0000)	115.674 (0.0000)	117.185 (0.0000)	113.878 (0.0000)
2002M2-2020M2	EUR	1536.19 (0.0000)	1387.49 (0.0000)	1480.69 (0.0000)	1420.82 (0.0000)	1475.49 (0.0000)	1413.47 (0.0000)
	USD	140.884 (0.0000)	106.316 (0.0000)	142.800 (0.0000)	107.619 (0.0000)	143.060 (0.0000)	108.406 (0.0000)
2002M2-2007M12	EUR	418.636 (0.0000)	378.904 (0.0000)	423.525 (0.0000)	-13.0455 (0.0000)	416.362 (0.0000)	392.364 (0.0000)
	USD	73.4882 (0.0265)	59.6991 (0.2161)	74.7673 (0.0210)	59.6662 (0.2170)	74.0471 (0.0239)	59.8177 (0.2131)
2009M7-2022M10	EUR	1517.45 (0.0000)	1270.55 (0.0000)	1498.15 (0.0000)	1359.14 (0.0000)	1495.09 (0.0000)	1384.02 (0.0000)
	USD	29.3483 (0.9953)	58.2042 (0.2477)	32.9492 (0.9819)	65.6695 (0.0964)	32.4511 (0.9847)	63.7731 (0.1268)

Source: Authors' calculations

**Table 5.** Results of Fisher PP tests (Choi Z statistic), CPI (All items) deflator

Sample	Reference currency	Bartlett kernel		Parzen kernel		Quadratic spectral kernel	
		Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends
		Z (p-value)	Z (p-value)	Z (p-value)	Z (p-value)	Z (p-value)	Z (p-value)
2002M2-2022M10	EUR	-29.7721 (0.0000)	-29.7936 (0.0000)	-29.5972 (0.0000)	-29.9685 (0.0000)	29.6331 (0.0000)	-30.0407 (0.0000)
	USD	-5.33035 (0.0000)	-6.01740 (0.0000)	-5.53659 (0.0000)	-6.13536 (0.0000)	-5.33035 (0.0000)	-6.01740 (0.0000)

2002M2- 2020M12	EUR	-28.4226 (0.0000)	-26.5486 (0.0000)	-27.6294 (0.0000)	-2.0247 (0.0000)	-27.5584 (0.0000)	-26.8798 (0.0000)
	USD	-6.94482 (0.0000)	-5.56639 (0.0000)	-7.06569 (0.0000)	-5.65544 (0.0000)	-7.09141 (0.0000)	-5.70167 (0.0000)
2002M2- 2007M12	EUR	-14.3603 (0.0000)	-12.9721 (0.0000)	-14.4514 (0.0000)	-13.0455 (0.0000)	-14.3047 (0.0000)	-13.3386 (0.0000)
	USD	-2.79687 (0.0026)	-2.09163 (0.0182)	-2.88660 (0.0019)	-2.11544 (0.0172)	-2.84388 (0.0022)	-2.09836 (0.0179)
2009M7- 2022M10	EUR	-29.6170 (0.0000)	-27.8986 (0.0000)	-29.4251 (0.0000)	-29.1773 (0.0000)	-29.3501 (0.0000)	-29.4357 (0.0000)
	USD	2.05960 (0.9803)	-2.16138 (0.0153)	1.56819 (0.9416)	-2.80474 (0.0025)	1.65338 (0.9509)	-2.65081 (0.0040)

Source: Authors' calculations

Table 6. Results of Levin, Lin and Chu test, CPI (All items) deflator

Sample	Reference currency	Bartlett kernel		Parzen kernel		Quadratic spectral kernel	
		Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends
		t* (p-value) [no. of lags]	t* (p-value) [no. of lags]	t* (p-value) [no. of lags]	t* (p-value) [no. of lags]	t* (p-value) [no. of lags]	t* (p-value) [no. of lags]
2002M2- 2022M10	EUR	1.36681 (0.9142) [0-13]	2.03139 (0.9789) [0-13]	-0.09635 (0.4616) [0-13]	-0.73034 (0.2326) [0-13]	-0.13162 (0.4476) [0-13]	-0.73401 (0.2315) [0-13]
	USD	-2.69403 (0.0035) [0-7]	-8.18550 (0.0000) [0-7]	-2.39598 (0.0083) [0-7]	-7.88830 (0.0000) [0-7]	-2.35920 (0.0092) [0-7]	-7.73071 (0.0000) [0-7]
2002M2- 2020M2	EUR	1.41886 (0.9220) [0-14]	3.71566 (0.9999) [0-14]	-0.14018 (0.4443) [0-14]	1.01058 (0.8439) [0-14]	-0.51255 (0.3041) [0-14]	-0.52406 (0.6999) [0-14]
	USD	-5.58281 (0.0000) [0-7]	-8.87669 (0.0000) [0-7]	-5.31250 (0.0000) [0-7]	-8.60589 (0.0000) [0-7]	-5.26012 (0.0000) [0-7]	-8.46474 (0.0000) [0-7]
2002M2- 2007M12	EUR	-3.73422 (0.0001) [0-11]	-3.03986 (0.0012) [0-11]	-5.75558 (0.0000) [0-11]	-6.60570 (0.0000) [0-11]	-5.86588 (0.0000) [0-11]	-6.66652 (0.0000) [0-11]
	USD	-7.25265 (0.0000) [0-2]	-4.90553 (0.0000) [0-1]	-7.28113 (0.0000) [0-2]	-5.10481 (0.0000) [0-1]	-7.25634 (0.0000) [0-2]	-4.96540 (0.0000) [0-1]
2009M7- 2022M10	EUR	2.30704 (0.9895) [0-13]	3.08865 (0.9990) [0-12]	0.40181 (0.6561) [0-13]	-0.53095 (0.2977) [0-12]	0.32106 (0.6259) [0-13]	-0.61789 (0.2683) [0-12]
	USD	3.45708 (0.9997)	1.78662 (0.9630)	3.80202 (0.9999)	2.33860 (0.9903)	2.75764 (0.9999)	2.24572 (0.9876)

