OPTIONS TRADING STRATEGIES FOR THE PRICE COVERAGE OF THE ALGERIAN OIL BARREL SAHARA BLEND

Adlane **HAFFAR**[*]
Eric **LE FUR**[**]
Nour El-Islam **DJEDAA**[***]
Samer **MEHIBEL**[****]

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Corresponding author: adlene.haffar@usthb.edu.dz

SUMMARY

This paper focuses on the problem of hedging the risk of financial loss generated by the fall in the price of the Algerian oil barrel Sahara Blend, with the aim of proposing an approach allowing the reduction of financial losses, following unfavorable movements in oil prices. After a reminder on the strategic importance of the energy sector for the Algerian economy, we will evaluate the derivative products using different models. We present some option hedging strategies. Our results indicate that the use of options would effectively cushion a possible drop in the price of Sahara Blend, provided that the choice of the option exchange strategy is optimal. The study covers the period from 12/31/2019 to 06/30/2021, and the data is available on the websites www.oilprice.com and www.fred.stlouisfed.org.

Finally, the results indicate that taking into account the cost of hedging and gains at maturity, bear spread and traddle strategies remain the most optimal.

[*] University of Science and Technology Houari Boumediene, Faculty of Mathematics, adlene.haffar@usthb.edu.dz, adlane.haffar@gmail.com MSTD Laboratory, Algeria.

[**] INSEEC School of Business & Economics, elefur@inseec.com, France.

[***] Research Center in Applied Economics for Development, djedaa nour el-islam@hotmail.com, Algeria.

[****] Research Center in Applied Economics for Development, samer.mehibel@gmail.com, Algeria.

KEY WORDS: B inomial tree model; Black & Scholes model; Energy Derivatives; Monte Carlo simulation; Option trading strategy.

CLASSIFICATION: G120; G130; G150; G170.

استراتيجيات تداول ا لخيارات لتغطية أسعار مزيج النفط الجزائري برميل الصحراء

ملخص

تركز هذه الورقة البحثية على مشكلة التحوط من مخاطر الخسائر المالية الناجمة عن انخفاض أسعار برميل النفط الجزائري- صحاري بلاند -بهدف

اقتراح منهجية تسمح بخفض الخسائر المالية، بعد التغييرات الغير مواتية في أسعار النفط. بعد التذكير بالأهمية الاستراتيجية لقطاع الطاقة بالنسبة للاقتصاد الجزائري، قمنا بتقييم المشتقات المالية بناءً على نماذج مختلفة، كما قدمنا بعد استراتيجيات تحوط الخيارات المالية. تبين النتائج المتحصل عليها أن استخدام الخيارات المالية يمكن أن يخفف بشكل فعال أي انخفاض محتمل في سعر الخام الجزائري- صحاري بلاند-شريطة أن يكون اختيار استراتيجية تبادل الخيارات هو الأمثل.

تغطي الدراسة الفترة من 31/12/2019 إلى 30/06/2021 والبيانات متاحة على المواقع الإلكترونية www.oilprice.com و.www. fred.stlouisfed.org

أخيرًا، تشير النتائج إلى أنه مع الأخذ في الاعتبار تكلفة الحماية والأرباح عند الاستحقاق، تظل استراتيجيات Bear Spread و traddle هي الأفضل.

كلمات المفتاحية: البناءالشبكي ذي الحدين، نموذج بلاك وسكولز، المشتقات المالية، محاكاة مونت كارلو، استراتيجية نداول الخيارات.

STRATEGIES D'ÉCHANGE D'OPTIONS POUR LA COUVERTURE DU COURS DU BARIL DE PÉTROLE ALGÉRIEN SAHARA BLEND

RÉSUMÉ

Le présent article traite de la problématique de couverture du risque de la perte financière, générée par la chute du prix du baril de pétrole Algérien Sahara Blend, dans le but de proposer une démarche permettant la réduction des pertes financières, à la suite de mouvements défavorables des cours pétroliers. Nous allons démontrer à travers ce travail, que le recours aux marchés financiers par la prise de positions dans les produits dérivés, notamment les options, permettrait d'amortir efficacement une éventuelle baisse constatée dans le cours du Sahara Blend, à condition que le choix de la stratégie d'échange d'options soit optimale. Après avoir fait un rappel de l'importance stratégique du secteur de l'énergie pour l'économie algérienne, nous évaluerons les produits dérivés par différents modèles, puis nous développerons quelques stratégies de couverture d'options, enfin, nous interpréterons les résultats dégagés des stratégies de couverture du cours du baril de pétrole Sahara Blend. L'étude s'étale sur la période du 31/12/2019 au 30/06/2021, et les données sont disponibles sur les sites internet www.oilprice.com et www. fred.stlouisfed.org. Enfin, les résultats indiquent qu'en tenant compte du coût de la couverture et des gains à échéance, les stratégies bear spread et traddle restent les plus optimales.

KEY WORDS : Produits dérivés, modèle de Black & Scholes, modèle de l'arbre binomial, simulation de Monte Carlo, stratégie d'échange d'options.

