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Mitigating Vulnerability to Oil Price Risk— Applicability of Risk Models to Pakistan's Energy Problem

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The paper examines the prospects of reducing the price risk of Pakistan's oil imports through hedging in the oil futures market. The paper evaluates the ex-ante cross hedge strategies over the 1990–2013 period using 1–4 months futures NYMEX in order to see how to reduce price risk? Our results indicate that in all cases except one, ex-ante hedging would have been effective in reducing price risk. We provide quantitative estimates of the return/risk trade-offs from hedging Pakistan's oil imports, and find that futures hedging offers the country significant risk-reduction potential.

Keywords: Risk-return Trade-off, Hedging, Oil Prices
JEL Classification: G100, G130

I. BACKGROUND

Since the early 1970s oil price shocks have been a major concern of the policy-makers around the world because of their adverse impacts, particularly, on the net oil-importing economies. In general, rising oil prices lead to deteriorating trade and fiscal balances, and generate inflation pressures, which in turn reduce the nation's competitiveness [Bielecki (2002)]. Oil price volatility leads to investment uncertainty and raises the associated project costs affecting economic growth. Therefore, any strategy for ensuring energy security must also address oil price volatility through adopting structural measures and use of the financial instruments [Bacon and Kojima (2008); Yépez-García and Dana (2012)].

Given the volatility of oil prices, many oil exporting countries have sought to achieve export revenue stabilisation through International Commodity Agreements. Such arrangements are, however, not available to oil importing countries. Other methods such as stabilisation funds, contingent financing and import diversification have also not been successful in stabilising import expenditure. An alternative approach to stabilise import expenditure is to use market based risk management tools such as futures hedging. Though futures hedging does not protect from a long-term secular increase in oil prices, they can be effective in managing short-term price risk. This approach in mitigating a country's vulnerability to oil price risk utilises the risk hedging instruments traded in the financial markets or the over-the counter markets contracts [Wu and Cavallo (2012)].

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Using futures markets for hedging price risk is an established practice in business, but not widely used by governmental agencies, particularly in the oil importing developing countries [Devlin and Sheridan (20040; Satyanarayan (1997), and Satyanarayan, *et al.* (1993)]. Daniel (2001) and Hotz and Unterschultz (2001) address issues in hedging risks at the national level. Claessens and Varangis (1995) noted, however, that since the first Gulf war, countries like Mexico, Brazil and Chile are regular users of the oil derivatives markets, and reported that, "the New York Mercantile Exchange (NYMEX) estimates that developing countries are increasingly holding a higher percentage of the total open interest in crude oil futures."

Since the energy sector deregulation and emergence of markets in energy products, the significance of energy price risk management has increased manifold. There has been a considerable amount of work done in the development of risk assessment models. For example, Fan, *et al.* (2008), Cabedoa and Moya (2003), He, *et al.* (2011), Huang, *et al*. (2007), Hung, *et al*. (2008), Marimoutou, *et al.* (2009) and Žiković (2011) have extended risk assessment using Extreme Value Theory. However, there are relatively fewer studies on the application of advanced risk model, especially to developing countries, such as Pakistan, which pose special challenges.

Development of oil price risk mitigation strategies is important for Pakistan for a number of reasons. The country's energy sector is heavily dependent on imported oil and related products, and therefore, is highly exposed to oil price volatility. Country's exchange rate is also closely linked to oil prices, which exacerbates country's vulnerability. In addition, the dynamic processes underling the oil prices in local currency return are characterised by spikes and extreme values, and may also not be stable due to frequent structural shifts in the institutional and regulatory environment. In general, the nature of oil price exposure would be specific to each country, and it would be instructional to examine and document it for Pakistan's policy development.

There have been a number of academic studies drawing attention to the link between the Pakistan's energy sector and economic growth. Ansar and Asghar (2013) show that there are positive relationships among oil prices, CPI and the KSE-100 Index. Basher and Sadorsky (2006) find strong evidence that oil price risk impacts stock price returns in emerging markets, including Pakistan. Malik (2008) points out that Pakistan's dependence on imported fuels is expected to increase even further in future given the depleting gas resources, which will have a negative impact on Pakistan's foreign reserves. Ghayur (2007) proposes a new energy modelling process, "Decube Framework," designed to help the policy and decision-makers by forecasting future energy demands and then assisting them in drafting a plan for energy supplies. He then develops a policy and finally an action plan for policy-makers. Siddiqui (2004) focuses on the issue of causality between energy use and economic growth and shows that energy expansion is expected to lead to higher growth and its shortage may retard the growth process. Malik (2010) finds that oil prices and output are found to be strongly related, and to a great extent this relationship is non-linear. However, the important issue of hedging in Pakistan has been largely unexplored; this paper seeks to fill this gap.

