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Does Purchasing Power Parity Hold Between Asian Economies Before and After the Financial Crisis? Evidence from the Time-Series Model

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ABSTRACT

In exchange rate determination models, the purchasing power parity (PPP) acts as a fundamental theory, which provides the basis for exchange rate determination across countries respectively. The main objective of this study is to investigate if there exists long-run purchasing power parity in the long run between the Asian economies and developed economies. This will help to understand the long-run exchange rate determination in these countries and helps to make effective monetary policies. This study tests the long-run PPP relationships between Asian economies (China, Japan, Singapore) with the UK and the US respectively. It is important to observe whether PPP holds between Asian economies and the economies of the UK and US by using time-series analysis respectively. Johansen Cointegration test is used to examine the relative PPP among these countries on full sample and sub-samples before and after the global financial crisis respectively. In full sample and subsamples, the Cointegration results show that PPP holds Asian economies (China, Japan, and Singapore) with the UK and the US respectively. This study finds significant evidence to accept that PPP holds which implies that the domestic prices of Asian economies are influenced by the US and UK prices and it explains a significant amount of variation in their domestic prices and inflation.

INTRODUCTION

In exchange rate determination models, the purchasing power parity (PPP) acts as a fundamental theory, which provides the basis for exchange rate determination across countries respectively. From the above previous background, it seems that the PPP holds in the long run and it provides a baseline in the long-run exchange rate determination respectively. In recent years, it is observed that the trade volume between Asian economies such as China, Japan, and Singapore has raised with the UK and the US (US, 2021). This has involved imports and exports of goods and services to each other, which could have some influence on the domestic prices of these countries. This study will be based on testing the long-run PPP relationships between Asian economies (China, Japan, Singapore) with the UK and the US respectively. It is important to observe whether PPP holds between Asian economies and the economies of the UK and US by using time-series analysis respectively.

Koedijk et al. (2004) studied the long-run relationship of PPP on the real exchange rate in the euro area with a panel of euro countries using unit root and Cointegration models. The study rejects the null hypothesis and concludes that long-run PPP holds in the euro area, which is significantly important in the long-run exchange rate determination. The aim of analyzing the PPP relationships between Asia (China, Japan, and Singapore) and the UK, US is to understand how these economies in recent years determine the real exchange rates. Additionally, if there exists a long-run PPP, this might be helpful to explain the mechanism of real exchange rate determination and will answer whether foreign prices affect domestic prices in these countries or not. This study chooses three Asian economies such as China, Japan, and Singapore, and two major economies in the world such as the UK and the US due to their trade openness and relationship with each other (US, 2021). The PPP relationship in long run will help the readers to understand the determination of exchange rates and the impact of foreign prices on the domestic markets in these countries.

This study is significant in the sense that it provides empirical evidence of trade relationships between the economies of Asia (China, Japan, and Singapore) and the UK, and the US. This will be studied through the exchange rate determination of these countries and therefore, the study on the PPP in long run would be significant in this field. Additionally, the US trade representatives have shown that the trade volumes of these countries have significantly increased in recent years (US, 2021). This study will not only be limited to studying the PPP relationship in the long run but also provides empirical evidence on the impact of foreign prices on domestic ones. At last, the study of (Baharumshah and Ariff, 1997) have shown that there exists no long-run PPP among Asian economies by employing the Cointegration method, this study will be considered as the extension of this research in the sense that it covers the PPP relationship between Asian (China, Japan, and Singapore) and the UK, US economies respectively.

The theory of purchasing power parity is important to study as it compares the markets of the different economies which further helps to determine the GDP of the involving economies. This study would benefit the Asian Economies to compare their market conditions with the developed economies such as the UK and the US. The study would also provide the status of exchange

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rate determination between the Asian economies and the developed economies in long run, which would help to build effective monetary policies for the Asian Economies.

The rest of the paper is organized as follows. Section 2 demonstrates the literature review, which shows the documented past studies related to purchasing power parity. Section 3 contains data and econometric model, which shows the data and the econometric methods used in this study. Section 4 shows the empirical results of this study. At last, section 5 depicts the conclusion and discussion of this paper including the economic interpretation and discussion based on the empirical results.

