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The Predictability of Exchange Rates Using Oil Price Changes

A thesis presented in partial fulfilment of the requirements for the degree of

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Abstract:

This study investigates the predictability of exchange rates using oil price changes. It is found that, on a daily basis, changes in oil prices predict several major currency exchange rate returns. In the twenty-three year sample of daily data for currency markets, a statistically significant predictability is found for the Australian Dollar, the Canadian Dollar, the British Pound, the Norwegian Krone and the New Zealand dollar. These currencies appreciate when oil price increases, and vice versa. While I do reject the random walk model for currency returns, my results do not necessarily imply a rejection of market efficiency.

Key words: Foreign exchange rate, oil price

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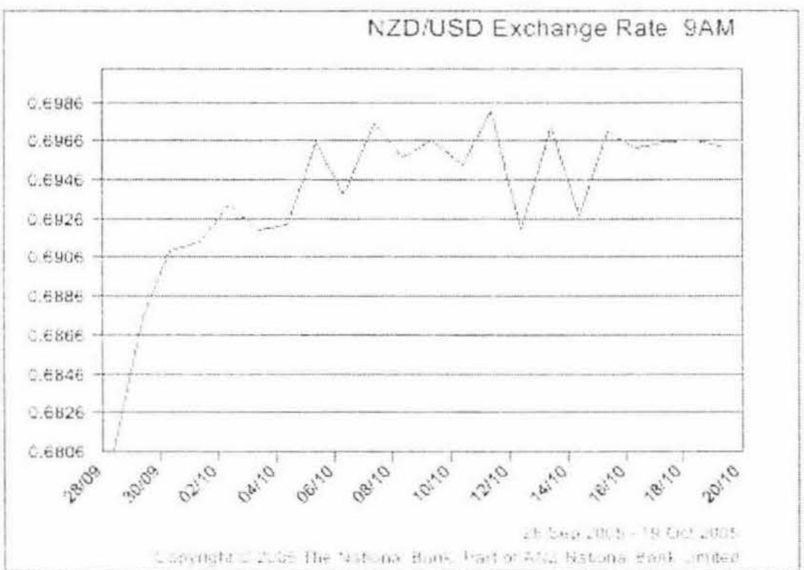
1. Introduction

Foreign exchange rates started fluctuating more after 1971. Under the Bretton Wood Agreement (1944-1971) currencies prices were pegged to the United States dollar, which could then be converted into gold at a fixed price. In August 1971 this agreement broke down and the regime of fixed exchange rates no longer existed (Shapiro, 2003). Under the freely floating monetary system, the exchange rate fluctuates freely (Figure 1). This raises some interesting questions. For instance, does the exchange rate change randomly, or can exchange rate movements be predicted?

Figure 1



This paper investigates whether oil price changes predict daily exchange rates. It is found in the current study that changes in crude oil prices on a particular day predict the returns of several major currency exchange rates on the following day. From the twenty-three year sample of daily currency data, it is found that there is a small, but statistically significant, degree of short run predictability of the exchange rates of the Australian Dollar (AUD), the Canadian Dollar (CAD), the British Pound (GBP), the Norwegian Krone (NOK) and the New Zealand dollar (NZD). These currency price returns are positively related to the lagged crude oil price returns. If crude oil prices rise at day t-1, those same currency prices will increase at day t. In other words, the daily changes of exchange rates are not random. The prices of the currencies indicated above can be predicted one day ahead.

The forecast results are robust. Although there are small autocorrelations in the exchange rate returns data; meaning that the exchange rate return at day t-1 and the exchange rate return at day t are slightly related; it was also found that, although oil price returns at days t, t-2 and t-3 have an impact on the movements of several exchange rates at day t, the forecast results and the predictability of exchange rates using 1 day lagged crude oil price returns change only a little.

The rational that lagged crude oil price returns can predict exchange rate returns is based on the premise that crude oil price is an important economic factor and is also an economic indicator. As a result, economic conditions, and/or the expectation of economic conditions, determine the exchange rates. So, changes of the crude oil price could capture changes in exchange rates. In addition, the crude oil price has a similar feature to the foreign exchange rates, in that crude oil prices also change frequently, which makes short run model forecasting possible.

While my results reject the random walk model this predictability might not, however, be evidence challenging the Efficient Market Hypothesis. The Efficient Market Hypothesis states that asset prices fully reflect historical, and publicly available, information in a semi-strong form efficient market. This hypothesis concerns the speed at which new asset prices incorporate information, and whether one could consistently earn excess returns on the asset (Elton, Gruber, Brown and Goetzmann, 2003).

Since oil prices are free, publicly available information, this paper tests the semi-strong form efficient market. Although this research finds short-run (daily) predictability of some foreign exchange rates, the predictability does not hold for longer frequencies (two days/one week/one month). Investors in foreign exchange markets access and quickly response to information provided by crude oil prices. The crude oil price information is incorporated into foreign exchange rates in a very short time period. Although this research found predictability of exchange rates, there is still a question of whether the profitability in transaction costs should be taken into account. This concern is not addressed in the current research.

2. Literature Review

The Efficient Market Hypothesis states that asset prices fully reflect historical and publicly available information in a semi-strong form efficient market. The hypothesis concerns the speed in which new information is incorporated in asset prices and whether it is possible to consistently earn excess returns on this asset. (Elton, Gruber, Brown and Goetzmann, 2003).

In the past three decades economists have attempted to challenge the efficient market hypothesis by testing the predictability of foreign exchange rates. They have studied the relationship between important economic factors and foreign exchange rates. Economic variables are free, publicly available data, so this test should be used to test semi-strong form market efficiency. The rational behind those analyses is that an exchange rate is one currency's price ranked against another currency. Like other asset prices, currency prices (exchange rates) are determined by the supply and demand of the two currencies being examined. Economic conditions are important factors in influencing the supply and demand of the two currencies. The Purchasing Power Parity and Uncovered Interest Parity theories explain how economic conditions can affect exchange rates.

The price levels of two countries are one of the factors that may affect the supply and demand of a currency. The absolute Purchasing Power Parity (PPP) theory explains the relationship of goods being traded and the currency exchange rate in two countries. For example, if goods in Country A are cheaper than goods in Country B when the good prices have been converted to a common currency, an arbitrager could make a profit from the price discrepancy by shipping goods from Country A to Country B. At the same time, the demand for A's currency will increase, because people in Country B will buy A's currency to pay for the goods in Country A. A's currency price will go up against B's currency until the arbitrage opportunity disappears. According to PPP, the customer price index (the common measure of the price level), the external trade figures (such as the trade balance) and the current account balance, will provide some level of indication in exchange rate determinations.

Another important factor in exchange rate determination is the deferential of interest rates between two countries. The Uncovered Interest Parity (UIP) theory explains the relationship of investment cash flows and the currency exchange rate between two countries. For example, if the domestic interest rate in Country A is higher than that in Country B, A's currency is expected to depreciate against B's currency in the future. The amount of money which is gained from the interest differential between A and B should be offset by the losses from future exchange rate changes between A and B. If investors borrow money from low-interest B's currency and invest in high-interest A's currency at exchange rate (e_{t-1}), when the investment comes to maturity the exchange rate (e_t) should change to a certain level which would make this foreign investment gain the same yield as a domestic investment. According to UIP, the interest rate differential would force future exchange rate change.

