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Volatility Spillovers between New Zealand Stock Market Returns and Exchange Rate Changes before and after the 1997 Asian Financial Crisis

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Abstract

Researchers in the last decade have been investigating the interdependence of stock returns and exchange rate changes within the same economy. Kanas (2000) and Yang and Doong (2004) find that for the G-7 countries, in general, the volatility of the stock market spills over to the exchange rate market but that volatility spillovers from the exchange rate market to the stock market are insignificant. Chen, Naylor, and Lu (2004) find that NZ individual firm returns are significantly exposed to exchange rate changes. This study complements their work by investigating the volatility spillover between the stock market and the foreign exchange market within the NZ economy.

Keywords: New Zealand, EGARCH model, volatility spillover, Asian financial crisis

JEL Classifications: E44, G01

1. Introduction

Volatility spillovers between stock market returns and exchange rate changes *within* the same economy have been examined over time and across different countries. Kanas (2000) and Yang and Doong (2004) find unidirectional volatility spillovers from stock market returns to exchange rate changes in the G-7 markets. The market capitalization of each of the G-7 countries is large and multinationals in the G-7 are fairly well-diversified. Chen, Naylor, and Lu (2004) point out that in a large market with well-diversified firms, domestic factors could be more important than international factors. In contrast, the New Zealand market is very small relative to the US market and firms in NZ are much less diversified. Using a two-factor model, Chen et al. find that NZ firm returns (the first moment) are significantly explained by exchange rate changes. However, Chen et al. do not examine the volatility (the second moment) spillover between the stock market returns and exchange rate changes within the NZ economy.

In this paper, a multivariate EGARCH model is used to investigate the volatility spillover between stock market returns and exchange rate changes in NZ. The EGARCH model takes into account New Zealand's asymmetric, or down-market effects. The sample period spans from 1990 to 2004. The 1997 Asian financial crisis (AFC) occurs in the middle of our sample period. It is thus appropriate to examine the change in volatility spillover effects before and after the AFC. Our empirical evidence shows that in the full sample the volatility of the NZ stock market returns spills over to all three exchange rates changes; only the NZD/USD volatility spills over to the stock market returns. The stock market returns maintain unidirectional volatility spillover to the NZD/AUD in the full sample as well as each subperiod. In the pre-AFC period, there are bidirectional volatility spillovers between the stock market returns and the NZD/USD and the TWI index. However, there are only unidirectional volatility spillovers from the NZD/USD and the TWI index to stock market returns in the post-AFC period.

2. Literature review

Brailsford (1996) is the first to investigate volatility spillovers between the NZ and Australian stock markets. He finds that, after controlling for the effects of the US volatility, the Australian market volatility spills over to the NZ market but not the reverse. However, Brailsford does not study the volatility spillover between exchange rate changes and stock market returns *within* either the NZ or Australian economy.

Kanas (2000) studies volatility spillovers between stock returns and exchange rate changes in six industrialized countries, namely, the US, the UK, Japan, Germany, France, and Canada. He finds evidence of spillovers from stock market returns to exchange rate changes for all countries except Germany. On the other hand, the volatility spillovers from exchange rate changes to stock returns are completely insignificant. Yang and Doong (2004) expand Kanas' sample to the G-7 by including Italy. Their empirical evidence shows stock price movements will impact on future exchange rate movements, but exchange rate changes have less direct effect on future stock returns, which is similar to Kanas' findings.

Chen, Naylor, and Lu (2004) observe that in large markets like the US, domestic factors are a major concern over international factors. Furthermore, US multinational firms tend to be fairly diversified. These two points may explain why there is unidirectional volatility spillover from stock market returns to exchange rate changes. In contrast to the US market, Chen et al. point out that the NZ market is very

small but open to the international economy. Moreover, most NZ firms are not very well-diversified. Dungey (1999) argues that it is the international factor that mainly affects the volatility of NZ dollars. He points out that the NZ currency is mainly affected by international factors as more than 50% of the decomposition of the NZ dollar volatility in the foreign currency market is due to overseas impacts. Moreover, the NZ stock market is small, illiquid, limited in diversification, and exposed to exchange rate volatility. In other words, volatility shocks in the local NZ stock market can have little effect on the movement of the NZ currency. It is thus very likely that NZ stock returns are impacted by exchange rate changes.

