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Risk Management of Oil Revenue Volatilities by Financial Derivatives

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Abstract

Oil price volatility is considered as the main source of oil revenue volatility. Since Iran's economy relies upon the oil revenues, stabilization and dealing with oil price volatility is necessary. Because of their efficiency and application in risk management, financial derivative tools are of interest of market players. The hedging instruments investigated in the present paper are 1- to 4-month derivative contracts of NYMEX oil stock. Employing various econometric methods, the paper investigates risk hedging strategies, where to select the optimum position efficiency and utility of each position is measured. The results indicate that applying derivative contracts leads oil revenue risks to reduce at least 59% and at most 98%.

Keywords: oil market volatility; risk management, hedging; financial derivative

Introduction

Revenues obtained from crude oil export have a considerable effect on Iran's economy, as above 80% of the export incomes (OPEC, 2014) and 40% of the governmental budgets depends on oil revenues. In this regard, stabilizing and hedging the oil revenue risks for achieving a stable economy seems necessary. However, presence of considerable volatility in the price of these resources in the market is among the permanent characteristics of crude oil markets, petroleum derivatives, and natural gas. Thus, many suppliers and consumers have been seeking for a solution for reducing their exchange risks in the market. To lower the risk in uncertain markets such as oil market, tools such as "Derivatives" is proposed. Nowadays, the importance of petroleum derivative market is up to a level that evens the price of crude oil, as a strategic product in the global markets, is affected by the activities of these derivatives. The stable relationship between oil market and financial derivative market can be desirable for speculators and risk hedgers (Bhar, and Hamori, 2005). Although, its only three centuries since foundation of oil stocks and supply of various financial derivatives, these derivatives have received that much attention that the size of oil paper exchanges is several times larger than the real oil contracts. The main objective of financial derivative exchanges of the oil is to hedge volatility of oil price. Under such conditions, there is no doubt about the importance of price mechanism in the financial markets and risk hedging method through these instruments. Thus, the price relationship of the crude oil and risk hedging methods in the financial derivative markets are interested by researchers.

The early studies on risk hedging through the future contracts were initially conducted in 1920. Ever since, Working (1953), Johnson (1960), Stein (1961), and Ederington (1979) enriched the risk hedging theory through their new remarks on risk hedging and criticizing the previously introduced theories. However, the theory of Ederington on risk hedging has been more welcomed to the researchers as it is used via the works conducted by Witt et al (1987), Myres and Thompson (1989), Castelliono (1990), and Myres (1991). The early works on risk hedging are organized using he ordinary least square (OLS), but Herbst et al (1989) found that estimation of variance minimum hedging rate through the OLS method accompanies with some serial correlation in residues, as they are biased. Ghosh (1993) and Lien (1996) indicated that there is a cointegration relationship between time series data of the future and spot prices. Lien and Tes (1999) estimated the optimum hedging rate using the OLS, VAR, and ECM methods for Nikkei Stock Average Index and reported that the classic regression method involves a poor performance as compared to other methods.

Yang (2001) estimated the hedging rate for market of future contracts in Australian market and concluded that the error correction model has a higher performance as compared to other models. Moreover, he reported that model efficiency increases by prolonging the studied time period. Sim & Zurbruegg (2001) empirically showed that utilizing an estimation technique, in which cointegration relationship between the future and spot prices is considered, can be an efficient solution. Pindyck (2001) suggests that the future contract such as stock inventory can be considered as tools for risk reduction, as they allow measuring the ultimate storing value of the goods. Through a study conducted on the hedging rate in the metals stock for aluminum and zinc, Johnson et al (2004) found that OLS model is not preferred for estimating the optimum hedging rate. Casillo (2005) measured hedging rates using the OLS, VAR, and ECM models and compared the results for three hedged, unhedged, and simple hedging states. Sudhakar (2005) studied risk hedging of oil price for Ecuador economy for the time period of 1991 to 1996 and concluded that every 1% drop in the risk reduced the return up to 0.65%. Ates and Wang (2007) found that the spot and future markets have cointegration and there is an intermittent relationship between these two markets. Caporale et al (2010) found that using the future contracts is suitable for hedging the crude oil risk, particularly for contracts for the future one or two month. Kaufmann (2011) indicated that the unprecedented boom and drop in the crude oil price in the time period of 2007 to 2008 is originated from the exchanges in the derivatives market.

