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PURCHASING POWER PARITY IN BELT AND ROAD INITIATIVE COUNTRIES RELATIVE TO CHINA

This paper used the Panel KSS unit root test accompanied by a Fourier function and Sequential Panel Selection Method (SPSM) to check the non-stationary properties of purchasing power parity (PPP) in Belt and Road Initiative (B&R) countries relative to China. The authors classified B&R into 21st-Century Maritime Silk Road (MSR) and Silk Road Economic Belt (SREB) to discuss the differences in PPP between the two groups. Stationary and non-stationary series in SREB and MSR can be picked out through this approach, which provided evidence that PPP holds in most countries in both regions. However, the percentage of countries that support PPP in MSR is higher, which is mainly due to closer unimpeded trade, facilities connectivity, policy coordination and financial integration between MSR countries and China. Hence, the main policies implicate that the equilibrium exchange rate can be determined by PPP, and it is unfeasible to obtain abnormal gains from arbitrage in exchanged commodities in the majority of B&R countries.

Keywords: Panel KSS Unit Root Test; Sequential Panel Selection Method; Purchasing Power Parity; Silk Road Economic Belt; Maritime Silk Road

JEL Classification: B41; E31; F13; C51

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1. INTRODUCTION

This paper examines the applicability of purchasing power parity (PPP) among Belt and Road (B&R) Initiative countries relative to China. The initiative proposed by China in 2013 mainly focused on opening up to cooperation, harmonious and inclusive, market-oriented and mutual benefit (Summers 2016). Since B&R was first proposed, it has gained favour from more than 100 international organisations and countries. Bilateral trade between China and B&R countries has maintained high-speed growth since 2013 and reached 1.34 trillion U.S. dollars in 2019, the highest in recent years. However, there are significant differences between SREB and MSR. First, the economic growth rates of SREB were 5.8%, 1.9%, -8.3% and -0.8% from

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2013 to 2016, but corresponding growth rates in MSR reached 12.3%, 12.9%, 10.2% and 11.3%. Second, bilateral trade with China is also different. The average growth rate for MSR was 1.4 % from 2013, and for SREB -7.5%. Up to the end of 2018, bilateral trade of MSR reached around 587.87 billion U.S. dollars and exceeded SREB, even though the number of countries in MSR was far lower than in SREB. Third, the Ministry of Commerce of the People's Republic of China (MCPRC) showed that Chinese companies invested 27.21 billion U.S. dollars in non-financial sectors in 153 countries and regions from January to July in 2019; this is an increase of 3.3% year-on-year. The major countries included Singapore, Laos, Indonesia, Malaysia, Pakistan, Cambodia and Russia, which indicates that MSR is the main investment destination for China. Finally, financial cooperation between MSR and China is ever closer. Currency swaps between MSR and China reached 970 billion renminbi (RMB), which is about three times more than SREB's volume. These differences may produce a significant influence on PPP and result in deviations. It is known that the equilibrium exchange rate can be determined by PPP, which can be used to evaluate the validity of the foreign exchange market (Bahmani-Oskooee et al. 2016). Therefore, those factors were the inspiration to investigate whether the differences influenced PPP in the MSR and SREB regions.

Since 2010 China has maintained steady economic growth and holds substantial foreign reserves as the world's second-largest economy (Liu et al. 2013; Tao et al. 2021a; Wang et al. 2021). The value of Chinese foreign trade grew almost eight-fold from 2011 to 2015, from 0.57 trillion to 4.47 trillion U.S. dollars. However, China's domestic economic growth has slowed down in recent years, affecting inter-regional and global trade. There is an urgent need to change development strategies and propose the B&R Initiative. Since B&R was first proposed in 2013, its construction and achievement have both exceeded expectations. Cooperation agreements have been signed by China with more than 50 countries, and 56 economic and trade cooperation zones were built. It has become an important way for all parties to strengthen international cooperation and to consider it an important international common good that involves and is promoted by all parties. Concerning the Chinese core role in policy cooperation, facilities connectivity, free trade and financial integration, the paper explored PPP among B&R countries relative to China.

In accordance with the PPP hypothesis, this paper investigated whether RER has any tendency towards a long-term equilibrium level. Inaccurate or wrong conclusions would be drawn if nonlinear factors in the RER generating process were ignored (Liu et al. 2013). Structural breaks may cause nonlinear characteristic, reducing the power of linear unit root tests (Perron 1989).

External and internal shocks, such as news and events, would create influences on exchange rate market, resulting in a short-run variation (Narayan et al. 2006; McMillan, Wohar 2011; Zhu et al. 2015; Ni et al. 2016; Tao et al. 2021b; Tao et al. 2021c). Due to structural breaks, linear unit root tests were ignored, thus they cannot provide convincing conclusions. The Fourier approximation solves the problem of structural breaks effectively. It performs quite well especially for gradual breaks often used in economic analysis and shows reasonable power. The results from traditional unit root tests were no longer depended on, regarding the nonlinearities of macroeconomic variables. Therefore, the nonlinear panel unit root test with the panel unit root testing procedure (Im et al. 2003) and KSS nonlinear framework (Kapetanios et al. 2003) is put forward by Ucar and Omay (2009), which have been proved to be appropriate to examine the null hypothesis. Thus, this paper aimed to identify the non-stationary properties of PPP in B&R countries relative to China, using the Panel KSS unit root test with a Fourier function and SPSM. The study classified B&R into SREB and MSR to discuss the differences in PPP between the two groups, providing evidence that PPP holds in most countries in both regions and the percentage that countries support PPP in MSR is higher. The purpose of this paper was to propose policy implications according to the empirical results, which includes some specific suggestions for SREB and MSR.