Fundamental monetary models based on PPP and or UIP carefully examine the relationship of different economic indicators which may have an impact on money supply and demand, and the foreign exchange rate, in order to determine the predictability of exchange rates. Meese and Rogoff (1983) tested the major exchange rate forecasting models in 1970s with the following equation:

$$e = \alpha + \beta_1(M_h - M_f) + \beta_2(G_h - G_f) + \beta_3(I_h - I_f) + \beta_4(P_h - P_f) + \beta_5 T_h + \beta_6 T_f + \varepsilon \quad (1)$$

where e is the exchange rate; M is the money supply (M1 or M3); G is the real income (real GDP or real GNP); I is the short term interest rate, P is the expected rate of inflation (expected CPI, etc.); T is the trade balance (current account balance); h denotes the home country; f denotes the foreign country; α is a constant; β is te coefficient; and ε is the error term. The Frenkel-Bilson/flexible-price model, $\beta_4= \beta_5= \beta_6=0$, assumes PPP holds. The Dornbusch-Frankel/sticky-price model, $\beta_5= \beta_6=0$, allows for price level adjustment. The Hooper-Morton/sticky-price model is incorporated into the external trade factors' model. No coefficients are constrained to 0, which not only allows for price level adjustment, but also reflects trade balance changes.

The economic indicators are published at different frequencies during the year. The time that investors take to access the impact of the information in the foreign exchange market varies. If PPP and UIP work well, the exchange rate should be only derivative from the equilibrium exchange rate; that is the exchange rate should not systematically decrease, or increase, the equilibrium price. Meese and Rogoff (1983) found that these models work well when used in the sample method, which checks the t-value of the coefficients and adjusts the R-square of the models.

Nevertheless, Meese and Rogoff (1983) found that when they compared those three models to the driftless random walk model (explained further below), they failed to outperform a simple random walk model at one to twelve month horizons for the USD/Brithish pound, USD/German mark, USD/Japanese yen and the trade-weighted dollar exchange rates.

"The random walk model assumes that successive returns are independent and that the returns are identically distributed over time. It implicates that the past information contains nothing about the magnitude of the deviation of today's return from expected return. If the random walk hypothesis holds, the efficient market hypothesis must hold with respect to past returns (though not vice versa). Thus, evidence supporting the random walk model is evidence supporting efficiency with respect to past returns" (Elton, Gruber, Brown and Goetzmann, 2003, p.405).

Meese and Rogoff's (1983) findings pointed out that those economic structure models generally don't work. None of them would outperform the random walk model. There is no predictability of exchange rate, as the foreign exchange market is efficient. Nevertheless, some economists argue that there is predictability of exchange rates if using more superior models, or using other economic variables. Neely and Sarno (2002) reviewed the literature of the past three decades and discussed a sophisticated model formulated by Mark (1995), the results and criticisms of the model. The sophisticated model does not appear to be the solution to forecasting spot rates.

This study is a trial of using another economic variable to predict exchange rates, that of crude oil prices. Krugman (1983) explained how crude oil price affected exchange rates. Krugman (1983) assumed a simple three country world, consisting of the US, Germany (European area) and OPEC. In that model the US and Germany imported oil from OPEC, and OPEC imported manufactures from the US and Germany. In this simple situation, when oil price increased the US and Germany paid more for their oil imports, their share of OPEC oil exporting being unchanged. At the same time, OPEC had more income and spent all the income immediately on importing more manufactured goods from the US and Germany, however, OPEC could change their manufactured import proportion from the US and Germany with the extra income. In this case, the original equilibrium in the goods market and the currencies market will break. In other words, "if Germany's share of OPEC imports is more than its (oil) share of the marginal oil payments burden, the mark (EUR) will appreciate; if it is less, the mark will depreciate" (Krugman, 1983, p.261).

Next the factors of lagged spending and capital flows are added into the simple situation. OPEC delays their extra spending from the oil price increase and invests part of the income in the US and German asset markets. The oil demand from the US and Germany is still assumed to be inelastic, but OPEC's proportional spending on goods and proportional investment on assets in the US and Germany change. As a result the original equilibrium in the goods market and the asset market (including the currencies market) breaks. Consequently, the mark (EUR) will initially depreciate or appreciate, depending on whether their share in OPEC's oil exporting is more or less than their share in OPEC's investing. When OPEC spends their surplus in the long run, whether the mark (EUR) will depreciate or appreciate depends on their new share in OPEC spending. This means that the mark value response to oil price increases may different in the short- and the long-run, the same as has happened to the value of the US dollar.

If the short-run and long-run changes of the value of the mark and the USD to the oil price changes are known, speculators can make gains from these changes. Therefore, the response of the exchange rate changes to oil price changes may be affected by expectations. For instance, the US is assumed to have a better share of the OPEC investments, but to have a worse share of the OPEC spending. As a result, the USD should appreciate in the short-run and depreciate in the long-run. With this expectation, the long-run factors may be taken into account from the beginning, and lead to two possible patterns (Figure 3) in the behaviour of the dollar after the oil price increase. One of these possible patterns is that OPEC investing the extra wealth from the oil price increase will lead to an immediately rising dollar, which in the long-run leads to an expected depreciation which will decrease the USD further. The other possible pattern is that the long-run factor which dominates at the beginning of the oil price increase, leads to a fall in the USD (Krugman, 1983).

Figure 2

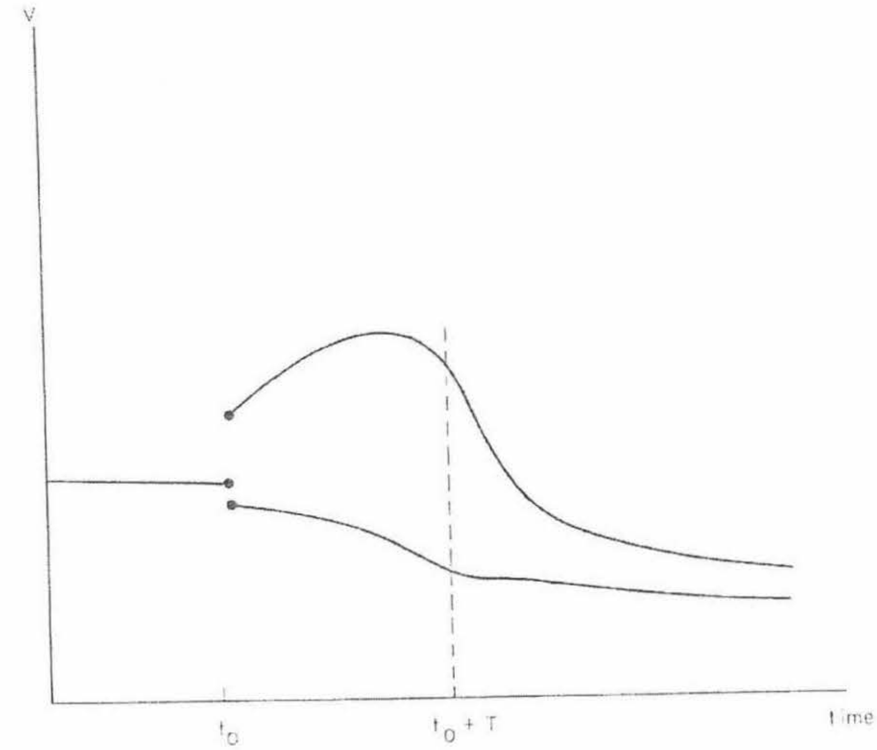


Fig. 8.5 Two possible patterns

(from Krugman (1983) PP.270)

Although Krugman's (1983) stimulations are simple, they provide a good understanding of the exchange rate response to oil price changes. The assumption of OPEC's lagged spending and investment, and the asymmetries of the goods and financial markets are reasonable in the real world.