The objective of this paper is to assess the prospects for hedging Pakistan's exposure to oil price risk by evaluating risk hedging strategies using oil futures. The following section discusses Pakistan's exposure to high and volatile oil prices. It is followed by an overview of the oil price volatility. In the next section, we elaborate the basic hedging strategy. Section V presents a framework for evaluating the costs and benefits of alternative hedging strategies. We show, using quoted spot prices for Dubai crude, that these are effective strategies for reducing risk for Pakistan. Section VI further evaluates the hedging strategy taking the specific case of prices of imported furnace oil by Pakistan from September 2005 to June 2012. Section VII summaries and concludes the paper.

II. PAKISTAN'S OIL EXPOSURE

The volatility of the world oil market since the OPEC oil price shocks of the 1970s has exposed the oil import dependent countries like Pakistan to a considerable degree of macroeconomic risk. The country since its birth in 1947 has been importing crude oil, however, over the last decade, the oil sector has emerged as the country's Achilles' heel.

Table 1 presents some summary statistics on the role of oil to underscore its critical position in the Pakistan's economy. Over the last ten years, the oil imports have increased from 2.7 percent of the GDP in constant 2005 US$ to about 9 percent, and from about 2 percent of the country's GDP in current US$ to about 6 percent in recent years. More importantly, from the early 2000s, oil import expenditure has increased from 18 percent to 57 percent as a percentage of exports, and the share of energy produced from oil sources has increased from about 16 percent to over 35 percent, rendering the economy more vulnerable to external shocks originating in the world oil market.

Table 1

Petroleum and Products Imports as a Percentage of Key Items

Year	As % of Exports	As % of Imports	As % of GDP (Constant 2005 US$)	As % of GDP (Current US$)	Electricity Production from Oil Sources, %
2003-04	18.3	16.6	2.4	2.7	15.7
2004-05	24.5	18.7	3.5	3.6	15.9
2005-06	36.0	23.8	5.4	5.4	20.3
2006-07	42.5	27.2	6.3	5.8	28.6
2007-08	51.4	29.7	8.5	7.3	32.2
2008-09	52.5	31.6	8.0	6.1	35.4
2009-10	53.2	33.5	8.1	6.5	38.0
2010-11	48.6	34.3	9.2	7.0	35.2
2011-12	58.2	35.5	10.4	6.8	35.4
2012-13	56.8	35.3	9.8	6.1	n.a.

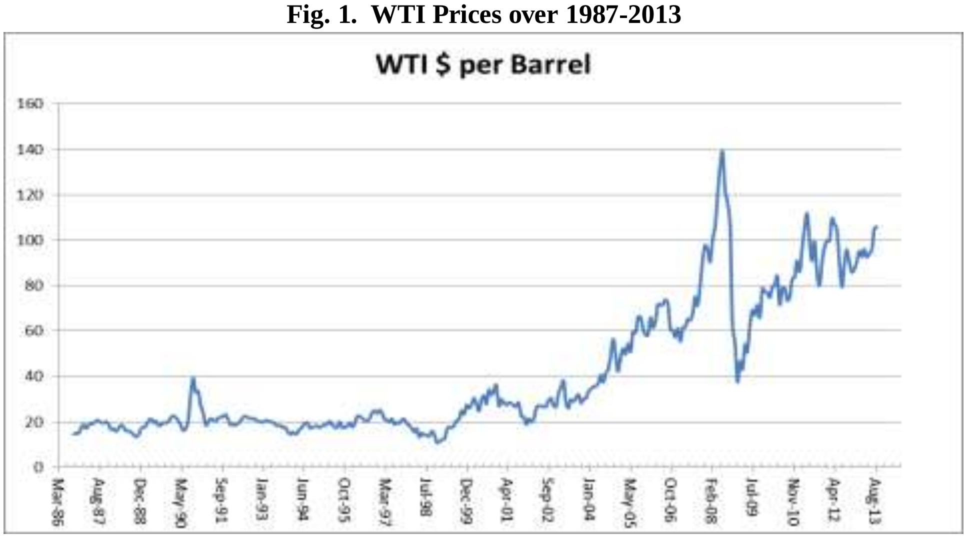
Source: State Bank of Pakistan, World Development Indicators and authors' calculations.

The oil sector is of great importance to government from many dimensions. The performance of the energy sector critically affects Pakistan's macroeconomic performance and any external shocks relating to this sector have economy-wide repercussions. Its performance affects the pace of economic growth, and rising oil prices create hardships for the consumers leading to political unrest and a backlash against the government. In consideration of equity and the unpalatable political consequences, the government has been subsidising the sector to a great extent. Volatility of oil prices is of major concern from the government's fiscal management perspective, as it can significantly affect the forecasts of oil imports and the subsidies built into the government budget. Pakistan's heavy dependence on imported oil for electricity generation renders it especially vulnerable to high and volatile oil prices, affecting its economy both at the macro and the micro level. The sharp increase in the world oil prices over 2008-2010 period has been a major cause of large public sector deficits and a worsening balance of payments situation. Following the oil price increase over 2003-2012, the expenditure on oil imports increased fivefold. Pakistan's dependence on oil has increased to such an extent that even minor oil price increases have a substantial adverse impact on its macroeconomic performance.