The main contributions of this paper concentrate on the following. First, this study investigated the applicability of PPP among B&R countries. Distinct from previous studies, the authors divided B&I into SRER and MSR, and further investigated the differences between the two regions for PPP. Second, it is important to model nonlinearities and structural breaks in RER properly. In recent years, China has suffered external and internal shocks such as exchange rate reforms, which could result in structural breaks for RER. Third, due to the existence of correlations in RER of different countries, the approximation of bootstrap distribution was used in this paper. The independence of individuals was the assumption of the existing studies, which is the difference in respect of this paper. The empirical findings show that PPP holds true for 20 of the SREB countries and 14 of the MSR countries relative to China, which means PPP can be utilised to determine whether the currency is overvalued or undervalued, and examine the effectiveness of the foreign exchange market for most B&R countries. This empirical study also indicates that nonlinearities and structural breaks may lead to rejecting the null hypothesis of a unit root. Therefore, it is important to model both factors in PPP of SREB and MSR countries properly.

The remaining part is as follow. A literature review is considered in the next section. Section 3 discusses purchasing power parity theory. Section 4 describes the methodology. The data is then described in Section 5, with the empirical results in Section 6. Section 7 concludes.

2. LITERATURE REVIEW

2.1. The Belt and Road Initiative

SREB puts emphasis on constructing a new Eurasian Land Bridge to connect Asia and Europe. It contains three major economic corridors: the China-Indochina Peninsula, China-Central Asia-West Asia, and China-Mongolia-Russia. The strength of SREB is that it can depend on current international transport routes, metropolises and industrial parks to build a generous economic network (Aoyama 2016). MSR focuses on establishing safe and efficient shipping routes to connect major seaports along B&R, and includes Bangladesh-China-India-Myanmar and China-Pakistan economic corridors (Clarke 2016).

Several mechanisms of B&R are framed to support infrastructure development, including the Chinese private capital of both foreign and Chinese companies, as well as the SREB Fund. The development of the Chinese domestic economy will be prompted by B&R via providing support to important domestic industries, enhancing access to natural resources, and boosting exports. It can also reduce income inequalities and settle the imbalances in socio-economic development between China's less-developed central and western provinces and the flourishing coastal provinces (Du and Zhang 2018).

2.2. Evidence for China

The high growth rate in the Chinese economy has become a focal point, which has produced tremendous influence on the whole world, especially the neighbouring countries and regions. The China-ASEAN Free Trade Area (CAFTA) came into effect in 2010, has generated significant influences on bilateral trade between the ASEAN countries and China (Wu, Liu 2017). The Shanghai Cooperation Organization, which includes China, Russia and Central Asian countries, was founded in 2001, and now expanded to include economic and energy cooperation (Song 2014). Since the China-Arab States Cooperation Forum was established, it has become a significant mechanism linking China and the Arab world (Mohamed 2014). China has started to

promote the B&R Initiative via these positive cooperation mechanisms (Yu 2017), and since 2010 it has maintained steady economic growth and holds substantial foreign reserves (Liu et al. 2013).

Together with remarkable regional cooperation, numerous studies have emphasised PPP in China. The results from tests of the threshold unit root (Chen et al. 2011), KSS (Arize 2011), the nonlinear unit root (Chang et al. 2012), panel SURADF with a Fourier function (Lee and Chou 2013) and panel stationary (Bahmani-Oskooee et al. 2016), support PPP for China. However, some studies arrived at different conclusions. The Engle-Granger test (Zhang, Wei 2010), exponential smooth transition autoregression (Bahmani-Oskooee et al. 2008) and quantile unit root (Ma et al. 2017) were employed to test PPP and were found not to hold true. Based on the above – confused – results, the authors had to adopt a more powerful method to detect whether PPP holds or not.

2.3. Evidence from other countries

The investigation of PPP is an important issue because it remains a core assumption in the long-run equilibrium in open economy macroeconomic models (Lee, Chou 2013). Many related studies have been conducted for PPP, but without consensus. Taylor and Sarno (1998) found that RER is subject to mean reversion in the UK, Germany, France and Japan. Taylor (2003) argued that there exists a trend for RER consistent with long-run PPP. Through the panel SURADF test, Lee and Chou (2013) showed that PPP is applicable to the G-20 countries. Cuestas and Regis (2013) examined PPP in the Organization for Economic Cooperation and Development (OECD) countries and concluded that most countries support PPP. Through the sequential panel selection method, Bahmani-Oskooee et al. (2014, 2016) pointed out that PPP holds for the majority of emerging economies and exporting countries. Jiang et al. (2016) indicated that PPP holds for seven Central Eastern European countries, however other studies have the opposite opinion about PPP. After the launch of the euro, Huang and Yang (2015) found little evidence for PPP. For China, Korea and Japan, Ma et al. (2017) held that PPP is invalid by using a conventional unit root test.

3. Purchasing power parity theory

According to the PPP theory, if the prices in the two countries are measured at the same exchange rate, the difference between them is temporary. PPP theory states that if there are no transaction costs, and no legal and trade barriers, the price of equilibrium between two countries will exist, which is

derived from the Law of One Price (LOP). LOP and PPP are invalid in the presence of these trade barriers.

