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PRICE VOLATILITY ON THE USD/JPY MARKET AS A MEASURE OF INVESTORS' ATTITUDE TOWARDS RISK

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Abstract: The aim of the paper is to show the relationship between the value of Japanese yen and the investors' risk aversion. The correlation results from the application of carry trade strategies by investors. An increase in carry trade positions is associated with the decrease in risk aversion. The Japanese yen is one of the most popular carry trade funding currency and therefore the change in the value of this currency reflects the change in the investors' mood. This paper shows that there is a negative relationship between the USD/JPY and the risk aversion measured by volatility index (VIX).

Keywords: risk aversion, USD/JPY market, volatility index VIX

INTRODUCTION

During last years the carry trade phenomenon has started to be one of the main feature of the present financial markets. This strategy is based on borrowing in low interest yielding currency and using the funds to invest in high interest rate currencies [Fong, 2010]. In this way the investors obtain the money in the country where interest rates are low and then invest the capital in bonds, shares or commodities markets in the country with higher interest rates. This trading strategy can exhibit a favourable payoff but the risk involved in it is high. A carry traders are associated with the investors of low aversion towards risk. It is believed that the carry traders' activity on the market is going up when the level of investors' risk aversion is decreasing. Carry trade is applied by hedge funds, pension funds, investment banks, other financial institution and individual investors [Gagnon at al., 2007]. As a result the change in investors' involvement in this strategy has a huge impact on the price movements on the currency market. Japanese yen is one of the most popular carry trade funding currency and consequently the change in

the value of this currency is likely to reflect the fluctuations in the investors' attitude towards risk. The growth in investors' risk aversion brings about the unwinding of carry trades [Brunnermeier at al., 2008]. It means that the investors start to withdraw their capital from the country of high interest rate and then buy Japanese yen to discharge a debt. Following, an increase in demand on the Japanese currency leads to the yen appreciation.

The aim of this paper is to investigate the relationship between the Japanese Yen exchange rate (USD/JPY) and the investor's risk aversion measured by the S&P500 option implied volatility index (VIX). It is shown that during the time in which the VIX decreases the Japanese yen depreciates. However, when there is unease on the market and when the risk aversion measured by VIX goes up then the Japanese currency appreciates. This articles studies the link between USD/JPY and volatility index VIX. By using the Autoregressive Conditional Heteroscedasticity (ARCH) model it provides evidence of negative relationship between the analyzed data. The data set used in research covers the period from January 2006 to February 2009.