INTRODUCTION

The current unprecedented global health crisis is having a very significant economic impact. Indeed, the lockdown imposed by the authorities and the drastic prevention measures have resulted in a radical change in household consumption behavior, causing crises in several sensitive sectors. A fall in the global demand for fossil fuels followed, in fact, between January 1, 2020 and April 21, 2020, the drop was 70%, and between March 3 and April 21 the fall was 62%. Algeria as a rentier economy depends extremely on hydrocarbon revenues. In this very particular and uncertain context, Algeria, like many other oil-producing countries, finds itself in a difficult situation with short term and then long-term repercussions that look disastrous.

The search for methods that are both easy to implement and effective, in order to cope with the financial risks generated by the fall in crude oil prices, is essential at this stage. Derivatives, especially options, are financial instruments that could meet the expectations of crude oil market players, because of their speculative, arbitrage and hedging purposes. This last characteristic is, without a doubt, the most attractive in our case given the large trading volumes on this hedging instrument on the oil markets. In this context, the problematic of our paper is to find out whether the use of options would make it possible to effectively hedge against the risk of a violent drop in oil prices caused by a major health crisis. For that purpose, we retain the price of Sahara Blend, the reference name of the Algerian crude oil barrel, which is quoted on the London market.

To deal with our problematic, we put some hypothesis. First, options represent a reliable alternative to the hedging of a long position taken on the Sahara Blend. Second, the acquisition cost of an option is not an obstacle to the implementation of an optimal hedging strategy, provided that the chosen combination meets the hedging objectives set. Third, the choice between subscribing to an isolated option or implementing a strategy involving the purchase or sale of several options depends on the scenarios ultimately envisaged, as well as on the approach adopted to reach an optimal solution. Finally, stock option valuation models do not take into account all the characteristics of the Sahara Blend, but nevertheless give reliable results.

The rest of this paper is organized as follows: Section 1 reviews the literature. Section 2 emphasizes the strategic importance of the oil sector in Algeria. Section 3 describes the methodology and data. Section 4 presents different evaluation methods of options of Sahara Blend. Section 5 explores the implementation strategies of option trading. Section 6 discusses the results. Section 7 concludes.

1-RELATED LITERATURE

The development of energy derivatives markets is one of the main reasons for the financialization of the energy market. Derivatives were first conceived as instruments for hedging against risk (MacDonald et al., 2006; Cotter and Hanly, 2006, 2012). The crude oil market is no exception and there is thus a large literature on the hedging of this commodity from derivatives. For example, many studies use options and futures contracts to examine market efficiency. The results contradict each other. Studies covering the 1980s and 1990s indicate evidence in favor of efficiency (Bopp and Sitzer, 1987; Bopp and Lady, 1991; Crowder and Hamid, 1993; Gülen, 1998; Peroni and McNown, 1998) as well as extending until the 2000s (Abosedra and Baghestani, 2004; Switzer and El-Khoury, 2007; Alvarez-Ramirez et al., 2008; Kim, 2015). On the other hand, many other studies fail to demonstrate the inefficiency of the crude oil market (Quan, 1992; Deaves and Krinsky, 1992; Moosa and Al-Loughani, 1994; Fujihara and Mougoue, 1997; Shambora and Rossiter, 2007). The interaction between spot and futures markets for crude oil has also been analyzed (e.g., Coppola, 2007; Bekiros and Diks, 2008).

The first empirical work of Chen et al. (1987) concludes that a substantial part of the spot price risk can be eliminated through futures contracts. However, Fleming and Ostdiek (1999) is a rare article that refutes the idea that derivatives markets can reduce volatility in spot crude oil markets. Indeed, using different econometric approaches, studies generally show that futures contracts provide hedging for investments in crude oil markets. For example, Veld-Merkulova and De

Roon (2003) develop a term structure model of commodity futures returns. This strategy minimizes both spot price risk and basis risk by using two futures contracts with different maturities. The results show that this strategy outperforms simple stack-and-roll hedging. Additionally, Bühler et al. (2004) demonstrate that the oil market is characterized by two price regimes – when the oil spot price is high (low), the futures price sensitivity is low (high). They propose a model with two continuous-time partial equilibrium regimes. This model implies relatively high (low) hedge ratios when oil prices are low (high). Ripple and Moosa (2007) examine the hedging effectiveness and NYMEX crude oil futures contract maturity. From daily and monthly data on the West Texas Intermediate (WTI) crude oil futures and spot prices, they show that futures hedging is more effective when the near-month contract is used.Switzer and El-Khoury (2007) confirm the previous study and show that hedging performance is improved when asymmetries are accounted for. In addition, Alizadeh et al. (2008) and Yun and Kim (2010) argue that state-dependent hedge ratios in the NYMEX can provide a significant reduction in portfolio risk. Shiraya and Takahashi (2012) use a Gaussian model of mean reversion of commodity spot prices. From 3 futures contracts with different maturities, they calculate the hedging positions by matching their sensitivities to the various sources of uncertainty. They demonstrate that their Gaussian model outperforms the stack and roll model. More recently, Shrestha et al. (2018) confirm that hedging effectiveness increases with hedging horizons. Finally, Wang et al. (2019) try to find the optimal hedge model for crude oil futures. They suggest that none of the models of interest outperforms all competitors for all futures contracts.

