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CENTRE FOR INTERNATIONAL BUSINESS STUDIES

MANAGING AVIATION FUEL RISK: EMERGING MARKET'S AIRLINE COMPANIES PERSPECTIVE ON THE INTERNATIONAL ARENA

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Paper Number 25-02

**RESEARCH PAPERS IN
INTERNATIONAL BUSINESS**

ISSN NUMBER 1366-6290

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Winner of the 2002 CiBS Routledge Prize for the Best Master Dissertation in International Business

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A version of this paper was presented at the Fourth Annual Conference on Economies in Transition, Trade and Factor Mobility held by European Bank for Reconstruction and Development (EBRD) in London.

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Abstract

An empirical analysis reveals two main directions for hedging. The first is to cross hedge jet fuel using other underlying futures contracts, which are highly correlated. The second method entails cross hedging emerging market currencies using major currencies futures contracts. In the oil market, empirical results imply that OLS estimators are superior to IV estimators in all cases. Cross hedging using the IV estimators would add more risk when compared to an unhedged position. The results reveal that jet fuel is best cross hedged with crude oil futures. As in the currency markets, only China, Singapore and Taiwan are able to effectively cross hedge. The performances of the estimators are mixed. Generally, the models using IV estimators have to be revised in most cases. Only in the case of Singapore and Taiwan were the findings consistent with results from other studies. However, in the case of China, OLS estimators outperform.

Managing Aviation Fuel Risk: Emerging Market's Airline Companies Perspective on the International Arena

I. Introduction

Deregulation of the oil market in the 1970s has increased oil price uncertainty. Oil market has received a lot of attention by numerous researchers such as Faff and Brailsford (1999), Jones and Kaul (1996), Khan (2000), Panas and Ninni (2000), Sadorsky (1999, 2001), Serletis and Herbert (1999), who have mainly investigated the direction of oil price movements and the impact of oil price movement on stock market. Hedging in the oil market has also received attention from Overdahl (1987), Gjolberg and Johnsen (1999). There have been numerous theoretical suggestions by various authors such as Hull (2000), Errera and Brown (1999), and Bullimore (2000) on how to manage jet fuel price risk, but no empirical evidence has been presented so far in literature. This paper bridges the gap in the research arena on how to hedge jet fuel price risk.

The major factor affecting the overall level of unit cost for an airline company has been the variation in the price of aviation fuel (Doganis 1991). Jet fuel (aviation fuel) is the direct operating cost of between 14 – 24%[1]. This in turn affects the profitability of an airline company (Spencer 1999). Low cost start-ups like Impulse and Virgin Blue are not able to pass on this increased cost, whereas the more established airlines are able to pass on cost increases to passengers (Co 2000) but it is rarely possible

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[1] Source: ICAO, Doganis (1991), p118.

due to the competitive market environment in which they operate (Bullimore 2000).

Airline companies that managed its fuel price risk are more competitive relative to its competitors who did not. Examples are Lufthansa, the German Airline, has not been forced to raise its prices because it has been hedging crude oil for most of the year 2000 (Khan 2000). Swiss Air, which has been hedging its jet fuel since 1996, saved $80 million in the year 2000. Despite this, Swiss Air was still forced to raise its fares by 3% in April 2000, and again in July 2000 because of the rising cost of fuel. Just imagine the competition Swiss Air has to cope with if it did not hedge. It is evident from Co (2000) that those airlines that did not hedge took a hit from high oil prices. Alitalia, an Italian airline, who did not hedge, thought that one would eventually have to pay the market price for jet fuel, lost IC500 billion between January and August 2000. This is because of oil price hikes forcing it to suspend its services to some of its destinations (Khan 2000).

It is apparent from these examples that jet fuel affects the price airline companies can charge its end users and in turn affects the profitability. Profitability or return is what investors are looking for in the capital market, and hence airline companies in the Emerging Market can not afford to be exposed to jet fuel price risk. In order to gain that competitive edge in a competitive airline industry, one has to manage its risk via hedging, an action of transferring the risk to counterparties.

Derivatives such as Forwards, Forward Rate Agreements (FRAs), futures, and swaps are some of the tools available for managing risk, which can be used to bring reassurance and certainty to anyone exposed to financial risk. Futures contracts can provide a clean, liquid, and low-cost way of hedging exposure to the underlying commodity (Galitz 1995).

II. Hedging

There are three main theories of hedging. Firstly, the **Traditional Theory** states that a hedger enter into futures market position (X_f) equal in magnitude but of the opposite sign to their position in the spot market (X_s), indicating a position of exposure should always be completely hedged, i.e. hedge ratio (â) = 1.

$$b = -\frac{X_f}{X_s} \qquad [1]$$

However Ederington (1979) and Hull (2000) stated that a hedge ratio of one is not necessarily optimal because a proportional but unequal movement of the futures price would accompany any changes in the spot price, which lead us to the next theory, the Holbrook Working hypothesis.

Holbrook Working hypothesis (1953) challenges the view of Traditional Theory and stated that a hedger is a pure risk minimiser who emphasis on expected profit maximisation. This was supported by Meier (2000) that the basis for hedging is the user's expectation of the market movement; and Co (2000) stated that hedgers should only start to hedge again if fuel price were starting to rise but should not hedge 100% because of the risk of the market going the other way. However, both these two theories failed to explain the basis risk in terms of risk-return payoffs, which is the important consideration when one hedges (Ederington 1979), which leads us to the next, Portfolio Theory.

Portfolio Theory was suggested by Johnson (1960) and Stein (1961), which stated that an entity should not hedge product by product basis, but should instead group all exposures in a portfolio and hedge only what is necessarily. Portfolio hedging is not the same as diversifying, since an entity is hedging only the risk of the portfolio that takes into account the correlation between products in the portfolio and not diversifying the risk of exposure between products within a portfolio. Benet (1990), Dehnad (1996), and Chen *et al* (1987) empirically showed that portfolio theory is more useful at reducing risk, since it enhances a portfolio's return.

In summary, hedging is not avoiding risk, but merely managing and transferring that risk so that a business is not exposed to any unexpected shocks. Hedging does not improve profitability and cash flow. It merely allows a hedger to lock in a certain profit margin today, given the volatile environment it is exposed to. Gary Pfeiffer, DuPont Chief Financial Officer, stated that hedging does not avoid cost increases; it just spreads them out over a longer period of time (Khan 2000). With this argument in mind, although hedging simply provides a company more time to realise the cost increase, this factor is extremely crucial and must be realised in order for the company to readjust its objectives, operations and strategies in the near future.

Theories are all simplistic in the sense that they make readers understand the concept of hedging easily. However, in practical or real world term, not all that is stated is straight forward. Hedging in futures market results in mismatch of either the underlying assets or maturity. The former mismatch leads to cross-hedging and the latter leads to delta-hedging.

With the combination of mismatch in both underlying asset and maturity, we have delta-cross-hedging.

The seminal ideas go back almost half a century and the usual approach is due to Johnson (1960), Stein (1961) and Ederington (1979). A wider perspective on cross hedging in a risk return framework is described by Anderson and Danthine (1981). It is now a common subject in textbooks such as Stoll and Whaley (1993) and Ritchken (1996) to name just a few, and yet there is still an ongoing debate about what techniques are more useful.

