Modeling Prices of Islamic Commodity Swaption

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Abstract. Derivatives that manage commodity risk over multiple periods are not *Sharī'ah*-compliant. This study proposes a *Sharī'ah*-compliant swaption model (*wa'dān* or two promises on swap) for hedging commodity risk. The model combines two separate and independent *wa'ds* (*wa'dān*) on commodity swap through *murābahah* contract. Black (1976) model is used to determine the intrinsic value for the counter-parties involved in the contract. The risk-free rate is replaced with the return on AAA *ṣukūk* to make Black (1976) model *Sharī'ah* compliant. The proposed *Sharī'ah*-compliant model is compared with the conventional swaption model, and with the Islamic commodity option (*wa'dān* on commodity) for its effectiveness. The tests of the model show that the proposed Islamic pricing model has a higher positive effect than the conventional swaption model. In addition, the proposed Islamic commodity swaption is more efficient than Islamic commodity options. The reliability of the proposed model was established by the Monte Carlo simulation run with 10,000 iterations.

Keywords: Islamic hedging, Pricing, Islamic commodity Swaption, *Wa'dān* on commodity swap.

KAUJIE Classification: K1, K14, L31

1. Introduction

The lack of Islamic hedging and the limited amount of available literature on pricing Islamic derivatives is an issue that the current study tries to solve. We do this by creating, evaluating and pricing a fair model. We propose the Islamic commodity swaption model, WCS (*Wa'dān* on Commodity Swap), to determine the intrinsic value in hedging risk. We also utilize the modified Black (1976) model to evaluate WCS regarding parties' returns and measure the profitability of WCS over the Islamic commodity option, WCO (*Wa'dān* on Commodity Option). The study tries to address three research questions.

- (a) What is the intrinsic value in the fair Islamic commodity swaption using *wa'dān* for hedging risk?
- (b) What is the value of the WCS regarding parties' returns?
- (c) How much is the profitability for using WCS over the WCO regarding parties' return?

To answer these questions the study proposes an innovative Islamic product called *wa'dān* on commodity swap (WCS). The International Islamic Financial Market (IIFM) has developed Islamic Foreign Exchange Product Standards based on *wa'dān* – two separate and independent *wa'ds* – for both the seller and the buyer. It is a hybrid product for commodity hedging combining two separate *wa'ds* for swap through *murābahah* contract. Also, we develop an Islamic pricing commodity swaption model for pricing WCS (which does not have a price in the market) by modifying Black (1976) model to be Shari'ah-compliant. Furthermore, we study the effectiveness of this model of hedging the two parties (the seller and the buyer) from potential risk in comparison with the normal *wa'dān* on commodity option (WCO).

The hedging commodity model in this study provides fairness for the users, buyer and seller, because both sides can exercise their promise and hedge. This will satisfy the Islamic scholars who claim that *wa'd* is not a fair contract due the loss that can occur to the counterparty if the holder exercises his promise.

We aspire, through this study, to enrich the Islamic finance literature and inspire scholars to explore this new product.

The rest of the paper is organized as follows: section 2 summarizes the literature review; the data and methodology is presented in section 3 in which we discuss the data and research design which clarifies the study's method for answering the three research questions. The findings and discussion of the results is given in section 4 while section 5 concludes the paper.

2. Literature review

Islamic finance is a rapidly growing market with Islamic scholars constantly trying to find new and innovative Islamic instruments and techniques to keep pace with the rapid growth of the economy. This innovative drive gained special significance after the 2008 financial crises. Hedging, which is important for protection and saving purposes, is one area in which Islamic finance scholars need to improve upon. It may be noted here that in 2006 IIFM has taken the lead to identify the need for hedging in Islamic finance and is the pioneer in this important risk mitigation segment.

Wa'd is a risk mitigation technique utilized by Islamic financial institutions to prevent the risk of price fluctuation, interest risk, foreign exchange risk, etc. For example, it is used in an innovative product proposed by Kok, Giorgioni, and Laws (2014, p. 246) for hedging commodity price risk through *murābahah* contract. The model proposed in this study takes its inspiration from their work. *Wa'd* can be a contract to hedge against currency risk and Islamic swap which happen in many contracts like *murābahah*, *tawarruq* and *bay' al-īnah*. Ayub (2011, p. 13) defined the *wa'd* based Islamic swap as an agreement between two parties to enter *wa'd* through *murābahah* contract; primary *murābahah* and reverse *murābahah* which is more commonly known as *tawarruq* or more correctly 'organized' *tawarruq*. This study is an attempt to explain how the hybrid structure of two unilateral *wa'ds* (*wa'dān*) for commodity swap through *murābahah* works.

Regarding the pricing of *wa'd* through *murābahah* contract, the authors could not find any research which discusses the pricing model of *wa'd* with real data or even without real data except one paper by Aboulaich and Dchieche (2015). They suggest pricing *wa'd bil murābahah* by adopting Black and

Scholes (1973) model and adjusting it to comply with Shari'ah laws. They use the European call option and adjust the Black and Scholes model by replacing the interest rate with the rate of return (R) derived from the model.

$$\text{They found } R = 1 + t \sqrt{\frac{p}{S_0(1 - Nd_1) + pe^{-rt}Nd_2}} - 1$$

where $N(d_1)$ and $N(d_2)$ are the cumulative standard normal distribution functions, R is the rate of return, e^{-rt} is the discount rate, p is the price at time T , and S_0 is the spot price (Aboulaich & Dchieche, 2015, pp. 529-531).

Wa'dān has recently caught the scholar's attention in the Islamic financial engineering industry in recent years. It is being used to develop Islamic finance products competitive with the derivatives used in conventional finance. *Al-wa'dān* has been defined by many Islamic scholars in many research papers. For instance, Aznan Hasan (2008) describes the concept of *wa'dān*. He clarifies that *wa'dān* refers to two promises (*wa'ds*) made by the parties involved in a particular business transaction. These two promises are given unilaterally by one party to another and vice versa, where they are unrelated to each other and their respective fulfillment depends on two independent conditions (Hasan, 2008, p. 31).

Wa'dān has two important characteristics:

- (a) The promises are independent from each other.
- (b) Their application depends on two different conditions (Muhammad, Yaacob, & Hasan, 2011, p. 31, Abdullah & Abdul Rahman, 2015, p. 130).

The Islamic Fiqh Academy allows Islamic researchers and scholars to improve the option contract using *wa'd* and *'urbūn* (deposit). Muhammad Elgari has suggested some restrictions in these contracts to avoid the gambling elements:

- 1) The institution must deal with the real owner of the stock.
- 2) Only European style option is exercised, which is exercised at maturity date to reduce the exposure for price fluctuation.
- 3) The option will expire at the beginning of the first hour in the last day of the contract to avoid the rise of price because of demand increase (Bashir, 2016, p. 10).