The NZ currency has been floating independently on the international exchange market since 1985. The NZ dollar takes price-taker positions because of its relatively small capitalization in the foreign exchange market. The Reserve Bank of New Zealand (RBNZ) has no intervening monetary policy to intervene for NZ dollar value within the sample period (The NZ government amended the RBNZ guidelines in 2006 to allow the Central Bank to actively trade to support or dampen the NZD if it was appreciating or falling too rapidly.) NZ is not a world leader in industrial or commercial areas and the GDP figures show that NZ is small and easily affected by international economical movements. Local NZ firms are less diversified, having either exports and/or imports orientations. The close linkage among local NZ companies ensures none of the firms can be exempted from international influences. Moreover, although the NZ stock market is very small and less liquid than many overseas markets, the NZ stock exchange is efficient with high market awareness, especially to the exchange rate uncertainty. All these unique and important characteristics of the NZ economy attract us to use its data for investigating how the NZ stock market volatility responds to the exchange rate variability.

A recent study of Alaganar and Bhar (2007) indicates that the first- and second-order effects of exchange rate changes impact significantly on diversified portfolios in the US share market. They use weekly returns of 16 World Equity Benchmark Series (WEBS) in the study while each WEBS series represents a diversified portfolio of investing in foreign shares in a country outside of the United States. The diversification technique is efficiently applied in WEBS while tracking the performance of a foreign country's Morgan Stanley Capital International (MSCI) index though WEBS are traded only in US Dollars. Alaganar and Bhar employ the GJR and GARCH-M models in testing the impact of exchange rate volatility on returns of diversified country index portfolios. They find that the exchange rate uncertainty is priced as a factor in WEBS returns. They point out that the second moment exchange rate information is important for diversifications in the stock market. The exchange rate risk is priced in returns and the exchange rate volatility is important to investors. The extent to which similar findings will hold for smaller economies remains open.

Chen et al. use a two-factor model with the market returns and exchange rate changes as factors to explain individual firm returns. Their empirical results show that sample firm returns are significantly impacted by exchange rate exposure. This paper differs from Chen et al.'s study in that the investigation focuses on the volatility spillover between stock market returns and exchange rate changes in NZ. Pinfold et al. (2001) point out that the NZ stock market is characterized by down market conditions. As a result, filtering away the leverage effect in volatility spillover tests is essential. The EGARCH model handles the leverage effect very efficiently. In this paper, a multivariate EGARCH model is used to take into account New

Zealand's asymmetric, or down-market effects.

3. Data and methodology

3.1 Data and descriptive statistics

Daily NZ total market index prices were collected from Datastream. The USA and Australian markets are the two largest export markets for NZ firms. The exchange rates NZD/AUD and NZD/USD as well as the TWI index were collected from the Reserve Bank of New Zealand.

The sample period spans 15 years from January 1990 to December 2004. There are 3,866 daily observations. The 1997 Asian financial crisis (AFC) occurs right in the middle of the sample period. The full sample data were split into two approximately equal sub-periods – the pre-AFC period (January 1990 to June 1997) and the post-AFC period (August 1997 to December 2004), each covering 7.5 years. In this study, the stock market returns and all exchange rate changes are defined as log relative returns.

Table 1 shows summary statistics of stock and foreign exchange market returns. The Jarque-Bera test is performed for the stock market returns and exchange rate returns in order to test the normality of each series. The results show that the distribution of the stock market returns and exchange rate returns are not normal. The EGARCH model is used to examine the dynamic volatility relationship between NZ stock market returns and foreign exchange rate changes. Table 1 also contains the results of Augmented Dickey-Fuller (ADF) unit root tests. All stock and exchange return series are integrated with I(0), i.e., stationary, as all t-statistics are highly significant at the 1% level.