The econometric studies show that oil price is a random variable which fluctuates with time. Oil price volatility results in the volatility of oil revenues and occurrence of risk in these revenues. Various approaches are applied for hedging the risks of oil revenues in the world. However, the most novel method presently utilized for dealing with oil price risk is the financial derivative instruments. This paper addresses the risk hedging of oil price volatility used the future contracts.

Materials and methods

Once the investor makes deal in the spot market without applying the financial derivatives, the expected return of such deal in time t is as Eq. (1):

$$E(R_U) = Q_S\left[E(S_{t+1}) - S_t\right] \quad (1)$$

As the price for time t + 1 is not clear and the investor has to predict it, the return is expressed in the expected form. The risk of mentioned situation is defined as return variance using Eq. (2):

$$\mathrm{var}(R_U) = Q_S^2 \delta^2 (\Delta S) \quad (2)$$

Here, if investor utilizes future contracts for hedging the price volatility risk, he is called as risk hedger. In this way, the return and risk relations are changed as Eq. (3) and Eq. (4).

$$E(R_h) = Q_S\left[E(S_{t+1}) - S_t\right] + (-)Q_F\left[E(F_{t+1}\right. \quad (3)$$

$$\frac{\partial EU}{\partial Q_F} = (\Delta F) - \Psi\left[2Q_F\delta^2(\Delta F) - 2Q_S COV_{S,F}\right. \quad (4)$$

The negative mark between the two terms in Eq. (3) represents the future sale. Moreover, as the prices of future and spot contracts were not known, they were expressed in the expected form. The variables in Eq. (3) and Eq. (4) are expressed as:

$E(R_h)$: the expected hedged portfolio return for t;

$E(R_U)$: the expected unhedged portfolio return for time t;
$var(R_h)$: variance of unhedged portfolio;
S_t: price of spot asset for t;
F_t: price of future contracts for t;
$E(S_{t+1})$: the expected price of the spot asset in t for t + 1
$E(F_{t+1})$: the expected price of the future contract in t for t + 1
Qs: amount of spot asset;
QF: size of future contract;
$\sigma^2(\Delta F)$: variance of fluctuations in the future prices;
$\sigma^2(\Delta S)$: variance of fluctuations in the spot prices;
COVs,F: covariance between the future and spot prices;
$\Delta S = E(S_{t+1}) - S_t$: the expected volatility of spot asset price in t;
$\Delta S = E(F_{t+1}) - F_t$: the expected volatility of future contract price in t;

Where, S_{t+1} and F_{t+1} are random variables If the purpose of hedger is to maximize the expected utility, utility functions of the investor should be determined. Brooks et al (2010) presented the expected linear utility functions for investor as Eq. (5):

$$EU = E(R_h) - \Psi \operatorname{var}(R_h) \tag{5}$$

Where, Ψ is the risk aversion level of the investor. The greater values of Ψ indicate higher levels of risk aversion. This risk would be in the range of 0 to ∞ for different people. Since the return is in the expected form, utility function is also expressed as expected. By substituting equations (3), (4), and (5), Eq. (6) is derived:

$$EU = Q_S(\Delta S) - Q_F(\Delta F) - \Psi\left[Q_S^2\delta^2(\Delta S) + Q_F^2(\Delta F) - 2Q_SQ_FCOV_{S,}\right. \tag{6}$$

As the risk hedger tends to maximize his utility, so that Eq. (6) is differentiate with respect to Q_F and is taken as zero to obtain Eq. (7):

$$\frac{\partial EU}{\partial Q_F} = (\Delta F) - \Psi\left[2Q_F\delta^2(\Delta F) - 2Q_SCOV_{S.F}\right. \tag{7}$$

The ultimate solving of Eq. (7) gives optimum hedge ratio (h) in terms of risk aversion level as Eq. (8):

$$h = \frac{C_F}{C_S} = -\frac{COV(\Delta S, \Delta F)}{\sigma^2(\Delta F)} + \frac{\Delta F}{2\varphi\sigma^2(\Delta F)Q_S} \tag{8}$$

Eq. (8) implies that once the risk hedger is infinitely risk aversion, Ψ limits toward infinity and $\frac{\Delta F}{2\varphi\sigma^2(\Delta F)Q_S}$ equals to zero. Therefore, the hedging rate is expressed as Eq. (9)

$$h = -\frac{Q_F}{Q_S} = -\frac{COV_{S.F}}{\sigma^2(\Delta F)} \tag{9}$$

The above results are extracted by maximizing the utility level. However, if the investor prefers to minimize the risk, again these results are obtained. To do so, Eq. (4) is differentiated with respect to Q_F and is taken as zero and then Eq. (9) is obtained by summarizing the results. Thus, the obtained hedge ratio (h) is called as “minimum variance hedging rate”. The greater is the correlation between the future and spot prices; the efficiency of the risk hedger would be higher; as for the complete correlation between these prices the risk is completely removed.