There are no futures contracts written on jet fuel except in Tokyo Commodity Exchange (TOCOM). An Airline company operating in emerging market has to buy jet fuel, which is sold in U.S dollars (USD) per unit worldwide or Japanese Yen (JY) per unit in TOCOM. This exposes airline companies to the exposure of its home currency to USD or JY, i.e. exchange rate risk. Researches such as Aggarwal and DeMaskey (1997), Allayannis and Ofek (1998), Braga *et al* (1989), Grammatikos and Saunders (1983), Hill and Schneeweis (1981) among others, look at ways for managing this risk. But most of these researches provide empirical evidence from the perspective of American Investors exposed to emerging market's currency. This paper tries to reverse the perspective, which is hedging the exposure of Emerging Market Investor to the USD or JY.

For the purposes of this paper, two major classes of cross-hedging examples used are commodity cross-hedging and currency cross-hedging. Although it has been shown that it is possible to cross-hedge commodity with currency as hinted by Sadorsky (2000) and currency with commodity as in Benet (1990), in this research, only the case of two markets from the same class is considered, one a futures market and the other a spot market with different but correlated underlying.

III. Cross Hedging Jet Fuel & Exchange Rate Risk

Oil related futures contract could be used because the prices of oil related products are correlated and priced within few cents from each other (NYMEX). The relationships between crude oil, heating and gas oil are complex (Errera and Brown 1999). This is because crude oil pricing is highly influenced by major oil companies and OPEC decisions on shortage and surplus. Heating oil and gas oil prices are influenced by seasonal demand; refinery cost and refiners' capability to produce different mixes of refined products (see Table 1 for the breakdown of a barrel of crude oil). Refineries have learned to use gas and heating oil futures to lock in refinery margins, as far into the future as are both feasible and profitable.

Table 1 Composition of a barrel of crude oil

Product	**Gallons per Barrel**
Gasoline	19.5
Distillate Fuel Oil (includes both home heating oil & diesel)	9.2
Kerosene	4.1
Residual Fuel Oil (heavy oils used as fuels in industry, marine transport and electric power generation)	2.3
Liquefied Refinery Gases	1.9
Still Gas	1.9

Coke	1.8
Asphalt and Road Oil	1.3
Petrochemical Feedstock	1.2
Lubricants	0.5
Kerosene	0.2
Other	0.3

Figures are based on 1995 average yields for US refineries. One barrel of oil contains 42 gallons. Excess due to "processing gain".

Source: www.CommoditySeasonals.com

Gas oil and heating oil contracts should be sold for delivery one month after the expiration of the crude oil contracts due to refining crude oil processes taking about a month. A premium is included for the cost of refining (processing) the crude oil, refinery margins and transportation costs (Errera and Brown 1999). Table 2 illustrates the futures contracts that can be used as a proxy hedge from various Exchanges.

Table 2 Futures contract across various exchanges

Futures	Contract Unit	Price Quotation	Exchange	Data Source
Brent Crude Oil	**100 kilolitre (kl)**	**Jap Yen/kl**	**TOCOM**	**TOCOM**
	1000 net barrels	**USD/barrel**	**IPE**	**DataStream**
	1000 barrels	**USD/barrel**	**NYMEX**	**DataStream**
Gas Oil	**100 metric tonnes**	**USD/tonne**	**IPE**	**DataStream**
Kerosene	**100kl**	**Jap Yen/kl**	**TOCOM**	**TOCOM**
Natural Gas	**1000 therms per lot**	**Sterling per therm**	**IPE**	**DataStream**
Heating Oil	**42000 gallons**	**USD/gallon**	**NYMEX**	**DataStream**
Unleaded Regular gas	**42000 gallons**	**USD/gallon**	**NYMEX**	**DataStream**

For the exchange rate risk, one could use the exchange rate futures contract written on other major currencies as cross hedge (Aggarwal and DeMaskey (1997). Empirical evidence provided by Williamson (2001) and Allayannis and Ofek (1998) found that managing exchange risk exposure can significantly reduce the exchange rate risk and improve international competitiveness. They concluded that firms belonging to competitive industries are likely to use currency derivatives.

The basic reason for cross hedging currencies is that currency futures only mature four times a year, so perfect hedges are coincidental (Lypny, 1988). Lypny (1988) considered several strategies to derive an optimal hedging based on a portfolio of n-currency spot portfolios. It was shown that the portfolio strategy performed relatively well but a random coefficient model (RCM) supported the idea of inter-temporal instability of at least one of the regression coefficients describing the portfolio effect.

Exchange rate movements may be an important stimulus for commodity price changes (Sadorsky 2000). Many emerging markets allow their exchange rates to compete directly in the system of the “dirty float”. In this case hedging operations for these currencies are not easy.

Benet (1990) suggested the “strict” form of a primary export commodity hypothesis would also suggest that the greater the world market share for a commodity held by a country, the stronger the size of the exchange rate/futures price correlation, and the more successful the hedge. Thereby, a country without an appropriate means of reducing its currency risk should use strong export commodities instead of the exchange rate, because strong export commodities appear more stable.

Benet’s (1990) findings were that primary export commodities provide significant risk reductions, and commodities cross hedge approaches greatly reduce minor currency foreign exchange exposure. They concluded that export commodity futures are equally effective and are more stable as an alternative to currency contracts for hedging minor currencies (Benet 1990).

The instability of hedge ratios in time has also been pointed out by Park *et al*. (1987), who investigated the cross hedging performance of the U.S. futures market relative to currencies from the European monetary system. They used a price change simple regression model and their tests for stability were based on dummy variables. The cross hedging was done via the German DM futures, a contract also used by Braga *et al* (1989) in cross hedging the Italian lira / US dollar exchange rate.

Recently, Sercu and Wu (2000) found evidence that for three-month currency exposures the price-based hedge ratios outperform the ratios estimated from regression models. One reason for this improved performance seems to be the adaptability of the price based ratios (IV estimates) to pick up lagged responses in the data.

There are some complications here, as the spot position is a unit of change of one currency to the other. For this research, the basis risk is the difference between emerging market currency per unit of U.S dollar and the futures contract used (usually a developed country’s currency), for example Canadian dollars per unit of US dollars. The basis risk then becomes the exchange rate between the emerging country's currency and Canadian dollars. Again, this can be considered as a second stage spot exposure and a possible hedge could be obtained.

These seem to be an infinite hedging strategy for use with emerging market currencies. In addition, as Benet (1990) pointed out that many minor currency nations allow their exchange rates to compete directly in the system of "dirty float", i.e. the minor currency is pegged to a major currency. Therefore, finding the appropriate proxy hedge through correlation approach can minimise the basis risk to some extent.

For the purpose of utilising the empirical evidence, only the first stage spot exposure is taken into account in this study, to ascertain if it were possible to hedge emerging currency against US dollars using futures contracts written in developed countries' currency against US dollars.

IV. Methodology

Initial investigation of random walk in the data need to be the Augmented Dickey Fuller (ADF) test, discussed in detail in Davidson and MacKinnon (1993, Chapter 20). A simple linear regression model, where P_t is either the spot price or the futures price,

$$P_t = a_0 + a_1 P_{t-1} + d_t \qquad [2]$$

which is fitted under the standard normal assumptions and the residuals d_t are saved. Then the regression model,

$$\Delta d_t = m d_{t-1} + n \Delta d_{t-1} + w_t \qquad [3]$$

where the last term on the right side is a white noise, is fitted and the ADF statistic is simply the t-statistic for the OLS estimate of m. The t-statistic is then compared to the critical values at 1% level is -2.7578.

