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Abstract

This paper investigates stock market integration by studying Asia-Pacific stock markets during the subprime mortgage meltdown which created the world-wide financial crisis in 2007-09. This crisis had one of the most devastating impacts on the stock markets all over the world. During that time, Asia-Pacific markets were also hit by negative forces but no investigation was conducted before studying the situation. Unit root test, Johansen multivariate co-integration test and Short-Run Granger Causality based on vector error correction model (VECM) were used in the attempt to find the linkage between Asia-Pacific markets and the developed market of USA. The question this paper seeks whether there was any co-integration between the USA and Asia-Pacific markets during the crisis. The results will give a glimpse at the forces which dominate the emerging Asia-Pacific markets for investors, policymakers and stakeholders who are getting ready for the next future financial crisis.

Keywords: Co-integration, Stock Market, Financial Crisis, Vector error correction model (VECM), Short-Run Granger Causality.

1. INTRODUCTION

Lehman Brothers, a large investment bank in the USA crashed on 15 September 2008 triggering an international financial crisis. Like an earthquake, the bank with $700 billion worth of liabilities shocked the global financial system, however, USA government refused to rescue the bank which was struggling to rollover its liabilities in the financial markets. The crisis started before the bust of Lehman brothers due to the bankers in USA developed a profitable way to make money by buying up the mortgages of USA citizens also known as subprime. The economic costs were deep. Unemployment increased prolifically; International financial system went into recession state; International trade declined notably international stock markets crumbled markedly.

Recent papers found co-integration confirmation among stock markets, making it possible to distress one part of the world with a crisis created in another part. USA, Europe and Japan have already been seen integrating with the Asia-pacific market players in many studies. Ghosh (1999) checked the Hong Kong, India, and Malaysia and found USA company domination whereas the economic connection between Indonesia, Singapore, and the Philippines found with Japanese markets. Kasa's (1992) investigation reported a single common stochastic trend in the developed markets USA, Japan, UK, Germany and Canada. Stulz (1981) studied and stated "if assets with perfectly correlated returns have the same price, regardless of the location in which they trade." (Jorion & Schwartz, 1986) found when investors earn the same risk-adjusted expected gain on similar financial instruments in different national markets; arbitrage profit will not be achieved and called fully integrated market. If returns from investments in different markets aren't completely correlated, the potential gain from global portfolio diversification is possible. This proves the benefit of diversifying the portfolio in the global markets attributes to lower actions in stock prices offered to the investors. With no elevation in risk, investors who allocate some of their portfolio to stocks from other nations can boost the portfolio's expected return. Thus, stock market correlation has found its significance with the rising global economy. It is important to find which countries stock prices move mutually for both institutional and individual investors, which is studying the, co-integration and short term and long-term relationship between stock prices.

However, short run or long run association of the Asian Markets, Asia-Pacific Markets and other major stock markets were incorporated in

the above investigations neglecting the possibility of impact on these markets during financial crisis. Thus the present study investigated whether USA dominated the Asia-Pacific markets during the financial crisis 2008. The Asia-Pacific markets which are studied are emerging economies, viz., Taiwan, Singapore, Philippines, South Korea, Indonesia, Hong Kong and Australia and developed economies Japan and USA. The USA indices have been known for its role as a leader in the international stock market. Previous studies found USA influencing other markets due to its dominating nature. The study used several econometric models- Unit root test, Johansen multivariate co-integration test and vector error correction model (VECM). To check whether the stock prices are stationary the unit root test is done, to check the long-term relationship co-integration test is done and VECM to examine short-term causal effects indicated by changes in other differenced explanatory variables.

The remainder of this article is organized as follows: Section 2 provides the review of the literature review. Section 3 presents data and empirical methodology of the study. The empirical results and discussion are provided in Section 4, and Section 5 presents concluding remarks.