The simplest technique for estimation of optimum hedging risk (OHR) is to perform a classic regression of the spot prices on future prices as Eq. (10):

$$\Delta S_t=\alpha+\beta\Delta F_t+\varepsilon_t \tag{10}$$

Where, ΔS_t and ΔF_t present the spot and future prices, respectively; α is a constant term; and β is the correlation coefficient, or OHR.

Although OLS model is very common because of its simple estimation and analysis, Herbst et al (1993) state that the movements in the future and spot markets affect the prices movements of the spot market, which is not taken into account in the regression model. This failure can be dealt using the vector auto regression (VAR) model.

In the works dealing with time series data, it is assumed that the time series are stationary; however, they are not stationary in practice. The unit root test is among the most common tests currently utilized for detecting stationary state of a time series process. Augmented Dickey-Fuller (ADF) and Philips-Prone (PP) tests are the most important methods for detection of unit root of time series. Yet, in the case that time series is not stationary, cointegration serves as solution for avoiding these two problems. The economic meaning of cointegration is that despite the non-stationary state of the time series, their difference is stationary; so that the long-term relation between the variables is proved. In this paper, Johansen- Juselius method was applied to study the long-term relation between the variables.

After proving the cointegration relation between future and spot prices, cointegration vector must be taken into account in the VAR model to develop a vector error correction model as Eq. (11) and Eq. (12):

$$\Delta S_t = C_s + \sum_{i=1}^{k} \beta_{s,i} \Delta S_{t-i} + \sum_{i=1}^{k} \lambda_{s,i} \Delta F_{t-i} + \alpha_s E_{t-1} + \tag{11}$$

$$\Delta F_t = C_f + \sum_{i=1}^{k} \beta_{f,i} \Delta S_{t-i} + \sum_{i=1}^{k} \lambda_{f,i} \Delta F_{t-i} - \alpha_f E_{t-1} + \tag{12}$$

Where, α is cointegration vector and α_s and α_f express modulation rate of the parameters.

Risk hedging efficiency can be estimated using the risks of hedged and unhedged states. In this method, the risk reduction percentage of spot asset is taken into account in the future contracts. In this regard, an unhedged portfolio consisting of stocks with equal ratios in the spot market and a hedged portfolio consisting of future and spot assets with various ratios are developed. Next, the hedged and unhedged portfolio variances, $var(R_h)$ and $var(R_U)$, are extracted using Eq. (13) and Eq. (14), respectively, and substituted in Eq. (15):

$$\mathrm{Van}(U)=\sigma^2(\Delta S) \tag{13}$$

$$\mathrm{Van}(h)=\sigma^2(\Delta S)+h^2\sigma^2(\Delta S)-2h\mathrm{COV}_S \tag{14}$$

$$\tau=\frac{Var(R_U)-Var(R_h)}{Var(R_u)}\times 100=\left[1-\frac{Var(R_h)}{Var(R_U)}\right] \tag{15}$$

Where, τ is efficiency, which represents the ratio of variation change in the group's variance induced by the risk hedging process to the initial unhedged state. Using the previous relations, a simple risk hedge efficiency relationship can be extracted as Eq. (16):

$$\tau=1-\frac{Q_S^2\left[Var(\Delta S)+h^2 Var(\Delta F)-2hCOV_{S.F}\right]}{C_S^2\, Var(\Delta S)} \tag{16}$$

Substituting the relation of risk minimizing hedge ratio result in relation (17):

$$\tau = \frac{COV_{S.F}^{2}}{Var(\Delta S).Var(\Delta F)} \times 100 \qquad (17)$$

Where, efficiency coefficient, τ, varies between 0 and 1.
In the above equations, each period is estimated using the hedging rate of the given period. However, the hedgers utilize hedging rate of the present period for the future period, in practice. So, Eq. (15) is modified as Eq. (18):

$$Var(R_h)_{t+1} = \sigma^2(\Delta S)_{t+1} + h_t^2\sigma^2(\Delta F)_{t+1} - 2COV_{S.F} \qquad (18)$$

Eq. (15) and Eq. (19) are so-called as in-sample and out-of-sample efficiencies, respectively.