Table 1. Summary statistics

Statistics	Stock Return	Exchange Rate Return		
	Total Market Index	NZD/AUD	NZD/USD	TWI Index
Observations	3867	3867	3867	3867
Mean	0.00013	0.00005	0.00005	0.00003
Median	0.00000	0.00009	0.00017	0.00020
Maximum	0.09153	0.03408	0.04298	0.03547
Minimum	-0.12788	-0.03632	-0.03619	-0.03214
Std. Dev.	0.00955	0.004474	0.006132	0.004808
Skewness	-0.41425	-0.07996	-0.07939	-0.32546
Kurtosis	17.76697	7.77129	7.11378	7.11155
Jarque-Bera	35246.08	3672.17	2730.81	2792.07
ADF Test	-41.07	-66.76	-37.83	-38.33

Note: This table presents basic descriptive statistics of daily stock and foreign exchange returns of the New Zealand market.

3.2 Methodology

The relationships between the movements of the stock market volatility and exchange rate fluctuations within an EGARCH model, developed by Nelson (1991), are examined. The multivariate EGARCH

models can effectively capture the asymmetric effects of innovations on volatility in stock market returns while the conditional volatility of currency movements can be included in the model at the same time. This important feature of the model gives direct and explicit measurement of the role of exchange rate fluctuations in explaining the time series behaviour of the stock market volatility. Similarly, EGARCH models can test whether the exchange rate volatility effects are asymmetrical in the foreign exchange market, that is, whether appreciations and depreciations of the NZ dollar in the past have the same impacts on the future exchange rate volatility. This means that the EGARCH model tests the leverage effect in the stock market and also the asymmetric effects in the foreign exchange market. The model is specified by the following equations:

$$R_t = \beta_{1,0} + \sum_{j=1}^{p} \varphi_{1,j} R_{t-j} + \sum_{j=1}^{p} \beta_{1,j} FX_{t-j} + \varepsilon_t^R \quad (1)$$

$$FX_t = \beta_{2,0} + \sum_{j=1}^{p} \varphi_{2,j} R_{t-j} + \sum_{j=1}^{p} \beta_{2,j} FX_{t-j} + \varepsilon_t^{FX} \quad (2)$$

$$h_t^R = \exp\left\{\alpha_{1,0} + \alpha_{1,1} f(Z_{t-1}^R) + \alpha_{1,2} f(Z_{t-1}^{FX}) + \gamma_1 \ell n(h_{t-1}^R)\right\} \quad (3)$$

$$h_t^{FX} = \exp\left\{\alpha_{2,0} + \alpha_{2,1} f(Z_{t-1}^R) + \alpha_{2,2} f(Z_{t-1}^{FX}) + \gamma_2 \ell n(h_{t-1}^{FX})\right\} \quad (4)$$

$$f(Z_{t-1}^R) = \left(\left|Z_{t-1}^R\right| - E\left|Z_{t-1}^R\right|\right) + \delta_1 Z_{t-1}^R \quad (5)$$

$$f(Z_{t-1}^{FX}) = \left(\left|Z_{t-1}^{FX}\right| - E\left|Z_{t-1}^{FX}\right|\right) + \delta_2 Z_{t-1}^{FX} \quad (6)$$

$$h_{R,FX,t} = \rho_{R,FX} \sqrt{h_t^R h_t^{FX}} \quad (7)$$

where R_t and FX_t denote the stock market returns and exchange rate changes. The TWI index, NZD/AUD and NZD/USD, for FX_t respectively, are used to examine the exchange rate effects to stock market returns. The number of lags, denoted by p in equations (1) and (2), is determined by the Akaike Information Criteria (AIC). The analysis searches for a dynamic relationship between stock market returns and exchange rate changes. The coefficients $\beta_{1,j}$ and $\beta_{2,j}$ in equations (1) and (2) show the effects of exchange rate changes to stock market returns and the reverse effects respectively.

In equations (3) to (7), h_t^R and h_t^{FX} denote the conditional variance of stock market returns and foreign exchange rate changes. Z_{t-1}^R and Z_{t-1}^{FX} denote the standardized innovations of NZ stock market returns and exchange rate changes, respectively. The coefficients $\alpha_{1,2}$ and $\alpha_{2,1}$ show whether volatility spillovers exist across the stock market and the foreign exchange market. In particular, $\alpha_{1,2}$ ($\alpha_{2,1}$) indicates volatility spillover effects sourced from the foreign exchange (stock) market to the stock (foreign exchange) market. Moreover, the coefficients $\alpha_{1,1}$ and $\alpha_{2,2}$ show the volatility clustering in the stock market returns and exchange rate changes. Although volatility autocorrelations are often identified in international stock markets, it is not clear if volatilities in the NZ currency are autocorrelated. A statistically significant $\alpha_{2,2}$ provides evidence that volatility in the foreign exchange market is significantly affected by the historical

volatility changes in the exchange rates. Finally, the coefficients γ_1 and γ_2 indicate volatility persistence in the stock market and foreign exchange market, respectively.