III. OIL PRICE VOLATILITY

The yearly price per barrel of crude over the 1987–2013 period shows an upward secular rise but with wide fluctuations, as shown in Figure 1. Table 2 contains annual average spot prices for West Texas Intermediate (WTI), along with standard deviation and the coefficients of variation for each year. The rise in oil prices over time and the price volatility is clearly seen from the Table; the coefficient of variation has been as high as 32.2 percent, but also as low as 5 percent over 1987–2013. The sharp increase in the oil prices in 2007-08 followed by an equally sharp drop is remarkable. It is the steep price increase since 2004 that has been a major factor responsible for Pakistan's energy crisis in the recent years.

Fig. 1. WTI Prices over 1987-2013



Pakistan imports crude oil from the Gulf and Arab countries under various bilateral agreements of different terms. It is likely that the exporters bear much of the price risk by offering long-term contracts, charge a premium to the importers, but themselves hedge their own short positions. The actual amount paid per unit, therefore, is not reflective of the spot price obtaining at the time, or its price volatility. A direct comparison of the WTI and Pakistan's import prices and volatility would, therefore, not be valid. Moreover, since procurement is mainly done through a public corporation, Pakistan State Petroleum, actual data on the amounts and volumes of imports is not publically available. Therefore, for the current analysis, we take the quoted spot prices for Dubai Crude (Dubai Fateh 32 API, fob Dubai) to be the relevant spot prices for Pakistan's imports. Dubai Crude is a light sour crude oil extracted from Dubai and is one of only a few Persian Gulf crude oils available immediately. Dubai Crude is generally used for pricing Persian Gulf crude oil exports to Asia. The crude spot price data for 1986–2013 was obtained from Datastream (Thomson Reuters).

Table 2

Yearly WTI Price USD per Barrel

Year	Average Price	Standard Deviation	Coefficient of Variation
1987	18.97	1.22	6.4%
1988	15.97	1.51	9.5%
1989	19.55	1.26	6.5%
1990	25.07	7.49	29.9%
1991	21.12	1.69	8.0%
1992	20.57	1.30	6.3%
1993	18.42	1.88	10.2%
1994	17.22	1.51	8.8%
1995	18.48	0.93	5.0%
1996	21.95	2.25	10.3%
1997	20.31	1.50	7.4%
1998	14.28	1.95	13.7%
1999	19.70	4.97	25.2%
2000	30.19	3.36	11.1%
2001	25.71	3.59	14.0%
2002	26.65	3.46	13.0%
2003	30.84	3.24	10.5%
2004	41.79	6.71	16.1%
2005	56.99	5.87	10.3%
2006	65.92	5.87	8.9%
2007	73.98	14.35	19.4%
2008	99.00	31.87	32.2%
2009	63.57	12.31	19.4%
2010	79.38	5.47	6.9%
2011	95.18	9.00	9.5%
2012	94.14	9.25	9.8%
2013	97.04	5.26	5.4%

The futures hedge involves buying futures contract to off-set possible adverse price movements in the spot market. The world's predominant oil futures market is the New York Mercantile Exchange (NYMEX), listing one of the most active futures contracts on the West Texas Intermediate (WTI) crude. Besides the NYMEX, crude futures are also traded on other futures exchanges around the world. However, an important question in considering large size hedging strategies involves market liquidity, i.e., if there is sufficient depth and trading in the listed contract. For liquidity consideration among others, the NYMEX futures contracts are considered preferable as the exchange is also the most liquid of the futures markets in oil.[1] We use four different nearby futures contracts, i.e., with deliveries one, two, three and four months ahead of the placing of the hedge. The futures prices for these contracts were obtained from the US Energy Information Agency.[2] Before hedging strategies can be evaluated, the time series properties of the spot and futures prices need to be examined. The prices of most commodities are typically generated by non-stationary stochastic processes, which creates an econometric problem since estimated parameters are unstable and can lead to spurious results [see Granger and Newbold (1974)]. Therefore, a non-stationary series needs to be transformed into a stationary series before further analysing and drawing inferences. The logic for requiring stationarity is that models inferred from stationary series are also stationary or stable. In general, a non-stationary series can be transformed into a stationary series by differencing. Here the focus is on the stationarity or otherwise of the series and not on estimating short term and long term effects of one time series on another, as can be studied employing models such as the Error Correction Models (ECMs).

Tables 3a and 3b report the results of Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests for non-stationarity on the levels and first differences of the spot and futures price series.[3] The ADF and PP test results confirm that both spot and futures prices are non-stationary at levels but stationary in the first differences. Thus, the model must be constructed in terms of the stationary, first differenced variables.

Table 3a

Stationarity Tests for Prices at Levels (Sep 1986-Aug 2013)

Price	ADF Test Statistic	PP Test Statistic
Dubai Spot Price (P_{DS})	–1.04 (16 lags)	–0.709
WTI Spot Price (P_{WS})	–0.87 (16 lags)	–1.206
WTI 1 Month Futures (P_{WF1})	–1.16 (16 lags)	–1.170
WTI 2 Months Futures (P_{WF2})	–1.12 (16 lags)	–1.119
WTI 3 Months Futures (P_{WF3})	–1.10 (16 lags)	–1.040
WTI 4 Months Futures (P_{WF4})	–1.09 (16 lags)	–1.032

[1]Some other exchanges that trade crude oil and petroleum futures are the IPE (International Petroleum Exchange), SIMEX (Singapore International Monetary Exchange) and ROEFEX (Rotterdam Exchange). Liquidity is however highest in the NYMEX. Besides, DME Oman Crude Oil Futures Contract (OQD) was launched by the Dubai Mercantile Exchange (DME) in June 2007 which trades on the CME Globex.