Wa'dān is not very widely utilized in Islamic finance due to the debate surrounding the permissibility of this kind of product in many research papers. It is usually used as a hedging instrument for Islamic capital markets. Some Islamic scholars argue that they consider *wa'dān* contract as more just and fair than the simple *wa'd* contract because in *wa'dān* contract, the two parties can exercise their promises and protect their position. A survey conducted through a questionnaire in Malaysia by the Malaysia Islamic bank 2008, revealed that *wa'd mulzim* is widely used. The researcher surveyed the possibility of Malaysia Islamic bank adopting *wa'dān* to protect both parties. The result showed great interest in using *wa'dān* (Hasan, 2008, p. 52). A good example of *wa'dān* product is *ijārah* rental swap (IRS) contract, which is a hedging technique against *ijārah* floating finance. In this contract, the holder can swap the floating rate cash flow to fixed rate cash flow and vice versa. (Abdullah & Abdul Rahman, 2015, p. 133)

There is no research that uses real data to calculate hedging payoff for two parties through real transaction. Although, some theoretical researches about *wa'dān* have been published, yet they are not enough to form a strong base for further empirical research. Accordingly, this paper develops the null and alternative hypotheses as follows:

H_{10} = this model offers no intrinsic value in hedging risk for a fair Islamic commodity swaption using *wa'dān*.

H_{1a} = this model offers intrinsic value in hedging risk for a fair Islamic commodity swaption using *wa'dān*.

The International Swaps and Derivatives Association (ISDA, 2013, p. 22) considers commodity swaption as a series of forward contracts entered into a trade date (T_0) with different settlement dates. The other party pays at maturity, if the holder exercises his right, the difference between the fixed price and the floating price in case of receiver swaption, or the difference between the floating price and the fixed price in case of payer swaption. There can be multiple settlement dates during the period. The payoff for the European commodity swaption of receiver swaption is calculated by:

$$P(T_0) = \sum p(T_0, T_i) * \max[X(T_i) - S_0]$$

And for payer swaption

$$C(T_0) = \Sigma p(T_0, T_i) * \max[S_0 - X(T_0)].$$

Black (1976) model is the standard market model to price swaptions, introduced by Fisher Black in 1976. It is an extension of the Black-Scholes model that is used to value the European swaption. To the best of our knowledge, there is no attempt of pricing the commodity swaption for European option. Most of the studies focus on pricing interest rate swaption. The present study focuses on pricing the Islamic crude oil swaption or *wa'dān* on crude oil swap by paying (payer *wa'd* on commodity swap) or receiving (receiver *wa'd* on commodity swap) a fixed price against the floating price of the underlying commodity. In order to develop the Black (1976) model to be more Shari'ah-complaint, the interest rate is substituted with the rate of return on triple A *shukūk* as done by Hakim, Hamid and Meera (2016, p. 26). They used the rate of return on triple A *shukūk* in CAPM model to calculate the return for Shari'ah-complaint stocks. Thus, this research can develop the second null and alternative hypotheses as follows:

H2₀ = There is no effect on the parties' return from the development of an Islamic pricing commodity swaption (WCS).

H2_a = There is an effect on the parties' return from the development of an Islamic pricing commodity swaption (WCS).

We calculate the pricing of (WCS) and (WCO) regarding parties return to provide this study with required data to justify choosing *wa'dān* on commodity swap over the *wa'dān* on commodity. Some argue that Islamic commodity swaption is no different than Islamic commodity option regarding the profitability for both parties. This study compares Islamic commodity swaption over Islamic commodity option. The proposed model (WCS) has several *wa'd* exercises on commodity swap that have a positive effect for the two parties in case of profit, while in the *wa'dān* on a commodity (WCO) model, the parties can only exercise the *wa'd* once on the maturity date. The available literature in the field of Islamic derivatives does not offer studies that test the difference in profitability between Islamic commodity swaption and Islamic commodity option. Therefore, this research provides a third null and alternative hypothesis as follows:

H3₀: Islamic commodity swaption (WCS) offers the same profitability when using Islamic commodity option (WCO) for both parties.

H3_a: Islamic commodity swaption (WCS) offers more profitability than commodity options (WCO) for both parties.

3. Data and Methodology

This research will formulate a model of *wa'dān* on commodity swap through *murābahah* contract to hedge against fluctuating price risk by using Black (1976) model. The proposed model for this study is evaluated by calculating the intrinsic value by using Black (1976) model to answer the first research question (what is the intrinsic value in the fair Islamic commodity swaption (WCS) using *wa'dān* for hedging risk?). To answer the second question of this research (what is the value of the Islamic price commodity swaption (WCS) regarding parties' returns?), this study will compare the profit of both parties after applying Black (1976) model on both the rate of return (triple A *shukūk*) and LIBOR interest rate. Regarding the third question (how much is the profitability for using Islamic commodity swaption, WCS, over the Islamic commodity option, WCO, regarding parties' return?), we calculate the profit for normal *wa'd*₁, put option, and *wa'd*₂, call option, and compare it with the profit of receiver swap based on *wa'd* (receiver swaption), and payer swap based on *wa'd* (payer swaption). The Monte Carlo simulation is conducted in this study to test the reliability of the Shari'ah-compliant Black (1976) results. The data used in this study is the time-series data of OPEC price crude oil and Arab light crude oil, obtained from the Quandl website (<https://www.quandl.com/data/OPEC/ORB-OPEC-Crude-Oil-Price>) and averaged for each two-month period starting from 2006 until 2016. Furthermore, time-series data on total return index of Dow Jones triple A rated *shukūk* is used as a substitute for interest rate in Black (1976) model. This is also averaged for each two-month period starting from 2006 until 2016. Additionally, LIBOR (The London Interbank Offer Rate) time series data, likewise, averaged for each two-month period starting from 2006 until 2016 is collected from Bloomberg database. Moreover, strike prices and variances will be calculated manually to be applied in the Black (1976) model and the Black & Scholes (1973) model.

Wa'dān on swap includes two separate *wa'ds* on swap, the receiver *wa'd* on commodity swap and the payer *wa'd* on commodity swap. Each party has a promise to be exercised at the maturity date to swap a commodity with a fixed price k , in case of receiver *wa'd* on swap, or swap the fixed price k with a commodity in case of payer *wa'd* on swap. This contract lasts for t years starting at year T . However, in the model proposed in this study, the contract lasts for one year with six two-month periods. There are m payments per year under the swap. The Black model for receiver and payer swaption (receiver and payer *wa'd* based on swap) is:

$$S_{\text{payer}} = \sum_{i=1}^{Mn} p(0, T_i) [S_0 N(d_1) - S_k N(d_2)]$$

$$d_1 = \frac{\ln \frac{S_0}{S_k} + (r_f + \sigma^2/2T)}{\sigma \sqrt{T}}$$

$$d_2 = d_1 - \sigma \sqrt{T}$$

$$S_{\text{receiver}} = \sum_{i=1}^{Mn} p(0, T_i) [S_k N(d_2) - S_0 N(d_1)]$$

τ = Tenure of swap in years.

S = Spot price of the underlying commodity.

K = Strike price of the swap based on *wa'd*

r = rate of return on triple A *shukūk*

T = Time to expiration in years or months

σ = Volatility of the forward-starting swap price.

m = Compounding per year in swap price

Figure (1) The Proposed Model of The Study

The designations of the parties in the structure above are as follows:

Party 1, receiver swap, is the seller of crude oil. Party 2, payer, is the buyer of crude oil. Party 3, is the third-party dealer, (OTC NYMEX), exercising *wa'd₁* on commodity swap (seller) and *wa'd₂* on commodity swap (buyer).