To our knowledge, no study focuses on derivatives applied to the Algerian Sahara Blend. Therefore, the originality of our paper lies in the implementation of strategies to hedge the risk linked to the fluctuation in the price of a barrel of Algerian oil Sahara Blend.

2-THE STRATEGIC IMPORTANCE OF THE OIL SECTOR IN ALGERIA

The hydrocarbon sector in Algeria has often been at the origin of internal economic crises (1986, 2009, 2014, 2020) but also offers ways out.

We can quote the crises from 1986 to 1996, the origin of which remains mainly the fall in oil prices, then the prosperous period of the 2000s until 2008 made possible due to the rise in oil prices. The view that is taken is often biased by the immediate or long-term interests of the various internal and external factors involved. It is for these reasons that this sector, which weighs heavily on the Algerian economy and society as a whole, reflects a complex and changing image, the structuring elements of which many analysts have difficulty identifying them. Before independence, the war of national liberation had been prolonged because of the positions of France which had the intention of separating the Sahara from Algeria in order to appropriate the recent oil discoveries. Since its independence to the present day, Algeria has seen its hydrocarbons sector crossed, alternately, by good times and periods of crisis which have led to changes and breaks in the institutional system governing it without ever questioning its strategic character. This is how we can date its evolution :

A first period, from 1962 to 1965, date of signature of the Algiers Accord with the French government, is characterized by the continuity of the management of Algerian oil by the mixed company REPAL under the influence of French legislation as documented in the Evian Agreements. However, 1963 witnessed the creation of the national company Sonatrach, a tool of the national hydrocarbons policy.

A second period, from 1965 to 1971, begins with the Algiers Accord and ended with the nationalizations of February 24, 1971. It was characterized by a difficult negotiating process with France, the start of the partnership with the American oil groups (Getty) and membership in OPEC.

The third period marks a qualitative change from 1971 to 1973 in the management of "Arab oil". It is that which begins with the nationalizations of February 1971 and ends with the historic reversal of prices following the war of October 1973 which unified the ranks of the Arab countries exporting hydrocarbons (oil embargo) against the USA in particular.

Then, there will be less good times or even crises. Thus, from 1973 to 1986, it is the period covered by the oil shock until the counter-shock resulting from the "price war" which was in fact a market share war led by Saudi Arabia to mark its supremacy against Iran. This led Algeria to its most serious financial crisis as a result of the ensuing fall in oil prices (less than $ 10 a barrel). With this brutal drying up of its financial capacities, Algeria - having no other choice - promulgated in 1986 the "liberal" law opening up the oil upstream, then revised it in 1991 to open gates to gas discoveries. From 1986 to 1998, the acute financial crisis widened to turn into a serious economic and social crisis (events of October 5, 1988) then political. This situation forced the country to reschedule its debt and to implement a structural adjustment program (1994-1998) under the aegis of the IMF and the World Bank.

However, Law 86 produced convincing effects. This is how Algeria in 1998 became the world's leading discoverer of hydrocarbons with prices that started to recover and larger quantities of gas produced for the European market (commissioning of the gas pipeline to Spain and extension of the gas pipeline to Italy). Nonetheless, an unforeseen but short-lived alert arose between 1998 and 1999 on financial balances due to the fall in oil prices (the price of a barrel fell to $ 10, i.e. half the price recorded in 1996). However, Algeria this time refused the proposal to support the Algerian balance of payments made by the Bretton Woods institutions. From 2000 until 2008 saw a decade of growth due to both the increase in prices and the quantities of hydrocarbons exported. It was in that auspicious situation that a new liberal law on hydrocarbons was promulgated in two stages: law n ° 05-07 of April 28, 2005 revised - in the sense of a more modest opening - by ordinance 06- 10 of July 29, 2006.

However, in the last quarter of 2008, a new situation of internal crisis emerged, resulting from the international financial crisis. The price of a barrel of oil dropped to less than $ 40, making long-term development financing problematic.

This long, contrasted and disrupted history of the hydrocarbon sector, particularly since 1973, has as a direct effect that the public authorities relax economic and social demand management policies in periods of rising oil prices and tighten them up in periods of low prices.

Thus, the complementary finance law for 2009 (LFC 2009) prohibited banks from granting consumption credit and limited bank payment instruments to only documentary credit in order to reduce imports.