Notes: The number of lags used in each cross-section ADF regression ( $p_i$ ) was defined by the Schwarz information criterion. Computation was conducted with Newey-West bandwidth selection.

Source: Authors' calculations

Table 7. Results of Breitung test, CPI (All items) deflator

Sample	Reference currency	Schwarz information criterion	Akaike information criterion	Hannan-Quinn information criterion
		Individual effects and individual linear trends		
		t-stat (p-value) [no. of lags]	t-stat (p-value) [no. of lags]	t-stat (p-value) [no. of lags]

2002M2- 2022M10	EUR	4.50768 (1.000) [0-13]	4.44414 (1.000) [0-15]	4.24031 (1.000) [0-13]
	USD	4.09138 (1.000) [0-7]	3.89616 (1.000) [1-15]	4.04705 (1.000) [0-13]
2002M2- 2020M2	EUR	0.24556 (0.4030) [0-13]	-0.10530 (0.4581) [0-14]	-0.22920 (0.4094) [0-14]
	USD	1.74548 (0.9595) [0-7]	1.97004 (0.9756) [1-14]	1.79023 (0.9633) [0-13]
2002M2- 2007M12	EUR	-1.30312 (0.0963) [0-11]	0.94250 (0.1730) [0-11]	-0.62994 (0.2644) [0-11]
	USD	-1.42759 (0.0767) [0-1]	-1.96242 (0.0249) [0-4]	-1.91247 (0.0279) [0-4]
2009M7- 2022M10	EUR	3.87283 (0.9999) [0-12]	4.65690 (1.0000) [0-13]	3.62470 (0.9999) [0-13]
	USD	-2.97103 (0.0015) [0-7]	-4.37493 (0.0000) [0-13]	-3.67756 (0.0001) [0-7]

Source: Authors' calculations

## 5.2. Results Derived from the Consumer Price Index for Hotels and Restaurants

Results of the first generation panel unit root tests for real exchange rates based on prices of tourism services (CPI CP11 Hotels and restaurants) are exhibited in Tables 8 to 14. Estimated W-statistics derived from Im, Pesaran and Shin test are presented in Table 8. For all exhibited test specifications and for both reference currencies the null hypothesis can be strongly rejected for the whole period, the pre-pandemic period and pre-crisis period confirming the PPP proposition. In the post-crisis period, the null is strongly rejected again for all test variants in the case of EUR reference currency, while the results for USD reference currency depend on the inclusion of deterministic parameters. If only individual effects are taken into account, the null hypothesis cannot be rejected. PPP validity can be confirmed if both individual effects and individual linear trends are included.

Tables 9 and 10 present the results of Fisher ADF tests. In the whole period, the results of both test statistics provide straightforward support for PPP validity when EUR is chosen as the reference currency. The Choi Z statistic (Table 10) yields strong evidence in favor of PPP also for USD-based real exchange rates, while Maddala and Wu  $\chi^2$  statistic (Table 9) supports the PPP theory in five out of six types of test specifications. During the pre-pandemic period and pre-crisis period, both test statistics reject the null hypothesis of unit root, suggesting that the panels are stationary for both reference currencies. In the post-crisis period, there is a strong confirmation of PPP theory in the case of EUR reference currency, while PPP is confirmed for real exchange rates based on USD, only when individual effects and individual linear trends are included in the test specification for both test statistics.

Tables 11 and 12 exhibit the results of Fisher PP tests. Both test statistics for all presented test specifications strongly reject the null hypothesis of unit root, providing support for PPP standard for both reference currencies in the whole observed period, in the pre-pandemic period and

the pre-crisis period. In the post-crisis period, the same holds true for EUR reference currency, while the USD-based real exchange rate panel is stationary when individual effects and individual trends are taken into account.