Secondly, to test whether the prices are drifting apart, a co-integration test can be performed. Co-integration is to search for long-term equilibrium relationships between different variables on financial markets. This is also based on an ADF statistic and can be done in two steps. Firstly, fit the simple linear regression model given by:

$$S(t) = a + bF_{T_2(t)}(t) + e_t \qquad [4]$$

where, $S(t)$ is the spot price at time t and $F_{T_2(t)}(t)$ is the price of the futures contract at time t with $T_2(t)$ the nearest maturity available and save the residuals $\{e_t\}$. Next, fit the regression model,

$$\Delta e_t = he_{t-1} + g\Delta e_{t-1} + w_t \qquad [5]$$

where the last term on the right is a white noise, is fitted and the ADF statistic is simply the t-statistic for the OLS estimate of h.

Engle and Granger (1987) developed the ADF test and it is still used despite the problem of standardising variables and estimation bias, meaning there is more than one co-integration vector. To solve this problem, some researchers (see Indjehagopian *et al* 2000) have introduced dummy variables specifying the existence of a structural break in a DF regression. Evidence of structural breaks led to the conclusion that long-term relationships with structural breaks in the constant exist (Indjehagopian *et al* 2000).

It is believed that most airline companies, though they might have some storage capacity, cannot afford to stock vast amounts of kerosene for long periods of time. Therefore, their concern is the current futures price and the ending basis and price level models. If there were any problem with autocorrelation, a more appropriate solution would be to try and correct the estimates of the regression coefficients using a Cochrane-Orcutt procedure (see Davidson and MacKinnon (1993), Chapter 10; and Pindyck and Rubinfeld (1998), p163).

Firstly, the residuals from

$$S(t) = a + bF_{T_2(t)}(t) + e_t \qquad [4]$$

are used to perform the regression $\hat{e}_t = r\,\hat{e}_{t-1} + v_t$ [6]. The estimated ñ is used to perform the generalised differencing transformation process (Quasi-Differencing method). The transformed equation is

$$Y_t^* = b_1 + b_2 X_t^* + m_t \qquad [7]$$

where

$$b_1 = b_0(1 - \hat{r}) \qquad [8]$$

$$Y_t^* = Y_t - \hat{r}Y_{t-1} \qquad [9]$$

and

$$X_{jt}^* = X_{jt} - \hat{r}X_{jt-1} \qquad [10]$$

where ñ is estimated using Cochrane-Orcutt procedure.

The Stepwise technique was used to search for the appropriate proxy hedge. However, there is some limitation to this procedure. It is such that the variable selection is based on economic theory to the extent that the list of potential explanatory variables was consciously chosen by the procedures. Multi-collinearity can make it difficult to choose between different variables (Brown 1991). The former is eliminated through the use of appropriate potential major currency futures contracts. The latter is eliminated by the use of changes in the exchange rates that is consistent with the findings from the Cochrane-Orchutt procedure.

Initially, all potential futures contracts were included in the regression model;

$$\Delta P_E = a + \Sigma b \Delta P_F + e \qquad [11].$$

Independent variables whose value is the most insignificant in terms of p-values and t-statistics are eliminated one at each stage of the process. This process continues until a simple linear regression is reached i.e. similar to [4] but in terms of currency. Those dependent variables that were omitted were added back into the [4] to ascertain the significance variable that can be used for cross hedging emerging market currencies. The findings of the appropriate futures contracts to be used are quite different from the correlation approach. This is evident from the hedge ratio significance in terms of p-values and t-statistics.

The hedge ratios were estimated using two techniques. Firstly is the Ordinary Least Square (OLS) regression:

$$S(t) = a + bF_{T_2(t)}(t) + e_t \qquad [4]$$

As for the currency data, this section is in a sense similar to the analysis presented in Aggarwal and DeMaskey (1997). However, while they considered hedging portfolios of emerging currencies as foreign investments, therefore having their hedging operations in U.S., our position is quite the opposite. The problem here is to hedge the cash flows in currencies of emerging markets. Hence, in this section the cross hedge for emerging market currency to U.S. dollar is cross hedged via futures on one of the following; Australian dollar, Japanese Yen, French franc, euro, Swiss franc or British pound to U.S. dollar. The analysis conducted is done simultaneously for the Asian emerging countries such as Hong Kong, Taiwan, Thailand, China, Philippines, Malaysia, and Singapore.

Instrumental-variable estimation technique can solve the measurement-error problem that occurred when using the OLS approach (Pindyck and Rubinfeld 1998). The method of instrumental variables involves the search for a new variable which is highly correlated with the independent variable and at the same time uncorrelated with the error term in [4].

This research follows the same line of the analysis done by Sercu and Wu (2000) that uses the Scholes-Williams instrumental-variable (IV) estimator developed by Scholes and Williams. The SW estimator is designed to pick up lagged responses between the regressor and the regressand (Sercu and Wu 2000).

$$SW = \frac{\hat{\mathrm{cov}}(\Delta S_{i,t}, IV_{j,t})}{\hat{\mathrm{cov}}(\Delta F_{j,t}, IV_{j,t})} \qquad [12]$$

Where the SW instrumental variable follows those proposed by Sercu and Wu (2000):

$$IV_{j,t} = \Delta F_{j,t-1} + \Delta F_{j,t} + \Delta F_{j,t+1} \qquad [13]$$

V. Measuring Hedging Effectiveness

The effectiveness or accuracy of the forecasts was measured by using R^2 and the Theil's *inequality coefficient.*

Measure of effectiveness [14] is useful because it summarises the breakdown of the variation in dependent variable in terms of an analysis of variance (Pindyck and Rubinfeld 1998). The measure of R^2 is as follows,

$$R^2 = 1 - \frac{s_e^2}{s_s^2} \qquad [14]$$

where the variance of the error term is s_e^2 from [4], and s_s^2 is the variance of the spot price. In this case it is the variance of jet fuel and the emerging market currency that is to be hedged. This measure is more appropriate according to Benet (1990), because the assumed objective of an individual hedger is to receive the maximum possible degree of risk (variance) reduction through an appropriate choice of a futures hedge position. This measure of effectiveness was also employed by Grammatikos and Saunders (1983), and Eaker and Grant (1987).

Theil's *inequality coefficient* is defined as:

$$U = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^s - Y_t^a)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^s)^2} + \sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^a)^2}} \qquad [15]$$

Where T is the number of periods being forecasted, Y_t^s is the forecasted value of Y_t, Y_t^a is the actual value, and the numerator U is the root mean square forecast error in relative terms which is a measure of the deviation of the simulated variable from its time path. This scaling of the U numerator is such that U will always fall between 0 and 1 (see Pindyck and Rubinfeld 1998). If U=0, then the model is a perfect fit; and if U=1 the model is as bad as it could be. This U measure can be decomposed in a useful way. See Pindyck and Rubinfeld (1998), p 211 for the decomposition. Generally, the proportion of inequality is defined as:

$$U^M = \frac{(\bar{Y}^s - \bar{Y}^a)^2}{\frac{1}{T}\sum(Y_t^s - Y_t^a)^2} \qquad [15A]$$

$$U^S = \frac{(s_s - s_a)^2}{\frac{1}{T}\sum(Y_t^s - Y_t^a)^2} \qquad [15B]$$

$$U^C = \frac{2(1-r)s_s s_a}{\frac{1}{T}\sum (Y_t^s - Y_t^a)^2}$$ [15C][2]

where r is measured by $\frac{\sum (Y_t^s - \bar{Y}^s)(Y_t^a - \bar{Y}^a)}{s_s s_a T}$ [15D], and $\bar{Y}^s, \bar{Y}^a, s_s, s_a$ are the means and standard deviations of the series Y_t^s and Y_t^a respectively. Equation 14A, B and C are called bias, the variance and the covariance proportions of U respectively. U^M is an indication of systematic error, U^S indicates the ability of a model to replicate the degree of variability in the variable of interest and U^C measures the unsystematic error.