In the B&R region, China is the largest economy, the most prominent exporter and importer, and a major capital-exporting country, which demonstrates enormous economic capacity and influence. Therefore, the authors chose it as a representative of a foreign country. The bilateral RER is constructed as follows:

$$RER_t = NER_t \cdot P_t^* / P_t, \quad (1)$$

where NER_t is expressed in local currency units per RMB for each B&R country, standing for the nominal exchange rate. At time t , foreign and domestic consumer price indices (CPI) are represented by P_t^* and P_t , respectively. Both sides of Equation (1) are taken the logarithm and further presented as follows:

$$RER_t = e_t + P_t^* - P_t. \quad (2)$$

In terms of Equation (2), when RER declines the null hypothesis of the unit root (random walk), purchasing power parity (PPP) is valid. If PPP holds true, it indicates that NER is modified by inflation differentials between home and abroad. Macroeconomic implications were provided from the non-stationary characteristic in the RER series. When RER follows a random walk, it may cause the devaluation to adjust the external imbalance.

PPP has received widespread attention as one of the economic theories. Based on the theory, for a long period the real exchange rates are expected to come to a constant equilibrium value, due to the existence of arbitrage activities in the international commodities market. The expectation for RER is to return to a constant equilibrium value, due to the existence of arbitrage in the international goods market over time. In particular, there is no long-term relation between foreign and domestic prices and the nominal exchange rate, indicating that non-stationary RER makes PPP invalid. Therefore, the equilibrium exchange rate cannot be determined by PPP, and the exchange rate cannot be inferred from the monetary approach via invalid PPP, which requires PPP to hold true. Many studies have tested PPP in different countries, extending its economic implication. Yıldırım (2017) stated that it is impossible for Turkey to make unbounded gains from arbitrage in the commodity market, and the equilibrium exchange rates cannot be inferred by PPP, which can be explained by transaction costs and trade barriers. Yoon et al. (2019) demonstrated that in the UK with a high degree of openness, due to the downward rigidity of wages and the character of the exchange rate as an asset

price, PPP was invalid. However, PPP is influenced positively by the export-oriented policies in China, a country with a low degree of openness. Yoon et al. (2020) revisited PPP for NAFTA countries (Mexico, Canada, and the United States), proving that the validity of PPP for NAFTA countries varies along with time.

4. METHODOLOGY

The KSS unit root test depended on the exponential smooth transition autoregressive (hereafter, ESTAR) process (Kapetanios et al. 2003). The model is as follows:

$$\Delta RER_t = \gamma RER_{t-1} \left\{ 1 - \exp(-\theta RER_{t-1}^2) \right\} + \mu_t, \quad (3)$$

where RER_t is the real exchange rate, ESTAR model's transition parameter is $\theta \geq 0$, and with constant and zero mean-variance, an *i.i.d.* error is shown by μ_t , and γ is not identified under the null hypothesis. The first-order Taylor series is approximated for $\left\{ 1 - \exp(-\theta RER_{t-1}^2) \right\}$ under the hypothesis that $\theta = 0$ (Kapetanios et al. 2003). Thus, through following auxiliary regression, Equation (3) can be approximated:

$$\Delta RER_t = \xi + \delta RER_{t-1}^3 + \sum_{i=1}^k \theta_i \Delta RER_{t-i} + \mu_t, \quad t = 1, 2, \dots, T. \quad (4)$$

Based on Equation (4), a nonlinear panel unit root test (Ucar and Omay 2009) is as follows:

$$\Delta RER_{i,t} = \gamma_i RER_{i,t-1} \left\{ 1 - \exp(-\theta_i RER_{i,t-1}^2) \right\} + \mu_{i,t}. \quad (5)$$

At the same time, $\theta_i = 0$ for all i in the panel ESTAR model and the first-order Taylor series approximation was introduced, which is shown below:

$$\Delta RER_{i,t} = \xi_i + \delta_i RER_{i,t-1}^3 + \sum_{j=1}^k \theta_{i,j} \Delta RER_{i,t-j} + \mu_{i,t}, \quad (6)$$

where $\delta_i = \theta_i \gamma_i$. Based on Equation (6), the hypotheses are as follows:

$$H_0 : \delta_i = 0, \text{ for all } i, \quad (7)$$

$$H_0 : \delta_i < 0, \text{ for some } i \quad (8)$$

Together with a Fourier function, the KSS panel unit root test is demonstrated as Equation (9):

$$\begin{aligned} \Delta RER_{i,t} = & \xi_i + \delta_i RER_{i,t-1}^3 + \sum_{j=1}^{k1} \theta_{i,j} \Delta RER_{i,t-j} + \\ & + a_{i,1} \sin\left(\frac{2\pi kt}{T}\right) b_{i,1} \cos\left(\frac{2\pi kt}{T}\right) + \varepsilon_{i,t}, \end{aligned} \quad (9)$$

where $[\sin(2k\pi t/T), \cos(2k\pi t/T)]$ is on account of the Fourier expression. The unknown structural breaks can be captured by the Fourier approximations, even though the function itself is not periodic (Enders, Lee 2012; Liu et al. 2013; Su et al. 2014).

At the beginning of the study, the authors selected the best method that relies on grid-search, and as a result none can be used to note the structural shifts.