**Table 8.** Results of Im, Pesaran and Shin test, CP11  
(Hotels and restaurants) deflator

Sample	Reference currency	Schwarz information criterion		Akaike information criterion		Hannan-Quinn information criterion	
		Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends
		W-stat (p-value) [no. of lags]	W-stat (p-value) [no. of lags]	W-stat (p-value) [no. of lags]	W-stat (p-value) [no. of lags]	W-stat (p-value) [no. of lags]	W-stat (p-value) [no. of lags]
2002M2-2022M10	EUR	-8.45378 (0.0000) [0-15]	-9.26773 (0.0000) [0-15]	-4.96031 (0.0000) [2-15]	-4.20099 (0.0000) [2-15]	-6.22200 (0.0000) [0-15]	-6.83329 (0.0000) [0-15]
	USD	-5.65312 (0.0000) [0-13]	-7.23880 (0.0000) [0-13]	-1.64128 (0.0504) [0-14]	-4.36878 (0.0000) [0-15]	-4.99475 (0.0000) [0-13]	-6.81894 (0.0000) [0-13]
2002M2-2020M2	EUR	-8.59184 (0.0000) [0-14]	-7.4420 (0.0000) [0-14]	-5.79892 (0.0000) [0-14]	-5.40052 (0.0000) [0-14]	-6.37968 (0.0000) [0-14]	-7.16983 (0.0000) [0-14]
	USD	-7.12203 (0.0000) [0-13]	-6.31751 (0.0000) [0-13]	-2.95247 (0.0016) [0-14]	-3.28230 (0.0005) [0-14]	-6.34356 (0.0000) [0-14]	-5.94558 (0.0000) [0-13]
2002M2-2007M12	EUR	-2.61104 (0.0045) [0-11]	-4.10230 (0.0000) [0-11]	-2.58036 (0.0049) [0-11]	-2.43149 (0.0075) [0-11]	-2.87985 (0.0020) [0-11]	-2.39616 (0.0083) [0-11]
	USD	-3.85975 (0.0001) [0-2]	-5.72075 (0.0000) [0-2]	2.99405 (0.0014) [0-11]	-3.74740 (0.0001) [0-11]	-3.13789 (0.0009) [0-3]	-4.58357 (0.0000) [0-2]
2009M7-2022M10	EUR	-9.72397 (0.0000) [0-13]	-10.9005 (0.0000) [0-13]	-6.78215 (0.0000) [0-13]	-7.51934 (0.0000) [0-13]	-9.18749 (0.0000) [0-13]	-10.4426 (0.0000) [0-13]
	USD	0.45883 (0.6768) [0-12]	-4.05686 (0.0000) [0-12]	0.56714 (0.7147) [0-13]	-4.47241 (0.0000) [0-13]	0.69193 (0.7555) [0-13]	-4.17287 (0.0000) [0-12]

Source: Authors' calculations

**Table 9.** Results of Fisher ADF tests (Maddala and Wu  $\chi^2$  statistic), CP11  
(Hotels and restaurants) deflator

Sample	Reference currency	Schwarz information criterion		Akaike information criterion		Hannan-Quinn information criterion	
		Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends
		$\chi^2$ (p-value) [no. of lags]	$\chi^2$ (p-value) [no. of lags]	$\chi^2$ (p-value) [no. of lags]	$\chi^2$ (p-value) [no. of lags]	$\chi^2$ (p-value) [no. of lags]	$\chi^2$ (p-value) [no. of lags]
2002M2-2022M10	EUR	281.151 (0.0000) [0-15]	287.311 (0.0000) [0-15]	147.271 (0.0000) [2-15]	108.324 (0.0000) [2-15]	200.254 (0.0000) [0-15]	195.080 (0.0000) [0-15]
	USD	129.698 (0.0000) [0-13]	139.364 (0.0000) [0-13]	63.8478 (0.1255) [0-14]	86.9130 (0.0017) [0-15]	117.794 (0.0000) [0-13]	131.158 (0.0000) [0-13]

2002M2-2020M2	EUR	270.043 (0.0000) [0-14]	206.379 (0.0000) [0-14]	159.923 (0.0000) [2-14]	132.259 (0.0000) [2-14]	180.397 (0.0000) [0-14]	198.206 (0.0000) [0-14]
	USD	151.664 (0.0000) [0-13]	122.107 (0.0000) [0-13]	79.4660 (0.0084) [0-14]	71.4639 (0.0379) [0-14]	136.396 (0.0000) [0-14]	115.419 (0.0000) [0-13]
2002M2-2007M12	EUR	9.2555 (0.0001) [0-11]	106.105 (0.0000) [0-11]	103.161 (0.0000) [0-11]	72.6305 (0.0309) [0-11]	97.3051 (0.0001) [0-11]	72.7038 (0.0305) [0-11]
	USD	84.4105 (0.0030) [0-2]	112.493 (0.0000) [0-2]	78.5550 (0.0101) [0-11]	82.2078 (0.0048) [0-11]	78.6620 (0.0099) [0-3]	95.6761 (0.0002) [0-2]
2009M7-2022M10	EUR	316.831 (0.0000) [0-13]	311.293 (0.0000) [0-13]	211.779 (0.0000) [0-13]	208.552 (0.0000) [0-13]	302.464 (0.0000) [0-13]	300.015 (0.0000) [0-13]
	USD	41.9958 (0.8378) [0-12]	85.8359 (0.0022) [0-12]	41.6091 (0.8484) [0-13]	92.2346 (0.0005) [0-13]	40.7085 (0.8713) [0-13]	88.0049 (0.0013) [0-12]