3. Data description

Foreign exchange rate data

This study selects nine currencies of developed countries. The prices of these currencies were pegged to the USD, which could be converted into gold at a fixed price, under the Bretton Woods Agreement (1944-1971), so the foreign exchange rates are officially fixed. In August 1971 this agreement broke down and the fixed exchange rate no longer exists (Shapiro, 2003). The currency systems shifted from being fixed to being free-floating in the 1970s and 1980s.

Table 1

Source: The Chinese University of Hong Kong and Norges Bank

Country	**Date float begins**
British pound sterling (GBP)	June 1972
Canadian dollar (CAD)	May 1970
U.S. dollar (USD)	March 1973
Japanese Yen (JPY)	February 1973
Swiss franc (CHF)	January 1973
Australian Dollar (AUD)	Dec 1983
New Zealand Dollar (NZD)	Mar 1985
Norwegian Krone (NOK)	Aug 1971
Euro (EUR)*	Jan 1999 (May 1971)

* EUR has been used since Jan 1999. German mark is used to converted as earlier data: 1.95583German mark/EUR

* German Mark begins freely floating in May 1971

When the currencies became free-floating, the extreme volatility was unexpected by the governors of those monetary systems and governments tried to intervene in the exchange rates to make them more stable. For example, several European currency values were pegged to a common currency (ECU), which later developed into the Euro. In this analysis, the British pound sterling and the Norwegian Krone were pegged to the ECU until September 1992.

Figure 3

In April 1981 and in 1994, the United States Treasury (for the US dollar) and the Bretton Woods Commission, 1994 (A5, for the European currencies) stated that they are not going to intervene in the foreign exchange market for the purpose of ensuring future exchange rate stability (Aldcroft and Oliver, 1998). The freedom from government intervention, stable economies and the political environments behind those currencies, as well as their availability for trading all over the world have made those currencies the major trading currencies in the world.

The British pound base exchange rate was retrieved from DataStream, in the form of adjusted closing prices (median rates), and produced the UD dollar, Swiss Franc, Euro and Japanese Yen base foreign exchange rate data. Median rates are calculated as the arithmetic mean of the bid and offered prices. All the exchange rates are provided by WM/Reuters (Data before 31.12.1993 is from the Financial Times) and they were all recorded at 16:45 London time, so there is no time overlap problem on the cross rate generation. The test data are used after the free-float dates of the currencies.

The changes of exchange rate are calculated as a logarithm form:

$$\Delta e_t = 100\% * \ln(e_t / e_{t-1}) \quad (2)$$

where Δ denote the change, t/t-1 is the time period and e is the exchange rate.

Oil price data

Crude oil prices began to fluctuate in October 1973. During the twentieth century a few large US oil companies controlled the oil price before 1973, but this control shifted from those US companies to the Organization of the Petroleum Exporting Countries (OPEC) in October 1973, as a result of the Yom Kippur War. Crude oil prices have fluctuated since that time.

Figure 4

Crude oil is a major energy source and an important industry material in modern society. The rational of using crude oil prices is that crude oil price is an important factor in modern economies. With oil price rises, oil importing countries need to pay more to oil exporting countries This is a form of international wealth transfer (Krugman, 1983). This impact shows on the affected countries' external trade figures. Furthermore, excess oil price increases would have serious impacts on economies. Robert and Kilian (2004) pointed out that oil price increases have led to recessions, periods of excessive inflation, reduced productivity and lower economic growth since the 1970s. Adelman (1993) showed that a US$5 increase in barrel prices of oil reduces global economic growth by 0.3% in the following year. An IEA study suggests that a US$10 increase in barrel prices of oil lowers world GDP by at least 0.5% in the following year (Findings of Recent IEA Work, 2005).

This test uses international oil prices, which quote in US dollars per barrel (1 barrel = 42 gallons=135.95kgs). The West Texas Intermediate (WTI) crude oil series is selected as the US marker, and the Brent crude oil current month series is selected as the North Sea marker (Brent/Forties/Oseberg). Both of these series are benchmark oil prices in oil trading. The WTI series consists of spot prices. The Brent crude oil current month series is traded on forward markets and is the basis of futures and options contracts listed on the IPE. WTI crude oil prices are generally higher than Brent crude oil prices, because the former is easier than the latter to refine. Nevertheless, these two series tend to move together. The correlations between the daily changes of the Brent oil price and the daily changes of the WTI oil price is 67.76%. The correlations of the oil price changes on the weekly and monthly base are higher.

The change of oil price is calculated through the logarithm form:

$$\Delta O_t = 100\% * \ln(O_t / O_{t-1}) \tag{3}$$

where Δ denotes change, t/t-1 is the time period and O is the oil price.

Table 2

	changes of oil price					
	Daily		**Weekly**		**Monthly**	
	Brent Oil	**WTI Oil**	**Brent Oil**	**WTI Oil**	**Brent Oil**	**WTI Oil**
Period	1/4/1982	4/4/1983	1/8/1982	4/8/1983	1/29/1982	9/30/1973
	5/31/2005	5/31/2005	5/27/2005	5/27/2005	5/31/2005	5/31/2005
mean%	0.01%	0.01%	0.03%	0.05%	0.12%	0.67%
Maximum%	19.42%	26.98%	29.03%	25.13%	44.61%	37.14%
Minimum%	-43.87%	-40.20%	-45.12%	-34.90%	-47.61%	-35.25%
Std.Dev%	2.28%	2.52%	5.08%	5.12%	10.73%	8.53%
# of Obs.	6106	5781	1220	1155	280	380
correlations	67.76%		80.08%		91.53%	

Source: original data from DataStream

4. Regression model analysis

The relationship of oil price changes to exchange rates changes is tested using the regression technique:

$$\Delta e_t = \alpha_1 + \beta_1 \Delta O_{t-1} + \varepsilon_t \tag{4}$$

where Δe_t is the change in the exchange rate at time t, ΔO_{t-1} is the change of the US dollar oil price at time t-1, α_1 is the constant, β_1 is the coefficient and ε_t is the error term. When β_1 is significant, the null hypothesis that oil prices have no impact on exchange rates is rejected.