Table 1. Hydrocarbon sector contribution to total exports (1997-2018)

Year	Hydrocarbon exports (Billion US$)	Total exports (Billion US$)	%
1997	13,18	13,82	95,37%
1998	9,77	10,14	96,35%
1999	11,91	12,32	96,67%
2000	21,06	21,65	97,27%
2001	18,53	19,09	97,07%
2002	18,11	18,71	96,79%
2003	23,99	24,47	98,04%
2004	31,55	32,22	97,92%
2005	45,59	46,33	98,40%
2006	35,61	54,74	65,05%
2007	59,61	60,59	98,38%
2008	77,194	78,589	98,22%
2009	44,415	45,168	98,33%
2010	56,121	57,09	98,30%
2011	71,661	72,888	98,32%
2012	70,584	71,736	98,39%
2013	63,327	64,377	98,37%
2014	58,462	60,129	97,23%
2015	33,081	34,565	95,71%
2016	27,918	29,309	95,25%
2017	33,202	34,569	96,05%
2018	38,897	41,115	94,61%

Source: (2018, 2013) Bank of Algeria Annual Reports

This direct influence of the hydrocarbon sector on public policies can be explained by the fact that it contributes to a third of the national GDP, to more than two thirds of the fiscal revenues, to almost all of the foreign exchange earnings (97%), hydrocarbon exports represents 96% of total exports (Table 1) and the share of hydrocarbon levy in the total revenues (Table 2).

Table 2. The share of Hydrocarbon levy in the total revenues

Year	Total revenues (Billion DZD)	Hydrocarbon levy (Billion DZD)	%
2001	1505,5	1001,4	66,52%
2002	1603,3	1007,9	62,86%
2003	1974,4	1350	68,38%
2004	2229,7	1570,7	70,44%
2005	3081,7	2352,7	76,34%
2006	3639,8	2799	76,90%
2007	3687,8	2796,8	75,84%
2008	5190,5	4088,6	78,77%
2009	4379,6	2412,7	55,09%
2010	4379,6	2905	66,33%
2011	5790,1	3979,7	68,73%
2012	6339,3	4184,3	66,01%
2013	5940,9	3678,1	61,91%
2014	5738,5	3388,4	59,05%
2015	5103	2373,5	46,51%
2016	5110,1	1781,1	34,85%
2017	6047,9	2177	36,00%
2018	6751,4	2887,1	42,76%

Source: (2018, 2013) Bank of Algeria Annual Reports

It is clear that the Algerian economy depends almost entirely on the oil sector, as the latter is the backbone on which it is based, and this is due to the basic role it plays in the overall economy, as well as to the pace of growth of this sector compared to the rest of the other sectors on the one hand, and on the other hand to the large financial collections it generates from foreign currency as a result of the process of exporting abroad (Table 1).

Covid-19 has had an impact of the oil sector in the world as well as in Algeria through the price of its oil "Sahara Blend". This impact manifested itself in a downward started in the beginning of January 2020 with the price of US$70 to reach US$11in April 21st, 2021. This shock unique in history in terms of its magnitude. Oil prices in general which fell instantly around US$20 per barrel in April 2020. While the price of a barrel of Brent was above US$100 between 2011 and 2013, it had already experienced a sharp drop at the end of 2014 for around US$35 dollars at the beginning of 2016. After a peak around US$80 at the end of 2018.

This situation is an unprecedented one in history, in which a health crisis amplified the economic crisis, an oil supply shock driven by the exploitation of the American shale oil, on the one hand. On the other hand, an oil demand shock, which fell by 20%, following the shutdown of economic activity around the world, following this pandemic.

It can be seen that the Algerian hydrocarbon sector has gone through several phases, influenced mainly by geopolitical considerations, which has generated in particular significant fluctuations in the price of a barrel of Sahara Blend oil, the losses generated by these latter could have been amortized over the financial markets, in particular through the use of derivatives, which will be the subject of the second and third part of this paper.

3- METHODOLOGY AND DATA

In order to determine the optimal trading strategy, for a hedge involving the use of options on the Sahara Blend barrel as the underlying asset, our methodology is subdivided into three distinct parts:

Valuation of premiums (option price) on the two basic positions, namely the call option and the put option: we first used the model of the binomial tree with periods, then the Black & Scholes model, and finally the Monte Carlo simulation. That enabled to compare the premiums of the three models and to choose one for each type of option falling under the second part of the methodology. We used the same types of data for the three models in question: the historical price of a Sahara Blend barrel[1] (daily observations for the 2019 year) from which we extracted the initial price t0 (12/31/2019); daily rates of return and the various probabilities of price variations; historical volatility; the risk-free interest rate at time T (06/30/2021) expressed by the LIBOR (London Inter-Bank Offered Rate[2]) latter which is considered as a benchmark rate on international financial markets. The period of the study is the same period as that of the observations of the data, since it is not a question of performing an econometric regression, but of

[1] https://oilprice.com/oil-price-charts/
[2] https://fred.stlouisfed.org/series/

evaluating hedging strategies based on options. The valuation models for these options are the binomial tree model, the Black and Scholes model and Monte Carlo simulation.

Implementation of the different options trading strategies at time t0, those are divided into two categories. The first category allows to benefit from a gain in the event of an increase in the price of a barrel of oil according to several possible scenarios on the price of the underlying asset, and the initial price of which was $ 67. The second category hedges against an eventual drop in the price below $ 67, and depending also on several scenarios that may arise in the event of a fall in the value of the underlying asset.

Discussion of the results released by each strategy at time T, for a final ST price of $ 40 and an exercise price K of $ 67. Then, analysis, interpretation and comparison between these strategies, which will allow to determine those seem the most appropriate for this type of situation (significant drop in the value of the underlying asset combined with strong fluctuations).