EGARCH models facilitate an examination of the asymmetric effects in volatility impacts. As mentioned above, the past volatility shocks can have asymmetric effects on future volatility changes in the market. The coefficients δ_1 and δ_2 in equations (5) and (6) reveal asymmetry effects in the stock market and foreign exchange market, respectively. A positive (negative) and statistically significant δ_1 indicates good (bad) news in the stock market has greater impact on the volatility of the stock index. Likewise, the coefficient δ_2 shows if appreciations in the NZ dollar have the same impact on the exchange rate volatility as depreciations.

EGARCH models are estimated by using a maximum log likelihood function specified by the following equation:

$$L(\varphi) = -0.5(NT)\ln(2\pi) - 0.5\sum_{t=1}^{T}(\ln|H_t| + \varepsilon_t' H_t^{-1}\varepsilon_t)$$

where φ is the 11×1 parameter vector to be estimated. N is the number of equations and as the volatility spillover between stock and foreign exchange markets is analysed N=2. T is the number of observations in the sample; H_t is a 2×2 time-varying conditional variance-covariance matrix with diagonal elements given by equations (3) and (4). $\varepsilon_t' = [\varepsilon_t^R \varepsilon_t^{FX}]$ is the vector of innovations from the stock market and the foreign exchange market at time t.

4. Empirical results

4.1. Full sample period results

The analysis provides evidence of bidirectional volatility spillovers between the NZ stock market returns and exchange rate changes when the exchange rate used is NZD/USD. The current study finds that there is significant volatility clustering, persistence, and asymmetry.

Volatility clustering ($\alpha_{1,1}$ and $\alpha_{2,2}$). Table 2 presents the conditional variances of the stock market returns and exchange rate changes which are significantly impacted by their own standardized innovation in the past. The coefficients $\alpha_{1,1}$ and $\alpha_{2,2}$ in Equations (3) and (4) are statistically significant at the 1% level, in all cases, indicating volatility clustering in both the NZ stock market and the fluctuations of the NZ dollar in the international foreign exchange market.

Volatility persistence (γ_1 and γ_2). Volatility persistence in stock market returns and exchange rate movements is also evident. The coefficients of volatility persistence (measured by γ_1 and γ_2) are statistically significant at the 1% level. These results are consistent with those of Najand and Yung (1991).

Table 2. Volatility spillover between stock returns and exchange rate changes (Full sample period: January 1990 – December 2004)

Panel A: Stock volatility					
Exchange Rate	$\alpha_{1,0}$	$\alpha_{1,1}$	$\alpha_{1,2}$	γ_1	δ_1
NZD/AUD	-0.2472*** (-10.07)	0.243*** (28.24)	-0.0001 (-0.01)	0.973*** (380.80)	-0.141*** (-5.38)
NZD/USD	-0.289*** (-14.16)	0.164*** (30.28)	0.092*** (14.74)	0.969*** (466.89)	-0.348*** (-12.63)
TWI index	-0.142*** (-4.97)	0.058*** (5.02)	-0.003 (-0.21)	0.984*** (310.26)	-0.698*** (-6.01)
Panel B: Exchange rate volatility					
Exchange Rate	$\alpha_{2,0}$	$\alpha_{2,1}$	$\alpha_{2,2}$	γ_2	δ_2
NZD/AUD	-4.518*** (-11.93)	0.087*** (4.16)	0.309*** (14.64)	0.582*** (16.73)	-0.022 (-0.53)
NZD/USD	-0.078*** (-5.15)	0.019*** (3.08)	0.194*** (22.36)	0.991*** (694.04)	-0.109*** (-4.94)
TWI index	-6.719*** (-50.83)	0.177*** (5.54)	0.328*** (10.97)	0.396*** (33.27)	-0.012 (-0.20)

Note: Above are the results of EGARCH models, where $\alpha_{1,1}$ and $\alpha_{2,2}$ indicate volatility clustering in the stock returns and exchange rate changes, respectively; $\alpha_{1,2}$ ($\alpha_{2,1}$) is the volatility spillover from the exchange rate changes (stock returns) to stock returns (exchange rate changes); γ_1 and γ_2 are volatility persistence in the markets, δ_1 and δ_2 are the asymmetry in the volatility effects.

