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Purchasing Power Parity Between China and Selected BRI Countries in Asia

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Abstract

Purpose: This study tests the validity of purchasing power parity (PPP) between China and the 18 other Asian countries that have joined the 'Belt and Road Initiative' (BRI). The Chinese Government launched the BRI plan to enhance trade and promote market integration among the participating countries. The validity of PPP reflects the degree of market integration and serves as a prerequisite for future economic integration.

Study design/methodology/approach: Nonparametric nonlinear rank tests are used to examine whether this is any cointegration in the PPP models. This testing approach is valid even if the functional form of PPP is unknown or nonlinear. Additionally, we address the rank problem in the multivariate PPP models.

Findings: Our empirical results reveal strong evidence of the PPP relationship and reasonably strong evidence of nonlinearity in the data. Our findings show that some Asian BRI countries have experienced integration of their markets with that of China during the recent decade but not over the entire sample period. This implies that China's economic power has been rising with larger trade volumes with Asian trading partners, especially during the most recent decade, which, in turn, infers that the integration of markets through BRI projects has been enhanced. However, hidden transaction costs due to geopolitical risks may have resulted in the failure of the PPP relationship between China and some Asian countries during the past decade. The findings of PPP in our paper are useful for academics, practitioners, and policymakers in making better decisions for trading between China and the Asian BRI countries.

Practical Implications: The findings imply that China should get better economic cooperation and greater economic integration with all the Asian BRI members. However, the fear of geopolitical risks and military conflicts in Asia could lead to an increase in transaction costs, resulting in drawbacks from the PPP relationship between China and the Asian countries, especially after the Russia-Ukraine war.

Keywords: Goods market integration, Belt and Road, nonparametric nonlinear cointegration, transaction costs, China

Paper Type: Research paper

JEL classifications: C10, F41

1. Introduction

1.1 Background and BRI

The Belt and Road Initiative (BRI) launched by the Chinese Government in 2013 concatenates its title from the Silk Road Economic Belt and the Maritime Silk Road (Huang & Luk, 2020). The former focuses on creating links between the mostly landlocked Central Asian countries and the western regions through historical trade routes. The latter focuses on nautical trade routes through the Indo-Pacific, to the Middle East, and towards Africa. The BRI is designed to foster mutually beneficial relationships between member countries and China by strengthening cross-border trading activities, policy coordination, economic integration, and social connections between the people of China and the BRI countries (Enderwick, 2018).

A combination of strategies has been implemented to enable BRI. Firstly, infrastructure facilities such as railroads, highways, and pipelines have been constructed to improve transportation to enhance regional connectivity and reduce the cost of logistics, and eventually accelerate flows of trade, economic growth, and development, especially among those developing countries which suffer from poor networks for transportation (Lu, et al., 2018). Secondly, creating trade links in these areas can reinforce the rising trend of international trade by negotiating bilateral and multilateral trade agreements that reduce all kinds of trade barriers. Thirdly, trade volume is enhanced by broadening the scope of bilateral currency swaps and settlements (Yu, 2021). Finally, promoting cultural ties and people-to-people bonds is instigated by encouraging tourism and social interactions to enhance cultural understanding and exchanges, which help the development of harmonious and trusting relationships along with continuing open communication. Research studies (Mukhtar, et al., 2022) find that cultural similarities and cross-cultural adjustments help increase BRI countries' trade flows and export performances. All of the above strategies are expected to reinforce the increasingly free flow of factors of production in response to the reduction of trade barriers and transaction costs, leading to the deepening of economic integration. The BRI may eventually serve as a platform for an economic union or economic community among China and other BRI countries as a long-run policy target (Soong, 2018), which refers to an area of a common market where goods and factors of production are free to move, and national economic policies are well coordinated.

Asia’s contribution to the world GDP growth has surpassed that of the EU and the US since 2001 (World Bank, 2021). In the coming decades, Asia is expected to play an even more significant role in leading the world’s GDP growth. Before the official commencement of the BRI, China had already started engaging with Asian countries to enhance regional trade cooperation, as evidenced by the China-ASEAN Free Trade Area (CAFTA), which has been in effect since 1 January 2010. Relaxation of trade and investment rules under the CAFTA has led to a surge in total trade between China and ASEAN from US$292 billion in 2010 to US$731 billion in 2020 (ASEAN, 2021; Chiang, 2019). Over the past decade, the creation of the BRI has further stimulated economic cooperation in Asia. China has played a significant role in the economic integration of Asian countries through its cross-border investment projects under the BRI and the deepening economic collaboration facilitated by the CAFTA (Ishikawa, 2021; Malik, et al., 2021).

1.2 PPP and BRI

Purchasing power parity (PPP) is a long-run equilibrium condition among exchange rates and prices. It means that the exchange rate between any two currencies equates to the ratio of the two relevant national price levels, assuming that there is instantaneous arbitrage in international goods markets. The validity of PPP is essential for policymakers (Holmes, 2008; Sarno & Taylor, 2002). Moreover, the validity of PPP can reflect the degree of goods markets integration among the trading partners (Yilanci & Eris, 2013) and hence PPP is a prerequisite for the formation of a potential common market to attain closer economic integration in the future (Lee, et al., 2023).

If PPP and goods markets integration between China and the collaborative BRI Asian countries are valid, the next step would involve strengthening economic cooperation by formulating policies to integrate financial and labour markets, potentially forming a common market. However, if PPP is rejected, barriers may prevent the integration of the goods markets. Then, policies to curtail those trade barriers, such as adjusting taxes, existing tariff and non-tariff barriers, and other protectionist policies, shall be needed. Also, increasing infrastructure and logistic networks can help reduce transportation costs. In other words, examining the PPP relationship can help evaluate the potential for further economic integration and development between China and the Asian BRI countries.

Our study aims to test the PPP between China and BRI countries in Asia. Recent studies adopt parametric tests to describe a particular functional form of PPP. We take a nonparametric approach for PPP testing with more considerable statistical power when the active state of PPP may be unknown or nonlinear. We employ econometric methods for PPP testing, applying statistical techniques to study economic data and yield optimal decision outcomes. Placed within economic analysis, our paper is connected with decision sciences (Chang, et al., 2018; Tisdell, 2018), pivotal in decision-making processes using quantitative methods (Hieu, et al., 2020; Truong, et al., 2019).

The remaining sections are structured as follows. Section 2 reviews the relevant literature. Section 3 outlines the PPP models and the econometric methodology. Section 4 describes the data. The empirical results are presented in Section 5, and conclusions are stated in the last section.

2. Literature review

As reported in extant literature, PPP testing has been undertaken with mixed empirical results (Sarno & Taylor, 2002). Traditional PPP tests have suffered low power because they assume linear price convergence in the data. However, nonlinearity in the exchange rate and price movements is an extant topic in literature (for example, Imane, et al., 2023; Maydybura, et al., 2023; Rajput, et al., 2019). Researchers have argued linear cointegration tests do not provide accurate results (Taylor, 2006). Also, there may be bias in calculating half-lives of nonlinear PPP convergence when linear methods are mistakenly used in the study (Taylor, 2001). Recent studies of PPP testing have adopted nonlinear econometric methods to consider possible nonlinearity in the data. The empirical evidence of nonlinearity in the PPP relationship for Asian countries is found in the form of, for example, structural breaks (Narayan, 2010), time-varying regime shifts (Kim, et al., 2009), nonlinear deterministic trends (Nusair, 2012), Markov switching process (Caporale & Spagnolo, 2004), threshold adjustments (Woo,

et al., 2021) and smooth transition (Ahmad & Rashid, 2008). The nonlinear functional forms are based on different theoretical models that are used to explain various sources of nonlinearity in PPP such as economic policy uncertainty (Huang & Luk, 2020), heterogeneity of opinions in foreign exchange markets (Kilian & Taylor, 2003), official intervention in nominal and real exchange rates (Gamboa-Estrada, 2019; Sideris, 2008), changes in exchange rate regimes (Ilzetzki, et al., 2022; Lothian, 2016), financial and speculative activities (Westerhoff, 2009) and the presence of transaction costs (Taylor, 2006). The actual nonlinear process may however be unknown in the data and even worse, a mixture of diverse forms of nonlinearities may be present in the PPP (Bahmani-Oskooee, et al., 2013; He, et al., 2014). Hence, no single theoretical model can represent the precise picture of the functional form of PPP. Parametric cointegration tests may suffer specification errors if erroneous functional forms and test statistics are adopted in PPP testing.