The risk hedging instrument used in this research is financial derivative. The petroleum stock derivatives of New York (NYMEX) are used as risk hedging tool for price of Iran's crude oil.

Time period for the historical data of crude oil price is of greatest importance. Once the selected time period is long, the old data are used; otherwise a large share of pervious information is ignored. Thus, similar to the previous information, a five year period (which is not either short or long) was selected for this purpose. The statistical data used in this work are for the time range of 2011 to 2014. Moreover, statistical data for price of light crude oil of Iran and future one to four months contracts of NYMEX oil stock were used in this article. To estimate out-of-sample efficiency of the price information of 2014 were used. The time series of the prices is on a weekly basis, as the price volatilities are severe and irregular within the daily time period. Besides, for the prices for time periods longer than one week many of these price volatilities neutralize each other. To adjust fluctuations of future and spot prices, their logarithmic values were utilized.

Results

Classic regression pattern is simplest model applied for estimation of optimum hedging rates. According to this model, the correlation coefficient of regression, variations of spot price on future price, and optimal heeding rate are obtained using Eq. (19):

$$\Delta S = \alpha + \beta \Delta F_i + \varepsilon_t \qquad (19)$$

Where, ΔS and ΔF_i represent volatilities of spot and future prices; and i is 1 to 4. The results of OLS model are represented in table (1) which indicate that the hedging rates of optimum risk for the future contracts are 1.007, 1.034, 1.076, and 1.113, respectively; implying that by prolonging the deadline of future contracts, hedging rates also grow, so that it is even greater than 1 for the four month contracts.

Table (1): OLS model results for estimation of hedging ratios

contract period	variable	coefficient	Std. Error	t-Statistic	Prob.
1-mounth	C	-0.034317	0.009741	-3.522965	0.0006
	LFP01	1.007344	0.002135	471.8573	0.0000
2-mounth	C	-0.159472	0.022509	-7.084776	0.0000
	LFP02	1.034192	0.004930	209.7556	0.0000
3-mounth	C	-0.350457	0.055542	-6.309763	0.0000
	LFP03	1.075744	0.012163	88.44426	0.0000
4-mounth	C	-0.521715	0.098602	-5.291131	0.0000
	LFP04	1.113180	0.021591	51.55694	0.0000

In the studies dealing with time series data, it is assumed that the time series are stationary; however, they are not stationary in practice. The unit root test is among the most common tests currently utilized for detecting stationary state of a time series process. Augmented Dickey-Fuller (ADF) and Philips-Prone (PP) tests are the most important methods for detection of unit root of time series. The tests of stationary of series in ADF test are summarized in tables (2) and (3) respectively for level and first difference of variables.

Table (2) unit root test of research data levels series in ADF

Variable / t-Statistic		LSP	LFP01	LFP02	LFP03	LFP04
Augmented Dickey-Fuller test statistic		-2.269134	-2.273590	-2.282814	-2.297183	-2.317253
Test critical values:	1% level	-4.052411	-4.052411	-4.052411	-4.052411	-4.052411
	5% level	-3.455376	-3.455376	-3.455376	-3.455376	-3.455376
	10% level	-3.153438	-3.153438	-3.153438	-3.153438	-3.153438
Prob.*		0.4464	0.4440	0.4390	0.4313	0.4206
*MacKinnon (1996) one-sided p-values.						

Reference: research finding

Table (3) unit root test of research data first differnce series in ADF

Variable / t-Statistic		LSP	LFP01	LFP02	LFP03	LFP04
Augmented Dickey-Fuller test statistic		-7.550609	-7.621400	-7.718133	-7.785512	-7.819517
Test critical values:	1% level	-4.052411	-4.052411	-4.052411	-4.052411	-4.052411
	5% level	-3.455376	-3.455376	-3.455376	-3.455376	-3.455376
	10% level	-3.153438	-3.153438	-3.153438	-3.153438	-3.153438
Prob.*		0.0000	0.0000	0.0000	0.0000	0.0000
*MacKinnon (1996) one-sided p-values.						