5. DATA

Monthly data from July 2005 to May 2018 were employed to investigate PPP. In the sample, the People's Bank of China (PBOC) launched several exchange rate reforms. The global financial crisis occurred at the end of 2008, which obviously impacted the world economy, affecting international trade, capital flow and the exchange rate. The Chinese government put forward strategies of SREB and MSR in 2013 (Aoyama 2016). The two regions have significant differences relative to China, namely: first, bilateral trade in MSR is higher than SREB, for example, bilateral trade with MSR countries make up 15.26% of China's total foreign trade volume in 2016, and the percentage in SREB is only 7.847%; second, Chinese ODI reached 4.99 billion U.S. dollars, mostly flowing into MSR countries such as Singapore, Laos and Indonesia; third, financial cooperation between MSR and China is becoming closer. Currency swaps between China and MSR reached 970 billion RMB, which is about three times more than SREB's volume. These reasons motivated the authors to investigate whether PPP holds differences in the above two regions. According to Figure 1, SREB covers 29 countries: Kazakhstan, Kyrgyzstan, Afghanistan, Oman, Egypt, Kuwait, Saudi Arabia, Turkey, Iran, Israel, Jordan, Bulgaria, Poland, Czech, Romania, Hungary, Albania, Croatia, Macedonia, Bosnia and Herzegovina, Serbia, Montenegro, Georgia, El Salvador, Ukraine, Armenia, Russia, Mongolia and Moldova. MSR contains two major routes: the first one is China's coast-South China Sea-Indian Ocean, the second one is China's coast- South China Sea-South Pacific. It includes 16 countries: Pakistan, the Maldives, Bangladesh, Nepal, Sri Lanka, India, Cambodia, Laos, Malaysia, Myanmar, Thailand, Brunei, Singapore, Indonesia, Vietnam and the Philippines.



Fig. 1. The geographical coverage of B&R Initiative

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China has accelerated its RMB internalisation strategy, and financial integration between China and B&I countries has strengthened in recent years. The cooperation mechanisms of currency, investment, finance and credit information are building. A series of financial organisations, such as the Asian Infrastructure Investment Bank and the Silk Road Fund, has been set up to promote financial cooperation (Song 2014; Etzioni 2016). Meanwhile, the Chinese government supports the efforts of B&R countries and their enterprises and financial organizations with a high credit-rating to issue RMB bonds in China. Regarding China's market share in global trade, RMB is not only considered for settlement in neighbouring countries, but also in other areas, which eventually will become a core regional currency in Asia (Zhong 2011). Therefore, according to Equation (1), all CPI (2010=100), and NER relative to RMB in each country were taken from the International Monetary Fund (IMF).

6. EMPIRICAL RESULTS

The results in Tables 1 and 2 demonstrate clearly that the null hypothesis cannot be refused by linear ADF, PP and KPSS unit root tests. The conclusions imply that PPP does not fit for SREB and MSR countries relative to China.

Table 1
Univariate unit root tests for SREB countries

	Level			First differences		
	ADF	PP	KPSS	ADF	PP	KPSS
Kazakhstan	-0.059 (1)	0.233 (5)	0.823 [9] ***	-8.722 (0) ***	-8.716 (4) ***	0.318 [5]
Kyrgyzstan	-1.467 (1)	-1.178 (6)	0.582 [9] **	-9.467 (0) ***	-9.284 (14) ***	0.209 [8]
Afghanistan	-0.369 (0)	-0.567 (5)	0.842 [9] ***	-10.552 (0) ***	-10.551 (5) ***	0.279 [5]
Oman	-1.347 (1)	-1.498 (1)	1.329 [9] ***	-9.339 (0) ***	-9.356 (3) ***	0.249 [0]
Egypt	-2.009 (0)	-1.953 (7)	0.706 [9] **	-10.402 (0) ***	-10.541 (12) ***	0.137 [9]
Kuwait	-1.636 (0)	-1.529 (9)	1.341 [9] ***	-12.145 (0) ***	-12.266 (9) ***	0.171 [12]
Saudi Arabia	-1.818 (0)	-1.913 (5)	0.874 [9] ***	-10.426 (0) ***	-10.522 (4) ***	0.107 [3]
Turkey	-0.934 (0)	-0.904 (3)	1.254 [9] ***	-10.993 (0) ***	-10.987 (5) ***	0.074 [5]
Iran	-2.414 (0)	-2.424 (1)	0.274 [9] ***	-11.852 (0) ***	-11.883 (5) ***	0.101 [6]
Israel	-1.871 (0)	-1.983 (3)	1.111 [9] ***	-10.995 (0) ***	-10.985 (2) ***	0.041 [2]
Jordan	-1.443 (0)	-1.559 (1)	1.081 [9] ***	-9.672 (0) ***	-9.603 (5) ***	0.207 [2]
Bulgaria	0.629 (0)	-0.544 (4)	1.097 [9] ***	-12.619 (0) ***	-12.618 (4) ***	0.249 [4]
Poland	-0.716 (0)	-0.749 (3)	1.299 [9] ***	-11.635 (0) ***	-11.636 (2) ***	0.084 [2]
Czech	-0.653 (0)	-0.699 (4)	1.158 [9] ***	-12.237 (0) ***	-12.222 (4) ***	0.164 [4]
Romania	-0.578 (0)	-0.573 (3)	1.311 [9] ***	-11.631 (0) ***	-11.632 (2) ***	0.089 [2]
Hungary	-0.979 (0)	-0.966 (3)	1.238 [9] ***	-12.144 (0) ***	-12.148 (4) ***	0.059 [5]
Albania	-0.548 (0)	-0.524 (2)	1.299 [9] ***	-11.699 (0) ***	-11.702 (2) ***	0.085 [2]
Croatia	-0.921 (0)	-0.895 (6)	1.389 [9] ***	-12.993 (0) ***	-12.961 (5) ***	0.046 [5]
Macedonia	-0.674 (0)	-0.592 (3)	1.307 [9] ***	-12.796 (0) ***	-12.785 (3) ***	0.089 [2]
Bosnia and Herzegovina	-0.429 (0)	-0.346 (4)	1.333 [9] ***	-12.989 (0) ***	-12.957 (4) ***	0.103 [3]
Serbia	-0.872 (0)	-1.041 (4)	1.145 [9] ***	-11.502 (0) ***	-11.539 (4) ***	0.112 [4]
Montenegro	-0.865 (0)	-0.775 (3)	1.251 [9] ***	-12.684 (0) ***	-12.707 (2) ***	0.091 [1]
Georgia	-0.101 (1)	0.164 (1)	1.105 [9] ***	-8.957 (0) ***	-8.857 (7) ***	0.037 [3]
Salvatore	-1.681 (0)	-1.657 (1)	1.354 [9] ***	-10.383 (0) ***	-10.436 (3) ***	0.131 [3]
Ukraine	-0.941 (2)	-1.177 (11)	1.165 [9] ***	-11.517 (0) ***	-17.492 (22) ***	0.149 [27]
Armenia	-1.126 (0)	-1.142 (1)	0.944 [9] ***	-11.651 (0) ***	-11.649 (2) ***	0.288 [3]
Russia	-1.791 (1)	-1.285 (11)	0.891 [9] ***	-8.764 (0) ***	-8.354 (23) ***	0.109 [13]
Mongolia	-2.355 (1)	-1.826 (3)	0.229 [9] ***	-8.311 (0) ***	-7.877 (13) ***	0.046 [5]
Moldova	-0.773 (0)	-0.781 (3)	0.824 [9] ***	-10.331 (0) ***	-10.339 (1) ***	0.302 [2]