Mechanism of the model

Party 1 (seller of crude oil) enters into an agreement with the buyer to sell the crude oil through *murābahah* contract. Both parties, the buyer and the seller, are fearful of a fluctuation in prices and wish

to protect themselves within this hybrid product. Party 1 (seller of crude oil) and party 2 (buyer of crude oil) agree to engage in *murābahah* contract through a dealer by purchasing, premium, two independent *wa'ds*; *wa'd₁* for receiver commodity swap and *wa'd₂* for payer commodity swap in OTC (over-the-counter) market. This *wa'd* swaps the market price of the commodity with a fixed price from the seller or the buyer by the dealer at maturity date. The dealer pays the difference for both parties to hedge their position. Strike price for the swap based on *wa'dān* contract is always ATM (At the money) and fixed for both counterparty.

Receiver *wa'd* on commodity swap (*wa'd₁*): is a promise from seller to dealer to sell or swap the crude oil at market price if the dealer hedges his position and pays the difference in case the market price is lower than the strike price at the maturity date.

Payer *wa'd* on commodity swap (*wa'd₂*): is a promise from buyer to dealer to buy or swap the crude oil at market price if the dealer hedges his position and pays the difference if market price is higher than the strike price at the maturity date.

This hybrid product is set up between party 1 and party 2 through party 3 whereby it is a series of *murābahah* linked with *wa'dān* on commodity swap contract entered at trade date (T_0) with different settlement dates (every two months). Party 1 (receiver *wa'd* on commodity swap), the seller, can exercise his promise and sell the crude oil to the buyer if the dealer pays the difference when the market price is lower than the strike price. Party 2 (payer *wa'd* on commodity swap), the buyer, exercises his *wa'd* and pays his installment every 60 days ($q+y$) if the dealer pays the difference when the market price is higher than the strike price. Both the markups and the premium will be known (and set) at the same time T_0 . This product is exercised every 60 days for one-year swap. Pricing this product will need a modified Black (1976) model to be acceptable in Islamic finance.

Payoffs for each of the parties:

Summary of symbols:

B_1 : premium for *wa'd₁* on commodity swap and *wa'd₂* on commodity swap

S_1 : spot price at time T_0

S_2 : spot price at T_1 (maturity date)

X_1 : cost + markup price of *murābahah* (S_1+y)

Y : profit percentage for *murābahah* contract

Q : exercise price of *wa'd₁* and *wa'd₂* which is the strike price at the money (ATM)

Receiver swaption and payer swaption scenarios:

*Scenario 1: For $S_2 < Q$, *wa'd* is exercised for party 1 and not exercised for party 2*

At time T_0 : in all Scenarios

Party 1 pays premium to party 3 = β_1

Party 2 pays premium to party 3 = β_2

Party 3 earns $\beta_1+\beta_2$

At time T_1 : *wa'd* is exercised for party 1 and not exercised for party 2

Party 1 sells or swap the commodity to party 2 at cost plus some markup, $x(Q+Y)$

After one year payoff of party 1 is $P(T_0) = \Sigma p(T_0, T_i) * \max[(Q+y) - (S_2+y)T_0]$

Party 2 takes delivery of commodity and pays Party 1 = $x(S_2+Y)$

Party 3 earns $(\beta_1 - (Q - S_2)) + \beta_2$

*Scenario 2: for $S_2 > Q$, *wa'd* is not exercised for party 1 but is exercised for party 2*

Payoffs at time T_1 :

Party 1 sells or swaps the commodity to party 2 at cost plus some markup, $x(S_2+Y)$ party 2 takes delivery of commodity and pays party 1 = $x(Q+Y)$

After one year payoff for party 2 is $C(T_0) = \Sigma p(T_0, T_i) * \max[(S_2+Y) - (Q+Y)T_0]$.

Party 3 earns $\beta_1 + (\beta_2 - (S_2 - Q))$

Table 1 below illustrates the model in different scenarios for each party. Notice that this structure is for a (receiver *wa'd* on commodity swap), (payer *wa'd* on commodity swap) and the dealer.

Table (1) Payoffs for each of the parties

	Party 1	Party 2	Party 3
At T_0	pays premium to Party 3 = β_1	pays premium to Party 3 = β_2	earns $\beta_1 + \beta_2$
At T_1 For $S_2 < Q$, <i>wa'd</i> is exercised	sells or swap the commodity to Party 2 at cost plus some mark-up, $x(Q+Y)$	takes delivery of commodity and pays Party 1 = $x(Q+Y)$	earns $(\beta_1 - (Q - S_2)) + \beta_2$
For $S_2 > Q$, <i>wa'd</i> is not exercised	sells the commodity to the market at cost plus some mark-up, $x = (S_2 + Y)$	purchases commodity from market at $x = (S_2 + Y)$	earns $\beta_1 + (\beta_2 - (S_2 - Q))$

Party 1 exercise his *wa'd* and party 2 does not.

Party 2 exercise his *wa'd* and party 1

Intrinsic value of the receiver *wa'd* on commodity swap after one year is given by:

$$P(T_0) = \sum p(T_0, T_1) * \max[(Q+Y) - (S_2+Y)T_0]$$

Intrinsic value of the payer *wa'd* on commodity swap after one year: $C(T_0) = \sum p(T_0, T_1) * \max[(S_2+Y) - (Q+Y)(T_0)]$.

***Wa'dān* on Commodity (commodity options):**

Payoffs for each of the parties regarding parties' return:

*Scenario 1: For $S_2 < Q$, *wa'd* is exercised for party 1 and not exercised for party 2*

At time T_0 : in all scenarios as well as *wa'dān* on commodity swap

Party 1 pays premium to party 3 = β_1

Party 2 pays premium to party 3 = β_2

Party 3 earns $\beta_1 + \beta_2$

At time T_1 : *wa'd* is exercised for party 1 and not exercised for party 2

Party 1 sells the commodity to party 2 at cost plus some markup, $x(Q+Y)$

After one year payoff of party 1 is $P(T_0) = \max[(Q+Y) - (S_2+Y)T_0]$

Party 2 takes delivery of commodity and pays Party 1 = $x(S_2+Y)$

Party 3 earns $(\beta_1 - (Q - S_2)) + \beta_2$

*Scenario 2: for $S_2 > Q$ *wa'd* is not exercised for party 1 but is exercised for party 2*

Payoffs at time T_1 :

Party 1 sells the commodity to party 2 at cost plus some markup, $x(S_2+Y)$ party 2 takes delivery of commodity and pays party 1 = $x(Q+Y)$

After one year payoff for party 2 is $C(T_0) = \max[(S_2+Y) - (Q+Y)(T_0)]$.

Party 3 earns $\beta_1 + (\beta_2 - (S_2 - Q))$

4. Findings and Discussions

4.1 Descriptive statistics

The data examined are OPEC price, Dow Jones triple-A rated *ṣukūk* total return index and LIBOR. The results are shown in Table 2.