[2]Available from EIA web page: http://www.eia.gov/dnav/pet/pet_pri_spt_s1_d.htm

[3]The ADF test for any series X_t is based on the regression: $\Delta X_t = \alpha + \beta X_{t-1} + \sum_{t=0}^{p} \delta_i \Delta X_{t-i} + \varepsilon_t$.

If β is significant, the null hypothesis of non-stationarity is rejected. The ADF test accounts for for higher order serial correlation by modeling the series as an AR(p) process. The Phillips-Perron test is similar to the ADF test but uses a non-parametric robust correction for serial correlation. For details, see Diebold (2000).

Table 3b

Stationarity Tests for First-order Difference in Prices (Sep 1986-Aug 2013)

Price Difference	ADF Test Statistic	PP Test Statistic
Dubai Spot Price (ΔP_{DS})	–13.91*(16 lags)	–13.47*
WTI Spot Price (ΔP_{WS})	–15.95*(16 lags)	–15.96*
WTI 1 month Futures (ΔP_{WF1})	–15.37*(16 lags)	–15.28*
WTI 2 months Futures(ΔP_{WF2})	–15.31*(16 lags)	–15.15*
WTI 3 months Futures(ΔP_{WF3})	–15.24*(16 lags)	–15.08*
WTI 4 months Futures (ΔP_{WF4})	–15.17*(16 lags)	–14.97*

Note: The MacKinnon 1 per cent level critical value is –3.45. *Indicates significance at 1 percent level.

Table 3c

Tests of Basis Risk (Sep 1986-Aug 2013)

Regression	α	β	R^2	Durbin-Watson
ΔP_{DS}= α+ β(ΔP_{WF1})	0.046	0.8799*	0.88	1.63
	(0.51)	(47.89)		
ΔP_{DS}= α+ β(ΔP_{WF2})	0.040	0.9084*	0.89	1.60
	(0.47)	(51.65)		
ΔP_{DS}= α+ β(ΔP_{WF3})	0.038	0.9269*	0.90	1.62
	(0.46)	(52.82)		
ΔP_{DS}= α+ β(ΔP_{WF4})	0.037	0.9428*	0.90	1.63
	(0.45)	(52.96)		

Note: t-statistics are in parentheses.

IV. HEDGING STRATEGY

The bulk of international trade in crude oil takes pace in light to medium grades (API gravity of 30 to 40). The composition of the Pakistan's crude oil imports is quite different from the commodities underlying the NYMEX futures contacts. If the quality of the spot (cash) commodity is identical to the quality of the commodity specified in the futures contract, the usual recommendation is to hedge all of the quantity to be transacted since the spot and futures prices in this case tend to be perfectly correlated or to place a 'naïve' hedge. But due to the difference of quality between the Pakistan's imports and the WTI crude underlying the NYMEX contracts, the effectiveness of *cross-hedging* Pakistan's crude import prices using the WTI futures contract needs to be determined. Moreover, the NYMEX crude oil futures contract is based on pipeline delivery of 1,000 barrels of West Texas Intermediate (WTI) crude in Cushing, Oklahoma. Since, a cross-hedging strategy would necessitate closing futures contracts before the delivery dates, there will be some divergence in the futures prices and the spot prices at the delivery date resulting in the *basis risk,* which needs to be evaluated.

In general, the higher the correlation between spot and futures prices, measured as the R-square (R^2), the more effective is the hedge. Hedging effectiveness is measured by R^2 and the basis risk is measured by $1–R^2$. Table 3c reports the results of a regression of spot price changes on four futures contracts available on the NYMEX, one for the nearby month and three with delivery in following second, third and the fourth month. As the table shows, the R^2 lies between 0.88 and 0.90 and the basis risk ranges from 0.12 to 0.10. This indicates that Pakistan's crude imports can be effectively cross-hedged using the **WTI** futures contract.

V. A FRAMEWORK FOR HEDGING

In this section, a simple framework is presented for placing the hedge and determining the optimum proportions of un-hedged (spot) and hedged (futures) output.[4] Taking the point of view of an oil importer, we consider only the use of a 'long-hedge' (i.e., the hedger buys futures contracts) to insure against price increases. In a long hedge, a short position in the spot market ($Q_s < 0$) is offset by a long position in the futures market ($n > 0$). At the initial time the hedger knows the spot and the futures current prices, P_{s0} and $P_{f\,0}$ but their one period ahead price, P_{s1} and P_{i1}, are unknown and are thus random variables. The expected (dollar) cost on the portfolio (EC) can then be represented as:

$$EC = Q_s E[P_{s1} - P_{s0}] - nQ_f E[P_{f1} - P_{f0}] \quad \dots \quad \dots \quad \dots \quad \dots \quad (1)$$

Where,

Q_s = Quantity needed to be purchased
$E[P_{s1} - P_{s0}]$ = Expected change in the spot price from time 0 to 1
n = Number of futures contracts to be bought
Q_f = Notional value of one futures contract
$E[P_{f1} - P_{f0}] = \Delta P_f$= Expected change in the futures price from time period 0 to 1.