4- EVALUATION OF SAHARA BLEND OPTIONS

We first present the assumptions on which the different valuation methods will be based (Boness, 1964). Then, the binomial tree model, the Black & Scholes model, and the Monte Carlo simulation are detailed.

4.1- Assumptions

The hypotheses retained in our empirical study are as follows:

a. There are no transaction costs or taxes.
b. Borrowing and investment are possible at a risk-free interest rate (r).
c. All financial assets are perfectly divisible.
d. There are no restrictions on short sales. The proceeds from these sales are immediately and fully available.
e. The option is a European option.
f. There is no dividend on the underlying during the life of the option.
g. No arbitrage opportunity.

h. The risk-free rate, r, is constant and fixed regardless of the maturity of the option. It is equal to the LIBOR (London Interbank Offered Rate).
i. There is no security deposit or intermediation fees.
j. The option is valued in a risk-neutral universe.
k. The standard deviation of the price performance of the underlying is constant throughout the life of the option.
l. There is no discounting when calculating the gains of a strategy. Option values are rounded.

The stock option valuation models are valid for the valuation of options on Sahara Blend

4.2- Evaluation of options with the binomial tree model

The binomial model (or CRR model) provides a numerical method for evaluating options. It was first proposed by Cox et al (1979). The model is a discrete model for the dynamics of the underlying. Option valuation is calculated by applying risk-neutral probability for which the discounted prices are martingales. Tables 3 presents the initial parameters of this evaluation.

Table 3. Initial parameters of the binomial tree model

Initial price (S0)	Strike price (K)	Risk-free interest rate (r)	Standard deviation (σ)	Maturi ty date (T)	Number of periods (n)	Time between two periods (Δt)
67.00	67.00	0.01995	0.31459	0.5	6	0.0833333

Source: Made by the authors

At the initial date, the S_0 price of the asset is known. At Δt, the price of the underlying asset becomes S_0u in the case of an increase, or, S_0d in the case of a decrease. On the date $2\Delta t$, three prices can be reached;S_0u^2; S_0ud and S_0d^2, and so on. The values of the input parameters of the option valuation, i.e. u, d, a and p, are presented in Table 4.

Table 4. Parameters calculated of the binomial tree model

Up *(u)*	Down *(d)*	*a*	Risk-neutral probability *(p)*	*1 - p*
1.0950674	0.9131858	1.0016639	0.4864598	0.5135402

Source: Made by the authors

Options are valued by backward induction starting from the end of the tree, which corresponds to the expiration date T. At this date, the value of the option is known. it is equal to its payoff terminal. i.e. $max\ (S_T - K; 0)$ for a call and $max\ (K - S_T; 0)$ for a put. As the universe in which we are situated is assumed to be risk-neutral, the value at each node of the date $T - \Delta t$ can be calculated as the expected value at date T discounted at the risk-free interest rate r over a duration Δt. Similarly, the value of the option at any node of date $T - 2\Delta t$ is calculated by discounting over a period of time Δt the expected value of the option at date $T - \Delta t$ at the risk-free interest rate r and so on until the initial date. This method is presented in the Graphs 1 and 2:

Figure 1. Call evaluation by the binomial tree model

	***n* = 1**	***n* = 2**	***n* = 3**	***n* = 4**	***n* = 5**	***n* = 6**
						115.5367
						48.456
					105.5064	
					38.5536	
				96.347		96.347
				29.5203		29.2982
			87.9827		87.9827	
			21.2806		21.059	
		80.3446		80.3446		80.3446
		14.5333		13.5444		13.3224
	73.3695		73.3695		73.3695	
	9.4981		8.1888		6.47	
67		67		67		67
5.9926		4.7593		3.1422		0
	61.1835		61.1835		61.1835	
	2.6913		1.526		0	
		55.8719		55.8719		55.8719
		0.7411		0		-
			51.0214		51.0214	
			0		-	
				46.592		46.592
				-		-
Color	Content				42.5472	
	Underlying asset price				-	
	Value ofcall *in* n					38.8535
	Call value in 0					-

Source: Made by the authors

We note that for an initial value of the Sahara Blend of $67 and an identical exercise price, the call price estimated by the binomial tree is approximately $6, i.e. almost 10% of the value of the underlying asset. This is largely due to the high historical volatility of the stock and the uncertainties surrounding the international oil market.
The value of the put remains very close to that of the call ($5.33). This indicates the difficulty to build reliable forecasts on the future evolution of Sahara Blend. In other words, it seems easier to adopt a hedger behavior than that of a trader on this market.