Table (2) Descriptive statistics

Data	N	Min	Max	Mean	Median	SD	Skew	Kurtosis
OPEC price	66	29.62	129.25	80.09	77.33	26.43	-0.08	-1.33
R.O.R triple A	66	-0.65	2.56	0.33	0.26	0.62	1.51	3
LIBOR	66	0.15	28337	430.68	0.27	3487.88	7.76	59.09

N: Number of the observation, Min: Minimum number of observations, Max: Maximum number of observations, SD: Standard Deviation, Skew: Skewness.

Mean and median are the best way to represent the central tendency of the numerical data. The average of OPEC price and rate of return on triple A *ṣukūk* has an exactable average which is 80.9 for the oil price and 0.33 for the rate of return. The mean of LIBOR is misleading because of skewness. The skewness is due to few of the LIBOR rates being abnormally high, over 5. This happened during the financial crisis in 2007 and 2008 which suffered from highly uncertain creditworthiness of financial institutions and most importantly subprime mortgages. This resulted in the lenders reducing the lending which caused an increase in demand for liquidity which in return affected the LIBOR interest rates. These large values tend to inflate the mean and make it unrepresentative of the majority of the interest rate. The median is the “middle” observation when the data is arranged for better representation of the central tendency. For LIBOR, this is 0.27. The standard deviation (SD) represents the spread of the data around the mean. The SD for OPEC price and rate of return on triple A *ṣukūk* are 26.4 and 0.62 respectively which means the spread is not misleading and outliers data are not affecting the spread. The skew is symmetric for OPEC price and highly positively for rate of return on triple A *ṣukūk*. Kurtosis for both is within acceptable range between (-3, 3). As mentioned earlier, the misleading skew, due to few of the LIBOR rates being abnormally high (over 5), affects the mean and makes it unrepresentative of most of the interest rates which consequently affects the standard deviation. Kurtosis is highly positively for LIBOR data.

4.2 Hypotheses testing

First hypothesis

This section tests the hypotheses presented in the literature review. We presented three hypotheses. The first one is about the intrinsic value of the proposed model.

The null hypothesis is:

H_{10} = this model offers no intrinsic value in hedging risk for a fair Islamic commodity swaption using *wa'dān*.

The alternative hypothesis is:

H_{1a} = this model offers intrinsic value in hedging risk for a fair Islamic commodity swaption using *wa'dān*.

Thus, the payoff model for an intrinsic value of the (receiver *wa'd* on commodity swap) after one year is:

$$P(T_0) = \sum p(T_0, T_i) * \max[(Q+y) - (S_2+y)T_0]$$

The intrinsic value of the (payer *wa'd* on commodity swap) after one year:

$$C(T_0) = \sum p(T_0, T_i) * \max[(S_2+Y) - (Q+Y)(T_0)].$$

Table 3 and figure 2 show the results for the intrinsic value for both parties.

Table (3) The intrinsic value for receivers and payer *wa'd* based on swap for the proposed model

Date	Intrinsic value for payer <i>wa'd</i> based on swap	Dif	Intrinsic value for receiver <i>wa'd</i> based on swap
2016	15.215833	0.17	15.045
2015	20.732	0	20.732
2014	45.075	0.075	45
2013	8.21	0.86	7.352
2012	13.592433	0.1	13.4884
2011	4.1001	0	4.0994
2010	15.855	0	15.855
2009	21.49	0	21.49
2008	89.36332	0.166	89.1975
2007	28.8866	2	26.87
2006	12.545	0	12.545

Note: dif is the difference between intrinsic value for payer *wa'd* based on swap and intrinsic value for receiver *wa'd* based on swap; dif = payer – receiver,

Figure (2.1) The payer intrinsic value

Figure (2.2) The receiver intrinsic value

Figure 2 (1, 2) The Receiver and Payer intrinsic value

The results above from the table and the figure showed that the proposed model has an intrinsic value due to the positive results that appear in the table 3 and the figure which means each party, the payer and receiver *wa'd* on commodity swap, receives after one year a payoff that ranges between \$7.352 and \$89.36332. The difference of the payoff between the two parties represented in the figure showed both parties received similar payoffs which is ascertained by the difference in the table 3 which shows that the difference is between \$0.1 and \$2.

Therefore, the study must accept the alternative hypothesis and reject the null hypothesis. Hence, this model offers intrinsic value in hedging risk for a fair Islamic commodity swaption.

Second hypothesis

In our second hypothesis, the null hypothesis was:

H₂₀ = There is no effect on the parties' return from the development of an Islamic pricing commodity swaption (WCS).

The alternative hypothesis was:

H_{2a} = There is an effect on the parties' return from the development of an Islamic pricing commodity swaption (WCS).

The study used RStudio for pricing the proposed model premium for both parties the receiver and payer *wa'd* based on swap by applying the Islamic Black (1976) model, then pricing second time for conventional model by using LIBOR interest rate for risk-free rate to compare and measure the effectiveness of this proposed model regarding parties' profit. This is represented by the following formula for receiver and payer *wa'd* passed on swap.

$$S_{\text{payer}} = \sum_{i=1}^{Mn} p(0, T_i) [S_0 N(d_1) - S_k N(d_2)].$$

$$S_{\text{receiver}} = \sum_{i=1}^{Mn} p(0, T_i) [S_k N(d_2) - S_0 N(d_1)]$$

The following tables illustrate the premium for both models, Islamic and conventional, which will be used for calculating the profits for each party.

Table (4) The premium for Islamic and conventional proposed model for both parties

Date	Idif	Islamic pricing for proposed model		Pdif	Rdif	Conventional pricing for proposed model		Cdif
		Payer premium	Receiver premium			Payer premium	Receiver premium	
2016	15.7	39.37229	23.651506	-0.2	-4.7	39.527502	28.315563	11.2
2015	10.2	49.303433	39.0888833	0.09	-23	49.204757	62.155082	-12
2014	15.2	93.54347	78.2991667	0	-249	93.542282	328.01863	-234
2013	7.97	78.10966	70.131725	-21	66.7	99.871101	3.3906069	96.5
2012	2.96	104.66002	101.695485	-1.8	64.4	106.51703	37.32483	69.2
2011	15.1	54.1660883	39.027355	-53	39	107.74655	0.0170258	107
2010	9.2	77.6496483	68.43349167	-0.8	27.7	78.375015	40.760798	37.6
2009	3.3	65.9217183	62.605095	-5.2	-21	71.11687	83.504082	-12
2008	3.9	90.2441667	86.375265	1.7	-368	88.567	454.40078	-365
2007	10.3	73.4005233	63.123033	-0.4	49.8	73.8333	13.277213	60.5
2006	2.9	54.3606767	51.50799167	-4.6	52.7	59.007058	1.2004941	57.8

Note: Idif: different between Islamic payer premium and Receiver premium (payer premium –Receiver premium). Cdif: different between conventional payer premium and Receiver premium (payer premium –Receiver premium). Pdif: different between Islamic payer premium and conventional payer premium (Islamic payer premium-conventional payer premium). Rdif: different between Islamic receiver premium and conventional receiver premium, (Islamic receiver premium-conventional receiver premium)