Dividing (1) throughout by Q_s yields the expected dollar cost on the portfolio per spot unit ($EC/Qs = EC_p$) for a long hedger as: $EC_p = \Delta P_s - h\Delta P_f$

The ratio $h = (nQ_f / Q_s)$, is defined as the hedge ratio—the percentage of the spot or cash position that is hedged in the futures market.

If each unit in the spot market is hedged with a unit of futures, then $h = 1$ (termed as the naïve hedge), the portfolio is completely hedged. If there is no hedging, $h = 0$, then gains/losses in the value of the portfolio are simply equal to the change in the value of the spot position. The risk of the portfolio measured as the variance of portfolio values (Var_p) in (2) is given as:

$$Var_p = Var(\Delta P_s) + h^2 Var(\Delta P_f) - 2hcov((\Delta P_s, \Delta P_f) \quad \dots \quad \dots \quad \dots \quad (2)$$

Where $Var(\Delta P_s)$ and $Var(\Delta P_f)$ are the variance of spot price changes and futures price changes and $cov((\Delta P_s, \Delta P_f)$ = covariance between spot price changes and futures price changes.

Following the mean-variance model [attributed to Markowitz (1959)], the optimal hedge ratio that maximises expected utility for infinite degree of risk aversion and also minimises portfolio variance, is:[5]

$$h^* = cov((\Delta P_s, \Delta P_f) / var(\Delta P_f) \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (3)$$

[4]The model here is similar to Raju (2005).

[5]The mean-variance model implicitly assumes that the hedger has a quadratic utility function, or that the returns are normally distributed. For explanation of hedging effectiveness, basis risk and derivation of hedge ratio, see, among others, Hull (2012).

The h^*, the risk-minimising hedge ratio, thus equals the slope coefficient of an Ordinary Least Squares (OLS) regression of spot price changes (dependent variable) on futures price changes (independent variable).

Since the contracts on NYMEX expire on 25th of the delivery month and stop trading three trading days before, we assume that positions are opened on the 26th of each month and closed on the 20th of the next month. There is a loss (gain) on the spot price equal to $S_1–S_0$, but a gain (loss) on the bought futures equals to $F_1–F_0$; which are added to get the portfolio gain or loss as per Equation (3): $P_{S1}–P_{S0} – h(P_{f1}–P_{f0})$. Hedge ratios for the year (t), h^*_t are computed using three years' data prior to the year of hedge. The h^*, the risk-minimising hedge ratio equals the slope coefficient of an Ordinary Least Squares (OLS) regression of spot price changes (dependent variable) on futures price changes (independent variable). The 1990 hedge ratio is estimated using data from January 1987 to December 1989. Thus, the hedge ratios are estimated using information available only up to the year in which the hedge is placed. We compute the gains/loss on the hedged portfolios using four different nearby futures contracts, i.e., one, two, three and four months ahead of the month in which the hedge is placed. The issue to be determined is, if the country is better off not hedging as compared to hedging.

Table 4 reports ex-ante (before the resolution of uncertainty) risk minimising hedge ratios for each year over 1990–2013 and contrasts the performance of unhedged portfolio with four ex-ante hedged portfolios. The table shows that in all hedges, except one in 1996 employing one month futures contract, the variance of the unhedged position exceeded the variance of the ex-ante hedged position. The benefits through risk reduction from the ex-ante hedges range from a reduction in risk of 98 percent for the 2010 (four month futures) hedge to 27 percent for the 2004 (four month futures) hedge, ignoring the 1996 hedge using one month futures contract. The results indicate that there could be substantial risk reduction benefits from hedging Pakistan's oil imports. For the 1996 hedge, a strategy employing one month futures contract would have actually led to an increase rather than a decrease in portfolio variance. This result simply underscores the fact that the expected benefits from ex-ante hedges based on hedge ratios estimated from the historical data may not actually materialise because of the basis risk.

Taking a hedged position carries an opportunity cost in terms of foregone returns or increase in costs. Therefore, typically a reduction in risk would be accompanied by lower returns or increased costs, reflecting the risk-return tradeoff. Whether the hedger considers these incremental costs acceptable or not depends upon the hedger's degree of risk aversion. As an illustration, the portfolio returns and variances for hedge (h) ratios between 0 and 1 are calculated for the year 2012 and reported in Table 5. These are also graphed in Figure 2, which is in the familiar mean-standard deviation space and draws the portfolio opportunity frontier, showing the return and risk trade-offs from hedging Pakistan's oil imports. When the portfolio is unhedged (h = 0) we observe the highest return (0.53) and the highest risk (standard deviation, 7.37). The minimum risk portfolio corresponds to the Point M with an associated (dollar) return of –0.23 (US $/barrel) and a standard deviation of US $/barrel of 2.85. For the hedge ratios ranging between 0 and 0.83, portfolios carry lower risk but also lower return. We can ignore the portfolios lying on the negatively sloped portion of the opportunity set as these portfolios are inefficient; for the same level of risk, the portfolios on the positively sloped segment are dominant as they yield a higher return.