The nonparametric rank tests of Breitung (2001) are potentially superior to parametric cointegration tests because they do not require an exact functional form and specification of nonlinearity for estimation. These rank tests are adopted for studying international stock market linkages (Li, 2006), the law of one price (Shum, et al., 2018; Woo, et al., 2020), the lending-deposit rate relationship (Chang & Su, 2010); the relationship between stock and real estate markets (Su, 2011) and the relationship between stock and bond indices (Lim, et al., 2012), where the functional forms may be unknown and possibly nonlinear. Under these circumstances, the rank tests have been adopted for PPP testing in many countries in the World (for example, Chang & Su, 2013; Haug & Basher, 2011; Liew, et al., 2010; Liu & Su, 2011; Su & Chang, 2011), where the PPP models are possibly nonlinear or of an unknown form. It is found that these previous studies on PPP were done before the start of BRI and used USD as the base currency.

Our study attempts to use nonparametric rank tests to examine PPP between China and BRI Asian countries described in the next section. China's Renminbi (RMB) is the base currency in PPP models. Our data periods cover the most recent two decades so that our empirical results can reflect the contemporary development of China and the BRI Asian economies compared to previous studies. Thus, our results can judge if the BRI can help enhance the goods market integration of China and the sampled Asian countries. Furthermore, we further enhance the statistical power of the rank tests by addressing the 'rank problem' in a multivariate PPP model. Our work's originality in PPP testing lies in using the RMB as a base currency, covering recent data on BRI countries, and employing nonparametric, nonlinear rank tests free of the 'rank problem' in a multivariate equation.

3. PPP MODELS AND ECONOMETRIC METHODOLOGY

3.1 Linear and nonlinear versions of PPP

The following equation shows the unrestricted linear version of the PPP relationship:

$$\text{Linear Model I: } e_t = \beta_0 + \beta_1 p_t - \beta_2 p_t^* + u_t \qquad (t = 1 \ldots T), \tag{1}$$

where e_t is the natural logarithm of the spot exchange rate, expressed as units of foreign currency per unit of Chinese currency; that is, RMB, β_0 is a constant term, β_1 and β_2 are the coefficients, p_t

and p_t^* refer to the natural logarithms of the foreign and Chinese price indices, respectively, T is sample size, and u_t is an equilibrium error representing the deviations from PPP. On the other hand, the restricted linear version of PPP can be re-specified by setting $\beta_2 = 1$ in Equation (1), and becomes the following equation (Cheung & Lai, 1993):

$$\text{Linear Model II:} \quad e_t + p_t^* = \beta_0 + \beta_1 p_t + u_t, \tag{2}$$

where $e_t + p_t^*$ and p_t are two prices expressed in terms of a common (foreign) currency, which can be directly compared in the PPP equation.

The limitation of the above two linear PPP models is that there will be misspecification when there are sources of nonlinearities in the data, which may also appear in unknown forms. To overcome the limitation, we consider the general forms of nonlinear versions of the above equations as shown in the following:

$$\text{Nonlinear Model II:} \quad g(e_t + p_t^*) = f(p_t) + u_t; \tag{3}$$

$$\text{Nonlinear Model I:} \quad g(e_t) = f_1(p_t) + f_2(p_t^*) + u_t, \tag{4}$$

where g(.), f(.), $f_1(.)$ and $f_2(.)$ are of nonlinear functional forms.

Our research aim is to detect the presence of PPP between China and the sampled BRI Asian countries using the nonparametric rank tests (Breitung, 2001). When PPP theory does not provide a specific nonlinear functional form as in Equations (3) and (4), these rank tests without the requirement of exact model specification for estimation are more powerful than other parametric methods. If the functional form is mis-specified, the statistical power of parametric tests would be reduced.

3.2 Nonparametric rank tests

The nonparametric rank tests proposed by Breitung (2001) involve the rank test for cointegration and the score test for nonlinearity. We will discuss the details and the use of the nonparametric rank tests in this subsection.

3.2.1 Rank test for cointegration

The rank test statistics are used to test for cointegration from the movements of ranked series $R_T(w_t)$, where w_t is a set of series under study, without knowing the exact specification of functional forms. Hence, to test for cointegration in the bivariate PPP Model II (Equation 3), we use the following two rank test statistics developed by Breitung (2001) for investigating the distance between sequences of the ranked series:

$$\kappa_T^* = \frac{\sup_{1<t<T} |d_t|}{T\hat{\sigma}_{\Delta d}}, \tag{5}$$

$$\xi_T^* = \frac{\sum_{t=1}^{T} d_t^2}{T^3 \hat{\sigma}_{\Delta d}^2}, \tag{6}$$

where $d_t = R_T(e_t + p_t^*) - R_T(p_t)$. We note that $\hat{\sigma}^2_{\Delta d} = T^{-2}\sum_{t=1}^{T}(d_t - d_{t-1})^2$ is used to adjust for any possible small value of correlation between the series $(e_t + p_t^*)$ and p_t. If the possible correlation is large, then κ_T^{**} and ξ_T^{**} are used:

$$\kappa_T^{**} \cong \kappa_T^*/\left(1 - 0.174\,(\rho_T^R)^2\right), \tag{7}$$

$$\xi_T^{**} \cong \xi_T^*/(1 - 0.462\,\rho_T^R), \tag{8}$$

where ρ_T^R refers to the coefficient of correlation between the rank differences and κ_T^* and ξ_T^* have the same critical values as κ_T^{**} and ξ_T^{**}, respectively.

Furthermore, Breitung (2001) suggests the two-sided rank test for cointegration:[1]

$$\Xi[1]^* = T^{-3}\sum_{t=1}^{T}(\tilde{u}_t^R)^2 / \hat{\sigma}^2_{\Delta\tilde{u}}, \tag{9}$$

where the least-squares residual, $\tilde{u}_t^R = R_T(e_t + p_t^*) - b_{1T}R_T(p_t)$, and b_{1T} is a least-squares estimator. We use $\hat{\sigma}^2_{\Delta\tilde{u}} = T^{-2}\sum_{t=1}^{T}(\tilde{u}_t^R - \tilde{u}_{t-1}^R)^2$ to adjust for a possible correlation among the series under examination. The two-sided rank test in (9) can be extended for cointegration in the multivariate PPP Model I (Equation 4) as shown in the following:

$$\Xi[2]^* = T^{-3}\sum_{t=1}^{T}(\hat{u}_t^R)^2 / \hat{\sigma}^2_{\Delta\tilde{u}}, \tag{10}$$

where $\hat{u}_t^R = R_T(e_t) - b_{1T}R_T(p_t) - b_{2T}R_T(p_t^*)$, and b_{1T} and b_{1T} are the least-squares estimators.

If the above rank test statistics (5) – (10) are found to be smaller than their respective critical values, the null hypothesis of no (nonlinear) cointegration will be rejected.