LITERATURE REVIEW
The study highlights the previous studies conducted on PPP concerning different countries and with different research methodologies respectively. The PPP relationship in long run will help the readers to understand the determination of exchange rates and the impact of foreign prices on the domestic markets in these countries. The section also focuses on the different economies and empirical models used to analyze the PPP among countries. This will help to understand how the trade volumes in these countries have significantly affected the PPP of three Asian economies such as China, Japan, and Singapore, and two major economies in the world such as the UK and the US through real and nominal exchange rates determination respectively. The purchasing power parity (PPP) acts as a fundamental theory, which provides the basis for exchange rate determination across countries respectively.

Sarno and Taylor (2002) have critically analyzed the previous research works on PPP which provides the reader a clear insight that what has been done in past regarding PPP and real exchange rates respectively. The author has considered a significant amount of papers for both accepting and rejecting the long-run PPP and concluded that the real exchange rate is important in the determination of PPP for major high-income countries. They also showed that real exchange rate with mean reversion exhibits non-linear relationships and the study on PPP relationships must be done further with different aspects respectively.

Alba and Park (2005) have investigated whether PPP holds between the euro and lira of Germany and Turkey using time series data. They wanted to test whether the prospects of Turkey joining the EU would have any vital effect on the real exchange rate using the autoregressive model of time series and test the unit root of the real exchange rate using the unit root test respectively. The estimation strategy of this paper is borrowed from another paper which allows testing the non-stationarity and non-linearity of the real exchange rate simultaneously. The empirical evidence supports that there must hold a PPP between the real exchange of Germany and Turkey in long run but not in the short run. Additionally, the paper

concludes that in recent years the PPP between Germany and Turkey holds with a stronger bond, which indicates that the prospects of Turkey joining the EU would have significantly affected their PPP relationships respectively. Hanck (2009) has employed the time-series tests of Cointegration and unit root to study the PPP relationships hold for multiple countries. The simultaneous testing of PPP facilitates the research to conduct more dynamically and avoids any ambiguous results. The empirical results of the paper strongly advocated that PPP holds among countries which indicates a long-run effect on the real exchange rates of these countries respectively. The paper draws the conclusion that suggests that the PPP holds in long and has a significant impact on the exchange rates due to trade flows among these countries.

Ca'Zorzi et al. (2016) have demonstrated the model performance of random walk over the PPP model using real and nominal exchange rates of different economies. They argued that the random walk model did not fully capture the PPP relationship and exchange rate regimes and the PPP half-life model is better in forecasting the PPP relationship among countries in the sample. The findings of the paper are described in four segments. Firstly, the PPP half-life model is better at forecasting the PPP relationships than the random walk model in long run. Secondly, the PPP among these countries holds if the data is calibrated based on the sample mean rather than the estimated values. Thirdly, the parameters in the PPP model are better calibrated rather than pre-defined in the estimation of PPP. At last, the PPP half-life model is not only better in forecasting the real exchange rate but also significant for the nominal exchange rate determination respectively.

Munir et al. (2018) studied the long-run PPP relationship in ASEAN-5 countries using Cointegration methods and found a significant long-term PPP relationship with exchange rates and nominal price movements. Similarly, BekHo and Boršič, (2018) use the data of ASEAN+3 economies to study the long-run PPP using the Cointegration approach. The study does find any conclusive evidence that supports the existence of long-run PPP among these countries. On the other hand, Al-Gasaymeh et al. (2019) investigate the long-term purchasing power parity relationship in India and Pakistan using the Cointegration method. The study finds that there exists a significant long-term relationship with higher movements in the exchange rates than the purchasing power parity for both countries. Yoon and Jei (2019) use the time-varying Cointegration model to study the relationship between the nominal prices and exchange rates in UK and China. The empirical results show that PPP does not hold for UK but holds for China in the long-run.

From the above-mentioned documented research papers, it is observed that these studies either investigate the long-run purchasing power parity in developing economies or among developing economies. In the last two decades, the trade volumes between the Asian economies and

the developed economies have significantly increased. The effective exchange rates between the economies are important for smooth trade transactions. Therefore, due to the limited number of researches based on the cross-study of the Asian, US, and UK economy, PPP relationships is appealing. This study will not only help the reader to provide clear insight into the previous studies on PPP among group countries but also demonstrate the comparison between Asian and developed economies (US and UK) in terms of PPP and exchange rate determination respectively.