The premium results in table 4 are the key to understanding the effectiveness of the development of Black (1976) model to make it Sharī'ah compliant. According to table 4, the premiums for Islamic commodity swaption for both parties are approximated with small difference between them around \$3 to \$15. This is due to the relatively close prices for the premiums for both payer *wa'd* on commodity swap and receiver *wa'd* on commodity swap because the rate of return on triple A *ṣukūk* is not affected by the financial crises of 2008. In addition, the arbitrage has an advantage of triple-A that has the smallest risk default and is based on an underlying asset *ṣukūk* which perceive the prices from fluctuation. The Idif difference is positive if the payer premium is higher than the receiver premium. A buyer of the Islamic payer premium must pay around \$3 to \$15 more than Islamic receiver premium. The cheapest Islamic payer premium is \$39 and the most expensive is \$104. However, the Islamic receiver premium is cheaper than Islamic payer premium with range of \$23.6 and \$101.6. In contrast, for the conventional commodity swaption there is a big fluctuation between the payer premium and receiver premium which is illustrated by the Cdif field which shows that \$107 is the highest positive difference with regard to the payer and \$365 is the highest negative difference, which is

considered positive for the receiver premium. Cdif difference is due to the fluctuation of the premium prices for both parties, with the cheapest payer premium being \$39 and \$28 in receiver premium. The highest price is \$107.7 for payer premium and \$454 for receiver premium. Fluctuation of prices in conventional commodity swaption between payer and receiver premium is affected by the LIBOR rate which reached abnormally high rates during the financial crisis of 2008, that exceeded 5%. Arbitrage opportunity arises if the interest rate is not affected in the option price (Hou & Skeie, 2014, p. 4). This abnormal rate during the crises period and the arbitrage are reflected on the payer prices which ranged from \$39.5 to \$107.7. The receiver price also ranged from \$28 to \$454. Therefore, the profit for both parties in conventional commodity swaption as well as Islamic commodity swaption was affected by the fluctuation of these prices that is illustrated in table 5.

The profit for both parties in the Islamic and conventional commodity swaption model can be obtained by applying the payoff Black (1976) in the suggested scenarios for both parties that was explained in the methodology section. Profit for both parties in Islamic and Conventional pricing model is shown in the next table (table 5).

Table (5) The Islamic and conventional profit for both parties

		Islamic Profit for Proposed Model				Conventional Profit for Proposed Model		
Date	Idif	Payer profit	Receiver profit	Pdif	Rdif	Payer profit	Receiver profit	Cdif
2016	-15	17.43770713	32.9876605	0.1	4.7	17.318465	28.3236	-11
2015	-9	22.81145667	31.72061667	-0.1	23	22.9097433	8.65	14
2014	-15	35.84903	51.01833	0	250	35.850218	-198.70113	234
2013	-7	35.5636733	42.68360833	21	-67	13.80223213	109.42472	-95
2012	-3	18.16657997	21.02708167	2	-64	16.309138	85.3977	-69
2011	-15	59.387345	74.52591163	53.6	-39	5.80688	113.535	-107
2010	-9	18.81035167	28.02650833	0.7	-27	18.0849	55.696	-37
2009	-3	21.99828167	25.314905	5.2	20	16.803	4.923	11.8
2008	-4	89.36332	93.06640497	-1.7	368	91.040466	-274.959	366
2007	-10	27.3194767	37.5803	1	-50	26.205	87.426	-61
2006	-3	18.6743233	21.52700833	4.6	-50	14.027	71.8345	-58

Note: Idif: difference between Islamic payer profit and Receiver profit. Cdif: difference between conventional payer profit and Receiver profit. Pdif: difference between Islamic payer profit and conventional payer profit. Rdif: difference between Islamic receiver profit and conventional receiver profit.

Figure (3.1) Profit for Islamic Commodity swapion**Figure (3.2) Profit for Conventional Commodity swapion****Figure 3 (1, 2) The Profit for both Parties from Islamic and Conventional Proposed Model** **Figure (3.3) Profit for Islamic and Conventional Payer Receiver Commodity swapion****Figure (3.4) Profit for Islamic and Conventional Commodity swapion****Figure 3 (3, 4) The Profit for both Parties from Islamic and Conventional Proposed Model**

The results from table 5 and figure 3.1 show that there is no loss for both parties by using the proposed model, Islamic commodity swaption. Profits are positive for both the payer *wa'd* on commodity swap and the receiver *wa'd* on commodity swap. The difference between Islamic payer profit and receiver profit is clear in figure 3.1 and ascertained by the results in table 5. According to Idif, the receiver *wa'd* on commodity swap is more profitable than the payer *wa'd* on commodity swap which ranges between \$3 to \$15 during the years of the study. The maximum profit of the receiver *wa'd* on commodity swap is \$93 and the minimum profit is \$21. The payer *wa'd* on commodity swap has a profitable range between \$17 and \$89. In the null model, conventional commodity swaption, the results (figure 3.2) showed that the receiver swaption suffered a loss in two different years during the period of the study which is also clearly shown in table 5. The payer swaption has positive profits for the whole period around \$5 and \$91. Table 5 shows the loss suffered by the receiver swaption in 2008 and 2014 and the loss amount was between \$198.7 and \$274.9 which is a result of the fluctuation of the premium prices in the crisis period of 2008 due to the abnormal LIBOR rate exceeding 5%. Also, in 2014 the loss is due to the fluctuation between payer swaption and receiver swaption because of the arbitrage effect (Hou & Skeie, 2014, p. 5).

When comparing the Islamic commodity swaption model for pricing (which used the rate of return on triple A *shukūk* as the risk-free rate) with the conventional commodity swaption (which used LIBOR as the risk free rate) regarding parties' profit, the results show that the payer *wa'd* on commodity swap

is more profitable than the payer commodity swaption which is clear in figure 3.3. Also, table 5 asserts this that the payer *wa'd* on commodity swap has more profit between \$1 and \$53.6 from 2006 until 2013. However, Pdif field shows that in the last three years of the test period, there was neither a pro-fit nor a loss. For the receiver *wa'd* on commodity swap figure 3.4 shows that the result is positive and no loss is incurred in the Islamic model unlike the conventional model which had huge losses within the period of the study. This was due to the premium fluctuation resulting from the abnormally high rate of LIBOR. The result for Islamic commodity swaption is positive in both payer *wa'd* on commodity swap and receiver *wa'd* on commodity swap due to the relatively close prices of the premium because the model is dependent upon the rate of return on triple A *shukūk*.

The rate of return on triple A *shukūk* was not affected by the financial crisis of 2008 and the arbitrage due to the characteristic of *shukūk* that it is based on an underlying asset and has very little risk of default. However, interest rate was affected by the financial crisis of 2008 and arbitrage effect. Figure 3.4 shows that the receiver commodity swaption is more profitable than Islamic receiver commodity swaption in the middle of the test period of the study as shown by Rdif in table 5 from 2010 to 2013.

The result from these tables and graphs allowed the study to accept the alternative hypothesis and reject the null hypothesis [which means that there is an effect on the parties' profit from the development of an Islamic pricing commodity swaption (WCS)] as Hakim also found in his study (Hakim, Hamid, & Meera, 2016, p. 26).