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53:3 (Autumn 2014) pp. 293–308

Table 4

Performance of Hedged and Unhedged Portfolios (1990-2013)

	Unhedged Position		One Month Hedged Portfolio				Two Month Hedged Portfolio				Three Month Hedged Portfolio				Four Month Hedged Portfolio			
Hedge Year	Expected Cost	Portfolio Variance	Expected Cost	Hedge Ratio, h	Portfolio Variance	Risk Reduction	Expected Cost	Hedge Ratio, h	Portfolio Variance	Risk Reduction	Expected Cost	Hedge Ratio, h	Portfolio Variance	Risk Reduction	Expected Cost	Hedge Ratio, h	Portfolio Variance	Risk Reduction
1990	1.35	31.03	0.91	0.75	10.71	65%	1.03	0.83	11.10	64%	1.07	0.86	11.59	63%	1.08	0.87	12.08	61%
1991	0.70	6.95	0.26	1.06	0.68	90%	0.33	1.18	0.82	88%	0.35	1.28	0.74	89%	0.40	1.39	0.78	89%
1992	–0.11	0.35	-0.09	1.06	0.19	44%	–0.03	1.17	0.20	44%	0.00	1.27	0.18	48%	0.03	1.38	0.18	50%
1993	0.38	1.03	–0.47	1.07	0.15	85%	–0.40	1.17	0.16	84%	–0.35	1.26	0.15	86%	–0.33	1.38	0.15	86%
1994	–0.21	0.81	0.04	1.02	0.62	24%	–0.10	1.05	0.40	51%	–0.16	1.11	0.34	58%	–0.20	1.18	0.34	58%
1995	–0.27	0.69	0.09	0.88	0.16	77%	0.07	0.96	0.16	77%	0.02	1.03	0.16	77%	–0.02	1.08	0.18	73%
1996	–0.26	0.76	0.88	0.91	1.32	–74%	0.69	1.03	0.48	37%	0.64	1.13	0.33	57%	0.55	1.21	0.28	63%
1997	0.47	2.05	0.11	0.80	0.51	75%	0.12	0.96	0.28	86%	0.15	1.10	0.27	87%	0.19	1.21	0.29	86%
1998	0.76	1.03	–0.18	0.85	0.56	46%	–0.22	0.98	0.44	58%	–0.27	1.11	0.41	60%	–0.30	1.23	0.41	60%
1999	–0.97	2.35	–0.22	0.83	0.39	83%	–0.03	0.94	0.38	84%	0.07	1.04	0.40	83%	0.13	1.13	0.46	80%
2000	0.18	10.63	1.21	0.92	1.58	85%	0.99	1.01	1.29	88%	0.98	1.11	1.21	89%	0.99	1.20	1.11	90%
2001	0.06	2.22	–0.13	0.85	0.94	58%	–0.12	0.98	0.86	61%	–0.04	1.11	0.91	59%	0.02	1.24	0.88	61%
2002	–0.92	2.84	–0.19	0.84	1.16	59%	–0.17	0.97	0.84	70%	–0.12	1.07	0.69	76%	–0.10	1.19	0.70	75%
2003	–0.20	5.21	0.37	0.79	1.01	81%	0.44	0.89	0.54	90%	0.56	0.99	0.57	89%	0.61	1.10	0.50	90%
2004	–1.14	9.18	0.02	0.72	3.41	63%	0.15	0.80	4.09	55%	0.33	0.88	4.41	52%	0.17	0.97	6.72	27%
2005	–0.51	15.00	–0.55	0.59	2.22	85%	–0.54	0.63	1.59	89%	–0.41	0.66	1.23	92%	–0.32	0.70	1.00	93%
2006	0.19	30.04	–0.46	0.66	3.44	89%	–0.45	0.69	2.20	93%	–0.32	0.70	1.92	94%	–0.22	0.72	1.78	94%
2007	–1.23	21.16	–0.19	0.77	3.19	85%	–0.22	0.78	2.55	88%	–0.21	0.78	1.96	91%	–0.25	0.79	1.65	92%
2008	4.93	159.29	0.12	0.83	19.89	88%	0.47	0.84	9.32	94%	0.67	0.85	6.69	96%	0.82	0.87	5.07	97%
2009	–2.26	32.12	–1.04	0.93	5.30	84%	–1.42	0.96	4.56	86%	–1.15	0.97	2.90	91%	–0.94	0.98	2.41	92%
2010	–1.10	34.41	–0.91	0.93	1.68	95%	–0.97	0.95	1.49	96%	–0.88	0.97	1.05	97%	–0.77	0.98	0.86	98%
2011	–0.70	40.09	–1.51	0.95	14.13	65%	–1.49	0.97	14.24	64%	–1.41	0.97	13.99	65%	–1.35	0.98	14.12	65%
2012	0.53	54.38	–0.18	0.79	10.25	81%	–0.22	0.81	9.79	82%	–0.21	0.82	9.42	83%	–0.17	0.83	8.99	83%
2013*	0.16	11.66	1.06	0.84	5.88	50%	1.12	0.85	5.32	54%	1.10	0.86	4.34	63%	1.05	0.87	3.68	68%

* Hedged position for 2013 is from January to August; Expected cost is defined as per equation (1), $EC = Q_s E[P_{s1} - P_{s0}] - nQ_f E[P_{f1} - P_{f0}]$.