Source: Authors' calculations

**Table 10.** Results of Fisher ADF tests (Choi Z statistic), CP11  
 (Hotels and restaurants) deflator

Sample	Reference currency	Schwarz information criterion		Akaike information criterion		Hannan-Quinn information criterion	
		Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends
		Z (p-value) [no. of lags]	Z (p-value) [no. of lags]	Z (p-value) [no. of lags]	Z (p-value) [no. of lags]	Z (p-value) [no. of lags]	Z (p-value) [no. of lags]
2002M2-2022M10	EUR	-7.83728 (0.0000) [0-15]	-8.05358 (0.0000) [0-15]	4.96701 (0.0000) [2-15]	-3.81047 (0.0001) [2-15]	-6.05343 (0.0000) [0-15]	-6.13864 (0.0000) [0-15]
	USD	-5.90311 (0.0000) [0-13]	-7.36306 (0.0000) [0-13]	-1.40576 (0.0799) [0-14]	-4.26592 (0.0000) [0-15]	-5.17618 (0.0000) [0-13]	-6.93296 (0.0000) [0-13]
2002M2-2020M2	EUR	-8.09746 (0.0000) [0-14]	-6.77719 (0.0000) [0-14]	-5.79076 (0.0000) [2-14]	-5.00837 (0.0000) [2-14]	-6.34685 (0.0000) [0-14]	-6.47304 (0.0000) [0-14]
	USD	-7.39160 (0.0000) [0-13]	-6.45591 (0.0000) [0-13]	-2.81862 (0.0024) [0-14]	-3.09736 (0.0010) [0-14]	-6.55870 (0.0000) [0-14]	-6.05822 (0.0000) [0-13]
2002M2-2007M12	EUR	-2.40834 (0.0080) [0-11]	-2.97914 (0.0014) [0-11]	-2.35415 (0.0093) [0-11]	-1.94030 (0.0262) [0-11]	-2.65562 (0.0040) [0-11]	-1.94060 (0.0262) [0-11]
	USD	-3.90798 (0.0000) [0-2]	-5.72260 (0.0000) [0-2]	-2.95656 (0.0016) [0-11]	-3.70139 (0.0001) [0-11]	-3.13328 (0.0009) [0-3]	-4.56924 (0.0000) [0-2]
2009M7-2022M10	EUR	-8.30900 (0.0000) [0-13]	-8.93200 (0.0000) [0-13]	-6.06757 (0.0000) [0-13]	-6.30327 (0.0000) [0-13]	-7.89596 (0.0000) [0-13]	-8.58427 (0.0000) [0-13]
	USD	0.59819 (0.7251) [0-12]	-4.19302 (0.0000) [0-12]	0.76170 (0.7769) [0-13]	-4.55180 (0.0000) [0-13]	0.86362 (0.8061) [0-13]	-4.26910 (0.0000) [0-12]

Source: Authors' calculations

**Table 11.** Results of Fisher PP tests (Maddala and Wu  $\chi^2$  statistic), CP11 (Hotels and restaurants) deflator

Sample	Reference currency	Bartlett kernel		Parzen kernel		Quadratic spectral kernel	
		Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends
		$\chi^2$ (p-value)	$\chi^2$ (p-value)	$\chi^2$ (p-value)	$\chi^2$ (p-value)	$\chi^2$ (p-value)	$\chi^2$ (p-value)
2002M2-2022M10	EUR	1646.26 (0.0000)	1718.29 (0.0000)	1525.50 (0.0000)	1604.65 (0.0000)	1506.07 (0.0000)	1578.20 (0.0000)
	USD	145.075 (0.0000)	153.521 (0.0000)	145.702 (0.0000)	153.205 (0.0000)	146.054 (0.0000)	154.861 (0.0000)
2002M2-2020M2	EUR	1516.88 (0.0000)	1529.41 (0.0000)	1424.23 (0.0000)	1476.14 (0.0000)	1406.26 (0.0000)	1455.14 (0.0000)
	USD	163.680 (0.0000)	132.425 (0.0000)	164.329 (0.0000)	132.365 (0.0000)	165.252 (0.0000)	133.634 (0.0000)
2002M2-2007M12	EUR	367.176 (0.0000)	348.317 (0.0000)	364.935 (0.0000)	336.098 (0.0000)	361.937 (0.0000)	338.887 (0.0000)
	USD	92.6917 (0.0004)	109.893 (0.0000)	93.2782 (0.0004)	111.464 (0.0000)	92.3517 (0.0005)	110.056 (0.0000)
2009M7-2022M10	EUR	1538.85 (0.0000)	1492.15 (0.0000)	1342.55 (0.0000)	1225.90 (0.0000)	1334.28 (0.0000)	1226.23 (0.0000)
	USD	52.3044 (0.4621)	112.723 (0.0000)	53.4267 (0.4192)	118.906 (0.0000)	53.6845 (0.4096)	118.128 (0.0000)