Figure 2. Put evaluation by the binomial tree model

	***n* = 1**	***n* = 2**	***n* = 3**	***n* = 4**	***n* = 5**	***n* = 6**
						115.5367
						48.456
					105.5064	
					38.5536	
				96.347		96.347
				29.5203		29.2982
			87.9827		87.9827	
			21.2806		21.059	
		80.3446		80.3446		80.3446
		14.5333		13.5444		13.3224
	73.3695		73.3695		73.3695	
	9.4981		8.1888		6.47	
67		67		67		67
5.9926		4.7593		3.1422		0
	61.1835		61.1835		61.1835	
	2.6913		1.526		0	
		55.8719		55.8719		55.8719
		0.7411		0		-
			51.0214		51.0214	
			0		-	
				46.592		46.592
				-		-
Color	Content				42.5472	
	Underlying asset price				-	
	Value ofcall *in* n					38.8535
	Call value in 0					-

Source: Made by the authors

4.3- Valuation of options using the Black & Scholes model

The fundamental concept of Black and Scholes (1973) is to relate the implicit price of the option to changes in the price of the underlying asset. Merton (1976, 1998) was the first to publish a paper developing the mathematical aspect of an option pricing model, citing the work of Black and Scholes. Table 5 presents the initial parameters of the Black & Scholes model.

Table 5. Initial parameters of the Black-Scholes model

S0	K	r	σ	T
67.0000	67.0000	0.01995	0.3145955	0.5

Source: Made by the authors

At T year of expiry of the option, S_0 represents the price of oil, K is the strike price of the option, $r$is risk-free interest rate and σ is the annual volatility. We then calculate the values of d_1 andd_2 as well as the distribution function of the standard normal distribution for the parameters $d_1, d_2, -d_1$ and $-d_2$ noted respectively N(d 1), N(d 2), N(-d 1) et N(-d 2) in order to implement them in the Black and Scholes equations. Table 4 presents all these parameters.

Table 6. The calculated parameters of Black and Scholes model

d_1	d_2	N(d 1)	N(d_2)	N(- d 1)	N(- d_2)
0.1560673	-0.0663853	0.56201	0.4735355	0.43799	0.5264645

Source: Made by the authors

The value of the call is then equal to $6.2427 while the value of the put is $5.5777. It can be seen that in the case of the valuation of the call as well as the continuous put, the price of the options is slightly higher than that estimated by the binomial tree method. This is mainly due to the discount factor that is solicited n times in the discrete approach.

4.4- Evaluation of options by the Monte Carlo simulation

Metropolis and Ulam (1949) were the first to highlight the Monte Carlo method. Boyle (1977) develops a Monte Carlo simulation method for solving option valuation problems. This simulation refers to a family of algorithmic methods aimed at calculating an approximate numerical value using random processes, i.e. probabilistic techniques. In this context, the valuation formula of a European Black and Scholes option can be tested using Monte Carlo simulation. Table 7 presents the results of this simulation in a spreadsheet. ParametersS_0, K, r, σ and$T$ are respectively in C2, D2, E2, F2, and G2 cells.

Table 7. Test Black and Scholes formula by the Monte Carlo simulation

	A	B	C	D	E	F	G
1	60.7910	6.1474	S_0	K	r	σ	T
2	67.5608	-	67.0000	67.0000	0.01995	0.3145955	0.5
3	67.3071	-					
4	76.9297	-		μ	6.2688		
5	62.9788	3.9813					
…	…	…					
…	…	…					
1000	45.5890	21.1985					

Source : Made by the authors

The function inverse. standard. normal.distribution () is the reciprocal function of the distribution function of the centered-reduced normal law. Thus, the formula:

$$= inverse.standard.normal.distribution\big(random(\quad)\big)$$

simulates a random draw according to this distribution. We then enter in cell A1:

$$= \$C\$2 * exp((\$E\$2 - 0.5 * \$F\$2 * \$F\$2) * \$G\$2 + \$F\$2 * inverse.standard.normal.distribution(random()) * root(\$G\$2))$$

This formula simulates a final price of the underlying asset. In cell B1, we can write:

$$= exp(-\$E\$2 * \$G\$2) * max(A1 - \$D\$2; 0)$$

This is the present value of the final payment generated by a call. These formulas are copied down to line 1000. In cell E4, the average of the results is obtained by the formula:

$$\mu = mean(B1{:}\,B1000)$$

which represents the value of the call the put value can be calculated using the same process.

Finally:

$$IC\ 95\%\ binf = valueofunderlyingasset - \hat{\sigma} \times 1.96$$
$$IC\ 95\%\ bsup = valueofunderlyingasset + \hat{\sigma} \times 1.96$$

Where
$\hat{\sigma}$ is the annual standard deviation of the estimated series;
$IC\ 95\%\ binf$ is the lower bound of the 95% confidence interval of the mean;
$IC\ 95\%\ bsup$ is the upper bound of the 95% confidence interval of the mean.

Table 8 presents results for a call and Table 9 presents results for a put. These results are used to validate the call and put values obtained in the Black and Scholes model. It can be seen that these results are almost similar.

Table 8. Monte Carlo simulation results for call estimation

μ (call)	σ	M	σ̂	IC 95% binf	IC 95% bsup
6.2688	9.9210211	1000	0.3137302	5.6539	6.8837

Source: Made by the authors

Table 9. Monte Carlo simulation results for put estimation

μ (put)	**σ**	**M**	**σ̂**	**IC 95% binf**	**IC 95% bsup**
5.7092	7.5638261	1000	0.2391892	5.2404	6.1780

Source: Made by the authors

5- IMPLEMENTATION OF OPTION TRADING STRATEGIES[3]

This section presents the various strategies to hedge against possible declines in the price of Sahara Blend during the first half of 2020.