Table (6) Dealer profit from the suggested Islamic model, *wa'dān* on commodity swap,

Date	Islamic profit for proposed model		
	Payer profit	Tpro	Receiver profit
2016	24.15645953	32.8	8.606506167
2015	27.26604333	48	20.732
2014	48.46847	81.8	33.29916667
2013	69.89966	132.7	62.779725
2012	91.0675867	179	88.207085
2011	50.06598833	85	34.9274217
2010	61.79464833	114	52.57849167
2009	44.43171833	85.5	41.115095
2008	0.880846667	2	1.046663367
2007	46.51385663	82.7	36.25303333
2006	41.81567667	80.7	38.96299167

Note: Tpro: total profit of the dealer from both parties

Table 6 shows the dealer profit from the Islamic commodity swaption (WCS) that has range between \$2 and \$179 which is earned by adding the payer profit and receiver profit. Profit from each party is calculated by subtracting from the premium price the compensation for receiver *wa'd* based on commodity swap which is represented by this formula $(\beta_1 - (Q - S_2)) + \beta_2$. For the payer *wa'd* based on commodity swap the formula is the following $\beta_1 + (\beta_2 - (S_2 - Q))$.

Third hypothesis

Finally, the third hypothesis in this study is about testing whether the profitability value of Islamic commodity swaption (WCS) is higher than Islamic commodity option (WCO) or not. The null hypothesis is:

H3₀: Islamic commodity swaption (WCS) offers the same profitability when using Islamic commodity option (WCO) for both parties.

The alternative hypothesis is:

H3_a: Islamic commodity swaption (WCS) offers more profitability than Islamic commodity options (WCO) for both parties.

To assess this hypothesis the study uses Black and Scholes (1973) model after modifying it to make it Shari'ah-compliant by replacing the risk-free rate with the rate of return on triple A *shukūk* to obtain both parties' premium. Black and Scholes (1973) model and Black (1976) have one important difference that can affect the result which is that in the Black and Scholes model, in normal *wa'd*, call option or put option, the holder can exercise only for one time at the maturity date while the Black (1976) model offers several exercise dates for different maturity lasting one year and having two-month periods. Hence, there are 6 payments per year under the swap. The following formulas are for the Black (1976) model for receiver and payer *wa'd* based on swap as mentioned earlier in this section.

$$S_{\text{payer}} = \sum_{i=1}^{Mn} p(0, T_i) [S_0 N(d_1) - S_k N(d_2)]$$

$$S_{\text{receiver}} = \sum_{i=1}^{Mn} p(0, T_i) [S_k N(d_2) - S_0 N(d_1)]$$

This is calculated by the following formulas:

$$P(T_0) = \sum p(T_0, T_i) * \max[(Q+y) - (S_2+y)T_0]$$

$$C(T_0) = \sum p(T_0, T_i) * \max[(S_2+Y) - (Q+Y)T_0].$$

To measure the premium of normal *wa'd* on commodity, using the Black and Scholes model for both parties, we use the following formulas:

$$C = S_0(Nd_1) - e^{-rt}k(Nd_2)$$

$$P = e^{-r}(N-d_2) - S_0(N-d_1)$$

And the payoff for both parties after one year is calculated by:

$$P = \max[(Q+y) - (S_2+y)T_0]$$

$$C = \max[(S_2+Y) - (Q+Y)T_0].$$

The research compared the Islamic proposed model, *wa'dān* on commodity swap, with Islamic model for *wa'dān* on commodity. The results are shown in the following tables, table 7 and table 8.

The results in table 7 represent the premium for both parties in the study's proposed model. Table 7 indicates that there is a fluctuation in premium prices for both *wa'd₂* on commodity and *wa'd₁* on commodity but it is higher in *wa'd₁* ranging between \$1 and \$787. These fluctuations during the study period affect the profit for both parties. The *wa'd₂* premium based on commodity ranges between \$39 and \$109 which is more stable than *wa'd₁* on commodity. The difference between *wa'd₁* and *wa'd₂* peaked in 2008 and 2014 with a value of \$749 and \$624 respectively. This was due to the fluctuation of the prices which make the *wa'd₁* on commodity more expensive than *wa'd₂*. Furthermore, the fluctuation can be explained by low market expectation of oil prices going down which caused the rise of *wa'd₁*, put price, (García & Prokopiw, 2010, p. 1). Moreover, the fluctuation is not caused by the financial crisis period of 2008 and the arbitrage effect due to the characteristics, explained earlier, of the rate of return on triple A *shukūk* which is used in the Black and Scholes model. However, the difference (Idif₂) between the premium prices shows that *wa'd₂* on commodity is more expensive than *wa'd₁* on commodity in most of the years which the study has covered. The difference between payer *wa'd* on commodity swap and *wa'd₂* is represented in Pdif and the difference between receiver on commodity swap and *wa'd₁* is represented by Rdif. The results show that *wa'd₂* on commodity is more expensive than the payer *wa'd* on commodity swap with a range

between \$8 and \$52 and that the $wa'd_1$ on commodity with a range between \$3 and \$701 is more expensive than the receiver $wa'd$ on commodity swap which affect the profits for both parties. These results are logical due to the normality of the

normal $wa'd$ and $wa'd_{\text{dān}}$ option contract which the holder can exercise only for one time at maturity date while the Black (1976) model offers several exercise dates for different maturity lasting for one year with two-month periods.

Table (7) The Result for the Premium of Islamic proposed model $wa'd_{\text{dān}}$ on commodity swap and Islamic proposed model for $wa'd_{\text{dān}}$ on commodity

Date	Idif ₁	Islamic premium for $wa'd_{\text{dān}}$ on commodity swap		Pdif	Rdif	Islamic premium for $wa'd_{\text{dān}}$ on commodity		Idif ₂
		Payer premium	Receiver premium			$wa'd_2$ premium	$wa'd_1$ premium	
2016	15	39.37229	23.651506	-9.6	-29	48.96798	52.54205	-3.5
2015	10	49.303433	39.0888833	14	-38	35.09857	77.2954	-42
2014	15	93.54347	78.2991667	39.6	-599	53.945	677.9956	-624
2013	8	78.10966	70.131725	-27	65	104.911819	5.142809	99.8
2012	3	104.66002	101.695485	-5	96.5	109.984	5.142809	105
2011	15	54.1660883	39.027355	-52	39	106.9640504	0.05619142	106
2010	9	77.6496483	68.43349167	-18	-8	95.49653	76.50029	19
2009	3	65.9217183	62.605095	-8	-105	74.08496	167.61349	-93
2008	4	90.2441667	86.375265	52	-701	38.8	787.867	-749
2007	10	73.4005233	63.123033	-16	30	89.3099	33.14022	56
2006	3	54.3606767	51.50799167	0	-3	54.15755	1.61389	52.5

Note: Idif₁: difference between premium of payer $wa'd$ on commodity swap and premium of receiver $wa'd$ on commodity swap. Idif₂: difference between premium of payer $wa'd$ on commodity and premium of receiver $wa'd$ on commodity. Pdif: difference between premium of payer $wa'd$ on commodity swap and premium of payer $wa'd$, on commodity. Rdif: difference between premium of receiver $wa'd$ on commodity swap and premium of receiver $wa'd$ on commodity.