3.2.2. Score statistic for nonlinearity

If the null hypothesis of the rank test for cointegration is rejected, we proceed to undertake the score test for nonlinearity to find whether the resulting cointegration is linear or nonlinear.[2]

Breitung (2001) proposes the bivariate score test statistic TR^2 computed from the following regression:

$$\tilde{v}_t = a_0 + \sum_{j=1}^{p} a_j(e_{t-j} + p_{t-j}^*) + b_1\,p_t + \sum_{i=-q}^{q} c_i\,\Delta p_{t-i} + \theta_1 R_T(p_t) + \varepsilon_t. \tag{11}$$

where $\tilde{v}_t$ is the residuals estimated from the dynamic OLS regression of $(e_t + p_t^*)$ on p_t (Stock & Watson, 1993); a_0, a_j, b_1, c_i, and θ_1 are the estimated parameters; p and q are the lag orders; and R^2 is the coefficient of determination of Equation (11).

Similarly, the multivariate score test statistic TR^2 is obtained from the following regression (Li, 2006):

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[1] $\Xi[k]^*$ is used to detect for the existence of cointegration among k+1 variables.

[2] Alternative tests of nonlinearity include, for example, Hui, et al. (2017) and Li & Li (2011).

$$\hat{v}_t = a_0 + \sum_{j=1}^{p} a_j e_{t-j} + b_1 p_t + b_2 p_t^* + \sum_{i=-q}^{q} (c_i \Delta p_{t-i} + d_i \Delta p_{t-j}^*) + \theta_1 R_T(p_t) + \theta_2 R_T(p_t^*) + \varepsilon_t, \quad (12)$$

where $\hat{v}_t$ is the residuals estimated from the dynamic OLS regression of e_t on p_t and p_t^*; a_0, a_j, b_1, b_2, c_i, d_i, θ_1 and θ_2 are the estimated parameters; and R^2 is the coefficient of determination of Equation (12).

When the bivariate (multivariate) score test statistic TR^2 is larger than the χ^2 critical values with one (two) degree(s) of freedom, the null of linear cointegration, i.e., $\theta_1 = 0$, ($\theta_1 = \theta_2 = 0$), is then rejected in favor of nonlinear cointegration.

4. Data

Our dataset comprises 18 selected Asian countries participating in the BRI, which include Bangladesh, Cambodia, Hong Kong, Macau, Indonesia, Iran, Iraq, Laos, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Singapore, South Korea, Sri Lanka, Thailand, and Vietnam (Green BRI Center, 2021).[3] The data series consists of 19 spot exchange rate series (including RMB per USD and foreign currency units of 18 BRI countries per USD) and 19 consumer price indices (CPIs) collected from the IMF International Financial Statistics. The timeframe of the data is from 2000:01 to 2020:12, comprising 252 monthly observations in total, with all spot exchange rates transformed into foreign currency units per RMB to use RMB as the base currency. All data series were re-based as 100 in January 2010 to ensure consistency, taken into natural logarithms, and seasonally adjusted using the X12 method.

5. Empirical Results

5.1 Unit root tests

To begin with, we verify the existence of a unit root in the data series using the Phillips and Perron (1988) unit root test. Table 1 shows that the null hypothesis of a unit root for data series in level cannot be rejected, while the null is rejected for the first differenced series. Thus, all the data and their corresponding ranked series are I(1).

Table 1. Phillips-Perron unit root tests

Country	Consumer price indices		Spot exchange rate series	
	Level	First Difference	Level	First Difference
Bangladesh	-2.540	-14.233***	-2.123	-15.275***
Cambodia	-1.428	-10.367***	-2.922	-18.342***
Hong Kong	-3.006	-21.275***	-2.759	-17.129***
Macau	-2.859	-15.454***	-2.855	-17.429***

[3] Out of the BRI countries in our sample, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam are ASEAN members. Hong Kong and Macau play a significant role in the BRI although they are not BRI 'countries' (Berlie & Hung, 2020).

Indonesia	-0.343	-13.933***	-2.458	-14.669***
Iran	-1.096	-7.383***	-2.577	-16.893***
Iraq	-0.203	-9.539***	-3.049	-39.836***
Laos	-1.610	-10.474***	-2.012	-13.035***
Malaysia	-1.326	-12.016***	-1.374	-14.505***
Myanmar	-1.305	-9.159***	-2.019	-15.823***
Nepal	-2.181	-12.876***	-1.508	-13.954***
Pakistan	-1.464	-12.866***	-1.712	-14.735***
Philippines	-1.030	-8.817***	-2.424	-16.074***
Singapore	-0.715	-16.330***	-1.412	-15.999***
South Korea	0.431	-14.392***	-2.523	-17.064***
Sri Lanka	-0.594	-13.454***	-2.926	-14.556***
Thailand	-0.123	-12.052***	-2.244	-13.809***
Vietnam	-0.680	-5.813***	-1.104	-15.944***
China	-2.444	-15.796***	-1.158	-12.249***

Notes:
An intercept and a linear trend are included in the test equation.
The bandwidth is estimated using Bartlett kernel, and the lag length is determined using the Newey-West automatic method.
Critical values at the 10%, 5%, and 1% significance level are -3.137, -3.427 and -3.994, respectively.
*** denotes statistical significance at the 1% level.

5.2 Linear cointegration tests

The next step of the analysis is to test for cointegration. For comparison purposes, we first undertake the parametric Engle and Granger (1987) linear cointegration tests (τ-test and z-test statistics). Empirical findings reported in Table 2 do not favor the evidence of linear cointegration for Linear Models I and II in all cases.

Table 2. Linear cointegration tests

	Model II		**Model I**	
	τ-test	**z-test**	**τ-test**	***z*-test**
Bangladesh	-1.2698	-2.9959	-1.7000	-4.2941
Cambodia	-2.4337	-11.080	-2.5706	-12.411
Hong Kong	-2.0203	-3.3435	-1.3690	-3.7816
Macau	-1.6197	-3.8657	-1.1539	-3.1893
Indonesia	-1.9288	-7.5666	-3.1602	-17.334
Iran	-2.5537	-12.351	-2.2610	-11.341
Iraq	-0.8427	-2.4244	-2.5937	-16.317
Laos	-1.3897	-5.9412	-1.5178	-6.4584
Malaysia	-2.2959	-10.115	-2.2265	-9.4466
Myanmar	-1.4727	-3.7874	-2.3295	-10.781

Nepal	-2.2594	-10.067	-2.2355	-9.8608
Pakistan	-1.7377	-6.5721	-1.7622	-6.7242
Philippines	-3.0394	-14.779	-3.3969	16.596
Singapore	-2.3812	-12.918	-2.8906	-17.227
South Korea	-2.1244	-8.4741	-2.1231	-9.0120
Sri Lanka	-1.3367	-4.8548	-3.3399	-18.988
Thailand	-1.9359	-7.1811	-2.1526	-8.4777
Vietnam	-2.6953	-14.048	-2.8106	-16.128

Notes:
An intercept is included in the test equation.
The modified SIC is used to determine the number of lag lengths.
Critical values for the **τ**-test statistics at the 10%, 5%, and 1% significance level, when the number of explanatory values is one (two) are -3.065 (-3.449), -3.365 (-3.767) and -3.961 (-4.307), respectively (Phillips & Ouliaris, 1990).
Critical values for the **z**-test statistics at the 10%, 5%, and 1% significance level when the number of explanatory values is one (two) are -17.039 (-22.194), -20.493 (-26.094) and -28.321 (-34.168), respectively (Phillips & Ouliaris, 1990).

5.3 Rank test for cointegration

We proceed with nonparametric rank tests for cointegration. As shown in Table 3, empirical findings for Model II (Equation 3) indicate that the null hypothesis of non-cointegration can be rejected by at least three rank test statistics out of five, κ_T^*, ξ_T^*, κ_T^{**}, ξ_T^{**} and $\Xi[1]^*$, in 12 (Bangladesh, Indonesia, Iran, Iraq, Laos, Malaysia, Nepal, Philippines, Singapore, South Korea, Sri Lanka, and Vietnam) out of 18 cases. The number of rejections is more significant for nonparametric rank tests than parametric linear tests. Our results align with the Monte Carlo experiments in Breitung (2001), which demonstrate a property of power in the rank tests superior to that in the traditional linear tests under the non-linear and linear cases.