Note: ** and *** denote the rejection of the null of unit root at 5% and 1% level of significance, respectively. The null hypothesis for KPSS is that the time series do not exist unit root. The number in parentheses indicates the select lag order of the ADF model. Lags are chosen based on AIC. The number in brackets indicates the lag truncation for the Bartlett Kernel.

Source: own study.

Table 2
Univariate unit root tests for MSR countries

	Level			First differences		
	ADF	PP	KPSS	ADF	PP	KPSS
Bangladesh	-1.775 (0)	-1.571 (1)	0.216 [9] ***	-8.305 (0) ***	-7.997 (9) ***	0.283 [2]
Brunei	-1.211 (0)	-1.178 (1)	1.254 [9] ***	-12.364 (0) ***	-12.387 (2) ***	0.046 [3]
Cambodia	-2.899 (1)	-2.407 (0)	0.167 [9] **	-10.461 (0) ***	-10.411 (5) ***	0.079 [5]
India	-2.106 (0)	-2.175 (1)	0.642 [9] **	-11.058 (0) ***	-11.052 (6) ***	0.051 [5]
Indonesia	-1.433 (0)	-1.546 (5)	0.819 [9] ***	-10.959 (0) ***	-10.952 (5) ***	0.074 [5]
Laos	-1.971 (1)	-1.591 (2)	1.317 [9] ***	-9.599 (0) ***	-9.554 (4) ***	0.052 [2]
Malaysia	-0.671 (0)	-0.653 (9)	1.122 [9] ***	-11.255 (0) ***	-11.246 (11) ***	0.107 [10]
Maldives	-1.828 (0)	-1.823 (3)	1.091 [9] ***	-12.312 (0) ***	-12.301 (3) ***	0.104 [2]
Myanmar	-0.678 (0)	-0.678 (0)	1.181 [9] ***	-11.626 (0) ***	-11.626 (1) ***	0.119 [1]
Nepal	-2.182 (0)	-2.232 (1)	0.549 [9] **	-11.379 (0) ***	-11.379 (5) ***	0.071 [5]
Pakistan	-1.524 (0)	-1.627 (3)	0.886 [9] ***	-10.013 (0) ***	-10.013 (0) ***	0.168 [2]
the Philippines	-2.874 (0)	-2.894 (2)	0.156 [9] ***	-11.774 (0) ***	-11.797 (6) ***	0.061 [6]
Singapore	-2.303 (0)	-2.303 (0)	0.374 [9] *	-12.779 (0) ***	-12.793 (3) ***	0.052 [5]
Sri Lanka	-1.649 (0)	-1.743 (3)	0.674 [9] **	-10.939 (0) ***	-10.926 (6) ***	0.088 [6]
Thailand	-0.991 (0)	-1.125 (3)	0.949 [9] ***	-11.124 (0) ***	-11.139 (2) ***	0.094 [2]
Vietnam	-2.978 (0)	-2.976 (2)	0.083 [9] ***	-12.109 (0) ***	-12.331 (7) ***	0.085 [7]

Note: ** and *** denote the rejection of the null of unit root at 5% and 1% level of significance, respectively. The null hypothesis for KPSS is that the time series do not exist unit root. The number in parentheses indicates the select lag order of the ADF model. Lags are chosen based on AIC. The number in brackets indicates the lag truncation for the Bartlett Kernel.

Source: own study.

Due to the presence of structural breaks, the findings cannot provide strong evidence that RER follows a random walk and further imply that PPP holds in B&R countries.