Data

For this paper, jet kerosene spot prices (fob-freight on board) in Singapore have been selected. This is because we would like to make the link between emerging markets in South East Asia, where Singapore seems to the most realistic geographical location to take delivery of this commodity.

The futures prices are obtained from two different exchanges, which are International Petroleum Exchange (IPE) in London and New York Mercantile Exchange (NYMEX) in the United States of America.

The potential cross-hedge instruments for kerosene are crude oil (LCR) on the IPE; and, light sweet crude oil (NCL), heating oil (NHO), unleaded regular gas (NHU), and liquid propane gas (NPG) futures contracts traded on NYMEX. Heating oil traded on the IPE was not taken into consideration because it was suspended in the year 2000.

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[2] $U^M + U^S + U^C = 1$

The prices used are Tuesday settlement prices, as according to Hill and Schneeweis (1982), and Lypny (1998) to reduce the effect of anticipations resulting from the release of U.S. money supply data on Thursday afternoons.

The data range from 4th February 1997 to 26th December 2000, gives us 204 observations that are large enough to avoid renowned problems with estimation in small samples. Data was extracted from the DataStream database using continuous settlement prices.

Kerosene futures contracts traded on TOCOM were not taken into consideration because there is no cash settlement, i.e. hedgers can not close out position at maturity. This means that a hedger is obligated to take delivery of the kerosene at maturity and the location of delivery is the Tokyo Bay Area only.

As for the exchange rates, the initial data obtained was inconsistent in terms of quotations (American convention and European Convention[3]). All currency data were transformed into European Convention i.e. prices are quoted per unit of US dollar (£/US$). The following spot prices are used for emerging market currencies in empirical analysis:
IR – Indian rupee, RI- Indonesian Rupiah, HKUS- Hong Kong Dollars, TW -Taiwan Dollar, PPUS –Philippines Peso, RMB – China, Yuan Renminbi, RM - Malaysia Ringgit, SD -Singapore dollars, TB- Thailand Baht.

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[3] See Clarke (1996)

The following potential futures contracts prices are used for the proxy exchange rates that are investigated for cross hedging operations.

FCEU- Euro/USD, FIAD-Australian Dollars/USD, FIBP-British Pound/USD, FICD-Canadian Dollars/USD, FIDM-Deutsche mark/USD, FIFR- French Franc/USD, FIJY-100Japanese Yen/USD, FIMX-Mexican Peso/USD, FINE-New Zealand Dollars/USD, FIRA-South African Rand/USD, FIRU- Russian Ruble/USD, FNYF-Swiss Franc/USD.

The futures are traded either on NYMEX, Chicago Mercantile Exchange (CME) or Chicago Board of Trade (CBOT). In the first case, the beginning of the code is FN, in the second case the code beginning is FI and in the last case the code starts with FC. For example, FIBP is the exchange rate between the British pound and the U.S. dollar.

Again, Tuesday settlement price is used and the data was obtained from DataStream.

The currency data range from 19th January 1999 to 21st August 2001, Tuesday settlement prices providing 137 observations.

VI. Empirical Findings

Figure 1 Time Series Price Oil Price Movements 1997-2001

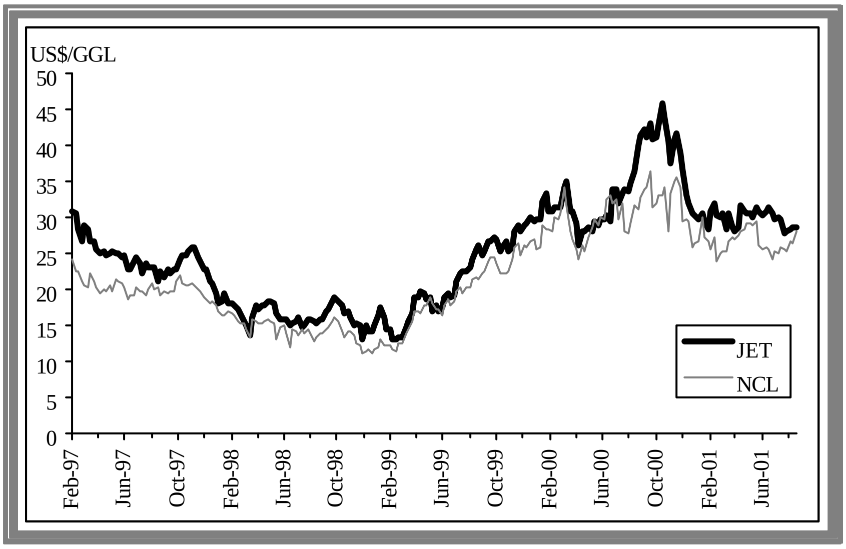

Figure 1 illustrates the price level movements between jet fuel (f.o.b Singapore) and crude oil futures traded on NYMEX. Visual inspection of Figure 1 does not appear to suggest that there were any changes in the movements and correlations between jet fuel and crude oil.

Table 3 Price level correlations between jet kerosene and proxy futures contracts

	JET	LCR	NCL	NHO	NHU	NPG
JET	1.00					
LCR	0.92	1.00				
NCL	0.96	0.94	1.00			
NHO	0.97	0.91	0.97	1.00		
NHU	0.91	0.93	0.97	0.92	1.00	
NP	0.90	0.90	0.92	0.94	0.86	1.00

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From the above Table 3, it is obvious that jet kerosene is highly correlated with all crude oil and its related products futures contracts traded in London or New York, making the futures contracts a highly potential for the purpose of cross hedging. It is apparent from Errera and Brown (1999), and NYMEX, among others, that suggest the use of oil related futures contracts to hedge jet fuel.

Table 4 Unit Root Test

Variable Y_t	JET	LCR	NCL	NHO	NHU	NPG
ADF statistics	-10.29*	-9.20*	-10.60*	-12.61*	-9.96*	-8.93*

*Significant at the 1% level and the null hypothesis is rejected,

Critical value at 1% level is -2.7578

Table 4 displays the unit root test (ADF) statistics for all the six variables of oil products from 4th February 1997 to 26th December 2000. The ADF statistics reject the null hypothesis of random walk for all series investigated and at all levels of significance. This implies that the regression of jet fuel variables against other variables would not lead to spurious results. Hence OLS would yield a consistent parameter estimator.

Table 5 Co-integration Test

Variable Y_t	LCR	NCL	NHO	NHU	NPG
ADF statistics	-4.90*	-3.96*	-3.68*	-2.84*	-3.80*

*Significant at the 1% level and the null hypothesis is rejected

Critical value at 1% level is -2.5757

Table 5 reports the co-integration test results. The hypothesis that the spot prices and futures prices are drifting apart in time is rejected for all futures contracts under analysis. Having done that, it seems that the remaining thing left is to use the regression model, $S(t) = a + bF_{T_2(t)}(t) + e_t$ [4] to fit the data and use the estimate for the slope coefficient to determine the hedge ratio. The OLS results are illustrated in Table 6. The only problem is the value of the Durbin-Watson statistic showing signs of positive autocorrelation in the data that will invalidate the "nice" OLS results.