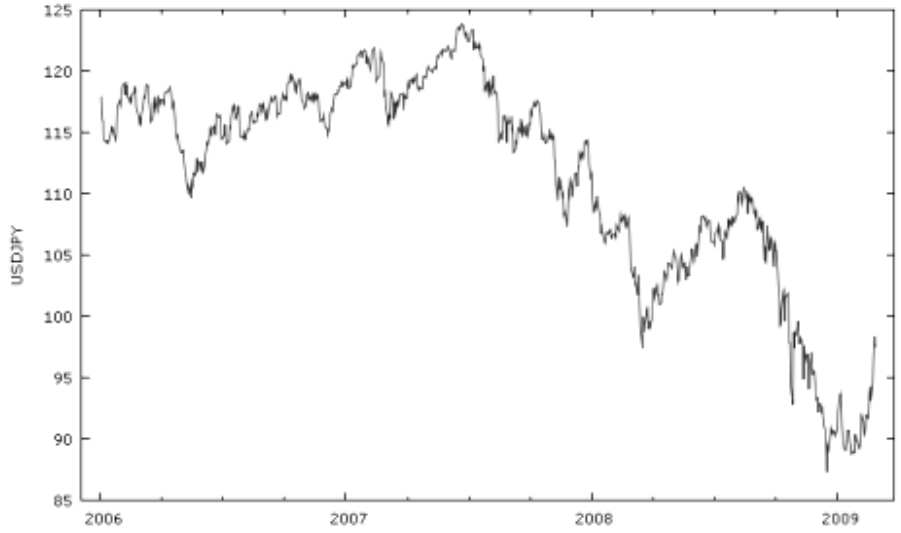
THE IMPACT OF CARRY TRADE ON THE VALUE OF JAPANESE YEN

There is several factors which have a crucial impact on the price movement on the currency market. Some of the most important are inflation rates, interest rates, change in a country's price competitiveness, balance of payments and the economic growth of the country. The article shows that the currency exchange rate can be also significantly influenced by a change in the level of investor's risk aversion. The driving force behind it is the implementation of carry trade strategies by the investors. This paper is focused on the Japanese yen which is a prominent funding currency in carry trade. Japanese Yen is a funding currency for overseas investments because of prolonged low-interest rate policy of the Bank of Japan. In order to describe the relationship between value of the yen and the level of investors' risk aversion the author scrutinizes the USD/JPY market volatility and the change in investors' risk aversion measured by volatility index VIX.

Before the financial crisis of 21st century Japan enjoyed rapid economic growth. However, the Japanese currency was constantly depreciating, which means that the rate USD/JPY was going up. Between May 2006 and July 2007 the level of USD/JPY went up from 109,67 to 123,86 (Graph 1). It means that the yen depreciated 12,5 per cent against the U.S. dollar. There was several factors which had a crucial impact on the yen depreciation. For instance, the yen decrease in value was caused by the reduction in the share of yen-denominated assets held by the central banks. However, undoubtedly the depreciation of Japanese yen was exacerbated by the carry trade. The high investors' involvement in the carry trade led to an outflow of speculative investment from Japan [Winters, 2008]. Moreover,

the carry traders activities contributed to the significant increase in supply of yen which also had a profound impact on the yen depreciation. The situation has changed when the sub-prime mortgage crisis began.

Graph 1. USD/JPY market between January 2006 and February 2009



Source: data - Reuters Information Agency

The collapse of U.S. sub-prime mortgage market had a ripple effect around the world. The global financial crisis of 21st century had a negative impact on the stock market. Many financial institution collapsed or were bought up. Because of the financial crisis of 21st century the market participants became more averse to risk. The carry traders simultaneously started to withdraw their funds and then buy Japanese yen to pay off a debt. It brought about the impressive increase of demand on the yen. Between July 2007 and February 2009 the level of USD/JPY went down from 123,86 to 87,32 (Graph 1). The Japanese currency became stronger although there were no sufficient fundamental reasons for it. It indicates that the carry trade accounts for the important factor which influences the value of Japanese yen.

THE RELATIONSHIP BETWEEN THE LEVEL OF INVESTORS' RISK AVERSION AND THE USD/JPY EXCHANGE RATE

The investors' risk aversion can be measured by the Chicago Board Options Exchange (CBOE) S&P 500 options implied volatility index (VIX) [Coudert at al., 2008]. It reflects the investors' expectations on future market volatility. The VIX value greater than 30 is associated with a high risk aversion among the market

participants. The table below provides descriptive statistics of VIX before and during the financial crisis. The calculation is based on daily data and covers the period from January 2006 to February 2009.

Table 1. Descriptive statistics of VIX before and during the financial crisis of 21st century

	01.2006-07.2007	08.2007-02.2009
mean	13,13	31,24
standard deviation	2,44	14,57
maximum	24,17	80,86
minimum	9,89	16,12
kurtosis	2,49	0,93
skewness	1,41	1,39
coefficient of variation	0,19	0,47

Source: data - Reuters Information Agency

Both mean value and the standard deviation of the VIX have increased during the second period (08.2007-02.2009). It implies that during the financial crisis of 21st century the volatility on the market have increased significantly. Moreover, one may presume that between 08.2007 and 02.2009 the investors' aversion to risk swelled considerably. The maximum value of VIX was 80,86 in comparison to the first period when it was just 24,27.

Based on the VIX descriptive statistics and the graphs of USDJPY one may assume that there is a positive relationship between the value of the Japanese currency and the level of investor's risk aversion. Thereby, there is negative association between USD/JPY and the VIX. When the investor's aversion towards risk is going up, the yen is appreciating which means the USD/JPY exchange rate is decreasing. Moreover, it is shown that this relationship became even stronger during the financial crisis of 21st century. The table below presents the Spearman's rank correlation coefficient between USD/JPY and the Volatility Index VIX. The calculation is based on the daily data and covers the period from January 2006 to February 2009. Spearman rank correlation coefficient is a non-parametric statistic and thus can be used when the data have violated parametric assumptions such as non-normally distributed data [Field A., 2005]. Moreover, it is a better indicator than Pearson's correlation coefficient when the relationship between two variables is non-linear. Taking into account the features of the analyzed data, the Spearman's rank correlation can be used for an initial analysis of the relationship between USD/JPY and VIX.