2. LITERATURE REVIEW

Some financial markets seem to be more correlated with certain markets while others are not although global financial markets have a general tendency to move together in the same direction. It is considered to be vital to understand why such different movements occur in the stock markets. Before only limited to developed markets, a good number of empirical papers investigating stock market integration have been published. These papers include Dumas and Solnik (1995), Hardouvelis et al. (2002), Aggarwal et al. (2003) and Gerard et al. (2003). The financial integration theory of developed equity markets is supported by these studies. Chaudhuri (1997) investigated the long-run relationship between six Latin American indices and the United States over the period 1985 to 1993 and found evidence in all indexes of a stochastic trend. Francis and Leachman (1998) revealed that the US influences on other markets around the world. Diamandis (2009) examined long-run relationships between four Latin America stock markets and a mature stock market that of the United States using weekly observations for the period January 1988 to July 2006. They observed that although there were small long-run benefits from international

portfolio diversification, co-integration exists as the stock prices adjust very slowly to these common trends.

However, the importance of emerging markets can't be denied so another group of researchers did some study on the Asia-Pacific region to understand the market dynamics of this part of the world. Guidi and Ugur (2014) studied and found South Eastern Europe stock markets were co-integrated with the German and the UK markets during year 2000–2013. Tripathi and Sethi (2012) investigated emerging markets and Indian stock market linkages. Alkulaib, Najand and Mashayekh (2009) studied equity markets of Middle East and North African countries and found vibrant correlation. Do (2011) checked six ASEAN stock markets (Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam) with four international stock markets (USA, ASEAN bloc, Asia and world) and found integration. Fan, Lu and Wang, (2009) investigated the Chinese stock markets and major global stock market relationships, including United States of America the United Kingdom, Japan and Hong Kong Stock Exchanges. Janakiramanan and Lamba (1998) investigated the Pacific-Basin region and showed the linkages between the U.S. market influences in all markets, except Indonesia. Chong, Wong, and Yan (1998) studied between the Tokyo Stock Exchange and the other G7 stock markets using the lead–lag method, and found Toronto, Paris, Frankfurt, London, Milan, and New York stock exchanges interdependent with the Japanese equity market. A. Masih and Masih (1999) checked international and Asian emerging stock markets for the long- and short-term dynamic linkages and found evidence that the U.S. stock market was a global leader in both short term and long term. They also found major relationship between the Organisation for Economic Co-operation and Development (OECD) and the Asian emerging markets. Furthermore, Hoque (2007) found Bangladesh, the United States, Japan, and India stock prices sharing a common stochastic trend.

Jeon and Von Furstenberg (1990) found the stock price indexes has increased significantly since the 1987 crash due to scale of international market correlation. Similarly, Arshanapalli and Doukas (1993) examined the pre- and post-October 1987 crisis period and observed strong integration among international stock markets except the Nikkei index. Cheung and Ng (1992) investigated Tokyo and New York using the GARCH model for the period January 1985 to December 1989 and found dynamic properties of stock returns. Arshanapalli, Doukas, and Lang (1995) studied the U.S. and six major Asian stock markets before and after October 1987 to find the possible links and dynamic interactions. The empirical results proved the

presence of a long-run equilibrium relationship. Liu, Pan, and Shieh (1998) examined the emerging and developed stock markets of Thailand, Taiwan, Japan, Singapore, Hong Kong, and the United States to check the interrelationship. They found interdependencies within the Asian Pacific regional after the October 1987 crisis.

3. DATA AND EMPIRICAL METHODOLOGY

The study used daily data starting from 26 March 2008 to 31 December 2008 of indices to see the effect of financial crisis 2008, for a total of 202 observations. To investigate the co-integration, the USA market, one of the most influential among the financial markets has been used with some other emerging indices in Asia-Pacific Markets. All the daily index data are converted into daily natural logarithms and are in local currencies. The indices selected in the study are S&P 500, Nikkei 225, TSEC weighted index, FTSE ST All-Share Index, PSEI Index, KOSPI Composite Index, Jakarta Composite Index, Hang Seng Index, All Ordinaries. The source of data is Yahoo finance. The names of the stock exchanges and indices are given in Table 1.