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53:3 (Autumn 2014) pp. 293–308

Figure 2 illustrates the basic risk-return trade off faced by the hedger. The basic question is whether it is worthwhile to incur additional cost (or to accept a lower rate of return) by hedging and insuring against possible oil price increase. This decision to hedge (and to what extend) vs. not to hedge is affected by the level of risk aversion.

Fig. 2. Return-Risk Trade-offs from Hedging

Following Raju (2005) we calculate the explicit costs of hedging Pakistan's oil imports by comparing the decrease in risk with the increase in the cost of acquiring oil (or decrease in return) in the spot market. A cost elasticity measure can be computed by comparing the return and variance of the unhedged and hedged positions as follows:

Cost elasticity of hedging = (% Reduction in Return) / (% Reduction in Variance)

Where,

% Reduction in Return = 1 – [(Return of Hedged) /(Return of Unhedged)]
% Reduction in Risk = 1 – [Variance (Hedged)/Variance (Unhedged)]

These cost elasticities are reported in the last column of Table 5 and range between 0.98 and 2.27, with larger values implying higher costs of risk reduction. The cost associated with the minimum-variance portfolios are: 1.64, 1.72, 1.68, and 1.58 respectively for one to four month futures contracts respectively. For the one month contract, for example, cost elasticity of 1.64 implies that a 1 percent reduction in risk will result in a 1.64 percent reduction in return. The hedger would need to make a judgment if this is an acceptable cost for achieving risk reduction? which will depend upon the hedger's degree of risk aversion.

Table 5

Risk-Return Trade-offs (for Year 2012)

Hedge Ratio, h	Portfolio Return	Portfolio Variance	Increase in Cost	Reduction in Risk	Cost Elasticity
		Hedging with One Month Futures			
0.0	0.5283	54.3816	–	–	
0.1	0.4397	45.6440	17%	16%	1.04
0.2	0.3510	37.8230	34%	30%	1.10
0.3	0.2623	30.9185	50%	43%	1.17
0.4	0.1737	24.9307	67%	54%	1.24
0.5	0.0850	19.8594	84%	63%	1.32
0.6	–0.0037	15.7047	101%	71%	1.42
0.7	–0.0923	12.4666	117%	77%	1.52
0.79*	–0.1761	10.2487	133%	81%	1.64
0.8	–0.1810	10.1450	134%	81%	1.65
0.9	–0.2697	8.7401	151%	84%	1.80
1.0	–0.3583	8.2517	168%	85%	1.98
		Hedging with Two Month Futures			
0.0	0.5283	54.3816	–	–	
0.1	0.4369	45.5749	17%	16%	1.07
0.2	0.3455	37.7006	35%	31%	1.13
0.3	0.2541	30.7587	52%	43%	1.19
0.4	0.1627	24.7492	69%	54%	1.27
0.5	0.0712	19.6720	87%	64%	1.36
0.6	–0.0202	15.5273	104%	71%	1.45
0.7	–0.1116	12.3149	121%	77%	1.57
0.8	–0.2030	10.0350	138%	82%	1.70
0.81*	–0.2159	9.7882	141%	82%	1.72
0.9	–0.2944	8.6874	156%	84%	1.85
1.0	–0.3858	8.2722	173%	85%	2.04
		Hedging with Three Month Futures			
0.0	0.5283	54.3816	0%	0%	
0.1	0.4392	45.5819	17%	16%	1.04
0.2	0.3500	37.7060	34%	31%	1.10
0.3	0.2608	30.7541	51%	43%	1.17
0.4	0.1717	24.7261	68%	55%	1.24
0.5	0.0825	19.6219	84%	64%	1.32
0.6	–0.0067	15.4417	101%	72%	1.41
0.7	–0.0958	12.1853	118%	78%	1.52
0.8	–0.1850	9.8529	135%	82%	1.65
0.82*	–0.2067	9.4244	139%	83%	1.68
0.9	–0.2742	8.4443	152%	84%	1.80
1.0	–0.3633	7.9597	169%	85%	1.98
1.1	–0.4525	8.3989	186%	85%	2.20
		Hedging with Four Month Futures			
0.0	0.5283	54.3816	0%	0%	
0.1	0.4450	45.6042	16%	16%	0.98
0.2	0.3617	37.7357	32%	31%	1.03
0.3	0.2783	30.7762	47%	43%	1.09
0.4	0.1950	24.7255	63%	55%	1.16
0.5	0.1117	19.5838	79%	64%	1.23
0.6	0.0283	15.3510	95%	72%	1.32
0.7	–0.0550	12.0271	110%	78%	1.42
0.8	–0.1383	9.6121	126%	82%	1.53
0.83*	–0.1670	8.9919	132%	83%	1.58
0.9	–0.2217	8.1060	142%	85%	1.67
1.0	–0.3050	7.5089	158%	86%	1.83