DATA AND ECONOMETRIC MODEL
Data
CPI and exchange rate concerning US$ are obtained for all sample countries using monthly frequency from Jan 2000 to Dec 2020 respectively. The table below shows the variable's description and data sources of the time- series respectively.

The CPI of China, Japan, the UK, and the US are obtained from the Federal reserved economic database (FRED) while the CPI of Singapore is obtained from the department of statistics, the government of Singapore's

Table 1: Data Description and Sources

Variables	Frequency	Period	Description	Source
CPI_China	Monthly	2000-Jan- 2020-Dec	CPI index China Base year 2015=100	FRED, economic Database
CPI_ Singapore	Monthly	2000-Jan- 2020-Dec	CPI index Singapore Base year 2015=100	Data.gov.sg
CPI_Japan	Monthly	2000-Jan- 2020-Dec	CPI index Japan Base year 2015=100	FRED, economic Database
CPI_UK	Monthly	2000-Jan- 2020-Dec	CPI index UK Base year 2015=100	FRED, economic Database
CPI_US	Monthly	2000-Jan- 2020-Dec	CPI index US Base year 2015=100	FRED, economic Database
CNY_US$	Monthly	2000-Jan- 2020-Dec	The exchange rate between CNY-US$	FRED, economic Database
SGD_US$	Monthly	2000-Jan- 2020-Dec	The exchange rate between SGD-US$	FRED, economic Database
YEN_US$	Monthly	2000-Jan- 2020-Dec	The exchange rate between Yen-US$	FRED, economic Database
UK_US$	Monthly	2000-Jan- 2020-Dec	The exchange rate between UK-US$	FRED, economic Database

official database. On the other hand, the exchange rate data between China-US, Singapore-US, Japan-US, and UK-US are also collected from the Federal reserved economic database (FRED). The frequency of the data is monthly with the sample period of Jan 2000 to Dec 2020 respectively. The full sample is further divided into two subsamples, to understand and analyze the pre and post-financial crisis effect on their inflation and exchange rates. To do so, the pre-financial crisis data is taken from Jan 2000 to Dec 2008 while the post-financial crisis data is sampled from Jan 2009 to Dec 2020 respectively. The econometric analysis will be implemented on three different models, which are based on the full sample, pre-financial crisis sample, and post-financial crisis respectively. To test the research questions, the following hypothesis is framed out

H_0= Purchasing Power Parity (PPP) does not hold between Asian and developed economies.

H_1= Purchasing Power Parity (PPP) does hold between Asian and developed economies.

The null hypothesis indicates that the developed economies and Asian economies do not have a significant relationship in terms of relative PPP. In other words, the prices of the US do not have a significant effect on the domestic prices of these countries and the inflation occurring in these countries in these countries is due to other factors. On the other hand, the alternate hypothesis examines that the foreign prices do have a significant impact on the domestic prices and there is a significant amount of relative PPP held among these countries respectively

Model
The time series is first used to check the stationarity assumption which indicates whether the time-series observations are uncorrelated with time. Stationarity is the basic assumption for time series analysis and in this study, the testing of Cointegration requires the series to be stationary. The Augmented Dickey-Fuller (ADF) (Said and Dickey, 1984) and Phillips and Perron (PP) tests (Phillips and Perron, 1988) are employed to examine the stationarity of CPI and exchange rates. If the series is found non-stationary, meaning the observations are correlated with time, then the first difference transformation is used on the data and will check the stationarity again. Stationarity of the time series is the prerequisite of the Cointegration method developed by Johansen (Johansen, 1992), which is based on testing the Cointegration of the time- series in the long run. The Cointegration model of Johansen is the benchmark model used to test the PPP relationship between or among countries. For instance, the testing of PPP between the five Asian economies by (Baharumshah and Ariff, 1997) are based on this approach too. The parsimonious nature of this model makes it easy and convenient for analyzing such kinds of studies respectively. The absolute PPP formula is described below as

$$e=(S*P^*)/P \qquad (1)$$

Where e is the real exchange rate, S is the nominal exchange rate, P* is the foreign price and P is the domestic price respectively. The absolute PPP holds if e=0, which means that

$$P=S*P^* \qquad (2)$$

Unfortunately, there is no variable available that measures

the foreign and domestic prices in absolute terms so the measurement of absolute PPP is impossible to get. The relative PPP is used to test the PPP relationship among the countries using PPP in relative terms over time.