Tables 3 and 4 show the empirical findings of the Panel KSS accompanied by a Fourier function. This method offers robust evidence for stationarity in the RER series, which brings the accurate conclusions that unit root hypothesis does not hold true for 20 of the 29 SREB countries relative to China, apart from Kazakhstan, Afghanistan, Iran, Egypt, Kuwait, Jordan, Oman, El Salvador and Saudi Arabia.

The study found that the most non-stationary countries are located in West Asia, the region which belongs to China-Central-West Asia economic corridor of SREB. It is located on the borders of Asia, Europe and Africa and its

Table 3
Results of Panel KSS with Fourier test for SREB countries

Sequence	OU statistic	p-value	Min KSS	k	Series
1	-2.959 ***	0.000	-5.877	3	Ukraine
2	-2.821 ***	0.000	-3.725	3	Armenia
3	-2.807 ***	0.000	-3.562	3	Russia
4	-2.747 ***	0.002	-2.949	3	Albania
5	-2.732 ***	0.002	-2.918	3	Poland
6	-2.699 ***	0.002	-2.843	3	Romania
7	-2.684 ***	0.003	-2.828	3	Montenegro
8	-2.659 ***	0.002	-2.801	3	Serbia
9	-2.647 ***	0.005	-2.719	3	Macedonia
10	-2.629 ***	0.005	-2.667	3	Mongolia
11	-2.554 ***	0.007	-2.661	3	Bulgaria
12	-2.521 ***	0.008	-2.651	3	Israel
13	-2.499 ***	0.008	-2.582	3	Kyrgyzstan
14	-2.461 ***	0.010	-2.573	3	Croatia
15	-2.437 ***	0.009	-2.554	3	Czech
16	-2.397 **	0.011	-2.523	3	Bosnia and Herzegovina
17	-2.339 **	0.012	-2.509	3	Turkey
18	-2.249 **	0.018	-2.479	3	Hungary
19	-2.175 **	0.026	-2.349	3	Moldova
20	-2.166 *	0.061	-2.344	3	Georgia
21	-2.012	0.108	-2.243	3	Kazakhstan
22	-1.869	0.181	-2.084	3	Afghanistan
23	-1.825	0.171	-1.838	3	Iran
24	-1.668	0.262	-1.161	3	Egypt
25	-1.659	0.315	-0.808	3	Kuwait
26	-1.583	0.339	-0.782	3	Jordan
27	-1.103	0.500	-0.023	3	Oman
28	-0.891	0.489	0.029	3	Salvatore
29	-0.169	0.571	0.058	3	Saudi Arabia

Note: The asymptotic p-values are computed by means of Bootstrap simulations using 10,000 replications. ***, ** and * indicates significance at 1%, 5% and 10% level.

Source: own study.

Table 4
Results of Panel KSS with Fourier test for MSR countries

Sequence	OU statistic	<i>p</i> -value	Min KSS	k	Series
1	-3.273 ***	0.000	-3.668	3	the Philippines
2	-3.239 ***	0.000	-3.621	3	Laos
3	-3.187 ***	0.000	-2.796	3	Thailand
4	-3.207 ***	0.000	-2.714	3	Indonesia
5	-3.126 ***	0.001	-2.644	3	Brunei
6	-3.141 ***	0.000	-2.458	3	Singapore
7	-3.149 ***	0.000	-2.412	3	India
8	-3.159 ***	0.000	-2.379	3	Sri Lanka
9	-3.123 ***	0.000	-2.348	3	Malaysia
10	-3.038 ***	0.000	-2.262	3	Myanmar
11	-3.037 ***	0.000	-2.115	3	Vietnam
12	-2.949 ***	0.007	-2.017	3	Nepal
13	-2.963 ***	0.007	-1.815	3	Cambodia
14	-2.543 **	0.037	-1.533	3	Bangladesh
15	-2.157	0.105	-1.299	3	Maldives
16	-1.695	0.141	-0.863	3	Pakistan

Note: The asymptotic *p*-values are computed by means of Bootstrap simulations using 10,000 replications. ***, ** and * indicates significance at 1%, 5% and 10% level.

Source: own study.

strategic position is very important. The following reasons can explain this phenomenon. First, most Arab countries peg their currencies to the U.S. dollar rather than adopt the floating exchange rate system, which determines the adjustment from nominal exchange rate for PPP as invalid (Kumah 2011). Second, due to the nominal rate being pegged, price adjustment is the main way for RER to adjust. However, price control has proved to be universal in Arab countries, which adjusts RER even harder (Ramly 2005). Third, being developing countries they usually impose tariffs to protect their infant industries, which causes that the differences in CPI between home and abroad cannot reflect the realities. Fourth, China and the Arab countries are not major trading partners for each other. The most significant trading partners for the Arab region are the European Union, Japan and the U.S. (Hanna 2015). Fifth, trade between the Arab countries and China is limited to the main imports of manufactured goods and oil exports, therefore the baskets used to build price

indices are different both in types of goods and corresponding weights. In terms of the above-mentioned analysis, PPP in the Arab countries relative to China is hard to maintain.