Table 2. The Spearman's rank correlation coefficient between USD/JPY and the VIX

	01.2006-07.2007	08.2007-02.2009
Spearman rank correlation coefficient	-0,12	-0,64
p-value	0,0118	0,0000

Source: data - Reuters Information Agency

The figures in the table suggest that there is the significant relationship between these two variables. The correlation itself is negative. When the USD/JPY exchange rate goes up, the Volatility Index (VIX) decreases. Additionally, the correlation between USD/JPY and VIX is substantially stronger from August 2007 to February 2009 (-0,64 versus -0,12).

THE APPLICATION OF ARCH MODEL

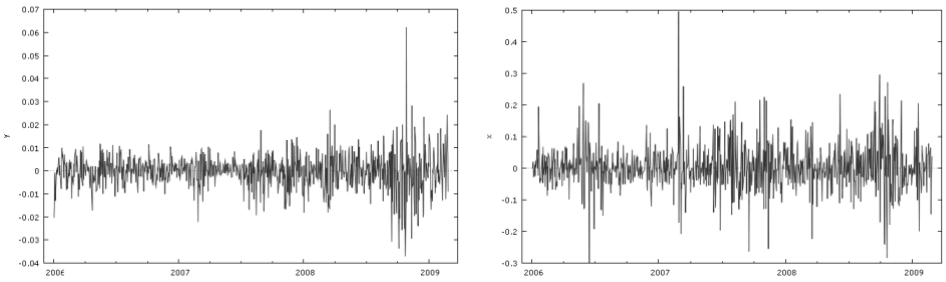
This paper adopts Autoregressive Conditional Heteroscedasticity (ARCH) model to explore the relationship between USD/JPY and VIX. The ARCH model was introduced by Engle (1982). This model is chosen mainly because it provides a way to solve the problem of heteroscedasticity. The volatility of USD/JPY is affected by change in investors' risk aversion. Therefore, the model additionally consists of the independent variable which expresses the investors' mood. The data series embrace daily closing values of USD/JPY and daily values of Volatility Index VIX. The daily series are generated from the following equation.

$$y = \ln(\frac{USD/JPY_t}{USD/JPY_{t-1}}) \quad (1)$$

$$x = \ln(\frac{VIX_t}{VIX_{t-1}}) \quad (2)$$

Where *ln* is the natural logarithm operator, *t* the time period, *y* is the outcome variable and *x* the independent variable. The data cover the period from January 2006 to February 2009. Both series are found to be stationary which was checked by the Augmented Dickey-Fuller unit root test (ADF). The graph below present fluctuations of the dependent variable y (left side) and independent variable x (right side) in the analysed time.

Graph 2. The volatility of dependent variable y and independent variable x



Source: data - Reuters Information Agency

The general form of ARCH is [Hughes at al., 2004 and Trzpiot, 2010]:

$$y_t = x_t'\beta + \varepsilon_t \tag{3}$$

$$\varepsilon_t = \xi_t \sigma_t \tag{4}$$

$$\sigma_t^2 = \alpha_0 + \sum_{t=1}^{q} \alpha_i \varepsilon_{t-i}^2 \tag{5}$$

Where y_t is the dependent variable, x_t is a $k \times 1$ vector of independent variables, ε_t is the disturbance term, ξ_t is the white noise process (with $E(\xi_t) = 0$ and $E(\xi_t^2) = 1$), σ_t^2 is the conditional variance, $\theta = (\beta', \alpha_0, \alpha_1, ..., \alpha_q)'$ is the vector of unknown parameters and q is the order of the ARCH model. By the time the unknown parameters are estimated the test for ARCH effects is carried out. The Lagrange Multiplier (LM) Test is applied to check the existence of ARCH effects. The null hypothesis is $H_0 : \alpha_0 = \alpha_1 = \alpha_2 = ... = \alpha_q$. The null hypothesis means that the ARCH effect does not exist. To verify this hypothesis the test statistics (LM) and the critical value ($\chi^2(q)$) are estimated for the q (order of ARCH) for 1, 5, 10, 15 lags. The results are presented in the table below.