Source: Authors' calculations

**Table 12.** Results of Fisher PP tests (Choi Z statistic), CP11 (Hotels and restaurants) deflator

Sample	Reference currency	Bartlett kernel		Parzen kernel		Quadratic spectral kernel	
		Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends
		Z (p-value)	Z (p-value)	Z (p-value)	Z (p-value)	Z (p-value)	Z (p-value)
2002M2-2022M10	EUR	-29.7358 (0.0000)	-31.0818 (0.0000)	-27.8368 (0.0000)	-29.3452 (0.0000)	-27.5268 (0.0000)	-28.9838 (0.0000)
	USD	-6.83600 (0.0000)	-8.01233 (0.0000)	-6.86481 (0.0000)	-7.98762 (0.0000)	-6.89367 (0.0000)	-8.07373 (0.0000)
2002M2-2020M2	EUR	-28.602 (0.0000)	-28.7356 (0.0000)	-27.0754 (0.0000)	-27.6182 (0.0000)	-26.7956 (0.0000)	-27.3720 (0.0000)
	USD	-8.07111 (0.0000)	-6.98555 (0.0000)	-8.11077 (0.0000)	-6.98640 (0.0000)	-8.16758 (0.0000)	-7.05077 (0.0000)
2002M2-2007M12	EUR	-13.0694 (0.0000)	-12.9698 (0.0000)	-13.0443 (0.0000)	-12.7983 (0.0000)	-12.9646 (0.0000)	-12.8078 (0.0000)
	USD	-4.52924 (0.0000)	-5.70804 (0.0000)	-4.55753 (0.0000)	-5.76883 (0.0000)	-4.49011 (0.0000)	-5.70133 (0.0000)
2009M7-2022M10	EUR	-30.2797 (0.0000)	-31.2532 (0.0000)	-27.5462 (0.0000)	-27.3986 (0.0000)	-27.3799 (0.0000)	-27.3852 (0.0000)
	USD	0.04237 (0.5169)	-5.64942 (0.0000)	0.04065 (0.5162)	-5.96722 (0.0000)	-0.07664 (0.4695)	-5.95479 (0.0000)

Source: Authors' calculations

**Table 13.** Results of Levin, Lin and Chu test, CP11 (Hotels and restaurants) deflator

Sample	Reference currency	Bartlett kernel		Parzen kernel		Quadratic spectral kernel	
		Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends
		t* (p-value) [no. of lags]	t* (p-value) [no. of lags]	t* (p-value) [no. of lags]	t* (p-value) [no. of lags]	t* (p-value) [no. of lags]	t* (p-value) [no. of lags]
2002M2- 2022M10	EUR	1.56910 (0.9417) [0-15]	2.14248 (0.9839) [0-15]	-1.04781 (0.1474) [0-15]	-2.73933 (0.0031) [0-15]	-1.18456 (0.1181) [0-15]	-2.93088 (0.0017) [0-15]
	USD	-3.02190 (0.0013) [0-13]	-8.27487 (0.0000) [0-13]	-3.13387 (0.0009) [0-13]	-8.84831 (0.0000) [0-13]	-5.93265 (0.0017) [0-13]	-8.32181 (0.0000) [0-13]
2002M2- 2020M2	EUR	-6.18619 (0.0000) [0-14]	-9.58728 (0.0000) [0-14]	-7.63947 (0.0000) [0-14]	-11.9205 (0.0000) [0-14]	-7.67016 (0.0000) [0-14]	-11.8885 (0.0000) [0-14]
	USD	-5.50982 (0.0000) [0-13]	-8.33662 (0.0000) [0-13]	5.63636 (0.0000) [0-13]	-8.80337 (0.0000) [0-13]	-5.38655 (0.0000) [0-13]	-8.23877 (0.0000) [0-13]
2002M2- 2007M12	EUR	3.30467 (0.9995) [0-11]	5.09327 (1.0000) [0-11]	-0.05693 (0.4773) [0-11]	-0.02802 (0.4888) [0-11]	-0.13699 (0.4455) [0-11]	-0.09656 (0.4615) [0-11]
	USD	-7.45163 (0.0000) [0-2]	-6.94050 (0.0000) [0-2]	-7.60761 (0.0000) [0-2]	-7.26210 (0.0000) [0-2]	-7.70555 (0.0000) [0-2]	-7.31277 (0.0000) [0-2]
2009M7- 2022M10	EUR	1.12839 (0.8704) [0-13]	1.42992 (0.9236) [0-13]	3.38923 (0.9996) [0-13]	5.64214 (1.0000) [0-13]	1.71491 (0.9568) [0-13]	1.89922 (0.9712) [0-13]
	USD	3.25976 (0.9994) [0-12]	1.91255 (0.9721) [0-12]	2.90377 (0.9982) [0-12]	1.20489 (0.8859) [0-12]	3.10765 (0.9991) [0-12]	1.62364 (0.9478) [0-12]