Table 6 Hedge Ratio Estimates Based on Price Level

Futures Contract	α	t-statistics	β	t-statistics	Adjusted [4]$R^{2\#}$	Durbin-Watson statistics
LCR	2.222	3.166	1.110	32.755	0.84	0.316
NCL	0.444	0.857	1.127	47.844	0.92	0.473
NHO	1.668	3.939	39.339	55.827	0.94	0.476
NHU	0.381	0.473	37.547	30.675	0.82	0.194
NPG	5.098	7.281	48.485	28.871	0.80	0.208

Table 7 exhibits the Cochrane Orchutt estimates of r. The adjusted estimates are BLUE and they are given below in Table 7 for the oil data. One of the first things to be noticed is the change in the Durbin Watson

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[4] The $R^{2\#}$ here is the goodness of fit of the regression models. These values are obtained from regression analysis done in statistical software. This is different from the R^2 proposed in section 7.3.1.

statistic. The value of $r \approx 1$ indicates that price change levels should be used to estimate hedge ratios instead of price level.

Table 7 Cochrane Orchutt Results

	r	Â$_1$	t-stats	â$_2$	t-stats	Adjusted [5]$R^{2\#}$	Durbin-Watson statistics
LCR	0.998	0.042	0.466	0.038	0.457	-0.004	1.834
NCL	0.997	0.040	0.496	0.416*	6.903	0.187	2.214
NHO	0.994	0.046	0.576	19.096*	7.975	0.236	2.223
NHU	0.993	0.094	1.132	14.986*	6.494	0.169	2.120
NPG	0.997	0.036	0.394	5.596	1.247	0.002	1.827

*Hedge ratio significant at 1% level without violating the autocorrelation assumption

In this type of situation, it is usual that researchers may change their regression models from equation [4] to

$$\Delta P_{jet} = a + b\Delta P_{crudeoil} + e \qquad [16]$$

and substituting Y as the jet fuel price change (ΔP_{jet}) and X as the NYMEX crude oil price change ($\Delta P_{crudeoil}$), we have;

$$Y_i = b_1 + b_2 X_{2i} + e_i \qquad [16A]$$

$$Y_j = a_1 + a_2 X_{2j} + e_j \qquad [16B]$$

Although a large group of studies (Hill and Schneeweis 1981; Park *et al.*, 1987; Braga *et al.* 1989 among many others) have emphasized that using price level models is incorrect due to visible *statistical* problems, this report strongly agrees with Witt *et al.* (1987) in saying that the statistical first difference model is not congruent with the price change model. This is due the lag operator for price (percentage) change models takes differences as the change in prices over the time interval representing the

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[5] The $R^{2\#}$ here is the goodness of fit of the regression models. These values are obtained from regression analysis done in statistical software. This is different from the R^2 proposed in section 7.3.1.

hedge exposure and, as long as this exposure is not identical to the frequency of the data under analysis, the autocorrelation may still be a problem if price differences are considered. Moreover, exposure is not important for price level models because the same ratio can be used, whereas when price changes or percentage change models are employed the hedge ratio depends on the hedging period.

The significance of the dependent variable is based upon the p-values and t-statistics of the hedge ratios. It appears that only light sweet crude oil, heating oil and unleaded regular gas traded at NYMEX are statistically significant to be considered as cross hedges. Brent crude oil traded on IPE in London and liquid propane gas on NYMEX do not seem to be the appropriate cross hedges for kerosene traded in Singapore. This has limited the examination to only three significant variables as potential cross hedging instruments for kerosene.

The goodness of fit ($R^{2\#}$) reported here is merely the regression results obtained from E-Views. This measure is different from the hedging effectiveness proposed earlier in [14]

Table 8 Hedge Ratio Estimates

	Regression estimates	t-statistics	p-values	Adjusted $R^{2\#}$	DW statistics	**IV estimates**
LCR	**0.0386**	0.452	0.652	-0.004	1.834	**0.033**
NCL*	**0.416**	6.899	0.000	0.187	2.214	**1.094**
NHO*	**19.088**	7.954	0.000	0.235	2.222	**32.195**
NHU*	**14.949**	6.475	0.000	0.168	2.120	**-29.755**
NPG	**5.540**	1.233	0.219	0.002	1.827	**1.856**

***variable significance at 1% without violating the autocorrelation statistics (DW   2)**

The IV and regression based estimates of hedge ratios presented in Table 8 tell us how the price of jet fuel, to which a firm is exposed to, moves in relation to the price embedded in the futures contracts. The OLS estimates and IV estimates of hedge ratios determine the number of futures contracts to long or short relative to jet fuel.

Caution has to be taken here in the interpretation of the hedge ratio, as heating oil and unleaded regular gas are quoted in US dollars per gallon, whereas crude oil contracts are quoted in US dollars per barrel. The futures contracts on these oil products are standardised at 1000 barrels and 42000 gallons per contract respectively (refer to Table 2).

For example, from the OLS based hedge ratio in table 8, in order to hedge 1000 barrels of jet fuel exposure, an airline company should short[6] either;

i. **0.4 units** of crude oil futures contracts, or
ii. (19.088/42)[7] **0.45 units** of heating oil futures contracts, or
iii. (14.949/42) **0.35 units** of unleaded regular gas futures contracts.

Nicholls (1999) and Co (2000) stated that a company usually hedges less than 80% and around 20-50% of their jet fuel exposure respectively. This means that the number of contracts to short or long would be the percentage of the figures (in bold) given in the example above. For example, 50% protection (hedge) for 1000 barrels of jet fuel would be to short 0.2 units of crude oil futures contracts on the NYMEX.

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[6] Airline Company should short futures contracts due to the long position in the spot market and the formula $b = \frac{-\operatorname{cov}(F,S)}{\operatorname{var}(F)}$, see Errera and Brown (1999), p92.

The same can be applied to the example above with the IV estimates, with the negative signs on the estimates indicating that the position of holdings should be identical in the spot and futures markets, i.e. long both jet fuel and futures contracts.

The hedging effectiveness of these two estimates (OLS based and IV estimates) are tested *out-of-sample*. The results of the effectiveness of hedge based on OLS and IV estimates are reported below.

Table 9 Hedging Effectives of OLS Based Estimates

	R^2 (%)	**U**	**U^M**	**U^S**	**U^C**	[8] **U^i**
NCL	**79.8**	0.69	0.001	0.304	0.730	1.03
NHO	61.1	0.98	0.001	**0.987**	0.041	1.03
NHU	62.8	0.64	0.000	0.145	0.893	1.03

The R^2 computed reveals that Light Sweet Crude Oil traded on NYMEX provides the best fit for hedging jet fuel.

The Theil inequality coefficient (U) reveals the goodness of fit of the models (U=0 represents perfect fit, and U=1 represents bad model). This measure has revealed some astonishing results. For instance, the performance of Heating Oil (NHO) as the cross hedge variable is considered to be very bad. This was the interpretation of the U value of unity (Pindyck and Rubinfeld 1998, p 210).

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[7] Computation is based on the formula, $N = \frac{b}{42}$, where N is the number of contracts to short or long, â being the estimates of hedge ratio. There are 42 gallons to a barrel.