*t-statistics in parentheses, *** denotes significance at the 1% level, two-tailed*

Asymmetry (δ_1 and δ_2). The asymmetry coefficients δ_1 are negative and statistically significant at the 1% level in all cases, suggesting strongly significant leverage effects in the NZ stock market. Bad news that results in stock decline in the market leads to a more volatile stock movement. This finding is consistent with the general leverage effect evidenced in the literature. At the same time, the asymmetry coefficient δ_2 is only statistically significant when NZD/USD is used in the model. This implies that currency depreciations in NZ dollar against the US currency result in more volatility in the international foreign exchange market. This case, however, is not applicable to other exchange rate variables for the NZ dollar.

Volatility spillover ($\alpha_{1,2}$ and $\alpha_{2,1}$). Looking at the volatility spillover coefficients, we notice significant volatility spillover effects from the stock market to the foreign exchange market. The coefficient $\alpha_{2,1}$ (Table 2, Panel B) has high statistical significance for all exchange rate measurements. The results are consistent with the findings of Kanas (2000) that volatility changes in the stock returns have impacts on the movements of foreign currency.

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The volatility of foreign exchange rate changes also spill over to the stock market returns. The coefficient $\alpha_{1,2}$ (Table 2, Panel A) is statistically significant at the 1% level when NZD/USD is applied as the foreign exchange rate in the model. This indicates that the volatility changes in NZD/USD exchange rate have spillover effects on the stock market returns. However, the spillover effects are not significant when the NZD/AUD and the TWI index are used in the model.

4.2. Sub-periods results

The 1997 Asian financial crisis (AFC) occurred in the middle of the sample period. The full sample period is thus partitioned into pre-AFC and post-AFC sub-periods. There is consistent unidirectional volatility spillover from NZ stock market returns to NZD/AUD in the two sub-periods. For both NZD/USD and TWI index, in the pre-AFC period, the volatility spillover between NZ stock market returns and these two exchange rate changes are bidirectional; in the post-AFC period, there is only unidirectional volatility spillover from the two exchange rate changes to the stock market returns. All EGARCH models exhibit significant volatility clustering, persistence, and asymmetry. In the following, we report only the evidence of volatility spillovers.

NZD/AUD and stock market returns. There is consistent unidirectional volatility spillover from the stock market returns to NZD/AUD in the full sample and both the two sub-periods. It can be seen that the coefficients $\alpha_{2,1}$ in Panel B of Tables 2, 3, and 4 are statistically significant, while the coefficients $\alpha_{1,2}$ in Panel A of Tables 2, 3, and 4 are insignificant.

NZD/USD and stock market returns. In the full sample, the volatility of stock index returns spills over to the three exchange rate changes (Table 2, Panel B, $\alpha_{2,1}$). These spillover effects are maintained in the pre-AFC period (Table 3, Panel B, $\alpha_{2,1}$) but vanish in the post-AFC period.

TWI index and stock market returns. In the full sample, the volatility of stock index returns spills over to exchange rate changes (Table 2, Panel B, $\alpha_{2,1}$). In this instance, this spillover effect is only maintained in the pre-AFC period (Table 3, Panel B, $\alpha_{2,1}$) but vanishes in the post-AFC period (Table 4, Panel B, $\alpha_{2,1}$).