Reference: research finding

According to tables (2) and (3), ADF tests on time series of future and spot prices indicate that the absolute values of the tests related to these time series are less than the critical value in the 1%, 5%, and 10% zones, and the zero assumption on unstationary state of time series data cannot be rejected. Moreover, PP tests on the first difference of times series data verify the results of ADF tests and evince that unstationary of the first difference of spot and future prices series are rejected. Therefore, the future and spot prices are not stationary, but their first differences are stationary. On the other words, the series of spot and future prices are not stationary at level but integrated from degree 1. As the series are not I(0), the long-run relationship of variables must be tested by cointegration tests. In the present research, Johansen- Juselius test was utilized to test the cointegration relation between the spot prices with the derivative prices. In, Johansen-Juselius test, accepting (rejecting) null hypothesis depends on presence (lack) of cointegration vector in each future contract which is determined by the trace matrix (λ trace) and maximum. Number of convergence vectors among the model variables is determined by the trace matrix test and maximum eigenvalue test. According to the results represented in Table (4), the trace matrix tests suggest that there is one cointegration vector between the variables at level of 5%.

Table (4): trace matrix (λ trace) test

Series: LSP LFP01				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.141642	20.80160	15.49471	0.0072
At most 1 *	0.059850	5.986462	3.841466	0.0144
Series: LSP LFP02				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.137645	20.24807	15.49471	0.0089
At most 1 *	0.058852	5.883483	3.841466	0.0153
Series: LSP LFP03				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.107025	16.72334	15.49471	0.0325
At most 1 *	0.057491	5.743305	3.841466	0.0165
Series: LSP LFP04				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.063507	15.56745	15.49471	0.0491
At most 1 *	0.047903	4.761619	3.841466	0.0291

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table (5): maximum eigen value (λ max) test

Series: LSP LFP01				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.141642	14.81514	14.26460	0.0409
At most 1 *	0.059850	5.986462	3.841466	0.0144
Series: LSP LFP02				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.137645	14.36458	14.26460	0.0482
At most 1 *	0.058852	5.883483	3.841466	0.0153
Series: LSP LFP03				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None	0.071935	16.241376	17.14769	0.0866
At most 1 *	0.053776	5.361727	3.841466	0.0206
Series: LSP LFP04				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None	0.142191	14.87721	17.14769	0.0939
At most 1 *	0.064259	6.442395	3.841466	0.0111

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

According to Table (4), presence of cointegration vector is accepted at confidence level of 95%, as λ trace statistics exceed the critical value. Thus, at confidence level of 95%, there is a long-term relation between all future and spot prices. Yet, it is necessary to test the long-run relationship between variables by maximum eigen value (λ max) test that is summarized in table (5).

According to Table 3, existence of cointegration vector is accepted at confidence level of 95%, as λ max statistics are more than the critical value. Thus, at confidence level of 95%, there is a long-term relation between all future and spot prices. For estimation of long-run relations among variables, Vector Auto-Regression Model (VAR) is a common method. For estimation in VAR, it is required to determine optimum number of lags. Akayek (AIC), Schwarz-Basian (SBC), and Hannan-Quinn (HQC) criteria are frequently applied for finding optimum lags. The absolute values of these statistics determine the optimum level of VAR model. The results indicate that for the 1- and 2-month derivatives, all three criteria present 2 lags as optimum level for VAR model. Nevertheless, for 3- and 4-month contracts, AIC suggests 4 lags; while, SBC and HQC propose 2 lags. Therefore, 2 lag is considered as the optimum lag of VAR for all contracts, as it satisfies larger number of criteria. After the models estimated, risk hedging rates are obtained by relations (9) and (17). These ratios are estimated 0.873539, 0.931633, 0.878952, and 0.995996, respectively for 1- to 4-mounth contracts. Focusing on the trend of hedging ratios, one can extract the direct relation between hedging rates and time period of the contracts. By comparing the hedging rate of each contract in OLS and VAR model, it is concluded that the hedging rates of VAR model are smaller than those of OLS. This fact is consistent with the previous theoretical and empirical findings. Once the future and spot prices are cointegrated, the error correction term must be added to the VAR model to estimate the new model which is called as vector error correction model (VECM). Hence, this model is applied in this research as another method for estimation of hedging ratios. Presence of cointegration relationship between the future and spot prices justifies application of error correction term in VAR model. The vector error estimation is estimated by Equations (12) and (13). Estimation results of VECM model are presented in Tables (6) to (9) repectively for 1- to 4-mounth contracts.