Table (8) The Profit for two parties for $wa'd_{\text{dān}}$ on commodity swap and $wa'd_{\text{dān}}$ on commodity

Date	Idif ₁	Profit for $wa'd_{\text{dān}}$ on commodity swap		Pdif	Rdif	Profit for $wa'd_{\text{dān}}$ on commodity		Idif ₂
		Payer profit	Receiver profit			$wa'd_2$ profit	$wa'd_1$ profit	
2016	-15	17.43770713	32.9876605	0.5	16	16.95618	-10.03789	27
2015	-9	22.81145667	31.72061667	44	59	-21.46057	-27.6034	6
2014	-15	35.84903	51.01833	79	635	-43.32584	-584.29644	541
2013	-7	35.5636733	42.68360833	29	-57	6.217341	100.046351	-94
2012	-3	18.16657997	21.02708167	23	-123	-4.7732	144.67871	-149
2011	-15	59.387345	74.52591163	62	-30	-2.490504	104.536191	-106
2010	-9	18.81035167	28.02650833	17	24	1.92347	4.13971	-2
2009	-3	21.99828167	25.314905	8	126	14.00084	-101.04769	115
2008	-4	89.36332	93.06640497	146	790	-56.3842	-697.5018	641
2007	-10	27.3194767	37.5803	8.5	-3.6	18.83081	41.20058	-22
2006	-3	18.6743233	21.52700833	23.7	23.6	-2.16175	59.24191	-61

Note: Idif₁: difference between Islamic payer profit and Receiver profit. Idif₂: difference between $wa'd_1$ profit and $wa'd_2$ profit. Pdif: difference between Islamic payer profit and $wa'd_2$, call option, Rdif: difference between Islamic receiver profit and $wa'd_1$ profit, put option.

Figure (4.1) profit for Islamic commodity swaption

Figure (4.2) profit for *wa'dān* on commodityFigure 4 (1, 2): the profit for both parties in *wa'dān* on commodity swap and in *wa'dān* on commodity Figure (4.3) profit for payer on swap and *wa'd₂* Figure (4.4) profit for receiver on swap and *wa'd₁*Figure 4 (3, 4) the profit for both parties in *wa'dān* on commodity swap and in *wa'dān* on commodity

The profit for the WCS is already clarified in table 5. Figure 4.2 shows that WCO is more profitable for *wa'd₂*, call option, than *wa'd₁*, put option, which suffers huge losses during the test period. Table 8 indicates that the enormous losses of *wa'd₁* happened in 2008 and 2014 with losses amounting to \$697.5 and \$584 respectively. These losses were caused by the premium prices fluctuation that happened within the study period. The profit that the holder of *wa'd₁* earned during the period of the study is between \$4 and \$144. The holder of *wa'd₂* earned between \$6 and \$16. However, the holder of *wa'd₂* had losses that ranged between \$2 and \$56 while the holder of *wa'd₁* had losses that ranged between \$10 and \$697. In table 8 the $Idif_2$ indicates that the greatest difference between *wa'd₂* and *wa'd₁* is in 2008 and

2014 with the value being \$641 and \$541 respectively where *wa'd₂* was more profitable than *wa'd₁*. However, in 2011, 2012 and 2013 with values of \$106, \$149 and \$94 respectively, *wa'd₁* was more profitable than *wa'd₂*. Profits in these years can be explained by the fluctuation of the premium prices due to low market expectation of oil prices meaning that the *wa'd₁*, put prices rose. On the other hand, *wa'd₂*, call prices rose when there was a high market expectation of oil prices (García & Prokopiw, 2010, p. 1). When comparing the proposed model of the study with *wa'dān* on commodity, figure 4.3 shows that the profit for payer *wa'd* on commodity swap is more profitable than *wa'd₂* due to the positive profit that the payer *wa'd* on commodity swap earned without any loss. Table 8 reveals that the profits of

the payer ranged from \$17 to \$89 without any loss. The receiver $wa'd$ on commodity swap is more stable than the $wa'd_l$. This is clear by observing figure 4.4 that reveals that the receiver $wa'd$ on commodity swap has positive profit without any loss and slightly less than $wa'd_l$. Table 8 indicates that the profit range for the receiver $wa'd$ on commodity swap is between the \$21 and \$93. These results are due to the special characteristic in $wa'd\bar{a}n$ on commodity swap that permit the holder to swap for several times in one year with two-month intervals while $wa'd\bar{a}n$ on commodity is exercised only one time at maturity date.

Therefore, the data above, as presented in the tables and figures, indicates that the study must reject the null hypothesis H_{3_0} and accept the alternative hypothesis H_{3_a} that Islamic commodity swaption (WCS) offers more profitability than commodity options (WCO) for both parties. The proposed model provides the holder with positive effect for $wa'd\bar{a}n$ on swap more than what is offered in normal $wa'd\bar{a}n$ due to the special characteristic in $wa'd\bar{a}n$ on swap that permit the holder to swap for several times in one year.

4.3 Monte Carlo simulation

Monte Carlo Option Price is a method to calculate the value of an option with multiple sources of uncertainties and random features, such as changing interest rates, stock prices or exchange rates, etc. (Lu, 2011, p. 1). In this study, RStudio software is used to easily create a sequence of a random number indicating the uncertainties that can occur in the proposed model prices. For comparing purpose, the study examines the accuracy of Black-Scholes and Black model prices by comparing them with Monte Carlo price. The following two formulas are for the Monte Carlo pricing model, which generate random numbers to predict the result and call price respectively.

$$S_{n+1}^K = S_n^{(k)} + rS_n^{(k)}\Delta t + \sigma S_n^{(k)}\varepsilon_n + 1\sqrt{t}, \quad S_0^K = S$$

$$c(s) = (1+r\Delta t)^{-N} \left\{ \left(\frac{1}{m} \sum_{i=1}^m \int (sN)^{(k)} \right) \right\}$$

Now we insert all data to the Monte Carlo model to check the accuracy of our results by comparing the Monte Carlo approximation with the exact values computed from the Black and Black Scholes models. The results are given in table 9.