Table 1: Selected stock markets and Indices

Countries	**Stock Exchange**	**Index**
USA	New York SE	S&P 500
Japan	Japan Exchange Group	Nikkei 225
Taiwan	Taiwan SE	TSEC weighted index
Singapore	SE of Singapore	FTSE ST All-Share Index
Philippine	Philippine SE	PSEI Index
Korea	Korea Exchange	KOSPI Composite Index
Indonesia	Indonesia SE	Jakarta Composite Index
Hong Kong	Hong Kong SE	Hang Seng Index
Australia	Australia SE	All Ordinaries

To describe the nature of the data set some statistical tools are used. The tools are described below:

3.1 Mean

Mean is the range of values Calculated by dividing the total of all values by the number of values.

$$\frac{\text{Sum of all observations}}{\text{Number of observations}} = \bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \quad (1)$$

Where $\bar{x}$ is the sample mean, x_i is the ith observation, n is the sample size and the notation $\sum_{i=1}^{n}$ represents the addition or summing up of all the observations from the first (i = 1) to the last (n).

3.2 Standard deviation

Standard deviation or SD is the set of data from its mean and the measure of dispersion of it.

$$\sqrt{\frac{\sum_{i-1}^{n}(x_i - \bar{x})^2}{n-1}} \quad (2)$$

Where $\bar{x}$ is the sample mean, x_i is the ith observation, n is the sample size and the notation $\sum_{i-1}^{n}$ represents the addition or summing up of all the squared deviations from the sample mean from the first (i = 1) to the last (nth) observation.

3.3 Skewness

Skewness is a distributional asymmetry measure. Conceptually, which side of tail distribution has a longer tail is called skewness. The skewness is rightward or positive if the long tail is on the right; the skewness is leftward or negative if the long tail is on the left.

3.4 Kurtosis

Kurtosis is the probability distribution measure of the "tailedness" of. Mesokurtic is a standard normal distribution which has kurtosis of 3. A decreased kurtosis corresponds to a broadening of the peak and "thickening" of the tails while an increased kurtosis (>3) can be visualized as a thin "bell" with a high peak. Leptokurtic is recognized as Kurtosis >3 and <3 as platykurtic.

A unit root test is done to check if the data is stationary or non-stationary. Testing for unit root test is conducted by performing the Augmented Dickey-Fuller test [24] which has the following specification:

$$\Delta y_t = a_0 + a_1 y_{t-1} + \sum_{i=1}^{p} a_1 \Delta y_{i=1} + \varepsilon_1$$

(3)

Determining the optimal number of lags of dependent variable is a problem and for choosing a large value for p loses the power of ADF. So Phillips and Perron[25] have developed a more comprehensive theory of unit root non-stationarity. The test suggested by Phillips and Perron (PP) which allows weak dependence and heterogeneity in disturbances is performed using the following regression:

$$y_t = b_0 + b_1 y_{t-1} + \mu_t \quad (4)$$

Where μ_t is serially correlated.

If the series are non-stationary in levels and stationary in differences, then there is a chance of co-integration between them and long-run relationship between the series. Johansen's test is a way to determine if three or more time series are co-integrated. Johansen's co-integration test has been used to investigate the long-run relationship between the variables. In time series analysis, we often encounter situations where we wish to model one non-stationary time series (y_t) as a linear combination of other non-stationary time series $(X_{1,t}, X_{2,t}, ..., X_{k,t})$. In other words:

$$Y_t = \beta_0 + \beta_1 X_{1,t} + \beta_2 X_{2,t} + ... + \beta_k X_{k,t} + \varepsilon_t \quad (5)$$

In general, a regression model for non-stationary time series variables gives spurious (nonsense) results. The only exception is if the linear combination of the (dependent and explanatory) variables eliminates the stochastic trend and produces stationary residuals.

$$Y_t + \gamma_1 X_{1,t} + \gamma_2 X_{2,t} + ... + \gamma_k X_{k,t} \sim I(0) \quad (6)$$

In this case, we refer to the set of variables as co-integrated. It is only in this case that we can look at regression as a reasonable and reliable model.

The Johansen test approaches the testing for co-integration by examining the number of independent linear combinations (k) for an m time series variables set that yields a stationary process. The Johansen test has two forms: the trace test and the maximum eigenvalue test. Both tests address the co-integration presence hypothesis, but each asks very different questions.

Vector error correction (VEC) model is used to test for co-integration using an estimated VAR object. A vector error correction (VEC) is a restricted VAR designed for use with nonstationary series that are known to be co-integrated. Equation object estimated using nonstationary regression methods, or using a Group object. The VEC has co-integration relations built into the specification so that it restricts the long-run behavior of the endogenous variables to converge to their co-integrating relationships while allowing for short-run adjustment dynamics. The co-integration term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.