[8] $U^i = U^M + U^S + U^C \quad 1$

The proportions of inequality; U^M, U^S, and U^C reveal the proportion of inequality. The U^M is an indication of systematic error, which none of the three models exhibit. This is due to the U^M value being close to zero. The large value (1) of U^S indicates that the actual series (NHO) has fluctuated considerably, while the simulated series (jet fuel) shows little fluctuation, and vice versa. This implies that the cross hedging of jet fuel using the heating oil models has to be revised.

As for crude oil (NCL) and unleaded gas (NHU), the variance (U^S) is less worrying. The covariance proportions (U^C) measure, which measures unsystematic error, is less concerning when applied to the three models.

Table 10 Hedging Effectives of IV Based Estimates

	R^2 (%)	**U**	**U^M**	**U^S**	**U^C**	**[9] U^i**
NCL	**-39.1**	0.64	0.001	0.017	1.019	1.04
NHO	**-10.7**	0.66	0.002	0.001	1.031	1.03
NHU	**-47.4**	0.79	0.000	0.015	1.009	1.02

The computed numeral of negative R^2 reveals that using these IV estimates as hedge ratios could add more risk to the hedge positions relative to unhedged positions (according to Eaker and Grant (1987) for negative R^2).

The Theil inequality coefficient reveals that none of the models need to be revised. Moreover, all the proportions of inequality satisfy the ideal

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[9] $U^i = U^M + U^S + U^C \quad 1$

distribution of inequality over the three sources that $U^M = U^S = 0$ and $U^C = 1$.

As for cross hedging the exchange rates, using the correlation of price level approaches to select a proxy hedge can lead to spurious results. This is because when we try to correct for autocorrelation to satisfy the Durbin-Watson statistics, the estimated ñ using the Cochrane Orchutt procedure equates to one in all cases (see Appendix I). Hence, using price level correlations to select proxy hedges is inappropriate.

The problem with using this correlation approach is that some of the currencies are highly correlated, up to as much as 96% in some cases (refer to Table I.1 in Appendix I). Benet (1990) pointed out that many minor currencies allow their exchange rates to compete directly in the system of “dirty float”. Therefore, a means for reducing foreign exchange risk for these currencies is not straight forward.

The use of price change in the OLS model is certain, i.e. comparable to equation [16]. Unit root test results are presented as follows below in Table 11.

Table 11 Unit Root Test

FCEU	**FIAD**	**FIBP**	**FIBR**	**FICD**	**FIDM**	**FIFR**	**FIJY**	**FIMX**
-7.953	**-7.344**	**-8.506**	**-9.599**	**-8.044**	**-8.422**	**-8.002**	**-8.461**	-8.643
		FINE	**FIRA**	**FIRU**	**FNYF**	**FNZX**		
		-7.359	**-8.578**	-7.490	-7.802	-7.346		
HK	**IR**	**PP**	**RI**	**RMB**	**RM**	**SD**	**TB**	**TW**
-11.68	**-8.119**	**-8.472**	**-7.267**	**-7.807**	**-5.179**	**-7.229**	-8.325	**-6.928**

Variables and their respective ADF statistics.

The unit root tests for all the variables reject the null hypothesis of a random walk. Hence, these variables can be used for the regression of one against another, without leading to spurious results.

The correlation table of price changes (Table 12) suggest the use of these variables (highlighted in bold) as cross hedges.

Table 12 Correlation of price changes

	CEU	IAD	IBP	IBR	ICD	IDM	IFR	IJY	IMX	INE	IRA	IRU	NYF
HK	-0.12	-0.04	**-0.17**	-0.09	-0.05	-0.15	-0.12	-0.04	-0.06	-0.04	-0.07	-0.08	-0.13
IR	0.15	0.12	0.09	0.00	0.06	0.16	0.15	-0.01	-0.06	**-0.19**	-0.03	-0.10	0.12
PP	0.14	0.06	0.04	0.02	0.00	0.11	0.13	-0.10	-0.04	-0.14	-0.02	0.07	**0.18**
RI	0.06	0.14	0.10	**0.21**	0.06	0.05	0.06	-0.12	-0.05	-0.18	-0.06	-0.07	0.03
RMB	0.04	-0.06	-0.05	-0.11	-0.12	0.04	0.04	-0.10	**0.17**	0.07	-0.10	-0.06	0.03
RM	-0.02	0.10	0.07	**-0.25**	0.03	-0.01	-0.02	0.06	-0.05	-0.01	0.12	0.07	-0.01
SD	0.28	**0.41**	0.23	0.12	0.09	0.28	0.28	-0.24	-0.07	-0.36	0.25	-0.05	0.22
TB	0.16	0.24	0.08	0.07	0.03	0.15	0.15	-0.18	-0.04	**-0.30**	0.09	-0.03	0.12
TW	0.10	0.14	0.06	0.07	**0.18**	0.11	0.09	-0.14	0.05	-0.09	0.11	0.06	0.06

Table 13 Hedge ratios based on price change correlation

	Regression estimates	t-statistics	Adjusted [10]$R^{2\#}$ (%)	DW statistics	**IV estimates**
HK	-0.032	-1.942	2.04	2.658	0.0214
IR*	**-3.661**	**-2.278**	**2.43**	**2.223**	-1.894

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[10] The $R^{2\#}$ here is the goodness of fit of the regression models. These values are obtained from regression analysis done in statistical software. This is different from the R^2 proposed in section 7.3.1.
*Hedge ratio is statistically significant at 1% level.

PP*	**5.365**	**2.096**	**2.45**	**2.410**	0.593
RI*	**1033.397**	**2.498**	**3.74**	**1.798**	1823.241
RMB	0.132	1.940	2.00	2.711	**0.04313**
[11]**RM***	**-0.004**	**-3.466**	**9.83**	**0.098**	**-0.001**
SD*	**0.166**	**4.505**	**16.04**	**2.045**	**0.252**
TB*	**-21.164**	**-3.830**	**11.93**	**2.219**	**-12.227**
TW	2.243	1.608	1.55	1.920	**3.467**

Using the price change correlation approach, the success of any hedging instrument must be related to the strength and stability of the correlation between movements in the spot price and the futures (hedge) price (Benet 1990). It appears that most of the Asian countries are able to obtain a statistically significant hedge ratio at 1% level (see Table 13) using the futures contracts highlighted in Table 12, except for Hong Kong (HK), China (RMB) and Taiwan (TW). The DW statistics indicate that there are no problems with autocorrelation. Co-integration test for these countries are presented in Table 14 below. The Stepwise approach was performed on Hong Kong, China and Taiwan to search for a proxy hedge. The results are presented in Table 15 below.

Table 14 Co-integration test

Dependent Variable	IR	PP	RI	RM	SD	TB
Independent variable	FINE	FNYF	FIBR	FIBR	FIAD	FINE
ADF statistics	18.25026	19.73596	13.97084	29.88423	14.04173	18.84292

The co-integration test in Table 14 rejects the hypothesis that emerging market exchange rates and the futures contracts prices are drifting apart in time. Hence, these futures contracts can be used as hedging instruments.

Table 15 is the continuation of the test on currencies not tested on the above table.