The results of Panel KSS for the MSR countries are shown in Table 4. MSR focuses on constructing safe and efficient transport routes to connect major seaports along B&R. The same procedure is indicated in Table 3, and the 14 countries (i.e. the Philippines, Laos, Thailand, Indonesia, Brunei, Singapore, India, Sri Lanka, Malaysia, Myanmar, Vietnam, Nepal, Cambodia and Bangladesh) are mean reversion, except for Maldives and Pakistan. The empirical conclusions provide robust support for PPP in all ASEAN countries. The findings are consistent with Bec and Zeng (2013). Since 2002, numerous free trade agreements have been signed by China and ASEAN, which cover settlement mechanism, trade and investment (Yang, Inmaculada 2014). Nowadays, China and ASEAN are major trading partners of each other, and bilateral trade reached about 0.47 trillion U.S. dollars in 2015, with an average annual growth of 18.5%. The rapid growth of bilateral trade, deepening bilateral cooperation and low tariffs, provide the basis for PPP. In the context of Asia, frequent government interventions have been regarded as the main factor that results in nonlinearities (Dutta, Leon 2002). As RER may influence imports, exports and foreign currency-denominated debt, thus the large and persistent deviations from PPP have been considered by central banks in every country along B&R (Chang et al. 2012). Dutta and Leon (2002) argued that countries should focus more on defending depreciation than appreciation, which may result in asymmetric behaviour in the foreign exchange market. It was noted that the government of the Maldives does not support PPP, which can be attributed to the small bilateral trade with China. Foreign trade between these countries was only 0.32 billion U.S. dollars in 2016 and accounted for 0.009% of Chinese total foreign trade volume, which is the lowest percentage in MSR. Therefore, the smaller bilateral trade of the Maldives may be the major reason for not supporting PPP. However, China and Pakistan have an 'all-weather' friendship, and their geographical proximity enhances geoeconomics value of their overall relationship. However, the bilateral trade has not reached the expected value, which can be attributed to single export products for China, low industry correlation of Sino-Pakistan and the high share for infrastructure investment (Yang 2015). Based on the above factors, RER would deviate from the equilibrium level determined by PPP.

Accompanied by a Fourier function, the Panel KSS unit root test in this study for RER shows that PPP is valid long-term for most SREB and MSR countries. The conclusions are that the equilibrium exchange rate can be determined by PPP, which concur with previous studies (Bahmani-Oskooee, Hegerty 2009; Kasman et al. 2010; Chang et al. 2012). However, one should

note the obvious difference between these two regions. The number of countries that support PPP in SREB, is lower than that in MSR. This might be explained by the following reasons. First, some SREB countries apply a planned economy system and thus produce a negative influence on themselves such as price control, which destroys the basis of PPP (Lin et al. 2011). Second, the bilateral trade volume between SREB and China is less than that in MSR. According to Tables 5 and 6, although SREB includes more countries, it only

Table 5
Percent of bilateral trade between SREB and China (%)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ukraine	0.230	0.236	0.300	0.342	0.262	0.260	0.286	0.268	0.267	0.200	0.179	0.182
Armenia	0.002	0.002	0.004	0.003	0.005	0.006	0.005	0.004	0.005	0.007	0.008	0.011
Russia	2.047	1.897	2.212	2.220	1.755	1.867	2.177	2.281	2.146	2.215	1.721	1.887
Albania	0.006	0.004	0.007	0.011	0.012	0.012	0.012	0.013	0.013	0.013	0.014	0.017
Poland	0.222	0.265	0.352	0.407	0.407	0.374	0.357	0.372	0.356	0.400	0.432	0.478
Romania	0.117	0.359	0.109	0.126	0.127	0.126	0.121	0.098	0.097	0.110	0.113	0.133
Montenegro	0.000	0.000	0.003	0.003	0.004	0.002	0.003	0.004	0.003	0.005	0.004	0.004
Serbia	0.000	0.000	0.017	0.020	0.015	0.013	0.013	0.013	0.015	0.012	0.014	0.016
Macedonia	0.002	0.002	0.004	0.003	0.004	0.005	0.007	0.006	0.004	0.004	0.006	0.004
Mongolia	0.060	0.090	0.093	0.095	0.110	0.135	0.177	0.171	0.143	0.170	0.136	0.125
Bulgaria	0.037	0.106	0.045	0.052	0.033	0.033	0.040	0.049	0.050	0.050	0.045	0.045
Israel	0.213	0.220	0.244	0.236	0.235	0.257	0.269	0.256	0.260	0.253	0.289	0.308
Kyrgyzstan	0.068	0.126	0.174	0.364	0.241	0.141	0.137	0.133	0.124	0.123	0.110	0.154
Croatia	0.043	0.053	0.073	0.071	0.054	0.047	0.044	0.036	0.036	0.026	0.028	0.032
Czech	0.143	0.164	0.228	0.254	0.279	0.298	0.274	0.226	0.227	0.255	0.278	0.299
Bosnia and Herzegovina	0.009	0.008	0.004	0.003	0.002	0.002	0.002	0.002	0.003	0.007	0.003	0.003
Turkey	0.343	0.458	0.541	0.490	0.457	0.508	0.514	0.494	0.535	0.535	0.545	0.528
Hungary	0.201	0.226	0.286	0.292	0.308	0.293	0.254	0.208	0.202	0.210	0.204	0.241
Moldova	0.004	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.003	0.003	0.003	0.003
Georgia	0.003	0.005	0.009	0.012	0.010	0.011	0.022	0.020	0.022	0.022	0.021	0.022
Kazakhstan	0.479	0.475	0.638	0.685	0.640	0.688	0.685	0.664	0.688	0.522	0.361	0.355
Afghanistan	0.004	0.006	0.008	0.006	0.010	0.006	0.006	0.012	0.008	0.010	0.010	0.012
Iran	0.709	0.821	0.946	1.083	0.961	0.988	1.238	0.943	0.948	1.205	0.856	0.847
Egypt	0.151	0.181	0.215	0.246	0.265	0.234	0.242	0.247	0.246	0.270	0.326	0.298
Kuwait	0.116	0.158	0.167	0.265	0.228	0.288	0.310	0.325	0.295	0.312	0.285	0.254
Jordan	0.064	0.059	0.054	0.076	0.094	0.069	0.076	0.084	0.087	0.084	0.094	0.086
Oman	0.305	0.367	0.334	0.485	0.279	0.361	0.436	0.486	0.552	0.601	0.434	0.384
Salvatore	–	–	–	–	–	–	–	–	–	–	–	–
Saudi Arabia	1.131	1.144	1.165	1.633	1.474	1.452	1.766	1.896	1.736	1.606	1.306	1.147
Total	6.708	7.435	8.233	9.485	8.276	8.479	9.476	9.313	9.069	9.232	7.824	7.874