To take the simplest possible example, consider a two variable system with one co-integrating equation and no lagged difference terms. The co-integrating equation is:

$$y_{2,t} = \beta y_{1,t} \quad (7)$$

The corresponding VEC model is:

$$\Delta y_{1,t} = \alpha_1 (y_{2,t-1} - \beta y_{1,t-1}) + \varepsilon_{1,t} \quad (8)$$

$$\Delta y_{2,t} = \alpha_2 (y_{2,t-1} - \beta y_{1,t-1}) + \varepsilon_{2,t} \quad (9)$$

In this simple model, the only right-hand side variable is the error correction term. In long run equilibrium, this term is zero. However, if y_1 and y_2 deviate from the long run equilibrium, the error correction term will be nonzero and each variable adjusts to partially restore the equilibrium relation. The coefficient α_i measures the speed of adjustment of the i-th endogenous variable towards the equilibrium.

4. EMPIRICAL RESULTS

To check the statistical properties of stock market, return the descriptive statistics are reported in *table 2*. The highest mean return was recorded 9.8761 by Hong Kong followed by lowest 6.4333 by Singapore. The risk of the stock markets which is denoted by SD. Indonesia recorded the highest S.D 0.2642 and Philippine recorded the lowest S.D 0.1588. All the nine indices in the study were negatively skewed. In stock market negative skewness means investors may expect frequent small gains and few large losses. The highest recorded skewness is by Japan while lowest skewness is recorded in Taiwan. The returns of indices are platykurtic as the distributions shows negative excess kurtosis which means the investment returns are desirable for investors. While Australia has the highest kurtosis 2.1413, Taiwan has the lowest 1.6570. The analysis of data statistics shows that Japan has the highest return with higher risks during the 2008 financial crisis.

Table 2: Descriptive Statistics

Statistics	USA	Japan	Taiwan	Singapore	Philippine	Korea	Indonesia	Hong Kong	Australia
Mean	7.0609	9.3567	8.7831	6.4333	7.7971	7.2856	7.5447	9.8761	8.4715
SD	0.1819	0.2080	0.2632	0.2640	0.1588	0.2008	0.2642	0.2318	0.1737
Skewness	-0.7446	-0.7791	-0.3192	-0.6446	-0.6380	-0.5793	-0.7283	-0.5876	-0.7031
Kurtosis	1.9578	1.9396	1.6570	1.7784	2.0277	2.0515	1.8765	1.9059	2.1413

As shown in *Fig. 1* shows the graphical representation of all the markets. The markets had a lateral movement till the 9th month of 2008. Then the markets started to fall in a unidirectional manner till the beginning of the 10th month. The markets tried to correct itself after the fall but again fell in 11th month and had another lateral movement afterwards.

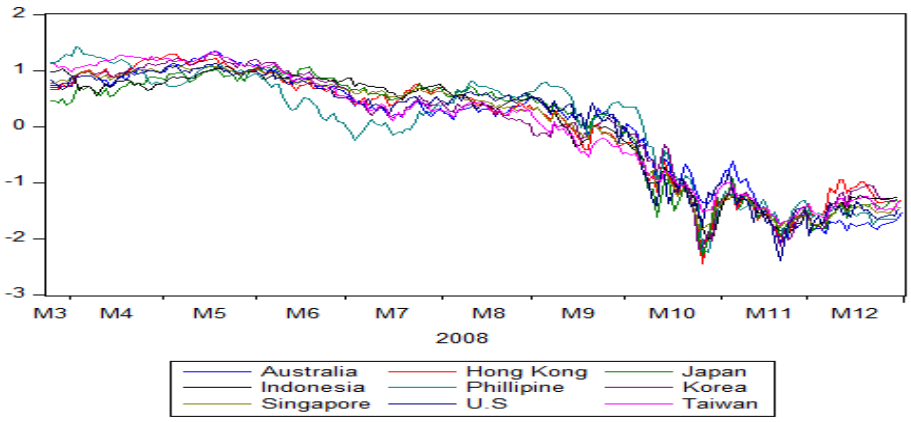

Figure 1: Graphical representation of Index prices

A precondition for testing the co-integration between the markets is that all the variables have to be non-stationary. In *Table 3*, the results showed Augmented Dickey Fuller Tests and Phillips-Perron Tests of daily data where all the results are presenting the stock indices were non-stationary in levels for both ADF and PP tests. However, first differences of the data are stationary at 10 percent level of significance so they are integrated in order of I(1). Critical values for the significance tests are taken from MacKinnon. A series is considered integrated I(1) if it is stationary after differencing once.