5. Results

Table 3 shows the main results of the daily basis analysis. It contains the estimation results, the coefficients and the t-value, for both the Brent oil series and the WTI oil series. In terms of capturing exchange rate movements, the Brent oil series and the WTI oil series are similar, except for the British pound-related exchange rate and the fact that the coefficients of the Brent oil series are generally a bit higher that the coefficients of the WTI oil series. This is reasonable. The Brent oil series and the WTI oil series are highly correlated, so there is not much difference in their impacts on exchange rates. The Brent oil series contains the major trade in the North Sea markets, which is more related to Britain geographically. This means that investors are more likely to use Brent oil prices as an indication of British pound-related exchange rate trading.

The results are interesting. Changes of the Australian dollar (AUD), the Canadian dollar (CAD), the Norwegian krone (NOK), the New Zealand dollar (NZD) and the British pound (GBP) are positively related to the changes of oil prices. This means that; in terms of the twenty-three year sample period used in this research; a rise (a drop) of oil prices at day t-1 leads to an increase (a decrease) of those currencies at day t.

It is not a surprise to find that the values of the Canadian dollar, the Norwegian krone and the British pound are positively related to the oil price changes. Norway and Canada are well-known as producers and exporters of crude oil. Norway produced 151Mt[1] of crude oil in 2003, which is 4.1% of the total world production; while Canada produced 138Mt crude oil in the same year, being 3.7% of the total world production. Norway exported 140Mt of crude oil in 2002 and Canada exported 80Mt of crude oil in 2002 (Key World Energy Statistics, 2004). The impact of changes in the oil price in relation to the British pound would be the same as in the case of the above two currencies. The United Kingdom produces crude oil and is also the base for several big global oil companies (BP and Shell), which have operations (including crude oil mining) all over the world. The net export of crude oil by the UK in 2002 was 30Mt (Key World Energy Statistics, 2004). Oil price increases are good news for the income of such

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[1] Mt/ Mtoe (Million tonnes of oil equivalent): the amount of oil required to release the same amount of energy as another energy source (for e.g. coal). (retrieved 12 Nov 2005, from http://www.energex.com.au/switched_on/project_info/electricity_production_glossary.html#M)

Crude oil, 1 Barrel=0.136 Tonne (retrieved 24 Nov 2005, from http://www.maproyalty.com/stanford/conversions.html) countries from exporting crude oil, plus from an increase in the demand for their currencies and, on the contrary, oil price decreases are bad news for their incomes and lead to a decrease in the demand for their currencies.

The reason why the values of the Australian dollar and of the New Zealand dollar are positive relative to changes of the crude oil price is not clear. That the values of these two currencies are positively related to oil price changes is not the case with the Canadian dollar and the Norwegian krone. As both Australia and New Zealand are net crude oil importers, increases in the oil price would worsen their oil import payments.

Australia produces crude oil and it imports crude oil at the rate of around 12.4Mt in 2003. Although Australia has an oil deficit, it is also rich in energy resources, including oil, natural gas, liquid natural gas and coal reserves (Australia Country Analysis Brief, n. d.). Therefore, Australia had net exports of 138.6Mt energy in 2002. New Zealand has some oil reserves, but the majority of the crude oil it consumes is imported. Though New Zealand has other energy resources, it is a net energy importer, importing 3.71Mt energy in 2002 (Key World Energy Statistics, 2004).

One possible explanation for this is similar to the explanation stated by McGuirk (1983) and Amano and van Norden (1998), that the pricing currencies are too weak compared to the Australian dollar and the New Zealand dollar. This means that when oil prices increase, the relative values of the Australian dollar and the New Zealand dollar go up. This would be a reasonable explanation with regards to the pricing of the following currencies: the US dollar, the Swiss franc, the Japanese yen and the Euro. Though the US produces oil, they still import a lot of crude oil to satisfy their consumption. In fact the US is the biggest oil importer in the world (Findings of Recent IEA work, 2005). The US produced 348Mt of crude oil in 2003 (9.4% of the world's total production), imported 515Mt of crude oil in 2002 (25.3% of world total oil imports), and imported a total of 629.75Mt of energy in 2002. Japan imported 206Mt of crude oil in 2002, second only in terms of crude oil imports after the US, and imported a total of 425.15Mt in energy in 2002. Switzerland and the Euro countries are also net oil importers. Switzerland imported a net amount of 15.24Mt of energy in 2002. In 2002 Germany, Italy, France and Spain were the major oil importers within the Euro countries, importing 333Mt of crude oil and a total of 608.01Mt of energy (Key World Energy Statistics, 2004). Compared to Australia and New Zealand, the countries listed above import a greater quantity of crude oil. Investors may be concerned about oil prices impacts on the economies of those Euro countries more than about the economies of Australia and New Zealand. This lead to an increase (decrease) in the currency values of Australia and New Zealand against the four Euro currencies when oil prices increase (decrease).

The other possible explanation for the value of the Australian dollar and the New Zealand dollar being positively related to changes of the crude oil price is similar to the explanation stated by Krugman (1983). When oil prices rise, oil export countries gain more wealth and spend more on importing goods and service. This kind of change in the proportions of the oil traded, and the other goods and services in each country, are different. Australia and New Zealand may gain a greater share of this goods and services trade than other countries, which may strong benefit the economies of Australia and New Zealand. This leads investors to treat oil price increases (decreases) as being good (bad) for the Australian dollar and the New Zealand dollar.

The value of the pricing currencies (the US dollar, the Swiss franc, the Japanese yen and the Euro) against the other five currencies, have a negative relationship with oil price changes. This means that their currency values against the other five currencies fall (rise) when oil prices increase (decrease). As with the above explanation, these countries are net crude oil importers, so an increase (decrease) in oil prices is bad (good) news for them. As their values tend to fall (rise) together, it is difficult to determine the relative exchange rates of one to another. There is no significant finding when the four currencies price each other.

Nevertheless, the movements of the British pound against the Australian dollar and against the New Zealand dollar are positively related to oil price changes, and this finding cannot be explained by the above two explanations.

Time overlap problem

The test data has a time overlap problem. The daily oil price data was retrieved at 7:30pm London time, but the daily exchange rates were retrieved at 4:45pm London time. When the oil returns and the exchange rates are calculated, the time overlap problem shows (see Figure 5, below). To overcome this problem, the exchange rates data was further tested with multiple periods of Brent oil returns, including day t, t-2 and t-3. The Brent oil series was used for two reasons. One is that the Brent oil series captures more exchange rates movement than does the WTI series. The other is that the Brent oil returns series do not have an autocorrelation problem, which means that the daily oil returns are independent.

$$\Delta e_t=\alpha+\beta_1\Delta O_t+\beta_2\Delta O_{t-1}+\beta_3\Delta O_{t-2}+\beta_4\Delta O_{t-3}+\varepsilon_t \quad (5)$$

where Δe_t is the exchange rate returns on dates t, ΔO_t, ΔO_{t-1}, ΔO_{t-2} and ΔO_{t-3} are the oil returns on days t, t-1, t-2 and t-3, respectively. α is the constant, β_1, β_2, β_3 and β_4 are the coefficients and ε_t is the error term.