Table 3. Rank tests of nonlinear cointegration for Model II

Country	**Rank tests for cointegration**					**Score test**
	κ_T^*	ξ_T^*	κ_T^{**}	ξ_T^{**}	$\Xi[1]^*$	TR^2
Bangladesh	0.5248	0.0193**	0.5283	0.0212*	0.0193**	2.0983
Cambodia	0.4671	0.0250	0.4671	0.0251	0.0250*	——
Hong Kong	0.6154	0.0501	0.6178	0.0538	0.0502	——
Macau	0.4665	0.0375	0.4977	0.0397	0.0374	——
Indonesia	0.5475	0.0204*	0.5521	0.0227*	0.0204**	3.2445*
Iran	0.3604**	0.0068***	0.3612**	0.0071***	0.0068***	0.0008
Iraq	0.5660	0.0242*	0.5660	0.0241*	0.0239*	8.4858***
Laos	0.5452	0.0216*	0.5495	0.0240*	0.0217*	10.202***
Malaysia	0.4157	0.0122***	0.4157	0.0123***	0.0123***	0.0013
Myanmar	0.5956	0.0433	0.5956	0.0431	0.0433	——
Nepal	0.3445**	0.0141***	0.3447**	0.0144**	0.0141***	0.1096

Pakistan	0.5632	0.0333	0.5660	0.0361	0.0334	——
Philippines	0.3967*	0.0179**	0.3970*	0.0185**	0.0179**	4.2848**
Singapore	0.3505**	0.0155**	0.3509**	0.0161**	0.0156**	2.1352
South Korea	0.4672	0.0198**	0.4674	0.0202*	0.0195**	0.0121
Sri Lanka	0.3339**	0.0041***	0.3339**	0.0041***	0.0041***	4.0092**
Thailand	0.4577	0.0421	0.4580	0.0433	0.0424	——
Vietnam	0.5207	0.0165**	0.5210	0.0169**	0.0165**	2.9608*

Notes:
The null hypothesis of no cointegration is rejected based on the following finite-sample critical values, which were generated by 10,000 replications of Monte Carlo simulations for T = 252:

	κ_T^*/κ_T^{**}	$\xi_T^*/\ \xi_T^{**}$	$\Xi[1]^*$
* 10%	0.3984	0.0247	0.0261
** 5%	0.3684	0.0200	0.0209
*** 1%	0.3190	0.0143	0.0147

Critical values of the χ^2 distribution with one degree of freedom for the nonlinear score test at the 10%, 5%, and 1% significance level are 2.706, 3.841 and 6.634, respectively.

Our rank test results for PPP in Model II (Table 3) do not encounter the rank problem proposed by Liew, et al. (2012). However, as not all three ranked series move in the same direction, the rank test for Model I may be susceptible to the rank problem with weak evidence of cointegration.[4] To address the rank problem, Model I is reconfigured by rearranging the variables as in Equations (13) and (14) below to guarantee that all ranked series move in the same direction (Woo, et al., 2022):

$$\text{Linear Model I}': \ p_t = \frac{-\beta_0}{\beta_1} + \frac{e_t}{\beta_1} + \frac{\beta_2}{\beta_1} p_t^* - \frac{u_t}{\beta_1} \ ; \tag{13}$$

$$\text{Nonlinear Model I}': \ f_1(p_t) = g(e_t) + f_2(p_t^*) + u_t. \tag{14}$$

We apply $\Xi[2]^*$ to test for Model I′ as given by Equation (14). Results in Table 4 indicate empirical support for the cointegration relationship in Model I′ for 6 more cases during the entire sample period (Cambodia, Hong Kong, Macau, Myanmar, Pakistan, and Thailand) compared to Model II (Table 3). The power of the rank test for Model I′ is higher than that for Model I (unreported) because the rank problem is removed and is higher than that for Model II when parametric restrictions not supported by the data are relaxed.[5]

Our entire sample covers the period when Chinese economic power was growing, and the rising trends of economic indicators in China were more evident in the past ten years (World Bank, 2021). To further investigate whether there are any changes in PPP relationship and goods markets integration of China and BRI countries under study during the sample period, we split the entire sample period into two subsamples: one from January 2000 to December 2010 and another from January 2011 to December 2020, for cointegration analysis of Model I′. Table 4 shows that PPP relationships with China have existed during both the subsamples in 6 cases (Bangladesh, Cambodia, Iran, Laos, Sri Lanka, and

[4] Results are available upon request.

[5] Hence, the subsequent analysis of cointegration results is based on Model I′.

Vietnam). Moreover, there are nine economies where PPP with China did not exist initially in the first subsample. Still, PPP has become evident in the second subsample (Hong Kong, Macau, Indonesia, Iraq, South Korea, Myanmar, Nepal, Pakistan, and the Philippines). This change is attributed to BRI (Foo, et al., 2020),[6] and China's active engagement in regional economic organizations and free trade areas (Chiang, 2019; Soong, 2018) over the past ten years, which have triggered positive impacts on trade relations with Asian trading partners. Though Hong Kong and Macau are Special Administrative Regions (SARs) of China, results show that they did not have PPP with Mainland China until after China-driven strategies, e.g. development of the Greater Bay Area that links Hong Kong and Macau to the adjacent Pearl River Delta economic zone in Southern China came into play (Woo, et al., 2022), and involvement of the two SARs in the BRI in the recent decade, stimulating the economic convergence between these two SARs and Mainland China (Berlie & Hung, 2020; Gong, et al., 2021).

The above findings indicate that China has successfully integrated its economy with regional goods markets, covering most BRI countries in Asia. The implication is that China should further strengthen economic cooperation in Asia using the Regional Comprehensive Economic Partnership signed in 2020 (RCEP, 2020) and formulate further liberalization policies in factors, services, and financial markets.

Surprisingly, it was found that the PPP with China, previously established in three ASEAN countries, Malaysia, Singapore, and Thailand, has been rejected in the past decade. Establishing CAFTA should help reduce transaction costs, promote goods arbitrage across countries, and supposedly foster price convergence and PPP. But political risk represents a crucial hidden transaction cost (Moser, et al., 2008) that may exist in the data and unfavorably affect the PPP. Consequently, more profits for goods arbitrage are required to compensate for the hidden transaction costs of trading across countries.

Table 4. Rank tests of nonlinear cointegration for Model I′

	Full sample period		Subsample: Year 2000-2010		Subsample: Year 2011-2020	
	$\Xi[2]^*$	TR^2	$\Xi[2]^*$	TR^2	$\Xi[2]^*$	TR^2
Bangladesh	0.0118***	1.9803	0.0085***	3.5568	0.0082***	1.3446
Cambodia	0.0087***	24.066***	0.0184**	7.2550**	0.0095***	1.1503
Hong Kong	0.0741	——	0.0412	——	0.0062***	2.7914
Macau	0.0563	——	0.0456	——	0.0092***	2.8390
Indonesia	0.0118***	2.6583	0.0251	——	0.0075***	4.4532
Iran	0.0114***	3.8043	0.0162**	0.1778	0.0088***	18.875***
Iraq	0.0068***	28.279***	0.0266	——	0.0111***	0.0812
Laos	0.0100***	4.8910*	0.0215*	0.3871	0.0097***	8.1920**
Malaysia	0.0126**	4.9501*	0.0221*	3.6448	0.0303	——
Myanmar	0.0120***	15.497***	0.0256	——	0.0166**	11.424***

[6] The BRI was proposed in 2013 within the second subsample.