Table (9) Comparing the accuracy of Black and Black Scholes model with Monte Carlo simulation

Product type	MCE (10.000) for each 1000		Black (1976)		Black & Scholes (1973)	
	Call	Put	Call	Put	Call	Put
Islamic commodity swaption	70.96967	62.1385	70.978	62.1348	————	————
Conventional commodity swaption	78.81121	95.30912	78.81222	95.2877	————	————
Islamic commodity option	73.78957	174.54	————	————	73.792 76813	174.47 595

Note: MCE is Monte Carlo estimates

Figure (5) $wa'd_2$ (call) and $wa'd_1$ (put) simulation for Islamic commodity swaption respectively

Figure (6) call and put for Conventional commodity swaption respectively

Figure (7) $wa'd_2$ (call) and $wa'd_1$ (put) for Islamic commodity option respectively

Figure 5 shows the option price as well as its mean return from simulation and it revealed that the mean price is close to the price of the Black model for the proposed model of the study which is 70.969 and 62.1385 for payer $wa'd$ based on swap and receiver $wa'd$ based on swap respectively. These numbers are very close to the Islamic Black model prices for the proposed model that are indicated in table 9 which are 70.978 and 62.1348 for payer and receiver respectively. These results were obtained after running 10,000 iterations for each 1000 which are represented in the figures in the y axis (frequency). Figure 6 shows the mean return of conventional commodity swaption as 78.811 and 95.309 for both payer swaption and receiver swaption respectively; this is very close to the Black (1976) which is found in table 9 with values of 78.812 and 95.287 for both payer and receiver respectively. Figure 7 revealed that MC (Monte Carlo), in the simulation is 73.789 and 174.54 for both parties $wa'd_2$, call option, and $wa'd_1$,

put option, respectively. In addition, these number are similar to the Islamic Black and Scholes, modified by replacing the risk-free rate with the rate of return on triple A *shukūk*. The prices for both parties which appear in the table are 73.792 and 174.475 for $wa'd_2$ and $wa'd_1$ respectively. From these result, it can be concluded that the Islamic Black model, conventional Black model and Islamic Black and Scholes results are reliable.

5. Conclusion

The proposed model provides risk management departments a good hedging tool for protecting the two parties against price risk. In addition, the product can be implemented to hedge many other kinds of risks such as currency risk and profit rate risk. The proposed model will improve Islamic hedging technique and fill the gap of Islamic derivatives products. This study also offers empirical evidence based on real data.

The main limitation in this study is the lack of available literature that offer a working model for *wa'dān* and apply or price it on real data. This prevented the study from comparing its result with previous work. Another limitation for the field of the study is the difference of opinion among Islamic scholars regarding the permissibility of derivatives due to the *gharar* that some argue is inherently included in these kinds of products if the guidelines of constructing an Islamic product are not strictly followed. The pricing formula for these products is based on interest rate or risk-free rate which is *ribā* in Islamic finance. Subsequently, these reasons discourage researchers from producing more work and products in this area. Thus, most researchers do not invest time and effort to investigate and eliminate the prohibited element in such products. Hence, this is a rare topic in Islamic literature.

The objective of this study were to create an innovative product for hedging purposes and pricing the proposed model in accordance to Sharī'ah laws; modify Black (1976) model through substituting the risk-free-rate with the rate of return on triple A *shukūk*; clarify the usefulness of Islamic commodity swaption over the Islamic commodity option; contribute and enrich the literature on practicing *wa'd* and *wa'dān* on real data; and reduce the gap currently present in the Islamic derivatives field.

The results that the study found, based on Monte Carlo simulation, positively proved that the proposed model has an intrinsic value via the amount of money that the product can protect from the loss which is determined by the payoff formula of Black model. Moreover, switching the risk-free-rate with the rate of return on triple A *shukūk* in the Black model has positively affected both party profit in our proposed model and proved to provide higher profits when compared to the conventional pricing model. Triple A *shukūk* have a very low risk of default as they are based on an underlying asset which hedge the prices from fluctuation. In contrast, LIBOR is affected by recent financial crises due to the abnormally high interest rate, over %5, that led to prices fluctuation as well as the arbitrage that arises if the option prices are not affected by the interest rate (Hou & Skeie, 2014, p. 4). Consequently, both LIBOR and triple A *shukūk* affect the profit for both parties. The results of this study are somewhat similar to Hakim, Hamid and Meera (2016, p. 26) regarding the efficiency of Islamic CAPM.

This research shows the effectiveness of the proposed model, WCS, over the WCO regarding the two parties' profit. Due to the special characteristic in WCS that permit the holder to swap for several times in one year with two-month periods while WCO is only exercised one time at maturity date.

5.1 Recommendations for future research

1. Hedging commodity price risk as was suggested by researchers to use *wa'd* through *murābahah* contract to hedge against commodity price risk which is the goal for the proposed model in this study, yet this study uses *wa'dān* (Kok, Giorgioni, & Laws, 2014, p. 6).
2. This proposed model can be applied as a *mushārah mutanāqishah* (MM) product which is a diminishing partnership that contains two separate independent *wa'ds*, *wa'd* from customers to bank to buy the shares of the asset, and *wa'd* from bank to customers in case the customer needs early settlement. The two *wa'ds* are also used to protect the bank from default of customers and customer from price risk. Some scholars suggested the use of a third *wa'd*, yet the proposed model eliminates the need for the third *wa'd* (Zaini & Isa, 2011, p. 39)
3. This proposed model is useful for oil hedging due to the innovation of combining the swap and Islamic option (*wa'dān*) that provide both parties several benefits. First, the holder of the *wa'd* can exercise the option many times before the maturity date. Second it increases the profit chances for each party and decreases the loss chances due to the special characteristic of this product.

The main contribution of this study is to apply the proposed model on real data and find results that helped in understanding the effectiveness of the model regarding parties' profit and hedging risk which is an important aspect in protecting Muslim wealth and fills the gap of empirical studies in the field of Islamic derivatives. Further research in this Islamic derivatives area is important and essential to develop and analyze further the results found in this study and to apply them to real assets like commodity, currency and profit rate. The more time scholars invest in this field of study the more will be the chances of solving the problems facing the Islamic derivatives field.

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نمذجة أسعار عقود سلع المبادلة الإسلامية

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المستخلص. إن المشتقات التي تدير مخاطر السلع على مدى فترات متعددة ليست متوافقة مع الشريعة الإسلامية. تقترح هذه الدراسة نموذج خيار مبادلة أسعار السلع متوافق مع الشريعة الإسلامية (نموذج الوعدين على مبادلة السلع) للتحوط من مخاطر السلع. يجمع النموذج بين وعدين على مبادلة السلع من خلال عقد المربحة. تم استخدام نموذج بلاك (1976م) لتحديد القيمة الجوهرية للأطراف المقابلة المشاركة في العقد. ولكي نجعل نموذج بلاك متوافقاً مع الشريعة الإسلامية استبدلنا المعدل الخالي من المخاطر بالعائد على الصكوك ذات التصنيف الائتماني المرتفع (AAA). وقد قام الباحثون أيضاً بمقارنة النموذج المقترح مع نموذج خيار مبادلة أسعار الفائدة التقليدية، ومع خيار السلع الإسلامية (وعدان على السلع) لمعرفة مدى فعاليته وتأثيره. تظهر نتائج اختبارات النموذج أن نموذج التسعير الإسلامي المقترح له تأثير إيجابي أعلى من نموذج خيار مبادلة أسعار الفائدة التقليدي. علاوة على ذلك، فإن نموذج خيار مبادلة السلع الإسلامية المقترح أكثر كفاءة من نموذج خيارات السلع الإسلامية. وقد تم إثبات موثوقية النموذج المقترح من خلال محاكاة مونت كارلو التي أجريت مع 10,000 تكرار.

الكلمات الدالة: التحوط الإسلامي، خيار مبادلة السلع الإسلامية، وعدان على مبادلة السلع.

تصنيف KAUJIE: K1, K14, L31