Figure 5

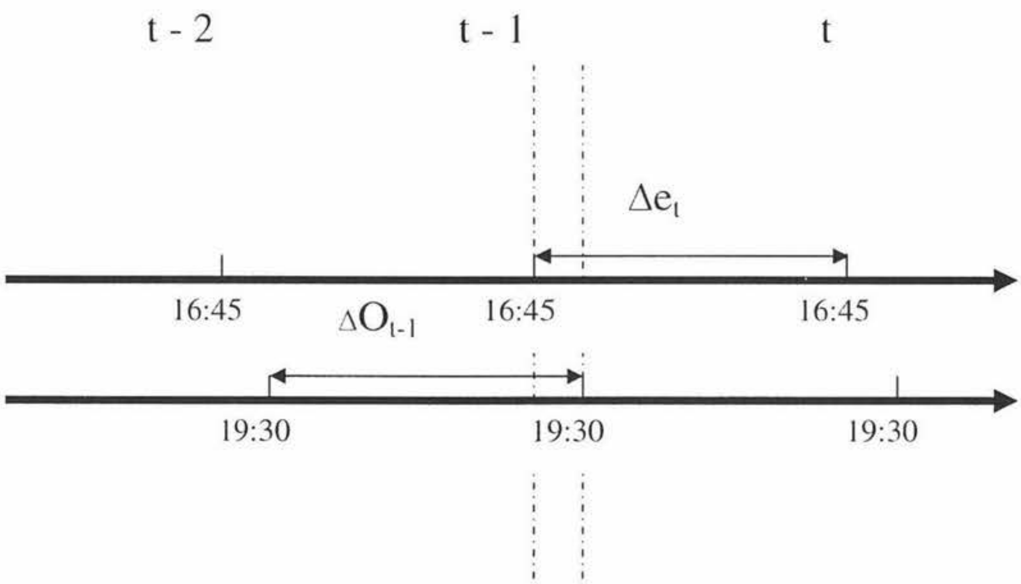

Table 4 shows the main results of the multiple period testing. Although there are some significant impacts on the changes of exchange rates from other periods, the magnitude of β_2, which is the coefficient for one day lagged oil returns, does not change much.

More interesting results are found. Nine exchange rates response to oil price changes on the same day. This response is consistent with the positive relationship between the oil prices and the one day lagged oil returns, which means a rise on this particular day would lead to exchange rate rises on this day and the next day.

The New Zealand dollar's relative exchange rates are also influenced by two day lagged oil returns, although this is a negative relationship. In other words, a rise in the oil price on a particular day would drag up the value of New Zealand dollar on that day and the next day, but would drag it down the day after next.

The US dollar's relative exchange rates have significant results for the day t-3 oil returns. The US dollar depreciates (appreciates) against the Swiss franc, the Japanese yen and the Euro three days after a rise (a drop) in oil prices.

Autocorrelation in exchange rate returns series

The exchange rate returns series mentioned above has an autocorrelation problem, which means that the exchange rate return on day t and the exchange rate return on day t-1 are not totally independent. The autocorrelation is, however, low. The Durbin Watson value for the residuals for Model (2) is tested. Only a few of the tests which produced significant results in regards to Model (2) are found to have no residual autocorrelation problems. The Durbin Watson (1971) test checks whether the residuals of the regression model are independent. In other words, if the residuals of the regression Model (2) are independent, the test results are valid. Therefore, a further test is carried out to determine whether the exchange rate returns autocorrelation problem will affect the predictability of exchange rates.

$$\Delta e_t=\alpha+\beta_1\Delta e_{t-1}+\beta_2\Delta O_{t-1}+\varepsilon_t \qquad (6)$$

where Δe_t and Δe_{t-1} are the exchange rate returns on date t and date t-1, respectively, ΔO_{t-1} is the oil price returns on the Brent oil price, α is the constant, β_1 and β_2, are the coefficients and ε_t is the error.

Table 5 Daily Data

t = 1 day

$\Delta e_t = \alpha + \beta_1 \Delta e_{t-1} + \beta_2 \Delta O_{t-1} + \varepsilon_t$

exchange rate return (t)	$\beta_1 (e_{t-1})$		$\beta_2 (O_{t-1})$	
e(GBP/AUD)	0.0502	**	0.0074	*
	(3.76)		(1.68)	
e(CHF/AUD)	0.0310	**	0.0173	**
	(2.33)		(3.54)	
e(GBP/EUR)	0.0371	**	-0.0092	**
	(2.90)		(-3.53)	
e(JPY/NOK)	0.0409	**	0.0084	**
	(3.19)		(2.20)	
e(GBP/CHF)	0.0322	**	-0.0102	**
	(2.52)		(-3.49)	
e(GBP/JPY)	0.0807	**	-0.0082	**
	(6.32)		(-2.15)	

* 90% significant, **95% significant ( ) t-value

Brent Crude Oil Price - Current Month, FOB U$/BBL: 04/01/1982-30/05/2005

Table 5 shows the main results of the tests. β_2 is the coefficient of the oil price returns. Compared to the test results from testing Equation (2), the magnitude of the coefficient is similar. Although the coefficient of the exchange rate returns (β_1) is significant for all the selected exchange rates, the predictability of exchange rates using oil price returns does not change.

Efficient Market Hypothesis and the Random Walk Hypothesis

The simple random walk model is:

$$e_t = e_{t-1} + \varepsilon_t \text{ with } E(\varepsilon_t)=0 \qquad (7)$$

where e_t and e_{t-1} are the exchange rates at date t and t-1, respectively and ε_t is the exchange rate return at day t and is supposed to be a random number. $E(\varepsilon_t)$ is the expected return of the exchange rate

Short-run (daily) predictability of some foreign exchange rates was found, which rejects the random walk hypothesis that "past information contains nothing about the magnitude of the deviation of today's return from [the] expected return." (Elton, Gruber, Brown and Goetzmann, 2003, p.405) The current study finds that $E(\varepsilon_t)$ should consist of two parts; one part is related to the lagged oil returns, and the other part is a random figure. That $E(\varepsilon_t)$ is not 0, and that the past oil information has an impact on the magnitude of the deviation of today's exchange rate returns are challenges to the random walk hypothesis.

Nevertheless, there is not enough evidence to reject the efficient market. The following two points may explain the reason for this. First, the predicability of the exchange rate doesn't hold for longer frequencies (two days/one week/one month). The speed at which the oil price news is incorporated into the foreign exchange rates is fast, which is consist with the efficient market hypothesis that a market reacts to information efficiently. Second, the profitability for day trading is a concern, when transaction costs are taken into account. Efficient Market Hypothesis states that no one will make consistent excess returns over the market (Elton, Gruber, Brown and Goetzmann, 2003).