Nepal	0.0105***	0.9288	0.0236	——	0.0068***	3.4002
Pakistan	0.0126**	3.3284	0.0298	——	0.0078***	3.1387
Philippines	0.0112***	5.4279*	0.0254	——	0.0096***	7.9394**
Singapore	0.0158**	9.3702***	0.0072***	6.3157**	0.0492	——
South Korea	0.0105***	4.8056*	0.0269	___	0.0077***	2.6546
Sri Lanka	0.0061**	0.8332	0.0123***	3.3756	0.084***	6.9577**
Thailand	0.0122***	1.1195	0.0162**	1.1198	0.0297	——
Vietnam	0.0149**	4.3965	0.0179**	14.718***	0.0069***	4.9104*

Notes

The sample sizes for the first and the second subsample period are 132 and 120, respectively. The simulated critical values of $\Xi[2]^*$ with different sample sizes are:

	$\Xi[2]^*$(T=252)	$\Xi[2]^*$(T=132)	$\Xi[2]^*$(T=120)
* 10%	0.0207	0.0222	0.0225
** 5%	0.0173	0.0186	0.0188
*** 1%	0.0127	0.0138	0.0140

Critical values of the χ^2 distribution with two degrees of freedom for the nonlinear score test are 4.605, 5.991, and 9.210, at 10%, 5%, and 1%, respectively.

From the political economy perspective, the 'China threat' theory has returned in Asian countries due to China's growing economic power, economic diplomacy, and the BRI. Some argue that China's frequent use of economic statecraft and coercive diplomacy to resolve territorial and other disputes has aroused intense geopolitical tensions with its Asian trading partners (Lai, 2018). Further, it is perceived that China has strategic, economic, political, and military motives behind the BRI. On one hand, the BRI offers economic benefits that BRI countries can potentially receive. But on the other hand, these countries may also be concerned with the possible economic, political, and security risks. These risks include economic vassalage, debt trap, and becoming diplomatically beholden to China, especially in the case of developing BRI countries (Pham & Giang, 2020; Trang, 2020). When confronting a rising China, some ASEAN countries have adopted mixed stances on establishing economic ties with China while maintaining military relations with Western powers (Wen, 2022). China's diplomatic pressures and national security threats sway some Asian countries towards aligning with the Western powers. Since Malaysia, Thailand, and Singapore enjoy higher GDP per capita than other ASEAN countries (World Bank, 2021), they have become more intensely aware of the potential security conflicts with China and more resistant to economic coercion. The increased hidden transaction costs caused by political risk might have weakened the integration of these countries' goods markets with China and led to the rejection of PPP during the most recent decade.

5.4 Nonlinear Score Test

After the rank tests for cointegration, we use the nonlinear score test to examine the nonlinearity. The results reported in Table 3 favor the nonlinear cointegration in Model II (Equation 3) for six countries (Indonesia, Iraq, Laos, Philippines, Sri Lanka, and Vietnam). On the other hand, as presented in Table 4, the score tests provide support for nonlinear cointegration in Model I' given by Equation (14) for 11 countries (Cambodia, Iran, Iraq, South Korea, Laos, Malaysia, Myanmar, Philippines, Singapore,

Sri Lanka, and Vietnam), where nonlinearity is found in either the entire sample or at least one subsample. Compared with Model II, Model I′ relaxes parameter restrictions on the PPP relationship and allows for more nonlinear functional forms. Consequently, more evidence of nonlinear cointegration is found in the data. In addition, the sources of nonlinearity in the functional form of PPP may include the mixture of transaction costs, uncertainty in economic policies, agents' heterogeneous opinions about the equilibrium exchange rate, official intervention in nominal and real exchange rates, changes in exchange rate regimes, and financial and speculative activities in foreign exchange markets.

6. Conclusion

Since the 18 BRI Asian countries studied in this paper have different characteristics and conditions, we adopt the nonparametric rank tests to investigate nonlinear cointegration in PPP models without requiring exact model specifications for estimation. Moreover, the rank tests may have higher power than the traditional linear tests, even under linearity. PPP Model I′ is free of rank problems in a multivariate equation. Also, Model I' is superior to Model II; the former is free from parameter restrictions, allows for more flexible nonlinear functional forms, and is more powerful in detecting cointegration and nonlinearity. The results of Model I′ in this study provide strong (reasonably strong) evidence of cointegration (nonlinearity) in the PPP relationship between China and selected BRI Asian countries over the entire sample period or across subsamples. Once evidence of PPP and goods market integration is found, policy implications, such as further liberalization of factors, services, and financial markets and other economic cooperation via BRI projects, are proposed to strengthen the economic achievements of BRI.

This study tests for PPP between China and Asian BRI countries so that nominal exchange rates relative to RMB, not Yen as in Liew, et al. (2009) or USD as in Chang and Su (2013), are used. Our data covers the most recent two decades, empirical results reflect more of China's current economic influence, and the policy implications are more relevant to the contemporary development of China and the BRI Asian economies. Hence, the adoption of rank tests for nonlinear cointegration with the removal of rank problems, using RMB as a base currency, and the coverage of more recent data on China and other BRI countries in Asia for study distinguish our work in the PPP literature. Moreover, when our results confirm strong evidence of goods market integration in Asia, the future scope of the study is to investigate the integration of labour and financial markets in China and Asian BRI countries (for example, Ghazouani, et al., 2019; Ha, et al., 2020; Singh, et al., 2022). Suppose integration of goods, labour, and financial markets can be established, then the necessary conditions for a common market or an economic union in Asia are satisfied, and economic integration in Asia is expected to intensify with many profitable business opportunities. Thus, our econometric results and their implications could assist both academics and practitioners in making optimal decisions, aligning our study with the discipline of decision sciences. Furthermore, it is essential to compare the applications of PPP in BRI countries in Asia and other countries. We leave it to further study in the future.

Nevertheless, challenges always come along with opportunities. Our results of PPP in the form of Model I′ show that Malaysia, Thailand, and Singapore have failed to achieve the PPP relationship in the most recent decade. The failure is attributed to hidden transaction costs, resulting from rising geopolitical risks in Asia. Worse still, there are presently more internal conflicts and political tensions

in Asia that adversely affect the BRI countries, and the conflicts could last for a long period. For example, there was a rebellion against the Myanmar Government in early 2021 (Bhattacharya & Raghuvanshi, 2021), and social disorder persists in the country. Thus, both production and consumption in Myanmar have almost come to a standstill. On the other hand, Sri Lanka is experiencing economic disarray with currency depreciation, rising inflation, and a severe debt crisis. This makes the ruling government step down finally in July 2022 (Bhowmick, 2022), but, yet, mass protests are still going on. Likewise, Pakistan is facing challenges in handling the economic crisis and is unable to meet its balance-of-payments needs and avoid sovereign default (Lakhan, et al., 2021). Essentially, many developing countries including Sri Lanka and Pakistan, have borrowed money from China to finance their BRI projects where provisions of the loans are often not publicized (Horn, et al., 2020). The debtor countries' concerns about economic or political concessions may negatively affect economic cooperation and integration with China. Moreover, South China Sea disputes and militarization in the Taiwan Strait are two long-standing, thorny sources of conflicts between China and Southeast Asian countries (Kurnia & Agustian, 2021; Oxford Analytica, 2022a). When the countries are more concerned with national security than economic benefits from the BRI, they may lean more towards the United States. Fears of military threat among Asian countries have increasingly intensified after the Russia-Ukraine war (Chang-Liao, 2023; Davis, 2023; Oxford Analytica, 2022b) started. To handle the issue, we anticipate that PPP and goods market integration with China will subside with increased transaction costs arising from geopolitical risks in most BRI countries, including Malaysia, Singapore, and Thailand in the next decade. To ward off the feelings of suspicion, our findings suggest that China should improve its diplomatic ties to maintain a peaceful atmosphere with other BRI countries to make the BRI successful.

Academics could extend our study of investigating different nonlinear PPP relationships by using other nonlinear processes, such as the regime-switching process, fixed threshold, and smooth transition dynamics (Sarno & Taylor, 2002; Taylor, 2006). Moreover, the sources and impacts of nonlinearity are different in different economic regimes (Chen, et al., 2020; Eggoh & Khan, 2014). The mixture of different kinds of nonlinearities in the data may justify a wide range of complex nonlinear correlations between exchange rates and price levels. These are the possible investigations in further study.