Table 15 Variable significance and Hedge Ratios Estimates

	Variable significant	**Regression-estimates**	t-stats	p-values	**IV estimates**
HK	IBP	-0.032	-1.942	0.0542	0.0214
RMB	IMX	0.132	1.940	0.0544	0.0431
TW*	INE*	**2.855**	2.168	0.0319	**5.329**

* Significant at 1% level

It appears that Taiwan (TW) has found a statistically significant hedge ratio with New Zealand Dollars. This is contrary to the suggestion by Benet (1990), among others, that the appropriate cross hedge instrument to use should be highly correlated (compare the correlation between Taiwan (TW) and New Zealand (INE) being only at 9% with Taiwan and Canadian Dollars (INE) at 18%). As for China (RMB) and Hong Kong (HK), it would appear that the hedge instruments are inappropriate to hedge the two currencies. However, a close inspection of the t-statistics and the p-values indicates that these hedge ratios are very close to the critical value of 1.96 at the 1% level. Therefore, the hedge ratios for Hong Kong and China were taken into consideration to ascertain performance.

Table 16 Co integration Test

Dependent Variable	HK	RMB	TW
Independent variable	FIBP	FIMX	FICD
ADF Statistics	24.881*	26.791*	13.876*

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[11] The reason Malaysia is still analysed is due to the t-statistics that is significant. The author is aware of the Malaysia Government’s capital control and the exchange rate being fixed at 3.8 Malaysian Ringgit to one USD.

*** Significant at 1% level.**

Table 16 above presents the ADF statistics for co-integration tests for Hong Kong, China and Taiwan against their respective futures contracts. The results again indicate that we can reject the hypothesis that the spot prices (dependent variable) and futures prices (independent variable) are drifting apart in time.

The hedge ratios estimated are now tested out-of-sample to ascertain the forecast ability of the individual models. Table 17 displays the effectiveness based on OLS estimates of hedge ratios and Table 18 presents the IV estimates.

Table 17 Hedging Effectiveness of OLS based hedge ratios

	R^2 (%)	**U**	**U^M**	**U^S**	**U^C**	**U^i**
HK	-11.5	0.670	0.519	0.075	0.422	1.01
IR	5.1	0.726	0.043	0.693	0.296	1.03
PP	2.6	0.890	0.004	0.957	0.070	1.03
RI	5.1	0.881	0.018	0.873	0.140	1.03
RMB	7.0	0.597	0.060	0.100	0.883	1.04
RM	-15.9	0.815	0.006	0.426	0.596	1.08
SD	11.0	0.824	0.000	0.884	0.151	1.03
TB	-3.9	0.760	0.030	0.414	0.588	1.03
TW	3.9	0.737	0.027	0.307	0.697	1.03

Table 18 Hedging Effectiveness of IV based hedge ratios

	R^2 (%)	**U**	**U^M**	**U^S**	**U^C**	**U^i**
HK	-23.5	0.835	0.000	0.376	0.651	1.03
IR	4.0	0.887	0.010	0.853	0.169	1.02

PP	0.5	0.987	0.001	1.015	0.014	1.01
RI	9.2	0.774	0.028	0.656	0.351	1.05
RMB	3.2	0.928	0.003	0.950	0.078	1.02
RM	-0.2	0.990	0.001	1.005	0.024	1.03
SD	9.3	0.550	0.000	0.087	0.964	1.05
TB	0.6	0.833	0.032	0.644	0.354	1.03
TW	4.7	0.678	0.023	0.002	1.006	1.03

The computed effectiveness does not favour either of the hedge ratio estimators, i.e. OLS or SW Instrumental Variable (IV) estimates. The former approach seems to perform better for Hong Kong, India, Philippines, China and Singapore, whereas the latter approaches perform better for Indonesia, Malaysia, Thailand and Taiwan.

The use of insignificant hedge ratios for Hong Kong resulted in an increase in risk relative to an unhedged position. This seems apparent when looking at the negative values of R^2 computed. Conversely, substantial risk reductions can be obtained using this insignificant ratio for China.

Theil's inequality coefficients uncover the need to revise some models. The most noticeable of U=1 here is displayed by Malaysia, China, and Philippines when using the IV estimates. This may be partly due to the fact that China and Malaysia both have Government capital controls. China, for instance, can only exchange their currency for US dollars, whereas Malaysia's Government has locked their exchange rate of US dollars to a fixed rate. This capital control affects the abilities of businesses who want to hedge (Horsewood 1997, Wood 1999 and Westlake 2000).

The bias proportions (U^M) of the inequality coefficient for all models satisfy the ideal distribution. This is can be seen as apparent from the calculated figures of approximating zeros, except in the case of Hong Kong. The variance proportions (U^S) indicate that Philippines, Indonesia and Singapore's OLS based models have to be revised. From the IV estimates models, the same applies to India and Malaysia.

From Tables 17 and 18, it appears that only China, Singapore and Taiwan can effectively manage home currency exposure relative to US dollars (USD). For China, the use of OLS based estimates can substantially reduce the risk by 7%, with the Theil equality coefficients satisfying the ideal distribution. This implies that China can use the hedge ratio estimated in Table 15 using Mexican Peso's per USD futures contract.

In the case of hedging the exposure of Singapore dollars against US dollars, one can use the IV estimated hedge ratios to effectively reduce the risk by 9.3%, using Australian Dollars per USD futures contracts. The same approach can be applied to hedge Taiwan Yuan against USD using New Zealand Dollars per USD futures contract.

VII. Summary

In summary, using the OLS based hedge ratio is superior to the IV estimate of hedge ratio. Crude oil futures and unleaded regular gas seem to be the most appropriate hedges for jet fuel, based on the OLS based hedge ratio. As the most effective proxy hedge, the crude oil appears to be the best for jet fuel. This statement is supported by the higher value of R^2 compared to the one obtained from using unleaded gas fuel. The variance proportion (U^S) of the Theil inequality coefficient indicates that the crude oil model is appropriate. Additional reasons may include the fact that crude oil is the primary[12] commodity, but unleaded regular gas, heating oil, and jet fuel being secondary[13] commodities of crude oil. As was stated earlier, refiners have the ability and flexibility to produce different mixes of refined products (Errera and Brown (1999). This in turn may have an affect on the prices of these refined products.

The IV estimates of hedge ratios can be seen to have underperformed when compared to all of the OLS based hedge ratios in terms of R^2. This suggests that the OLS based hedge ratios are superior to the IV estimates. This may be partly due to the use of instrumental variables [13] proposed by Sercu and Wu (2000) in the exchange rates markets.

The results gained from cross hedging currencies reveals that only certain emerging countries were able to effectively hedge. Only financial futures contracts written on other major currencies were considered for the analysis in this study. This may have limited the selection for the proxy hedge. The countries that could effectively hedge was limited to Singapore, China and Taiwan.

In the majority of cases, for currencies cross hedging, the Theil U statistics indicated that the models suggested by the SW estimates of hedge ratios were superior to OLS based ratios. However, the SW estimated hedge ratios only increased the effectiveness of hedge (R^2) compared to the OLS based hedge ratios in the cases of Singapore, Thailand, Taiwan and Indonesia. These results were consistent with Sercu and Wu's (2000) findings. Nevertheless, the actual proposed models from

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[12] Commodity as raw material (Stephens 2000)

[13] Refined products (Stephens 2000)

the SW estimates were in most cases inappropriate for such countries as Malaysia, Philippines and China. This was one area highlighted by this research that Sercu and Wu (2000) failed to consider.

VIII. Conclusion

The means to hedge jet fuel was investigated using commodity futures contracts written on other related oil commodities. The results reveal that jet fuel is best cross hedged with crude oil futures in traded New York, and not as otherwise suggested by various authors and institutions such as Hull (2000), Errera and Brown (1999) and NYMEX, to hedge jet fuel using heating oil and gasoline.