6. Conclusion

This study finds that several major exchange rates can be forecast one day ahead. Through the investigation of the predictability of exchange rates through the use of oil price changes, it is found that changes in oil price on a particular day predict several major currency exchange rate returns for the next day. Using a twenty-three year sample of daily basis data for currency markets, statistically significant predictability can be found for the Australian Dollar, the Canadian Dollar, the British Pound, the Norwegian Krone and the New Zealand Dollar. These currency prices appreciate (depreciate) when oil prices increase (decrease). The forecast results are robust. Although there is autocorrelation on the exchange rate returns data and it is also found that oil price returns on other days have an impact on the movements of some exchange rates, the forecast results did not change much.

From an academic viewpoint, this test result is a challenge to the random walk hypothesis. Nevertheless, the results are not robust enough to challenge the Efficient Market Hypothesis. From the practical viewpoint, the profitability of day trading must be left to the investors to decide.

References

Some Windows on History (n.d.) Retrieved 25/08/2005, http://www.norges-bank.no/english/

Historical Exchange Rate Regime (n.d.) Retrieved 25/08/2005, http://intl.econ.cuhk.edu.hk/exchange_rate_regime/

Findings of Recent IEA work 2005 (2005) Retrieved 25/08/2005, from http://www.iea.org/findings

Key World Energy Statistics (2004) Retrieved 25/08/2005, from http:// www.iea.org

OPEC Annual Statistical Bulletin 2003 (2003) Retrieved 25/08/2005, from http://www.opec.org

Brent Crude Oil Profile (n.d.) retrieved 31 Oct. 05, from http://www.mcxindia.com/BrentCrude_oil.aspx

Amano, R. A. & van Norden, S. (1998, a) Exchange rates and oil prices [Electronic version] *Review of International Economics, 6(4),* 683-694

Aldcroft, D. H. & Oliver, M. J. (1998) *Exchange rate regimes in the twentieth century*, UK, Edward Elgar Publishing Limited

Durbin, J. & G.S. Watson (1971) Testing for serial Correlation in Least Squares Regression 3 [Electronic version] *Biometrika, 58 (1)*, pp1-19

Elton, E.J., Gruber, M.J., Brown, S.J. and Goetzmann (2003) *Modern portfolio theory and investment analysis,* 6th Ed. , U.S., John Wiley & Sons.

Mark, N. C. (1995) Exchange rates and fundamentals: evidence on long-horizon predictability [Electronic version] *The American Economic Review 85* (1), 201-218

McGuirk, A. K. (1983) Oil price changes and real exchange rate movements among industrial countries *International Monetary Fund Staff Papers, 30,* pp.843-877

Meese, R. A. & Rogoff, K. (1983a) Empirical exchange rate models of the seventies: Do they fit out of sample? [Electronic version] *Journal of International Economics 14,* 3-24

Neely, C. J. & Sarno, L. (2002) How well do monetary fundamentals forecast exchange rates? [Electronic version] *Review Federal Reserve Bank of St. Louis,* September/October 2002, pp. 51-74

Krugman, P. (1983) Oil shocks and exchange rate dynamics Exchange Rates and International macroeconomics Ed: Frenkel, J. A. Chicago the University of Chicago Press

Shapiro, A.C. (2003) Multinational Financial Management 7th Ed. United States of America: Jonn Wiley& Sons, Inc.

Appendix A

Table 3

Summary Statistics of exchange rate return and oil return

Daily Data

$\Delta e_t = \alpha_1 + \beta_1 \Delta O_{t-1} + \varepsilon_t$ t=1 day

exchange rate return (t)	$\beta(O_{t-1})^1$	t-value	$\beta(O_{t-1})^2$	t-value
e(GBP/AUD)	0.0078	**1.77**	0.0081	**2.00**
e(USD/AUD)	0.0115	**2.86**	0.0055	1.50
e(CHF/AUD)	0.0176	**3.59**	0.0110	**2.44**
e(JPY/AUD)	0.0154	**3.17**	0.0100	**2.23**
e(EUR/AUD)	0.0168	**3.67**	0.0102	**2.37**
e(GBP/CAD)	0.0012	0.34	0.0055	**1.65**
e(USD/CAD)	0.0055	**2.83**	0.0030	1.62
e(CHF/CAD)	0.0114	**2.74**	0.0085	**2.18**
e(JPY/CAD)	0.0093	**2.31**	0.0075	**2.01**
e(EUR/CAD)	0.0106	**2.77**	0.0076	**2.13**
e(GBP/EUR)	-0.0094	**-3.58**	-0.0021	-0.88
e(USD/EUR)	-0.0050	-1.37	-0.0047	-1.35
e(CHF/EUR)	0.0008	0.51	0.0008	0.59
e(JPY/EUR)	-0.0013	-0.36	-0.0001	-0.03
e(GBP/NOK)	0.0002	0.07	0.0052	**1.99**
e(USD/NOK)	0.0045	1.32	0.0027	0.83
e(CHF/NOK)	0.0104	**4.04**	0.0082	**3.47**
e(JPY/NOK)	0.0083	**2.23**	0.0072	**2.08**
e(EUR/NOK)	0.0096	**4.48**	0.0073	**3.74**
e(GBP/NZD)	0.0071	1.55	0.0098	**2.33**
e(USD/NZD)	0.0102	**2.39**	0.0070	**1.78**
e(CHF/NZD)	0.0167	**3.30**	0.0126	**2.71**
e(JPY/NZD)	0.0143	**2.85**	0.0116	**2.50**
e(EUR/NZD)	0.0158	**3.32**	0.0118	**2.69**
e(GBP/CHF)	-0.0102	**-3.48**	-0.0030	-1.10
e(USD/CHF)	-0.0059	-1.45	-0.0055	-1.47
e(JPY/CHF)	-0.0021	-0.57	-0.0010	-0.28
e(EUR/CHF)	-0.0008	-0.51	-0.0008	-0.59
e(GBP/USD)	-0.0043	-0.29	0.0025	0.80
e(CHF/USD)	0.0059	1.45	0.0055	1.47
e(Yen/USD)	0.0038	1.00	0.0045	1.31
e(EURO/USD)	0.0050	1.37	0.0047	1.35
e(USD/GBP)	0.0043	1.29	-0.0025	-0.80
e(CHF/GBP)	0.0044	**3.48**	0.0013	1.10
e(JPY/GBP)	0.0081	**2.12**	0.0020	0.57
e(EUR/GBP)	0.0094	**3.58**	0.0021	0.88

e(GBP/JPY)	-0.0081	**-2.12**	-0.0020	-0.57
e(USD/JPY)	-0.0038	-1.00	-0.0045	-1.31
e(CHF/JPY)	0.0021	0.57	0.0010	0.28
e(EUR/JPY)	0.0013	0.36	0.0001	0.03