Source: own study.

Table 6
Percent of bilateral trade between MSR China (%)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Philippines	1.235	1.330	1.407	1.117	0.930	0.933	0.885	0.941	0.915	1.034	1.154	1.281
Laos	0.009	0.012	0.012	0.016	0.034	0.036	0.036	0.044	0.066	0.084	0.070	0.063
Thailand	1.534	1.574	1.591	1.611	1.730	1.780	1.777	1.804	1.713	1.688	1.909	2.058
Indonesia	1.181	1.082	1.148	1.230	1.286	1.437	1.663	1.713	1.644	1.477	1.372	1.452
Brunei	0.018	0.018	0.016	0.009	0.019	0.035	0.036	0.042	0.043	0.045	0.038	0.019
Singapore	2.331	2.321	2.166	2.047	2.168	1.919	1.749	1.791	1.825	1.853	2.012	1.911
India	1.315	1.412	1.775	2.023	1.965	2.077	2.029	1.719	1.573	1.641	1.811	1.903
Sri Lanka	0.069	0.065	0.066	0.066	0.074	0.071	0.086	0.082	0.087	0.094	0.115	0.124
Malaysia	2.159	2.108	2.131	2.089	2.354	2.497	2.472	2.452	2.551	2.371	2.460	2.357
Myanmar	0.085	0.083	0.095	0.102	0.131	0.149	0.179	0.180	0.245	0.580	0.382	0.333
Vietnam	0.576	0.565	0.695	0.759	0.953	1.011	1.104	1.304	1.574	1.944	2.425	2.665
Nepal	0.014	0.015	0.018	0.015	0.019	0.025	0.033	0.052	0.054	0.054	0.022	0.024
Cambodia	0.040	0.042	0.043	0.044	0.043	0.048	0.069	0.076	0.091	0.087	0.112	0.129
Bangladesh	0.175	0.181	0.159	0.183	0.208	0.237	0.227	0.219	0.248	0.292	0.372	0.412
Maldives	0.001	0.001	0.001	0.001	0.002	0.002	0.003	0.002	0.002	0.002	0.004	0.009
Pakistan	0.300	0.298	0.317	0.275	0.308	0.291	0.289	0.321	0.342	0.372	0.479	0.519
Total	11.041	11.108	11.641	11.587	12.224	12.550	12.638	12.741	12.972	13.620	14.738	15.260

Source: own study.

accounted for 7.874% of China's total foreign trade in 2016, while MSR was 15.26% in the same period. Less bilateral trade is one of the major reasons that lead to deviations. Third, government intervention should also be taken into account. Concerning Asia, non-stationarity may come from frequent interventions from the government. Lastly, in recent years, wars and political upheavals often occur in this region such as the Arab Spring. The unrest would distort prices and drive the exchange rate to deviate from PPP. On the contrary, most MSR countries are export-oriented, have a market economic system and fewer interventions in the market.

CONCLUSIONS

The primary purpose of this paper was to investigate whether PPP holds true for SREB and MSR countries relative to China by adopting the Panel KSS unit root test with a Fourier function and SPSM. The empirical results are as follows. First, applying the Panel KSS unit root test accompanied by

a Fourier function and SPSM has statistical strengths. Compared with the previous panel approach based on joint unit root tests for all members, this innovative method put forward by Ucar and Omay (2009) can select stationary and non-stationary series. The method provided robust empirical evidence, according to which PPP holds true for most SREB and MSR countries. Second, the number of countries that supports PPP in SREB is lower than that in MSR, mainly due to their closer unimpeded trade, facilities connectivity, policy coordination and financial integration between MSR countries and China. Finally, accurate conclusions were provided for B&R countries so that they can use PPP to appreciate whether the currency is overvalued or undervalued.

The findings carry useful implications for policymakers and regulators. First, exchange policies must consider the existing economic, social and political conditions of each country. For example, the financial system should be deepened more actively in B&R partner countries such as SREB countries (i.e. Ukraine, Armenia, Albania, Poland, Romania, Montenegro, Serbia). Second, in order to improve the absorption power of foreign direct investment (FDI) inflows, policymakers in the MSR region should seek strengthening the human capital and the quality of the institutions via proper training and education systems. Third, relying on the B&R Initiative, China should further strengthen cooperation in trade, investment and infrastructure with the assistance of the Asian Infrastructure Investment Bank and the Silk Road Fund. Meanwhile, China ought to stabilise its domestic prices, and encourage trading partners to use RMB for settlement.

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