**Notes:** The number of lags used in each cross-section ADF regression ( $p_i$ ) was defined by the Schwarz information criterion. Computation was conducted with Newey-West bandwidth selection.

**Source:** Authors' calculations

Levin, Lin and Chu test results, demonstrated in Table 13, strongly confirm PPP in the case of EUR reference currency only in the pre-pandemic period. While only two test specifications out of six in the whole period provide support for PPP when EUR base exchange rates are tested. This test provides more support for PPP in the case of USD reference rates, namely the PPP validity is strongly confirmed in the whole sample, in the pre-pandemic period and the pre-crisis period. As for the post-Great Recession period, no evidence of PPP is detected no matter which reference currency and which test specification is taken into account.

**Table 14.** Results of Breitung test, CP11 (Hotels and restaurants) deflator

Sample	Reference currency	Schwarz information criterion	Akaike information criterion	Hannan-Quinn information criterion
		Individual effects and individual linear trends		
		t-stat (p-value) [no. of lags]	t-stat (p-value) [no. of lags]	t-stat (p-value) [no. of lags]
2002M2- 2022M10	EUR	0.36167 (0.6412) [0-15]	1.97595 (0.9759) [2-15]	0.71821 (0.7637) [0-15]
	USD	3.88920 (0.9999) [0-13]	4.15112 (1.0000) [0-15]	3.83795 (0.9999) [0-13]

2002M2- 2020M2	EUR	-1.17392 (0.1202) [0-14]	-0.49001 (0.3121) [2-14]	-0.93132 (0.1758) [0-14]
	USD	2.54520 (0.9945) [0-13]	2.66317 (0.9961) [0-14]	2.45261 (0.9929) [0-13]
2002M2- 2007M12	EUR	-0.69885 (0.2423) [0-11]	-0.75909 (0.2239) [0-11]	-0.07318 (0.4708) [0-11]
	USD	-0.69072 (0.2449) [0-2]	3.09800 (0.9990) [0-11]	1.90896 (0.9719) [0-2]
2009M7- 2022M10	EUR	0.97937 (0.8363) [0-13]	3.19177 (0.9993) [0-13]	1.14872 (0.8747) [0-13]
	USD	-2.04805 (0.0203) [0-12]	-0.80152 (0.2114) [0-13]	-1.11179 (0.1331) [0-12]

Source: Authors' calculations

Breitung test results listed in Table 14 provide almost no support for PPP as in all cases the null hypothesis of unit root cannot be rejected. Only when Schwarz information criteria in the post-crisis period are applied for lag selection, the USD-based exchange rates show support for PPP.

### 5.3. Results Derived from the Second-Generation Panel Unit Root Test

Before proceeding to the second generation panel unit test, Table 15 presents the results of the cross-section dependence test. All four test specifications strongly reject the null of no cross-section dependence for all four periods under investigation and for both reference currencies. These results provide support for applying the second-generation panel unit root tests. In this study, the Pesaran CIPS test was applied for the same periods, price indices, and reference currencies as the above-presented first-generation panel unit root tests.

Table 15. Cross-Section Dependence Test

	Breusch-Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD
<b>2002M2 – 2022M10</b>				
EUR CPI	8474.125***	319.6350***	319.5826***	20.95241***
USD CPI	49712.58***	1937.140***	1937.088***	199.3473***
EUR CP11	7781.483***	292.4673***	292.4149***	14.48261***
USD CP11	49531.61***	1930.042***	1929.990***	199.5850***
<b>2002M2 – 2020M2</b>				
EUR CPI	7623.628***	286.2758***	286.2156***	21.62850***
USD CPI	43778.01***	1704.367***	1704.307***	189.5820***
EUR CP11	6693.385***	249.7886***	249.7284***	15.04277***
USD CP11	43721.02***	1702.132***	1702.072***	190.0578***
<b>2002M2 – 2007M12</b>				
EUR CPI	2128.719***	70.74768***	70.56196***	11.5691***
USD CPI	20659.99***	797.6038***	797.4181***	143.3675***
EUR CP11	3444.050***	1223.392***	1221.535***	1889.405***
USD CP11	20518.44***	792.0519***	791.8662***	142.8362***
<b>2009M7 – 2022M10</b>				
EUR CPI	5334.113***	196.4736***	196.3918***	28.07937***
USD CPI	35572.23***	1382.510***	1382.429***	170.3549***
EUR CP11	4603.435***	167.8140***	167.7323***	20.26979***
USD CP11	35333.69***	1317.154***	1373.072***	170.8734***