[1] Brent oil series: 04/01/1982-30/05/2005

Observations number 6104, expect for AUD 5601 NZD 5281

[2] WTI oil series: 04/04/1983-30/05/2005

Observations number 5779, expect for AUD 5601 NZD 5281

values in bold refer to significant t-values at the 10% significant level

Table 4 Multiple periods

$\Delta e_t = \alpha + \beta_1 \Delta O_t + \beta_2 \Delta_{Ot-1} + \beta_3 \Delta O_{t-2} + \beta_4 \Delta O_{t-3} + \varepsilon_t$

exchange rate return (t)	β_1		β_2		β_3		β_4	
e(GBP/AUD)	0.0075	*	0.0077	*	-0.0021		-0.0010	
	(1.71)		(1.74)		(-0.47)		(-0.23)	
e(USD/AUD)	0.0119	**	0.0113	**	-0.0006		0.0039	
	(2.97)		(2.82)		(-0.15)		(0.98)	
e(CHF/AUD)	0.0068		0.0174	**	-0.0014		-0.0043	
	(1.39)		(3.55)		(-0.29)		(-0.89)	
e(JPY/AUD)	0.0066		0.0153	**	-0.0037		-0.0030	
	(1.37)		(3.15)		(-0.77)		(-0.61)	
e(EUR/AUD)	0.0119	**	0.0166	**	-0.0030		-0.0030	
	(2.55)		(3.57)		(-0.64)		(-0.65)	
e(GBP/CAD)	0.0033		0.0011		-0.0022		-0.0038	
	(0.94)		(0.32)		(-0.63)		(-1.06)	
e(USD/CAD)	0.0077	**	0.0054	**	-0.0005		0.0013	
	(3.95)		(2.78)		(-0.27)		(0.65)	
e(CHF/CAD)	0.0023		0.0113	**	-0.0020		-0.0066	
	(0.56)		(2.71)		(-0.49)		(-1.59)	
e(JPY/CAD)	0.0021		0.0093	**	-0.0046		-0.0054	
	(0.51)		(2.30)		(-1.15)		(-1.33)	
e(EUR/CAD)	0.0071	*	0.0104	**	-0.0036		-0.0055	
	(1.85)		(2.73)		(-0.95)		(-1.44)	
e(GBP/EUR)	-0.0037		-0.0093	**	0.0014		0.0017	
	(-1.43)		(-3.55)		(0.53)		(0.67)	
e(USD/EUR)	0.0006		-0.0050		0.0031		0.0068	*
	(0.17)		(-1.36)		(0.84)		(1.83)	
e(CHF/EUR)	-0.0047	**	0.0008		0.0016		-0.0011	
	(-3.01)		(0.54)		(1.00)		(-0.69)	
e(JPY/EUR)	-0.0050		-0.0012		-0.0010		0.0001	
	(-1.41)		(-0.33)		(-0.28)		(0.04)	
e(GBP/NOK)	-0.0015		0.0001		0.0038		-0.0003	
	(-0.54)		(0.05)		(1.34)		(-0.11)	
e(USD/NOK)	0.0029		0.0045		0.0055		0.0047	
	(0.83)		(1.30)		(1.59)		(1.37)	
e(CHF/NOK)	-0.0025		0.0103	**	0.0040		-0.0031	
	(-0.99)		(4.01)		(1.53)		(-1.22)	
e(JPY/NOK)	-0.0028		0.0083	**	0.0014		-0.0019	
	(-0.76)		(2.22)		(0.37)		(-0.51)	
e(EUR/NOK)	0.0022		0.0095	**	0.0024		-0.0021	
	(1.03)		(4.43)		(1.11)		(-0.96)	
e(GBP/NZD)	0.0076	*	0.0072		-0.0108	**	0.0023	
	(1.65)		(1.57)		(-2.37)		(0.50)	
e(USD/NZD)	0.0118	**	0.0103	**	-0.0090	**	0.0073	**
	(2.77)		(2.41)		(-2.11)		(1.70)	
e(CHF/NZD)	0.0066		0.0167	**	-0.0099	**	-0.0012	
	(1.31)		(3.30)		(-1.97)		(-0.24)	
e(JPY/NZD)	0.0064		0.0144	**	-0.0123	**	0.0003	
	(1.28)		(2.88)		(-2.44)		(0.06)	
e(EUR/NZD)	0.0118	**	0.0158	**	-0.0117	**	0.0001	

	(2.48)	(3.32)		(-2.46)	(0.02)	
e(GBP/CHF)	0.0010	-0.0102	**	-0.0002	0.0028	
	(0.34)	(-3.47)		(-0.06)	(0.97)	
e(USD/CHF)	0.0054	-0.0059		0.0015	0.0079	*
	(1.33)	(-1.45)		(0.37)	(1.94)	
e(JPY/CHF)	-0.0003	-0.0020		-0.0026	0.0012	
	(-0.08)	(-0.55)		(-0.70)	(0.33)	
e(EUR/CHF)	0.0047	-0.0008		-0.0016	0.0011	
	(3.01)	(-0.54)		(-1.00)	(0.69)	
e(GBP£/USD)	-0.0044	-0.0043		-0.0017	-0.0050	
	(-1.30)	(-1.28)		(-0.50)	(-1.49)	
e(CHF/USD)	-0.0054	0.0059		-0.0015	-0.0079	*
	(-1.33)	(1.45)		(-0.37)	(-1.94)	
e(JPY/USD)	-0.0057	0.0038		-0.0041	-0.0066	*
	(-1.51)	(1.02)		(-1.09)	(-1.77)	
e(EUR/USD)	-0.0006	0.0050		-0.0031	-0.0068	*
	(-0.17)	(1.36)		(-0.84)	(-1.83)	
e(USD/GBP)	0.0044	0.0043		0.0017	0.0050	
	(1.3)	(1.28)		(0.50)	(1.49)	
e(CHF/GBP)	-0.0004	0.0044	**	0.0001	-0.0012	
	(-0.34)	(3.47)		(0.06)	(-0.97)	
e(JPY/GBP)	-0.0013	0.0082	**	-0.0024	-0.0016	
	(-0.34)	(2.13)		(-0.63)	(-0.42)	
e(EUR/GBP)	0.0037	0.0093	**	-0.0014	-0.0017	
	(1.43)	(3.55)		(-0.53)	(-0.67)	
e(GBP/JPY)	0.0013	-0.0082	**	0.0024	0.0016	
	(0.34)	(-2.13)		(0.63)	(0.42)	
e(USD/JPY)	0.0057	-0.0038		0.0041	0.0066	*
	(1.51)	(-1.02)		(1.09)	(1.77)	
e(CHF/JPY)	0.0003	0.0020		0.0026	-0.0012	
	(0.08)	(0.55)		(0.70)	(-0.33)	
e(EUR/JPY)	0.0050	0.0012		0.0010	-0.0001	
	(1.41)	(0.33)		(0.28)	(-0.04)	

* 90% significant, **95% significant ( ) t-value

Brent Crude Oil Price - Current Month, FOB U$/BBL: 04/01/1982-30/05/2005

Appendix B

Test for longer frequencies

The main test was extended through the use of longer frequencies (two days/one week/one month). The test still uses Model (4), which only checks whether there is any aggregate predictability in the exchange rates.

Two day test

The two day daily returns for the exchange rates and the oil prices are added together to produce a new series. This test is only for the four currencies which produced significant results in the first model testing. Table 6 shows that the Australian dollar still has some predictability, however, the other three currencies do not have any significant results in the two day series test.