The rank problem occurs in the PPP models, where not all variables move in the same direction. The issue can be resolved in our study by re-arranging the variables as shown in Model I′. However, resolving the limitation of the rank tests for the productivity bias hypothesis, in which the relationship between the real exchange rates and productivity differentials is negative in a two-variable model (Anwar & Ali, 2015), may not be achievable. Thus, further study is required to tackle the rank problem in the PPP testing.

Finally, it is common that the cointegration tests are used to examine the long-run validity of the PPP relationship. Nonetheless, the existence of Granger causality between variables under study in at least one direction also implies the existence of cointegration (Granger, 1986). Moreover, Grange causality tests help detect the causal links between exchange rates and relative prices in the PPP models, offering more economic insights (Islam & Ahmed, 1999). While our study does not delve into Granger causality tests of the PPP relationship, future research, utilizing advanced nonlinear tests like Bai, et al. (2010, 2011, 2018) and Chow, et al. (2017), is suggested for investigating possible nonlinear causal linkages

in the system.

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References

Ahmad, S., & Rashid, A. (2008). Non-linear PPP in South Asia and China. *Economics Bulletin,* 6(17), 1-6. Retrieved from https://ideas.repec.org/a/ebl/ecbull/eb-.

Anwar, S., & Ali, S. Z. (2015). Productivity bias hypothesis: evidence from South Asia. *Applied Economics Letters*, 22(17), 1389-1394. https://doi.org/10.1080/ 13504851.2015.1034832

ASEAN. (2021). *ASEAN Statistical Yearbook 2021*. The ASEAN Secretariat. https://www.aseanstats.org/wp-content/uploads/2021/12/ASYB_2021_All_Final.pdf

Bahmani-Oskooee, M., Chang, T., & Hung, K. (2013). Revisiting purchasing power parity in Latin America: sequential panel selection method. *Applied Economics*, 45(32), 4584-4590. https://doi.org/10.1080/00036846.2013.795279

Bai, Z. D., Hui, Y. C., Jiang, D. D., Lv, Z. H., Wong, W. K., & Zheng, S. H. (2018). A new test of multivariate nonlinear causality. *PLoS ONE*, 13(1): e0185155. https://doi.org/10.1371/journal.pone.0185155

Bai, Z. D., Li, H., Wong, W. K., & Zhang, B. Z. (2011). Multivariate causality tests with simulation and application. *Statistics and Probability Letters*, 81(8), 1063–1071. https://doi.org/10.1016/j.spl.2011.02.031.

Bai, Z. D., Wong, W. K., & Zhang, B. Z. (2010). Multivariate linear and nonlinear causality tests, *Mathematics and Computers in Simulation*, 81(1), 5–17. https://doi.org/ 10.1016/j.matcom.2010.06.008.

Berlie, J. A., & Hung, S. (2020). The Greater Bay Area and the role of Hong Kong and Macau SARs in the Belt and Road Initiative. In: Berlie, J. (ed.) *China's Globalization and the Belt and Road Initiative. Politics and Development of Contemporary China*. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-22289-5_5

Bhattacharya, S., & Raghuvanshi, S. (2021). Political turmoil, leadership fiasco and economic fallout of Myanmar crisis in 2021. *International Journal of Research in Engineering, Science and Management*, 4(3), 30-32. Retrieved from https://journals.resaim.com/ijresm/article/view/550

Bhowmick, S. (2022). Understanding the economic issues in Sri Lanka's current debacle. *ORF Occasional Paper*, (357). Retrieved from https://www.orfonline.org /research/understanding-the-economic-issues-in-sri-lankas/

Breitung, J. (2001). Rank tests for nonlinear cointegration. *Journal of Business and Economic Statistics*, 19(3), 331–340. https://doi.org/10.1198/ 073500101681019981

Caporale, G. M., & Spagnolo, N. (2004). Modelling East Asian exchange rates: a Markov-switching approach. *Applied Financial Economics*, 14(4), 233-242. https://doi.org/10.1080/0960310042000201192

Chang, C. L., McAleer, M., & Wong, W. K. (2018). Decision sciences, economics, finance, business, computing, and big data: Connections. *Advances in Decision Sciences*, 22(1), 36-94. https://doi.org/10.47654/v22y2018i1p36-94.

Chang, H. L., & Su, C. W. (2010). The lending-deposit rate relationship in Eastern European countries: Evidence from the rank test for non-linear cointegration. *Finance a Uver: Czech Journal of Economics & Finance*, 60(6), 534-544.

Chang, T. Y., & Su, C. W. (2013). Revisiting purchasing power parity for East Asian countries using the rank test for nonlinear cointegration. *Applied Economics*, 45(19), 2847-2852. https://doi.org/10.1080/00036846.2012.657354

Chang-Liao, N. C. (2023). The limits of strategic partnerships: Implications for China's role in the Russia-Ukraine war. *Contemporary Security Policy*, 44(2), 226-247. https://DOI: 10.1080/13523260.2023.2174702

Chen, L., Du, Z., & Hu, Z. (2020). Impact of economic policy uncertainty on exchange rate volatility of China. *Finance Research Letters*, 32, 101266. https://doi.org/10.1016/j.frl.2019.08.014

Cheung, Y. W., & Lai, K. S. (1993). A fractional cointegration analysis of purchasing power parity. *Journal of Business and Economic Statistics*, 11(1), 103-112. https://doi.org/10.2307/1391310

Chiang, M. H. (2019). China–ASEAN economic relations after establishment of free trade area. *The Pacific Review*, 32(3), 267-290. https://doi.org/ 10.1080/09512748.2018.1470555

Chow, S. C., Cunado, J., Gupta, R., & Wong, W. K. (2017). Causal relationships between economic policy uncertainty and housing market returns in China and India: Evidence from linear and nonlinear panel and time series models. *Studies in Nonlinear Dynamics & Econometrics*, 22(2), 20160121. https://doi.org/10.1515/ snde-2016-0121

Davis, P. K. (2023). Potential implications of the Russia–Ukraine War for Northeast Asia, *Journal for Peace and Nuclear Disarmament*, 1-11. https://DOI: 10.1080/ 25751654.2023.2178205

Eggoh, J. C., & Khan, M. (2014). On the nonlinear relationship between inflation and economic growth. *Research in Economics*, 68(2), 133-143. https://doi.org/ 10.1016/j.rie.2014.01.001

Enderwick, P. (2018). The economic growth and development effects of China's One Belt, One Road Initiative. *Strategic Change*, 27(5), 447-454. https://doi.org/10.1002/jsc.2229

Engle, R. F., & Granger, C. W. J. (1987). Co-Integration and error correction: representation, estimation and testing. *Econometrica*, 55(2), 251-276. https://doi.org/10.2307/1913236

Foo, N., Lean, H. H., & Salim, R. (2020). The impact of China's one belt one road initiative on international trade in the ASEAN region. *The North American Journal of Economics and Finance*, 54, 101089. https://doi.org/10.1016/ j.najef.2019.101089

Gamboa-Estrada, F. (2019). The effectiveness of foreign exchange intervention in Latin America: A nonlinear approach to the coordination channel. *Global Finance Journal*, 40, 13-27. https://doi.org/10.1016/j.gfj.2018.11.004

Ghazouani, T., Drissi, R., & Boukhatem, J. (2019). Financial integration and macroeconomic volatility: New evidence from DSGE modeling. *Annals of Financial Economics*, 14(02), 1950007. https://doi.org/10.1142/ S2010495219500076

Gong, Z., Chan, F., & Wu, Y. (2021). Borrowing Hong Kong's international standards: A steppingstone for the Chinese "Belt and Road" going out?. *Sustainability*, 13(6), 3485. https://doi.org/10.3390/su13063485