$$e_t = (S_t P_t^*)/P_t \quad .... (3)$$

The P_t^* and P_t are measurable using the CPI index and therefore the estimation of relative PPP is possible to achieve. The only thing this is needed here is to measure the above equation concerning time t.

$$\Delta e_t = (\Delta S_t \Delta P_t^*)/\Delta P_t \quad ....(4)$$

The relative PPP holds if $\Delta e_t = 0$ which means

$$\Delta P_t = \Delta S_t \Delta P_t^* \Delta S_t = \Delta P_t/(\Delta P_t^*)......(5)$$

The econometric representation of the testing of the relative PPP can be written as

$$\ln \Delta S_t = \beta_0 + \beta_1 \ln \Delta P_t^* + \beta_2 \ln \Delta P_t + \varepsilon_t ...... (6)$$

Where, $\ln \Delta S_t$ is the nominal exchange rate in the log form, $\ln p_t^*$ are the foreign prices in the log form and $\ln p_t$ is domestic prices in the log form. ε_t is the error term of the model.

The above equation 6 is the final equation that is used to test the Cointegration between the CPI and exchange rates of the selected Asian and developed economies. The null hypothesis of the Cointegration model rejects the Cointegration between the CPI and exchange rate which indicates that there is no PPP exists between Asian and developed economies in the long run while the alternative hypothesis accepts the existence of the PPP between them.

EMPIRICAL RESULTS
Full Sample Analysis: Jan-2000 to Dec-2020
Table 2 presents the summary statistics of the variables and it is observed that most of the variables are right-skewed and have long tails. The average values of the variables are very close to their standard deviations which indicate that the data tends to be normal. Japan has the highest average CPI while Singapore has the lowest average CPI respectively.

Table 2: Summary statistics of CPI and exchange rates (Jan-2000- Dec 2020)

Variables	Observations	Mean	SD	Minimum	Maximum	Skewness	Kurtosis
CPI China	252	88.5	13.649	69	113.7	0.093	1.619
CPI Singapore	252	88.037	10.357	73.878	100.469	-0.087	1.265
CPI Japan	252	101.793	1.787	99.145	105.983	0.656	2.315
CPI UK	252	100.012	13.026	80.395	121.431	0.001	1.541
CPI US	252	99.337	11.709	77.412	118.629	-0.254	1.825
CNY US	252	7.181	0.804	6.054	8.28	0.31	1.499
SGD US	252	1.474	0.186	1.202	1.847	0.496	1.859
YEN US	252	106.591	13.009	76.25	133.825	-0.684	2.886
POUND US	252	1.573	0.212	1.216	2.07	0.372	2.423

Note: - SD represents the standard deviation.

Table 3: ADF and PP test for Stationarity

Variables	ADF	PP
CPI China	0.171	0.085
CPI Singapore	-0.776	-0.814
CPI Japan	-1.944	-1.824
CPI UK	-1.505	-1.532
CPI US	-1.983	-1.609
CNY-US$	-1.163	-1.1
SGD-US$	-1.276	-1.214
YEN-US$	-1.657	-1.646
Pound-US$	-1.493	-1.237

Note: The significance level is *** p<0.01, ** p<0.05, * p<0.1

Table 4: ADF and PP Test for Stationarity (Jan 2000-Dec 2020)

Variables	ADF	PP
ΔCPI China	-10.602 ***	-12.531 ***
ΔCPI Singapore	-13.002 ***	-18.743 ***
ΔCPI Japan	-10.839 ***	-8.37***
ΔCPI UK	-10.819 ***	-7.86***
ΔCPI US	-10.352 ***	-8.78***
ΔCNY-US$	-8.727 ***	-12.88***
ΔSGD-US$	-11.660 ***	-10.33***
ΔYEN-US$	-10.227***	-10.88***
ΔPound-US$	-9.241 ***	-11.25***