Source: Authors' calculations

**Table 16.** Results of Pesaran CIPS test (CIPS statistic), CPI (All items) deflator

Reference currency	Schwarz information criterion		Akaike information criterion		Hannan-Quinn information criterion	
	Constant	Constant and trend	Constant	Constant and trend	Constant	Constant and trend
	CIPS statistic					
<b>2002M2 - 2022M10</b>						
EUR	-3.36153***	-3.90506***	-1.99959	-2.60789*	-2.59301***	-3.16161***
USD	-2.63605***	-3.20595***	-2.93027***	-3.57668***	-2.65126***	-3.33661***
<b>2002M2 - 2020M2</b>						
EUR	-4.25714***	-4.85505***	-2.41736***	-3.02483***	-3.18667***	-3.90681***
USD	-2.63121***	-3.08017***	-3.04885***	-3.55478***	-2.83944***	-3.33945***
<b>2002M2 - 2007M12</b>						
EUR	-4.59711***	-4.92420***	-2.61018***	-3.18834***	-3.27001***	-4.24434***
USD	-1.99020	-2.63491*	-2.28560**	-2.24956	-2.01142	-2.54499
<b>2009M7 - 2022M10</b>						
EUR	-4.12493***	-4.75191***	-2.14467*	-2.72910**	-2.64381***	-3.31385***
USD	-3.08528***	-3.53425***	-2.79838***	-3.22227***	-2.89687***	-3.30892***

Source: Authors' calculations

Table 16 (CIPS statistics) and Table 17 (truncated CIPS statistics) display the results of the Pesaran CIPS test when CPI for the whole economy are utilized, while Table 18 (CIPS statistics) and Table 19 (truncated CIPS statistics) demonstrate the results of Pesaran CIPS test when CPI for tourism services (CPI CP11 Hotels and restaurants) are taken into account when calculating the real exchange rates.

Results in Table 16 and Table 17 provide similar conclusions about PPP validity. Concerning the CIPS statistics, estimated results support PPP in the whole sample, in the pre-pandemic period and post-crisis period for exchange rate panels based on both, EUR and USD reference currencies. During the pre-crisis period, the PPP can be confirmed for EUR-based exchange rates, while for the USD-based exchange rates the PPP is not supported since four out of six test specifications do not reject the null of unit root. The truncated CIPS statistics also show some deviations from PPP validity in the case of EUR-based exchange rates in two cases of specifications in the whole period, one case in the pre-pandemic period and one case in the post-crisis period.

**Table 17.** Results of Pesaran CIPS test (truncated CIPS statistic), CPI (All items) deflator

Reference currency	Schwarz information criterion		Akaike information criterion		Hannan-Quinn information criterion	
	Constant	Constant and trend	Constant	Constant and trend	Constant	Constant and trend
	Truncated CIPS statistic					
<b>2002M2 - 2022M10</b>						
EUR	-2.78886***	-3.38086***	-1.98700	-2.60594	-2.35474***	-2.96452***
USD	-2.63605***	-3.20595***	-2.93027***	-3.57668***	-2.65126***	-3.33661***
<b>2002M2 - 2020M2</b>						
EUR	-3.27115***	-3.93773	-2.32410***	-2.95096***	-2.77495***	-3.52661***
USD	-2.63121***	-3.08017***	-3.04885***	-3.55478***	-2.83944***	-3.33945***
<b>2002M2 - 2007M12</b>						
EUR	-3.92762***	-4.17361***	-2.49636***	-3.03140***	-2.99360***	-3.82136***
USD	-1.99020	-2.63491*	-2.28560**	-2.24956	-2.01142	-2.54499
<b>2009M7 - 2022M10</b>						
EUR	-3.18878***	-3.86430***	-2.02036	-2.61152*	-2.40725***	-3.09904***
USD	-3.44290***	-3.90603***	-2.68976***	-3.09466***	-2.92791***	-3.33922***