Table (6): Results of vector error correction model (VECM) for 1-mounth contracts

Cointegrating Eq:	CointEq1	
LSP(-1)	1.000000	
LFP01(-1)	-1.196923	
	(0.03001)	
	[-39.8841]	
C	0.045015	
Error Correction:	D(LSP)	D(LFP01)
CointEq1	-0.324824	0.844795
	(0.10726)	(0.14019)
	[-3.02823]	[6.02568]

Table (7): Results of vector error correction model (VECM) for 2-mounth contracts

Cointegrating Eq:	CointEq1	
LSP(-1)	1.000000	
LFP02(-1)	-1.277470	
	(0.04173)	
	[-30.6127]	
C	0.356927	
Error Correction:	D(LSP)	D(LFP02)
CointEq1	-0.453214	0.717830
	(0.15349)	(0.15315)
	[2. 95263]	[4. 68710]

Table (8): Results of vector error correction model (VECM) for 3-mounth contracts

Cointegrating Eq:	CointEq1	
LSP(-1)	1.000000	
LFP03(-1)	-1.342818	
	(0.10959)	
	[-12.2535]	
C	1.569467	
Error Correction:	D(LSP)	D(LFP03)
CointEq1	-0.480897	0.682303
	(0.16168)	(0.19119)
	[2.97437]	[3.56872]

Table (9): Results of vector error correction model (VECM) for 4-mounth contracts

Cointegrating Eq:	CointEq1	
LSP(-1)	1.000000	
LFP04(-1)	-1.700423	
	(0.23459)	
	[-7.24856]	
C	3.202322	
Error Correction:	D(LSP)	D(LFP04)
CointEq1	-0.49915	0.653781
	(0.15601)	(0.18551)
	[-3.19946]	[3.52423]

The significance of coefficients of error correction term implies the relationship between short-term volatilities of future and spot prices with their long-term values. As the absolute value of the error correction coefficients in the model whose dependent variable is future prices is higher than that of the model whose dependent variable is spot prices, the future prices, compared to the spot prices, require higher rate for correction of deviation of the previous period for reaching long-run balance.

Among the four contracts, 1-month derivatives indicate maximum adjustment in the future prices and minimum adjustment for the spot prices. In the model whose dependent variable is spot, adjustment coefficient is 0.325, indicating that the created imbalance in the long-term relationship is adjusted with a rate of 0.325 by changing the spot changes. In this regard, the adjustment coefficient for the future prices is 0.845, signifying that the future prices, in compare to spot prices, have a higher rate for reaching long-term equilibrium.

The cointegration equation indicating the long-term equilibrium between future and spot prices is represented in Equation (16). The variation coefficients for future prices are statistically significant for all derivatives, indicating the long-term relationship between the long-term future and spot prices.

The optimum hedging rates are obtained by relations (9) and (17), which are 0.965715, 0.991423, 1.033541, and 1.168512 respectively for 1- to 4-mounth financial derivatives. As the deadline of derivative contracts is prolonged, the optimum hedging rate (h) increases; which is consistent with findings of previous studies.

Efficiency of risk hedging strategies

In the present research, the risk hedging rates are extracted from three econometric models for 1- to 4-month derivative contracts. The rate of hedging is estimated in the range of 0.87 to 1.17. Risk and return of each hedging rate is separately estimated in order to select optimum hedging rate. To do so, first, a portfolio consisting of spot and future assets is developed and then optimum number of derivatives of this portfolio was estimated by hedging rates.