Table 3. The Lagrange Multiplier Test's results

	LM	p-value
q = 1	16,1548	0,0000
q = 5	54,2893	0,0000
q = 10	60,7871	0,0000
q = 15	110,837	0,0000

Source: data - Reuters Information Agency

The LM test for ARCH(1), ARCH(5), ARCH(10) and ARCH(15) errors confirm the presence of ARCH effects in the analyzed data. The p-value

($P(\chi^2(q) > LM)$) is less than the required significance level which means that the null hypothesis is rejected.

Further, the investigation if the VIX has any explanatory power for USD/JPY exchange rate is carried out. The model is estimated and evaluated using daily data (variable x and variable y computed like in equations 1 and 2). The sample covers the period 02.01.2006 – 27.02.2009 which corresponds to 825 daily observations. The table below presents the results for ARCH(1) and ARCH(2). The ARCH(q) with q larger than 2 do not fulfil all requirements (e. g. the significance of all parameters) that is why they are not included in the Table 4.

Table 4. ARCH(1) and ARCH(2) models

	ARCH(1)	ARCH(2)
β_1	-0,04324**	-0,04064**
α_0	0,00003**	0,00003**
α_1	0,27066*	0,16423**
α_2		0,17506*
Akaike's Information Criterion (AIC)	-5934,06	-5964,08
Schwarz Criterion (SC)	-5915,17	-5940,51

*significant at the 0,05 level **at the 0,01 level

Source: data - Reuters Information Agency

In order to select the most appropriate model the Akaike's Information Criterion and the Schwarz Criterion are used. The lower the value of AIC and SC the better the model is. On the basis of Akaike's Information Criterion (AIC) and Schwarz Criterion (SC), the model ARCH(2) is chosen (Table 4). On the basis of equations 1 through 5, the form of ARCH(2) is written as:

$$\ln\left(\frac{USDJPY_t}{USDJPY_{t-1}}\right) = -0{,}04064 \ln\left(\frac{VIX_t}{VIX_{t-1}}\right) + \varepsilon_t \quad (6)$$

$$\varepsilon_t = \xi_t \sigma_t \quad (7)$$

$$\sigma_t^2 = 0{,}0003 + 0{,}16423\varepsilon_{t-1}^2 + 0{,}17506\varepsilon_{t-2}^2 \quad (8)$$

The coefficient β_1 is negative and significant. Therefore, the results show that there is a statistically significant relationship between USD/JPY exchange rate and the Volatility Index VIX. At the same time, the outcomes indicate that the association between the value of Japanese yen and the level of investors' risk aversion exists. The negative coefficient β_1 suggests that when there is an increase in risk aversion among investors then the USD/JPY exchange rate decreases. Consequently, the growth of risk aversion brings about the appreciation of the Japanese currency. As a result, the change in investor's mood is observed in the USD/JPY market.

The volatility in the Japanese yen market reflects the change in investors' risk aversion. When the market expands, share prices increase, the investors have positive attitude towards risk then one can expect the depreciation of Japanese yen. However, when stock market crashes, the financial market is hit by crisis of confidence, investor's risk aversion is rising a drop of USD/JPY exchange rate follows.

CONCLUSIONS

1. There is statistically significant relationship between USD/JPY exchange rate and the Volatility Index VIX. The negative coefficient β_1 suggests that when there is growth in investors' risk aversion then the USD/JPY exchange rate is decreasing.
2. During the financial crisis of 21st century the volatility in the market increased significantly. Between August 2007 and February 2009 investors' aversion to risk increased considerably. The maximum value of VIX was 80,86 in comparison to the time before the financial crisis (01.2006-07.2007) when the maximum value of the VIX was just 24,27. Moreover, the relationship between USD/JPY and VIX is substantially stronger during the financial crisis.
3. The yen market reflects the change in investor's attitude towards risk. The USD/JPY exchange rate is decreasing when there is an increase in investors' risk aversion. On the other hand, the Japanese currency depreciates when investors' attitude towards risk is positive.

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