Source: Authors' calculations

**Table 18.** Results of Pesaran CIPS test (CIPS statistic), CPI (Hotels and restaurants) deflator

Reference currency	Schwarz information criterion		Akaike information criterion		Hannan-Quinn information criterion	
	Constant	Constant and trend	Constant	Constant and trend	Constant	Constant and trend
<b>CIPS statistic</b>						
<b>2002M2 - 2022M10</b>						
EUR	-3.30060***	-3.05651***	-2.46055***	-3.97388***	-2.57809***	-3.20826***
USD	-2.89008***	-3.53071***	-2.74425***	-3.34334***	-2.82753***	-3.39792***
<b>2002M2 - 2020M2</b>						
EUR	-3.15403***	-3.75811***	-2.52609***	-2.99746***	-2.57560***	-3.10018***
USD	-2.95348***	-3.41856***	-2.85941***	-3.38429***	-2.81199***	-3.23840***
<b>2002M2 - 2007M12</b>						
EUR	-3.20765***	-3.56766***	-1.19134	-2.53769	-2.45674***	-3.12386***
USD	-2.19510**	-2.87999***	-2.18854**	-2.35881	-2.12208*	-2.49928
<b>2009M7 - 2022M10</b>						
EUR	-5.05388***	-5.18354***	-2.90074***	-3.71204***	-3.34730***	-4.01385***
USD	-3.80114***	-4.26465***	-2.68976***	-3.09466***	-2.98188***	-3.38976***

Source: Authors' calculations

**Table 19.** Results of Pesaran CIPS test (truncated CIPS statistic), CPI (Hotels and restaurants) deflator

Reference currency	Schwarz information criterion		Akaike information criterion		Hannan-Quinn information criterion	
	Constant	Constant and trend	Constant	Constant and trend	Constant	Constant and trend
<b>Truncated CIPS statistic</b>						
<b>2002M2 - 2022M10</b>						
EUR	-2.80508***	-3.47963***	-2.29585*	-2.90157***	-2.37285***	-3.01285***
USD	-2.84524***	-3.47158***	-2.74425***	-3.34334***	-2.78269***	-3.33879***
<b>2002M2 - 2020M2</b>						
EUR	-2.80787***	-3.41454***	-2.37146***	-2.89441***	-2.41215***	-2.94050***
USD	-2.95348***	-3.41856***	-2.85941***	-3.38429***	-2.81199***	-3.23840***
<b>2002M2 - 2007M12</b>						
EUR	-3.06673***	-3.47432***	-1.01683	-2.50337	-2.35168***	-2.99620***
USD	-2.19510**	-2.87999***	-2.18854**	-2.35881	-2.12208*	-2.49928
<b>2009M7 - 2022M10</b>						
EUR	-3.59820***	-4.09247***	-2.53507***	-3.35644***	-2.81239***	-3.54038***
USD	-3.44290***	-3.90603***	-2.68976***	-3.09466***	-2.92791***	-3.33922***

Source: Authors' calculations

Results displayed in Table 18 and Table 19 are strongly in favor of PPP for both reference currencies in the whole sample, in the pre-pandemic period and the post-crisis period. Evidence supporting the relevance of PPP is also provided for the pre-crisis period, where only one out of six types of test specifications do not support the PPP validity for USD-based exchange rates and two out of six types of test specifications do not confirm PPP for EUR-based exchange rates.

## 6. FUTURE RESEARCH DIRECTIONS

The current study can be upgraded in three possible directions. Analyzing the nonlinearity and persistence properties of real exchange rates of OECD countries is clearly an important future research task. Results from quantile unit root tests can also provide new insights into the PPP puzzle. Revealing possible cointegration relationships between nominal exchange rates and movements of relative prices of tourism services is the third complementary research alternative.

## 7. CONCLUSION

This study reports a thorough analysis of the validity of PPP for the group of 26 OECD economies. Several important findings can be emphasized from the research. First, in the complete sample of estimations comprising two price indices (general consumer price index and consumer price index for hotels and restaurants), two benchmark currencies and a rich collection of panel stationary tests for four time periods (144 estimates in total), the hypothesis about the unit root process can be rejected in 83% of the cases. Second, the PPP model with general consumer price indices is supported in 82% of the cases, when the consumer price indices for hotels and restaurants are considered the PPP holds in 85% of the cases assessed. Third, the evidence of mean reversion of real exchange rates is not dependent upon the selection of numeraire currency, thus the null hypothesis of unit root is for US dollar rates rejected in 61 of out 72 cases, whereas for euro rates in 59 out of 72 examples. Fourth, the PPP is verified for all four-time frames: for the whole time sample, over the period without the Covid-19 pandemic time interval, in the pre-Great Recession period as well as for the post-Great Recession period. Even in the post-crisis period, where the evidence of mean reversion is comparatively the weakest among all the time frames observed, the percentage of PPP cases reaches 78%. Fifth, when tested for cross-sectional dependencies the null hypothesis of nonstationarity of real exchange rates in OECD economies is rejected in 94% of the cases.

Empirical results, documented in this study, strongly support the existence of PPP and are also consistent with the evidence about the advancing traceability of services reported by Rabe and Waddle (2020) and with the growing role of the tourism sector in influencing international prices and relative incomes between countries described in Tubadji and Nijkamp (2018). From the macroeconomic standpoint, the validity of PPP implies that the PPP model can be a useful tool to predict the scrutinized OECD countries' equilibrium exchange rates. From the sectoral perspective, however, the permanence of PPP reflects the intensity of price competition and gains from expanding trade with services and goods encapsulated in the tourism sector of OECD economies.

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