VI. HEDGING EFFECTIVENESS WITH IMPORTED PRICES

As noted above the price data on Pakistan's actual procurement prices of oil and oil products is not publically available. However, the authors found limited data on the prices of furnace oil (PSO sale price ex-Karachi for imported oil) reported in the *Energy Year Book*, HDIP (2012) from September 2005 to June 2012. Based on this data the correlation coefficients between the monthly PSO imported prices and the Dubai spot and WTI futures are reported in Table 6.

Table 6

Correlation With PSO Ex-Karachi Imported Furnace Oil Prices

Price Series in 1st Differences	Correlation Coefficient
ΔDubai Spot	0.7287
ΔWTI Spot	0.6496
ΔBrent Spot	0.6929
ΔWTI Futures 1 Month	0.6515
ΔWTI Futures 2 Month	0.6558
Δ WTI Futures 3 Month	0.6576
Δ WTI Futures 4 Month	0.6586

As expected the correlations between PSO import prices and international spot and futures prices are not as high as between Dubai spot and WTI futures contracts. However, the correlation seems to be in a range where effective hedges may be placed.

In order to judge the effectiveness of hedging PSO imported oil prices using WTI futures contracts, monthly hedges were simulated, as per hedging framework explained in the earlier section. The hedge ratios were computed using prior three year rolling window; i.e., the hedge placed in August 2008 is based on hedge ratio computed over September 2005 to July 2008 periods, and so on for the following months. The results obtained from such ex-ante hedges over the August 2008 to June 2012 period are reported in Table 7.

As the table shows, the hedging achieves about 45 percent reduction in the variance. There is an increase in cost of 4.8–7.5 cents per gallon per month. The increase in cost of purchase is, however, a small percentage (0.06 percent to 0.10 percent of the average purchase price of oil. The results thus point out to a significant scope in price risk reduction at a relatively small cost.

Table 7

Results of Ex-ante Monthly Hedging PSO Import Prices

	Unhedged Position	Hedged Positions with WTI Futures			
		1 Month	2 Month	3 Month	4 Month
Expected Cost ($) *	0.0251	0.0730	0.0781	0.0891	0.0999
Variance	53.0864	29.5312	29.2523	29.2074	29.2276
%Δ in Variance	–	–44.37%	–44.90%	44.98%	–44.94%
Increase in Cost over Unhedged Position ($)		0.0478	0.0530	0.0639	0.0747
Increase in Cost as % of Average Oil Price		0.064%	0.070%	0.085%	0.099%

*Expected costs is as per Equation (1), $EC = Q_sE[P_{s1} - P_{s0}] - nQ_f\, E[P_{f1} - P_{f0}]$.

VII. SUMMARY AND CONCLUSIONS

In this paper we investigate the prospects of reducing oil price risk for Pakistan's oil imports through hedging in the oil futures market. We simulate ex-ante cross hedges for 1990–2013 and find that in all cases except one, ex-ante hedging was effective in reducing price risk. The estimated return and risk trade-offs from hedging indicate that for a risk minimising long hedger, a 1 percent reduction in risk would have cost a reduction in return of 1.58 to 1.72 percent. The results establish that there are risk reduction benefits from hedging Pakistan's oil imports, which together with the estimates of the opportunity costs of hedging should help in the hedging decision.

Besides the cost of hedging, there are other important considerations in the hedging decision from the country's perspective, which involve the cost of the structural adjustments (fiscal and budgetary adjustments) that are often necessitated as a consequence of unexpected price increases or declines. We have not included transaction costs into our analysis, which include brokerage fees and the opportunity cost of holding a margin account. However, the former are similar in magnitude to the fees for the spot transactions, and the latter costs are likely to be minimal considering that margin can be posted by depositing interest bearing securities.

Pakistan is reported to have considered hedging its oil import bill in 2005, but no decision was made. In 2009 there were fresh initiatives to opt for oil hedging, and the then Advisor to the Prime Minister on Finance hinted that such a programme may be put in place, and the Economic Coordination Committee (ECC) was to consider it. However, no final decision was taken. In 2009, September, the Securities and Exchange Commission of Pakistan (SECP) allowed trading in futures contracts of crude oil on the National Commodity Exchange Limited (NCEL). "The SECP while granting approval had also advised the NCEL to ensure that appropriate level of awareness, regarding risks associated with and significant matters of futures trading, was communicated amongst all futures market participants specially prospective individual investors," as reported in *Dawn* (2009). Perhaps there is a need to raise awareness on the benefits and costs of hedging. We hope that this paper advances such awareness.

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