The findings in the report also reveal that the use of heating oil as the cross hedge model has to be revised. This may be due to the fact that refiners have the ability and flexibility to mix production output, which in turn may have an effect on the prices. Additionally, the OLS based hedge ratio, i.e. the hedge ratio obtained from historical data, outperformed the SW Instrumental Variable hedge ratios in all cases observed. This could indicate that the Instrumental Variable estimates may not be suitable for use in the commodity futures market to provide more effective hedges, as claimed by Sercu and Wu (2000).

As for the currency hedge, the results obtained in this study are somehow consistent with Sercu and Wu’s (2000) findings. The findings in this study also reveal that only certain emerging countries were able to use financial futures contracts written on other major currencies as a means of cross hedge. This may be because each country has its own unique characteristics that affect its individual exchange rates.

The way to tackle the cross hedging currency problems may be solved by using primary exports of that individual country as a mean to cross hedge a currency. Benet (1990) stated that using primary export prices could produce a more stable and realistic hedge ratios, hence reduces currency exposure.

Appendix I

Table I.1 below illustrates the correlation of spot exchange rates against the futures prices. Using this approach to choose a proxy hedge is irrelevant as pointed out by Benet (1990) because minor currencies, the emerging market currencies in this case, are pegged to major currencies. The estimation of hedge ratios from this approach produces spurious results. Using price correlation approach has also produced spurious results in Table I.2, as one can observe that the hedge ratios are in most cases insignificant and the regression models violate the DW statistics. This is apparent from the DW statistics that these models exhibit autocorrelation. The Cochrane Orchutt procedure reveals (see Table I.3) that price change series should be used to correct for the autocorrelation. Using price change level would produce a significant hedge ratio.

Table I.1 Correlation Table

	FCEU	FIAD	FIBP	FIBR	FICD	FIDM	FIFR	FIJY	FIMX	FINE	FIRA	FIRU	FNYF	FNZX
HKUS	**0.92**	0.83	0.84	0.50	0.38	0.92	0.92	0.07	0.52	**-0.92**	0.84	-0.23	0.91	0.44
IRUS	0.90	0.94	0.95	0.69	0.65	0.90	0.90	-0.27	0.51	**-0.96**	**0.96**	-0.18	0.84	0.46
PPUS	0.87	**0.94**	0.92	0.75	0.68	0.87	0.87	-0.31	0.49	-0.93	**0.96**	-0.24	0.80	0.45
RIUS	0.64	**0.83**	0.78	0.67	0.78	0.64	0.64	-0.54	0.28	-0.72	**0.83**	-0.25	0.56	0.30
RMBUS	-0.25	-0.37	-0.33	**-0.46**	-0.39	-0.25	-0.25	0.19	-0.13	0.32	**-0.40**	-0.06	-0.21	-0.08
RMUS	0.02	**0.16**	0.14	0.02	0.31	0.02	0.02	**-0.32**	-0.02	-0.05	0.18	0.03	-0.03	0.00
SDUS	0.76	**0.87**	0.86	0.73	0.72	0.76	0.76	-0.59	0.46	-0.78	**0.87**	-0.21	0.70	0.33
TBUS	0.84	**0.94**	0.91	0.79	0.73	0.84	0.84	-0.35	0.53	-0.92	**0.94**	-0.23	0.77	0.44
TWUS	0.20	0.45	0.43	**0.72**	**0.68**	0.21	0.21	-0.80	0.23	-0.28	0.51	-0.08	0.10	0.14

Table I.2 Co integration test of variable prices

X_i	$\acute{a}_5$	t-statistics	0.190638	t-statistics	Adjusted R^2	Durbin-Watson statistics
Dependent Variable: HKUS						
FCEU	7.583982	1058.970		27.71496	0.849411	0.209757
FINE	7.942936	1348.547		-27.53139	0.847700	0.145103

IRUS						
FINE	59.55818	156.3370	-31.25034	-39.22242	0.918728	0.266082
FIRA	30.76632	82.35968	2.010933	37.54691	0.911961	0.195351
PPUS						
FIAD	-4.807292	-3.098604	28.51714	31.54412	0.879649	0.302498
FIRA	1.454731	1.430248	6.125479	42.00551	0.928401	0.413604
RIUS						
FIAD	-2404.853	-3.763989	6487.714	17.42603	0.689970	0.178564
FIRA	-669.8540	-1.217480	1348.772	17.09850	0.681766	0.178884
RMBUS						
FIBR	8.283054	9966.584	-0.002537	-5.945654	0.201647	1.350758
FIRA	8.282442	9743.462	-0.000620	-5.087910	0.154685	1.282225
RMUS						
FIAD	3.798592	6552.790	0.000648	1.917931	0.019314	1.321509
FIJY	3.803085	4430.763	-0.003786	-3.952905	0.097098	1.457320
SDUS						
FIAD	1.337182	70.44161	0.229156	20.71650	0.758939	0.172570
FIRA	1.397494	85.80609	0.047781	20.46250	0.754386	0.190013
TBUS						
FIAD	10.76721	11.27193	17.34619	31.16349	0.877052	0.246105
FIRA	15.11685	19.42070	3.647948	32.68811	0.886997	0.242981
TWUS						
FIBR	25.13368	42.40087	3.623325	11.90741	0.508646	0.116265
FICD	-3.232585	-0.986330	23.64427	10.79750	0.459429	0.136339

Table I.3 Estimation of ñ to correct for autocorrelation

	ñ	â$_1$	t-statistics	â$_2$	t-statistics	Adjusted R^2	Durbin-Watson statistics
HKFCEU	1.00005	1.70E-06	0.014373	-0.01109	-1.42517	0.007580	2.600140
HKFINE	1.00004	-2.20E-07	-0.00183	-0.00825	-0.51196	-0.00549	2.637038
IRFINE	0.99972	0.04324	3.654816	-3.66030	-2.27673	0.030058	2.223086
IRFIRA	1.00076	0.00018	0.010512	-0.05448	-0.36827	-0.00644	2.260041
PPFIAD	1.00212	0.07651	1.267747	1.807282	0.740944	-0.00335	2.441125
PPFIRA	1.00007	0.08894	1.446758	-0.15319	-0.20692	-0.00714	2.424785
RIFIAD	1.00062	-4.53801	-0.188808	1539.276	1.583182	0.011036	1.779929
RIFIRA	0.99982	0.98203	0.837494	0.008297	0.982653	0.005435	2.265767

RMBFIBR	0.99821	-0.00025	2.452677	4.878976	2.007487	0.003425	2.534242
RMBFIRA	0.99974	-0.4144	0.563857	0.000673	2.874534	-0.017835	2.653865
RMFIAD	1.00287	0.52525	0.198789	-0.897467	-1.09789	-0.04426	2.389865
RMFIJY	1.00064	0.94744	3.986764	-0.000521	-0.09767	0.000835	2.252586
SDFIAD	0.99996	0.00789	2.8907893	0.235425	-1.78678	-0.00062	2.145674
SDFIRA	1.00003	0.87786	1.325348	-0.576277	-0.00786	0.004165	2.036357
TBFIAD	1.00432	6.34314	0.978967	2.987897	-0.93434	0.000647	2.367547
TBFIRA	0.99735	5.252Q5	1.974897	0.846184	1.867868	-0.00042	2.253453
TWFIBR	1.00073	3.23423	2.3446906	1.097803	1.487897	0.000123	2.554588
TWFICD	1.00123	0.85755	2.089789	-0.00056	1.98789	-0.00014	2.357545

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