Table (10): efficiency of hedging rates in different models

date of maturity	model	hedge ratio	return mean of hedged portfolio	variance of hedged portfolio	efficiency (percent)	utility change
1-mounth	unhedged		0.002424628	0.028149393		
	OLS	1.007344	0.000486553	0.004406818	84.34	0.002477
	VAR	0.873539	0.000957797	0.008524071	69.72	0.003042
	VECM	0.965715	0.000937	0.011673652	58.53	0.001332
2-mounth	unhedged		0.002424628	0.028149393		
	OLS	1.034192	0.001006875	0.002370448	91.58	0.002477
	VAR	0.931633	0.001002104	0.005209518	81.49	0.003042
	VECM	0.991423	0.000986409	0.00222361	92.10	0.001332
3-mounth	unhedged		0.002424628	0.028149393		
	OLS	1.075744	0.001051811	0.002320033	91.76	0.002477
	VAR	0.878952	0.001436469	0.002273669	91.92	0.003042
	VECM	1.033541	0.001996628	0.001980171	92.97	0.001332
4-mounth	unhedged		0.002424628	0.028149393		
	OLS	1.11318	0.001006875	0.000566965	97.99	0.006054
	VAR	0.995996	0.001636825	0.002092249	92.57	0.011395
	VECM	1.168512	0.002424628	0.000507746	98.20	0.007905

Finally, risk, earning, and utility of each portfolio is extracted by Eq. (20), Eq. (21), and Eq. (5).

$$R_h=(S_t - S_{t-1})+h(F_t - F_{t-1}) \tag{20}$$

$$\hat{R}_h=\text{Mean}\,(R_h) \tag{21}$$

To estimate utility, the assumptions applied by Jonathan, et al (2004) were applied; based on which, the expected utility and risk aversion level are taken as 0 and 4, respectively.

To investigate the effect of applying derivatives on risk reduction, the out-of-sample efficiency is computed by Eq. (21). The obtained results are summarized in Table (10). Moreover, to compare the hedged and unhedged portfolios, the abovementioned procedure is applied for the position that hedging rate is zero (the derivatives are not applied).

The results of Table 3 indicate the presence of a direct relation between risk and return. On the other words, the higher is hedging rate, the greater return would be obtained. For instance, for unhedged position -in which hedging rate is zero- the return is at maximum level as risk reaches to its maximum. This finding is consistent with the "higher risk-higher return" principle (Fabozzi et al, 2012). Furthermore, the results indicate that as the deadline of future contracts prolongs, the risk is reduced and, consequently, return is lowered. Thus, the one-month contracts involve maximum risk and return, while the 4-month contracts have minimum risk in all models. As derivatives are not employed in the unhedged positions, its efficiency is zero, but the other models have high performance. As the worst scenario, which is in VECM model in the 1-month derivative contract, risk is reduced 58.53% by employing derivatives.

Moreover, efficiency of each model enhances by prolonging the length of future contracts. Therefore, the maximum and minimum efficiency of each model is for 4-month and 1-month contracts, respectively.

For future contracts, OLS model returns maximum utility. In addition, by prolonging the deadline of future contracts, utility of the models is increased, as it is maximum for VECM model in the future four-month contracts.

Conclusion and suggestions

The revenues obtained from crude oil export have a considerable impact in Iran's economy. Therefore, stabilization and hedging of the oil revenues is necessary of reaching a stable economy. Besides, the crude oil markets are constantly facing with considerable volatility of the price of these resources in the market, due to the high fluctuations of oil revenues induced by the unpredictable changes of oil price. These price fluctuations result in oil revenue risks. Hence, many suppliers and consumers are seeking for a solution for reducing their risk exchange in the market. To reduce risk in the uncertain markets such as Iran's oil, instruments such as financial derivatives are proposed. Iran as a mono-exporter oil exporting country which relies on oil revenues is considered as a risk averting investor, as a large share of its annual budget and 5-year plans are adjusted based on the oil dollars and the most important concern of government is obtaining stable revenue from these resources. Moreover, since some oil resources are communal between Iran and its neighbors, storage of these resources for the future generations in not possible through their sustainable excavation. Thus, it is required to propose strategies through which these resources are excavated under the current conditions are stored for the future generations as the financial and physical resources. In this regard, guaranteed revenue gained from these resources through the price risk management is proposed. Here, applying the financial derivatives is considered as a tool which guarantees the revenue obtained from natural resources. The results of present work indicate that financial derivative are efficient tools for reducing the risk level, as they reduce it up to 59 to 98%. This range depends on the type of contract and the model selected for determination of optimum hedging rate. However, choosing optimum model and contract depends on the aim of risk hedger of applying the given risk hedging strategy. The longer contracts reduce crude oil volatility risk up to 98.2% and return more stable oil revenues. For the cases that the predictions show the drop in future prices, government can do paper exchange of oil for hedging the oil price volatility. In this regard, it is recommended to make future contracts with longer deadline for optimum hedging of the risk.

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