Note: The significance level is *** p<0.01, ** p<0.05, * p<0.1

Tables 3 and 4 present the ADF and PP unit root test analysis. In table 3, it is observed that the variables are not stationary at their original series while in table 4, the first difference transformation of the series makes every variable stationery in the analysis respectively

Table 5 presents the optimal lag selection criteria before implementing the Johansen Cointegration analysis to demonstrate the long-run PPP relationship. As the

number of parameters is more than three, this study chooses the AIC criteria of choosing optimal lag which is three for the Johansen Cointegration test respectively. Table 6 presents the Johansen Cointegration Estimates on the full sample for each country. It is observed from the analysis that the series for China, Japan, and the UK, are co-integrated at order 0 while for Singapore it is 1. It

Page 4

Table 5: Optimal Lag selection, CPI, and exchange rates (Jan 2000-Dec 2020)

lag	LL	LR	DF	P	FPE	AIC	HQIC	SBIC
0	4414.99				3.00E-27	-35.532	-35.481	-35.405
1	7757.16	6684.3	81	0	1.10E-38	-61.832	-61.3187*	-60.5569*
2	7851.97	189.61	81	0	1.00E-38	-61.943	-60.968	-59.521
3	7946.77	189.62	81	0	9.2e-39*	-62.055*	-60.617	-58.485
4	8022	150.45*	81	0	9.70E-39	-62.008	-60.109	-57.29

Note: - LL and LR stand for log-likelihood and likelihood ratio respectively. DF represents the degrees of freedom. * indicates significant lag term

Table 6: Johansen Cointegration Estimates (Jan 2000-Dec 2020)

China				Trace	Critical
Rank	**Parameters**	**LL**	**Eigenvalue**	**Statistics**	**Values (5%)**
0	10	1799.0753		2.5790*	15.41
1	13	1800.3182	0.00993	0.0931	3.76
2	14	1800.3648	0.00037		
Singapore				**Trace**	**Critical**
Rank	**Parameters**	**LL**	**Eigenvalue**	**Statistics**	**Values (5%)**
0	10	1659.0916		47.7544	15.41
1	13	1682.2764	0.16991	1.3848*	3.76
2	14	1682.9688	0.00555		
Japan				Trace	Critical
Rank	Parameters	LL	Eigenvalue	Statistics	Values (5%)
0	10	1599.3149		7.8230*	15.41
1	13	1601.8842	0.02043	2.6844	3.76
2	14	1603.2264	0.01072		
UK				**Trace**	**Critical**
Rank	**Parameters**	**LL**	**Eigenvalue**	**Statistics**	**Values (5%)**
0	10	1465.5736		10.6039*	15.41
1	13	1469.6048	0.03186	2.5415	3.76
2	14	1470.8755	0.01016		

Note: - LL represents the log-likelihood. * denotes the significance at 5%, lag order of Cointegration

shows that PPP holds in the long run among three Asian and two developed economies respectively.

Sample 1: Jan 2000- Dec 2008 (Before the Financial Crisis)

Table 7 presents the Johansen Cointegration Estimates on sample 1 before 2008 for each country. It is observed from the analysis that the series for China, Japan, and the UK, are co-integrated at order 0 while for Singapore it is 1. It shows that PPP holds in the long run among three Asian and two developed economies respectively.

Table 7: Johansen Cointegration Estimates (Jan 2000-Dec 2008)

China				Trace	Critical
Rank	**Parameters**	**LL**	**Eigenvalue**	**Statistics**	**Values (5%)**
0	10	839.86357		13.1730* 15.41	
1	13	846.37162	0.11659	0.1569	3.76
2	14	846.45005	0.00149		
Singapore				**Trace**	**Critical**
Rank	**Parameters**	**LL**	**Eigenvalue**	**Statistics**	**Values (5%)**
0	10	706.25232		21.2605	15.41
1	13	716.41675	0.17602	0.9317*	3.76
2	14	716.88259	0.00883		