Granger, C. J. (1986). Developments in the study of cointegrated economic variables. *Oxford Bulletin of Economics and Statistics*, 48(3), 213-228. https://doi.org/10.1111/j.1468-0084.1986.mp48003002.x

Green BRI Center. (2021). Countries of the Belt and Road Initiative (BRI). Retrieved January 21, 2021. Available from: https://green-bri.org/countries-of-the-belt-and-road-initiative-bri/

Ha, N. M., Ngoc, B. H., & McAleer, M. (2020). Financial integration, energy consumption and economic growth in Vietnam. *Annals of Financial Economics*, 15(03), 2050010. https://doi.org/10.1142/S2010495220500104

Haug, A. A., & Basher, S. A. (2011). Linear or nonlinear cointegration in the purchasing power parity relationship? *Applied Economics*, 43(2), 185-196. https://doi.org/ 10.1080/00036840802403656

He, H., Chou, M. C., & Chang, T. Y. (2014). Purchasing power parity for 15 Latin American countries: Panel SURKSS test with a Fourier function. *Economic Modelling*, 36, 37-43. https://doi.org/10.1016/j.econmod.2013.09.012

Hieu, N. T., Huy, L. M., Phat, H. M., Anh, N. N. P., & Wong, W. K. (2020). Decision sciences in education: The STEMtech model to create stem products at high schools in Vietnam. *Advances in Decision Sciences*, 24(2), 15-65. https://doi.org/10.47654/v24y2020i2p15-65

Holmes, M. J. (2008). Real exchange rate stationarity in Latin America and relative purchasing power parity: A regime switching approach. *Open Economies Review*, 19, 261-275. https://doi.org/10.1007/s11079-007-9020-1

Horn, S., Reinhart, C. M., & Trebesch, C. (2020). How much money does the world owe China?. *Harvard Business Review*, 26. Retrieved from https://hbr.org/ 2020/02/how-much-money-does-the-world-owe-china

Huang, Y., & Luk, P. (2020). Measuring economic policy uncertainty in China. *China Economic Review*, 59, 101367. https://doi.org/10.1016/j.chieco.2019.101367

Hui, Y., Wong, W. K., Bai, Z., & Zhu, Z. Z. (2017). A new nonlinearity test to circumvent the limitation of Volterra expansion with application. *Journal of the Korean Statistical Society*, 46, 365-374. https://doi.org/10.1016/ j.jkss.2016.11.006

Ilzetzki, E., Reinhart, C. M., & Rogoff, K. S. (2022). Chapter 3 - Rethinking exchange rate regimes. In: G. Gopinath, E. Helpman, & K. Rogoff (eds.), *Handbook of international economics*, 6, 91-145, Elsevier. https://doi.org/10.1016/ bs.hesint.2022.02.010.

Imane, E., Chang, B. H., Elsherazy, T. A., Wong, W. K., & Uddin, M. A. (2023). The External Exchange Rate Volatility Influence on The Trade Flows: Evidence from Nonlinear ARDL Model. *Advances in Decision Sciences*, 27(2), 75-98. https://doi.org/10.47654/v27y2023i2p75-98

Ishikawa, K. (2021). The ASEAN Economic Community and ASEAN economic integration, *Journal of Contemporary East Asia Studies,* 10(1), 24-41. ISSN 0301-4207. https://doi.org/10.1080/24761028.2021.1891702

Islam, A. M., & Ahmed, S. M. (1999). The purchasing power parity relationship: causality and cointegration tests using Korea-US exchange rate and prices. *Journal of Economic Development*, 24(2), 95-111.

Kilian, L., & Taylor, M. P. (2003). Why is it so difficult to beat the random walk forecast of exchange rates? *Journal of International Economics*, 60(1), 85–107. https://doi.org/10.1016/S0022-1996(02)00060-0

Kim, B. H., Kim, H. K., & Oh, K. Y. (2009). The purchasing power parity of Southeast Asian currencies: A time-varying coefficient approach. *Economic Modelling*, 26(1), 96-106. https://doi.org/10.1016/j.econmod.2008.05.009

Kurnia, A. C., & Agustian, R. A. (2021). South China Sea: conflict, challenge, and solution. *Lampung Journal of International Law*, 3(1), 51-62. https://doi.org/ 10.25041/lajil.v3i1.2266

Lai, C. (2018). Acting one way and talking another: China's coercive economic diplomacy in East Asia and beyond. *The Pacific Review*, 31(2), 169-187. https://doi.org/10.1080/09512748.2017.1357652

Lakhan, G. R., Soomro, B. A., Channa, A., Jameel, I., & Ahmed, S. (2021). COVID-19 uncertainties and Pakistan’s economic problems during the pandemic. *Journal of Contemporary Issues in*

Business & Government, 27(5), 994-1005. Retrieved from https://cibgp.com/article_11904_47ee37d7b89c2d4b10212cc7a7d6162e.pdf.

Lee, S. K., Shum, P. K. C., & Woo, K. Y. (2023). Tests of goods market integration between China and African BRI countries. *International Studies of Economics.* 1–24. https://doi.org/10.1002/ise3.71

Li, G. D., & Li, W. K. (2011). Testing for linear time series models against its threshold extension. *Biometrika* 98(1), 243-250. https://doi.org/10.1093/ biomet/asq074

Li, X. M. (2006). A revisit of international stock market linkages: New evidence from rank tests for nonlinear cointegration. *Scottish Journal of Political Economy*, 53(2), 174–197. https://doi.org/10.1111/j.1467-9485.2006.00375.

Liew, V. K. S., Chia, R. C. J., & Ling, T. H. (2010). Long-run validity of purchasing power parity and rank tests for cointegration for Central Asian countries. *Applied Economics Letters*, 17(11), 1073-1077. https://doi.org/10.1080/ 00036840902762704

Liew, V. K. S., Lee, H. A., & Lim, K. P. (2009). Purchasing power parity in Asian economies: further evidence from rank tests for cointegration. *Applied Economics Letters*, 16(1), 51-54. https://doi.org/10.1080/13504850601032057.

Liew, V. K. S., Ling, T. H., Chia, C. J., & Yoon, G. (2012). On the application of the rank tests for nonlinear cointegration to PPP: The case of Papua New Guinea. *Economic Modelling*, 29(2), 326-332. https://doi.org/10.1016/ j.econmod.2011.10.017

Lim, S. Y., Ong, S. L., & Ho, C. M. (2012). Co-Movement between Malaysian stock index and bond index: Empirical evidence from rank tests for cointegration. *IUP Journal of Applied Finance*, 18(1), 5-18.

Liu, Y. S., & Su, C. W. (2011). Purchasing power parity with rank tests for nonlinear cointegration in African countries. *South African Journal of Economics*, 79(1), 17-26. https://doi.org/10.1111/j.1813-6982.2011.01259.x

Lothian, J. R. (2016). Purchasing power parity and the behavior of prices and nominal exchange rates across exchange-rate regimes. *Journal of International Money and Finance*, 69, 5-21. https://doi.org/10.1016/j.jimonfin.2016.06.015

Lu, H., Rohr, C., Hafner, M., & Knack, A. (2018). China Belt and Road Initiative. *Cambridge & Santa Monica: RAND Corporation.* https://doi.org/ 10.7249/RR2625

Malik, A., Parks, B., Russell, B., Lin, J., Walsh, K., Solomon, K., Zhang, S., Elston, T., & Goodman, S. (2021). *Banking on the Belt and Road: Insights from a new global dataset of 13,427 Chinese development projects*, Williamsburg, VA. Retrieved from: https://static1.squarespace.com/static/563a4585e4b00d0211e8dd7e/t/61545d1dfad5231964567caa/1632918816116/Banking_on_the_Belt_and_Road__Insights_from_a_new_global_dataset_of_13427_Chinese_development_projects.pdf