Table 6 2 days returns

$\Delta e_t=\alpha+\beta_1\Delta O_{t-1}+\varepsilon_t$

exchange rate return (t)	β_1[1]	t-value
e(GBP/AUD)	0.0110	**1.89**
e(USD/AUD)	0.0091	**1.82**
e(CHF/AUD)	0.0140	**2.17**
e(JPY/AUD)	0.0062	0.99
e(EUR/AUD)	0.0143	**2.36**
e(GBP/CAD)	0.0027	0.56
e(USD/CAD)	0.0008	0.33
e(CHF/CAD)	0.0059	1.06
e(JPY/CAD)	-0.0018	-0.34
e(EUR/CAD)	0.0063	1.24
e(GBP/NOK)	-0.0009	-0.23
e(USD/NOK)	-0.0027	-0.59
e(CHF/NOK)	0.0024	0.72
e(JPY/NOK)	-0.0054	-1.08
e(EUR/NOK)	0.0028	1.04
e(GBP/NZD)	0.0006	0.11
e(USD/NZD)	-0.0016	-0.30
e(CHF/NZD)	0.0033	0.52
e(JPY/NZD)	-0.0044	-0.68
e(EUR/NZD)	0.0037	0.60

[1] West Texas Int. Oil Price Cushing $/BBL : 04/04/1983-30/05/2005

values in bold refer to significant t-values at the 10% significant level

One week test and one month test

The original weekly and monthly data retrieved from DataStream was used in this testing. There is a longer period of oil price monthly data for the WTI oil series. Therefore, the earlier tests for the monthly data begin from October 1973, when the oil prices began to fluctuation. Table 7 and Table 8 show only that the exchange rate of the British pound against the New Zealand dollar still has a significant result in one week test. All other weekly and monthly data tests do not produce any significant results.

Table 7 **Weekly Data**

$\Delta e_t = \alpha_1 + \beta_1 \Delta O_{t-1} + \varepsilon_t$ t = 1 week

exchange rate return (t)	$\beta(O_{t-1})^1$	t-value	$\beta(O_{t-1})^2$	t-value
e(GBP/AUD)	-0.0053	-0.54	-0.0023	-0.23
e(GBP/CAD)	0.0037	0.45	0.0008	0.09
e(GBP/EUR)	0.0021	0.34	-0.0075	-1.21
e(GBP/NOK)	0.0090	1.45	0.0047	0.74
e(GBP/NZD)	-0.0198	**-2.00**	-0.0111	-1.11
e(GBP/CHF)	0.0017	0.25	-0.0039	-0.57
e(GBP/USD)	0.0025	0.32	-0.0004	-0.05
e(GBP/JPY)	-0.0057	-0.62	-0.0119	-1.25

values in bold refer to significant t-values at the 10% signigicant level

[1] Brent Crude Oil Price - Current Month, FOB US/BBL: 08/01/1982-30/05/2005

[2] West Texas Int. Oil Price Cushing $/BBL : 08/04/1983-30/05/2005

Table 8 **Monthly data**

$\Delta e_t = \alpha_1 + \beta_1 \Delta O_{t-1} + \varepsilon_t$ t = 1 month

exchange rate return (t)	Starting Date	# obs.	$\beta^1(O_{t-1})$	t-value	$\beta^2(O_{t-1})$	t-value
e(GBP/AUD)	Dec-83	255	-0.0131	-0.55	-0.0132	-0.63
e(GBP/CAD)	Oct-73	377	-0.0096	-0.51	-0.0099	-0.56
e(GBP/EUR)	Oct-73	377	-0.0119	-0.77	-0.0173	-1.32
e(GBP/NOK)	Oct-73	377	-0.0057	-0.39	-0.0148	-1.14
e(GBP/NZD)	Mar-85	240	0.0043	0.19	0.0040	0.20
e(GBP/CHF)	Oct-73	377	-0.0029	-0.17	-0.0133	-0.94
e(GBP/USD)	Oct-73	377	-0.0138	-0.76	-0.0072	-0.43
e(GBP/JPY)	Oct-73	377	0.0027	0.13	0.0073	0.38

[1]West Texas Int. Oil Price : 10/1973-04/2005

[2] Brent Oil Price : 01/1982-04/2005

Ask-offered spread concerns

This study uses the middle rate of the exchange rates for testing. Table 9 shows that the daily changes in exchange rates are usually small. In reality there is an ask-offered spread on the spot rate, which is equal to a transaction cost. The cost may vary from time to time and between different exchanges. Whether this forecast can be used profitability when the transaction costs are taken into account must be left to the investor to decide.

Table 9

Daily exchange rate returns	**mean(%)**	**Std. dev.(%)**	**Daily exchange rate returns**	**mean(%)**	**Std. dev.(%)**
e(GBP/AUD)*	-0.0074%	0.77%	e(GBP/NZD)*	-0.0011%	0.80%
e(USD/AUD)*	-0.0033%	0.71%	e(USD/NZD)*	0.0090%	0.75%
e(CHF/AUD)*	-0.0135%	0.86%	e(CHF/NZD)*	-0.0069%	0.89%
e(JPY/AUD)*	-0.0173%	0.85%	e(JPY/NZD)*	-0.0078%	0.88%
e(EUR/AUD)*	-0.0131%	0.82%	e(EUR/NZD)*	-0.0053%	0.84%
e(GBP/CAD)	-0.0001%	0.63%	e(GBP/CHF)	0.0068%	0.52%
e(USD/CAD)	-0.0009%	0.35%	e(USD/CHF)	0.0061%	0.72%
e(CHF/CAD)	-0.0070%	0.74%	e(JPY/CHF)	-0.0055%	0.66%
e(JPY/CAD)	-0.0125%	0.72%	e(EUR/CHF)	0.0003%	0.28%
e(EUR/CAD)	-0.0067%	0.68%			
e(GBP/EUR)	0.0065%	0.47%	e(GBP/USD)	-0.0004%	0.60%
e(USD/EUR)	0.0059%	0.66%	e(CHF/USD)	-0.0061%	0.72%
e(CHF/EUR)	-0.0003%	0.28%	e(Yen/USD)	-0.0117%	0.67%
e(JPY/EUR)	-0.0058%	0.64%	e(EURO/USD)	-0.0059%	0.66%
e(GBP/NOK)	-0.0008%	0.50%	e(USD/GBP)	0.0004%	0.60%
e(USD/NOK)	-0.0016%	0.61%	e(CHF/GBP)	-0.0068%	0.52%
e(CHF/NOK)	-0.0077%	0.46%	e(JPY/GBP)	-0.0125%	0.68%
e(JPY/NOK)	-0.0132%	0.66%	e(EUR/GBP)	-0.0065%	0.47%
e(EUR/NOK)	-0.0074%	0.38%			
			e(GBP/JPY)	0.0125%	0.68%
			e(USD/JPY)	0.0117%	0.67%
			e(CHF/JPY)	0.0055%	0.66%
			e(EUR/JPY)	0.0058%	0.64%

All data begins 5/01/1982. expect * Australia begins at 1/03/1985, New Zealand begins at 9/12/1983