Table 3. Volatility spillover between stock returns and exchange rate changes (pre-AFC, 3 January 1990 – 30 June 1997)

Panel A: Stock volatility					
Exchange Rate	$\alpha_{1,0}$	$\alpha_{1,1}$	$\alpha_{1,2}$	γ_1	δ_1
NZD/AUD	-0.092*** (-3.97)	0.123*** (8.54)	-0.010 (-1.02)	0.990*** (395.56)	-0.025 (-0.46)
NZD/USD	-0.490*** (-8.10)	0.258*** (9.96)	-0.052*** (-3.59)	0.969*** (466.88)	-0.284*** (-6.68)
TWI index	-0.134*** (-4.49)	0.141*** (8.39)	-0.025*** (-2.35)	0.985*** (304.96)	-0.101** (-2.09)
Panel B: Exchange rate volatility					
Exchange Rate	$\alpha_{2,0}$	$\alpha_{2,1}$	$\alpha_{2,2}$	γ_2	δ_2
NZD/AUD	-8.418*** (-9.24)	0.112*** (3.52)	0.380*** (11.41)	0.221*** (2.65)	0.181*** (3.18)
NZD/USD	-1.102*** (-10.67)	0.064*** (3.47)	0.210*** (11.50)	0.991*** (694.04)	-0.095*** (-2.10)
TWI index	-2.437*** (-9.99)	0.091*** (3.08)	0.222*** (12.89)	0.782*** (35.76)	-0.097** (-2.13)

Note: Please see Table 2 for variable definitions.

t-statistics in parentheses; ***(**) denote significance at the 1% (5%) level, two-tailed

Table 4. Volatility spillover between stock returns and exchange rate changes (post-AFC, August 1997 – 31 December 2004)

Panel A: Stock volatility					
Exchange Rate	$\alpha_{1,0}$	$\alpha_{1,1}$	$\alpha_{1,2}$	γ_1	δ_1
NZD/AUD	-0.531*** (-5.92)	0.280*** (18.63)	-0.033 (-1.32)	0.945*** (106.23)	-0.353*** (-8.31)
NZD/USD	-6.728*** (-12.16)	0.056*** (5.42)	0.067*** (2.53)	0.288*** (4.79)	-0.460* (-1.85)
TWI index	-1.015*** (-9.42)	0.324*** (22.52)	0.053*** (3.74)	0.984*** (310.26)	-0.062** (-2.19)
Panel B: Exchange rate volatility					
Exchange Rate	$\alpha_{2,0}$	$\alpha_{2,1}$	$\alpha_{2,2}$	γ_2	δ_2
NZD/AUD	-0.855*** (-3.23)	0.081*** (3.58)	0.120*** (4.68)	0.921*** (38.24)	-0.103 (-1.1037)
NZD/USD	-4.935*** (-3.80)	-0.007 -0.2975	0.121*** (3.91)	0.492*** (3.67)	-0.871*** (-3.67)
TWI index	-6.097*** (-2.39)	-0.003 (-0.10)	0.067*** (5.19)	0.396*** (33.27)	-0.635*** (-3.12)

Note: Please see Table 2 for variable definitions.

t-statistics in parentheses; ***(**,*) denote significance at the 1% (5%, 10%) level, two-tailed

It is clear that the 1997 Asian financial crisis is a critical event for the volatility transmission between the foreign exchange market and the stock market in NZ. Before the crisis, there were bidirectional volatility spillovers between exchange rate changes (NZD/USD and TWI index) and the stock market returns within the NZ economy (Table 3, $\alpha_{1,2}$ in Panel A and $\alpha_{2,1}$ in Panel B). After the crisis, only the volatility of NZD/USD and TWI index changes spill over to the stock market returns (Table 4, $\alpha_{1,2}$ in Panel A and $\alpha_{2,1}$ in Panel B). This is consistent with the view that the NZ currency is driven by international factors instead of domestic factors.

5. Summary and conclusions

This paper examines volatility spillovers between stock market returns and exchange rate changes within the New Zealand economy. Down-market effects, in the NZ stock market, are effectively controlled by incorporating the leverage effect in the EGARCH framework. The 1997 Asian financial crisis (AFC) occurs in the middle of our sample period encouraging us to partition the full sample period into pre-AFC and post-AFC sub-periods.

There is consistent unidirectional volatility spillover from NZ stock market returns to NZD/AUD changes in the full sample and each of the two sub-periods. For both the NZD/USD and the TWI index, The volatility of NZ stock market returns spills over to both the NZD/USD and the TWI in the pre-AFC period but not in the post-AFC period. However, the volatility of NZD/USD and TWI index changes spills over to

the stock market returns both before and after the AFC. Our empirical evidence agrees with Chen et al. (2004) that the small and open NZ stock market is exposed to and impacted by foreign currency movements.

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