Maydybura, A., Gohar, R., Salman, A., Wong, W. K., & Chang, B. H. (2023). The asymmetric effect of the extreme changes in the economic policy uncertainty on the exchange rates: evidence from emerging seven countries. *Annals of Financial Economics*, 18(02), 2250031. https://doi.org/10.1142/S2010495222500312

Moser, C., Nestmann, T., & Wedow, M. (2008). Political risk and export promotion: evidence from Germany. *World Economy*, 31(6), 781-803. http://dx.doi.org/ 10.2139/ssrn.2785263

Mukhtar, A., Zhu, Y., Lee, Y., Bambacas, M., & Cavusgil, S. (2022). Challenges confronting the 'One Belt One Road' Initiative: Social networks and cross-cultural adjustment in CPEC projects, *International Business Review*, 31(1), 101902. https://doi.org/10.1016/j.ibusrev.2021.101902

Narayan, P. K. (2010). Evidence on PPP for selected Asian countries from a panel cointegration test with structural breaks. *Applied Economics*, 42(3), 325-332. https://doi.org/10.1080/00036840701604446

Nusair, S. A. (2012). Nonlinear adjustment of Asian real exchange rates. *Economic Change and Restructuring*, 45(3), 221-246. https://doi.org/10.1007/s10644-011-9116-x

Oxford Analytica. (2022a). Chinese drills escalate Taiwan tension permanently. *Emerald Expert Briefings*, (oxan-db). https://doi.org/ 10.1108/OXAN-DB271994

Oxford Analytica. (2022b). Washington shows support for Taiwan during Ukraine war. *Emerald Expert Briefings*, (oxan-db). https://doi.org/10.1108/OXAN-DB270223

Pham, Q. M., & Giang, L. H. (2020). The Belt and Road and the World: Why China's "One Belt, One Road" Initiative is a dilemma for everyone. In: Chong, A., Pham, Q. (eds.) *Critical Reflections on China's Belt & Road Initiative*. Palgrave Macmillan, Singapore. https://doi.org/10.1007/978-981-13-2098-9_4

Phillips, P. C., & Ouliaris, S. (1990). Asymptotic properties of residual based tests for cointegration. *Econometrica*, 58(1), 165-193. https://doi.org/10.2307/2938339

Phillips, P. C. B., & Perron, P. (1988). Testing for a unit root in time series regression, *Biometrika*, 75(2), 335-346. https://doi.org/10.2307/2336182

Rajput, S. K. O., Ghumro, N. H., & Anjum, N. (2019). Do exchange rate changes have symmetric or asymmetric effects on international trade integration?. *Annals of Financial Economics*, 14(03), 1950013. https://doi.org/10.1142/ S2010495219500131

RCEP. (2020). Legal text of the RCEP agreement. Retrieved from https://rcepsec.org/legal-text/

Sarno, L., & Taylor, M. P. (2002). Purchasing power parity and the real exchange rate. *IMF staff papers*, 49(1), 65-105. https://doi.org/10.1017/ CBO9780511754159.005

Shum, P., Woo, K. Y., & Lee, S. K. (2018). Rank tests for price convergence in Australian beverage markets. *Applied Economics Letters*, 25(12), 862–866. https://doi.org/10.1080/13504851.2017.1374531

Sideris, D. A. (2008). Foreign exchange intervention and equilibrium real exchange rates. *Journal of International Financial Markets, Institutions and Money*, *18*(4), 344-357. https://doi.org/10.1016/j.intfin.2007.04.001.

Singh, A. K., Shrivastav, R. K., & Mohapatra, A. K. (2022). Dynamic linkages and integration among five emerging BRICS markets: pre-and post-BRICS period analysis. *Annals of Financial Economics*, 17(03), 2250018. https://doi.org/ 10.1142/S201049522250018X

Soong, J. J. (2018). China's one belt and one road initiative meets ASEAN economic community: Propelling and deepening regional economic integration? *The Chinese Economy*, 51(4), 291-297. https://doi.org/10.1080/ 10971475.2018.1457335.

Stock, J. H., & Watson, M. W. (1993). A simple estimator of cointegrating vectors in higher order integrated systems. *Econometrica*, 61(4), 783–820. https://doi.org/10.2307/2951763

Su, C. W. (2011). Non-linear causality between the stock and real estate markets of Western European countries: Evidence from rank tests. *Economic Modelling*, 28(3), 845-851. https://doi.org/10.1016/j.econmod.2010.10.021

Su, C. W., & Chang, H. L. (2011). Revisiting purchasing power parity for Central and East European countries: Using rank tests for nonlinear cointegration. *Eastern European Economics*, 49(1), 5-12.

Taylor, A. M. (2001). Potential pitfalls for the purchasing-power-parity puzzle? Sampling and specification biases in mean-reversion tests of the law of one price. *Econometrica*, 69(2), 473-498. https://doi.org/10.1111/1468-0262.00199

Taylor, M. P. (2006). Real exchange rates and purchasing power parity: mean-reversion in economic thought. *Applied Financial Economics*, 16(1-2), 1-17. https://doi.org/10.1080/09603100500390067

Tisdell, C. A. (2018). Diversity in economic decision-making and behaviour: A new brief review. *Advances in Decision Sciences*, 22(A), 351-368. https://doi.org/10.47654/v22y2018i1p351-368

Trang, N. T. T. (2020). China's Belt and Road Initiative: China's motivations and its impacts on developing countries. In: Chong, A. & Pham, Q. (eds.) *Critical Reflections on China's Belt & Road Initiative*. Palgrave Macmillan, Singapore. https://doi.org/10.1007/978-981-13-2098-9_11

Truong, B. C., Van Thuan, N., Hau, N. H., & McAleer, M. (2019). Applications of the Newton-Raphson method in decision sciences and education. *Advances in Decision Sciences*, (4), 52-80. https://doi.org/10.47654/v23y2019i4p52-80

Wen, Y. (2022). ASEAN States' hedging against the China question: Contested, adaptive, transformative. In: Pavlićević, D., & Talmacs, N. (eds.) The China Question. Palgrave Macmillan, Singapore. https://doi.org/10.1007/978-981-16-9105-8_12

Westerhoff, F. (2009). *Exchange rate dynamics: A nonlinear survey*, In: Rosser, J. & K.L. Cramer (eds.), *Handbook of Research on Complexity*, Edward Elgar, 287 – 325. https://doi.org/10.4337/9781781952665.00020

Woo, K. Y., Lee, S. K., & Chan, A. (2020). Food price convergence in Canada: A nonparametric and nonlinear cointegration analysis. *Economics Bulletin*, 40(3), 2361-2371.

Woo, K. Y., Lee, S. K., & Shum, P. (2022). Nonparametric cointegration tests for price convergence within the Greater Bay Area of China, *The Chinese Economy*, 55(6)**,** 410-424. https://doi.org/10.1080/10971475.2021.2022838

Woo, K. Y., Lee, S. K., & Shum, P. K. (2021). Evidence on PPP with China along the Belt and Road using the three-regime TAR cointegration tests, *Empirical Economics*, 60(5), 2391–2405. https://doi.org/10.1007/s00181-020-01884-6

World Bank. (2021). *World development indicators*, Washington, DC. https://databank.worldbank.org/source/world-development-indicators

Yilanci, V., & Eris, Z. A. (2013). Purchasing power parity in African countries: Further evidence from Fourier unit root tests based on linear and nonlinear models. *South African Journal of Economics*, 81(1), 20-34. https://doi.org/10.1111/j.1813-6982.2012.01326.x

Yu, M. (2021). The effect of RMB internationalization on Belt and Road Initiative. In: *Exchange Rate, Credit Constraints and China's International Trade*, 245-260. Palgrave Macmillan, Singapore. https://doi.org/10.1007/978-981-15-7522-8_9.