Japan				Trace	Critical
Rank	Parameters	LL	Eigenvalue	Statistics	Values (5%)
0	10	698.4288		7.5907*	15.41
1	13	701.55167	0.05775	1.345	3.76
2	14	702.22415	0.01273		
UK				**Trace**	**Critical**
Rank	**Parameters**	**LL**	**Eigenvalue**	**Statistics**	**Values (5%)**
0	10	696.08923		8.7583*	15.41
1	13	698.9449	0.05294	3.047	3.76
2	14	700.46839	0.0286		

Note: - LL represents the log-likelihood. * denotes the significance at 5%, lag order of Cointegration

Sample 2: Jan 2009- Dec-2020 (After the Financial Crisis)
Table 8 presents the Johansen Cointegration Estimates on sample 2, after 2008 for each country. It is observed from the analysis that the series for China and Japan, are co-integrated at order 0 while for Singapore and UK it is 1. It shows that PPP holds in the long run among three Asian and two developed economies respectively.

Table 8: Johansen Cointegration Estimates (Jan 2009-Dec 2020)

China				**Trace**	**Critical**
Rank	**Parameters**	**LL**	**Eigenvalue**	**Statistics**	**Values (5%)**
0	10	1003.23		5.8160*	15.41
1	13	1005.57	0.03266	1.1335	3.76
2	14	1006.14	0.00801		
Singapore				**Trace**	**Critical**
Rank	**Parameters**	**LL**	**Eigenvalue**	**Statistics**	**Values (5%)**
0	10	943.524		44.0163	15.41
1	13	959.371	0.20131	12.3222*	3.76
2	14	965.532	0.08368		
Japan				Trace	Critical
Rank	Parameters	LL	Eigenvalue	Statistics	Values (5%)
0	10	894.92		9.3658*	15.41
1	13	899.039	0.05676	1.127	3.76
2	14	899.603	0.00796		
UK				**Trace**	**Critical**
Rank	**Parameters**	**LL**	**Eigenvalue**	**Statistics**	**Values (5%)**
0	10	803.881		15.9693	15.41
1	13	809.989	0.08299	3.7532*	3.76
2	14	811.866	0.02627		

Note: - LL represents the log-likelihood. * denotes the significance at 5%, lag order of Cointegration

DISCUSSION AND CONCLUSION

The previous studies either investigate the long-run purchasing power parity in developing economies or among developing economies. The empirical results of this study find that relative PPP holds between Asian (China, Japan, and Singapore) and the UK, and US economies using the Johansen Cointegration approach. This study finds significant evidence to accept that PPP holds which implies that the domestic prices of Asian economies are influenced by the US and UK prices and it explains a significant amount of variation in their domestic prices and inflation. The inflation target is one of the primary concerns of many economies in the world and with these results; the future implication would rely on how to control inflation in the context of stabilization of exchange rates and domestic prices of these three Asian economies respectively.

The study simply provides empirical evidence that supports that the Asian markets are integrated with the developed economies. The significant trade relationships between these economies are one of the primary reasons that purchasing power parity holds between the Asian economies and the developed economies. The

policy implications of this study are straightforward. Firstly, the long-run PPP holds will indicate that the Asian economies are integrated with the markets of the developed economies. Secondly, due to the long-run PPP, inflation is one of the main concerns in the Asian economies, which needs to be controlled by making efficient monetary policies by the Asian economies. At last, exchange rate stabilization is the primary motive of the monetary policy authorities in the Asian economies. This study would also be helpful to the investors, investing in the Asian economies, as the PPP holds, the exchange rate stabilization and inflation targeting monetary policies would only ensure significant investments in the Asian economies.

Furthermore, this study divides the sample into two sub-samples which are before and after the global financial crisis as it is believed that trade relationships among countries are affected after the crisis. The results of the sub-sample are consistent with the full sample analysis and this study successfully establishes a relative PPP relationship respectively. One of the limitations of this study is the absence of some other major Asian economies such as India, Thailand, and Pakistan which could be involved in the sample of this study. The inclusion of these countries in the study would make this study more advanced and robust and if the PPP relationship holds, then it would be a significant contribution to the existing literature in this field. Another limitation of this is that this study employs a time series model which is based on a parametric approach, this study could use the additive model proposed by Hastie and Tibshirani, (2017) which is based on a non-parametric approach, and as this will use to test the model selection between Cointegration and additive models and could be one of the potential future research in this field.

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