5.1- Buy call option

Details of Code R are presented in Appendix 1. This strategy corresponds to an anticipation of the market's increase. The buyer of the call anticipates that the price of the underlying will have risen and exceeded the strike price before the maturity date. The potential gain is unlimited while the maximum loss is equal to the price of the purchased option. The payoff is then written:

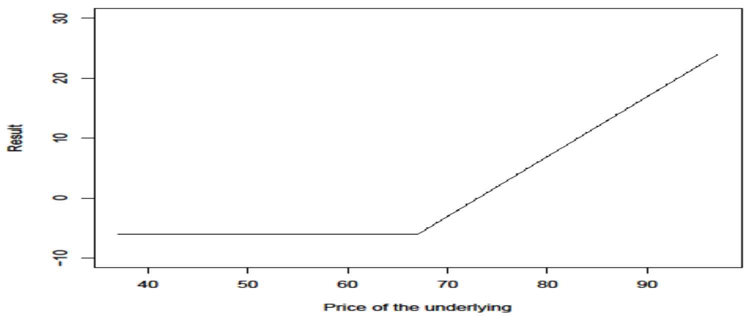
$$max\ (S_T - K; 0)$$

This formulation reflects the fact that the option is only exercised if $S_T > K$. In other words, if$S_T < K$, the option is abandoned and the

[3] Details of the R code used for each strategy are available from the authors.

payoff is null. The prospects of loss are limited to the amount of the premium paid, whereas the prospects of gain are all the more important as the price of the underlying increases. It is therefore an upside speculation strategy. On 12/31/2019, the investor buys a call option for \$6 at an initial price and strike price of \$67 and for a 6-month maturity. He anticipates that oil prices will increase. Graph 3 shows this strategy.

Figure 3. Gain profile of a long position on the call option



Source: Made by the authors

On the maturity date of 30/06/2020, the price per barrel of oil is \$40. Table 10 shows the total flow generated by a call buying strategy when $S_T = \$40$. Since the price of oil at maturity is lower than the strike price, the option will not be exercised. The investor therefore incurs a maximum loss of \$6.

Table 10. Gain at the maturity date of the call strategy

Strike price	Gain of call at maturity	Gross result	Buy call	Net result
$S_T \leq K$	0	0	6	-6

Source: Made by the authors

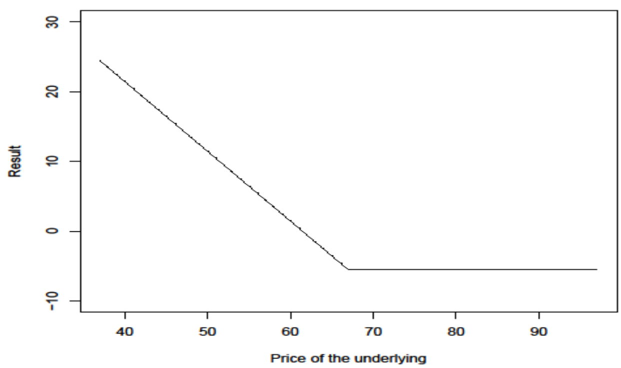
5.2- Buy put option

The buyer of a put anticipates a sharp decline in the underlying. The potential gain is unlimited. The maximum loss is equal to the price of the purchased option. The payoff of a put purchase is then written:

$$max\ (K - S_T; 0)$$

The exercise of the option is performed only if$S_T < K$. Si$S_T > K$, the option is abandoned and the payoff is null. The prospects of loss are limited to the amount of the premium paid, while the prospects of gain are all the more important as the price of the underlying decreases. It is therefore a strategy of speculation on the decrease of oil prices. For example, on 12/31/2019 an investor buys a put for $5.5 of an initial price and at a strike price of $67, maturing in 6 months. This strategy is represented in graph 4.

Figure **4.** Gain profile of a long-put position



Source: Made by the authors

On the maturity date, 30/06/2020, the barrel of Sahara Blend is at $40. Table 11 presents the total flow generated at maturity by a put buy strategy in the case where$S_T = 40$ $. At maturity, the price of oil is lower than the strike price. The investor will then exercise his right to buy. He buys a put at the strike price of $67. If he sells it immediately at the market price of $40, he realizes a gain of $27. Deducting the $5.5 premium, his net gain is $21.5. During the first half of 2020, the price of a barrel of Sahara Blend drops from $67 to $40. The holder of such a barrel therefore suffers a loss of $27. However, by hedging his position by buying a put, he could limit his loss to the price of the premium (-$5.5 = -27 + 21.5).