Table 3: Augmented Dickey fuller test and Phillips-Perron Test

Countries	Test on Index Level		Test on First Differences	
	ADF	PP	ADF	PP
USA	-2.73**	-2.40**	-12.88	-16.51
Japan	-1.52**	-1.54**	-12.64	-12.63
Taiwan	-2.39**	-2.33**	-7.69	-13.81
Singapore	-1.79**	-1.77**	-15.13	-15.12
Philippine	-2.23**	-2.27**	-10.87	-10.67
Korea	-2.77**	-2.85**	-13.60	-13.60
Indonesia	-1.61**	-1.52**	-10.04	-9.85
Hong Kong	-2.75**	-2.65**	-9.02	-14.54
Australia	-2.53**	-2.52**	-14.17	-14.23

** Non stationary

Johansen and Juselius (1990) multivariate co-integration test was performed to examine the long-run relationship between the indices S&P 500 and other Asia-Pacific Markets Nikkei 225, TSEC weighted index, FTSE ST All-share index, PSEI index, KOSPI Composite index, Jakarta Composite index, Hang Seng Index, and All ordinaries. *Table 4* shows the results of the Trace test and Maximum Eigen test values. The investigation found that the Trace test values and Maximum Eigen test values rejects the null hypothesis "There is no long run relationship between USA market and selected Asia pacific stock market index return" At most 3 significances has been found where both Trace test and Maximum Eigen test values of the selected indices were greater than 5% critical value. So, there was a significant co-integration between the markets and in long run the markets moved together for having high correlation. There is an indication that the common forces of the markets, such as arbitrage keep the market mutual in

the long run. So, the findings are consistent with the findings of Ghosh (1999), who found Co-integration between USA and Japan markets with other Asia-Pacific markets in the previous studies.

Table 4: Johansen Co-integration Test

Counties	Null Hypothesis	Alternative Hypothesis	Trace Statistics	5% Critical Value	Maximum Eigen Statistics	5% Critical Value
USA	$H_{0:r=0}$	$H_{1:r=1}$	342.8589**	197.3709**	104.554	58.43354
Japan	$H_{0:r\leq 1}$	$H_{1:r=2}$	238.3048**	159.5297**	96.41317	52.36261
Taiwan	$H_{0:r\leq 2}$	$H_{1:r=3}$	141.8916**	125.6154**	79.60767	46.23142
Singapore	$H_{0:r\leq 3}$	$H_{1:r=4}$	62.28398	95.75366	33.52754	40.07757
Philippine	$H_{0:r\leq 4}$	$H_{1:r=5}$	28.75643	69.81889	11.57092	33.87687
Korea	$H_{0:r\leq 5}$	$H_{1:r=6}$	17.18552	47.85613	6.952776	27.58434
Indonesia	$H_{0:r\leq 6}$	$H_{1:r=7}$	10.23274	29.79707	5.717812	21.13162
Hong Kong	$H_{0:r\leq 7}$	$H_{1:r=8}$	4.514929	15.49471	2.986144	14.2646
Australia	$H_{0:r\leq 8}$	$H_{1:r=9}$	1.528784	3.841466	1.528784	3.841466

(Notes: r is the number of cointegrating vector. Critical values are noted from MacKinnon, Haug, and Michelis (1999). **Significance at 5% level.)

Table 5 provides the results of VEC Granger Causality/Block Exogeneity Wald Tests [28]. The test shows short run causality between the stock markets. It also provides the assumption which market exerts influence over the others. The investigation confirms unidirectional short run causality running from USA market to Taiwan, Singapore, Korea, Hong Kong and Australia. The investigation found some evidence of one-way Granger Causality between the countries- Singapore and USA, Korea and USA, Hong Kong and USA, Australia and USA. Besides other major Asia-pacific markets like Taiwan and Hong Kong, Korea and Singapore, Indonesia and Singapore, Australia and Singapore, Hong Kong and Philippines, Indonesia and Philippine, Korea and Hong Kong also have one-way unidirectional causality.

Table 5: Short-Run Granger Causality/Block Exogeneity Wald Test Based on VECM

Dependent Variable	Δ USA	Δ Jap	Δ Tai	Δ Sng	Δ Phil	Δ Kor	Δ Indo	Δ HK	Δ Aus
Wald χ 2 statistics									
Δ USA		0.0299	0.0834*	0.0002	0.0158	0.0074	0.2006*	0.0024	0.0007
Δ Jap	0.0252		0.876*	0.0126	0.1041*	0.0091	0.8679*	0.704*	0.368*
Δ Tai	0.984*	0.1958*		0.2905*	0.1565*	0.0951*	0.3619*	0.0259	0.3011*
Δ Sng	0.382*	0.015	0.0621*		0.0034	0.0095	0.0031	0.0001	0.0072
Δ Phil	0.001	0.081*	0.313*	0.0028		0.0354	0.1492*	0.0061	0.2643*
Δ Kor	0.5297*	0.0266	0.8882*	0.0708*	0.0392		0.6963*	0.3652*	0.0844*
Δ Indo	0.0004	0.2762*	0.1132*	0.081*	0.0454	0.5049*		0.0338	0.0907*
Δ HK	0.1655*	0.0739*	0.416*	0.0008	0.0856*	0.004	0.0008		0.0046
Δ Aus	0.4602*	0.5853*	0.1137*	0.6259*	0.098*	0.6916*	0.3844*	0.0397	

Notes: Δ implies first difference operator; USA=United States of America; Jap=Japan; Tai=Taiwan; Sng=Singapore; Phil=Philippine; Kor=Korea; Indo=Indonesia; HK=Hong Kong; Aus=Australia; * Indicates statistical significance at the 5% level.

Table 6 shows the results of diagnostic tests, viz, Jarque–Bera test and Autocorrection LM test, to check the validity and dependability of the Vector error correction model. The Jarque–Bera test suggests that the residuals are normally distributed with the constants and variables. The Autocorrection LM test indicates the errors are free from serial correlation.

Table 6: Diagnostic test of the VECM

Diagnostic test	**Purpose of test**	**Probability**	**Inference**
Jarque–Bera test	Normality	0.6787	Normally Distributed
Autocorrection LM test	Serial Correlation	0.184	No serial Correlation

5. CONCLUSION

In the article World in crisis: Insights from six shadow financial regulatory committees from around the world it is stated that "The financial crisis that began in 2007 and its aftermath will have ramifications for many years." We have already studied the impact of financial crisis on Asia-Pacific markets in 2008 when USA markets clearly dominated the emerging stock markets using the co-integration theory. As previously no study was made to find the reasons why the international markets were moving together during financial crisis of 2007-09, the co-integration study made it possible to help the investors to look at the possible patterns before any future crisis develops. The evidence of co-integration among the variables has been tested and found with positive results. The results demonstrated a common trend. Both long term and short term dynamics have been found in the study.

The investigation tested the variables with unit root test and found the series in first differential. Then Johansen and Juselius (1990) multivariate co-integration test found long term relationships between the indices S&P 500 and Nikkei 225, TSEC weighted index, FTSE ST All-share index, PSEI index, KOSPI Composite index, Jakarta Composite index, Hang Seng Index, and All ordinaries. Both the Trace test values and Maximum Eigen test values rejected that there are no long run relationship between USA market and Asia pacific stock market index return. So, Johansen co-integration test shows a dynamic linkage which brings these stock markets together in the long run. The study also used the Granger causality/Block exogeneity Wald test based on VECM to find short run causality between the stock markets. The results showed unidirectional short-term causality between USA and other Asia-Pacific stock markets. There is also indication of one-way unidirectional short-term causality among some Asia-Pacific markets.

On the whole, the study results suggest that the Asia-Pacific markets were dominated by USA market in the year 2008 when it was hit by a financial crisis due to high co-integration among the markets. The long-term relationship and short term causality between USA markets made it possible to sink the investigated Asia-Pacific stock markets while the USA market itself was in turmoil.

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