Table 10. Gains at the maturity of the put strategy

Strike price	Gain of put at maturity	Gross result	Buy put	Net result
ST ≤ K	27	27	5.5	21.5

Source : Made by the authors

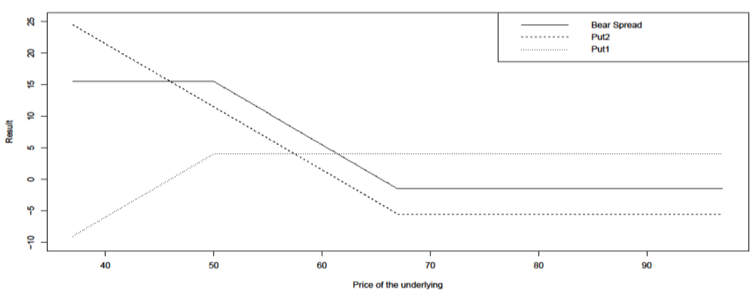
5.3- Bear spread strategy

In this strategy, the investor anticipates that oil prices will fall by the end of the maturity. However, he wants to hedge against a possible weak increase. This strategy therefore combines the buying of a put and the selling of a put. The payoff of a put sale is written as follows:

$$-max\ (K - S_T; 0) = min\ (S_T - K; 0)$$

For example, on 12/31/2019, an investor buys a put for $5.5 at an exercise price of $67 and a maturity date of 6 months. At the same time, he sells another put for $4 on the same maturity date but at a lower strike price than the previous one, equal to $50. Graph 5 shows this strategy.

Figure **5.** Bear spread strategy



Source : Made by the authors

On June 30, 2020 the barrel of Sahara Blend is $40 on the market. Being lower than the strike price of the two puts, the investor will exercise his right to buy and will be subject to the decision of the buyer of the sold put who will also exercise his right to buy. Table 12 shows the total flows generated at maturity. For the put sale, the investor is obliged to sell his put option at a price of $40. He incurs a loss of $10.

Deducting the premium, he received from the buyer of $4, the total cost is $6. With respect to the purchase of the put, the investor will buy the put at a strike price of $67. If he resells it immediately, he makes a profit of $27. Subtracting the $5.5 premium, the net gain is $21.5.

Finally, the bear spread strategy yields $15.5. By covering his position with a bear spread strategy the holder of a barrel of Sahara Blend could reduce his loss by $15.5 for a final result equal to -27 + 15.5 = -11.5 $.

Table 11. Gains generated by a bear spread strategy

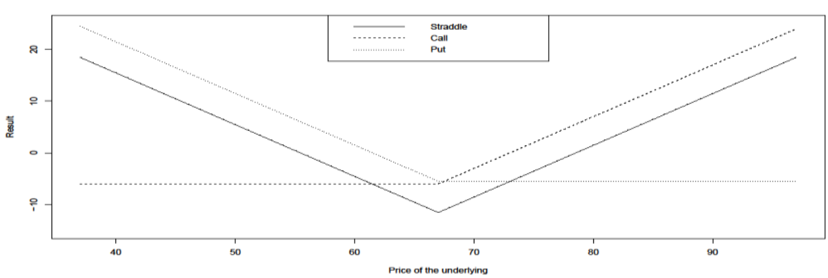
Value of underlying asset	Gain of sell put	Gain of buy put	Gross result	Sell put	Buy put	Net result
$ST \leq K1$	-10	27	17	4	5.5	15.5

Source : Made by the authors

5.4- Straddle strategy

The straddle is a strategy in which one anticipates a significant variation in the price of a barrel of oil without knowing the direction. The straddle corresponds to the simultaneous buying of a call and a put on the same underlying asset, with the same strike and maturity. For example, on 12/31/2019, an investor buys a call at $6 and a put at $5.5, with a strike price of $67 and a maturity of 6 months. Graph 6 presents this strategy.

Figure 6. Gains at straddle maturity



Source: Made by the authors

At the maturity date, June 30, 2020, the price of Sahara Blend is $40 on the market. Table 13 shows the flows generated at maturity with a straddle. At maturity, the price per barrel is lower than the strike price. The investor then exercises his right to buy put. He buys the put option at the market price of $40. If he sells it immediately, he wins $27.

Deducting the initial investment of $11.5 (in this case the call is not exercised), the straddle returns $15.5 to the investor. By hedging his position with a straddle, the holder of a barrel of Sahara Blend reduces his loss by $15.5, which is then equal to -27 + 15.5 = -$11.5.

Table 13. Straddle maturity gains

Strike price	Gain of buy call	Gain of buy put	Gross result	Buy call	Buy put	Net result
ST ≤ K	0	27	27	6	5.5	15.5

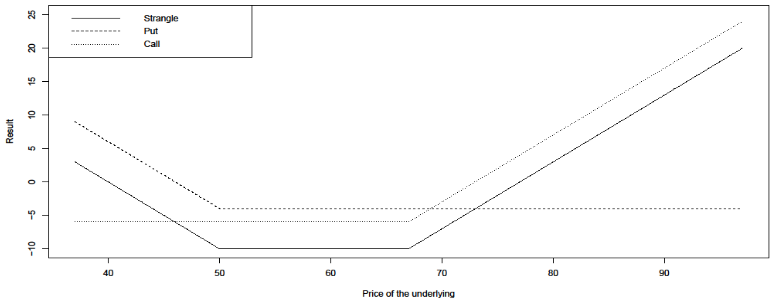
Source: Made by the authors

5.5- Strangle strategy

As in the case of a straddle, the strangle combines the simultaneous buying of a call and a put with the same maturity. However, the strike prices differ. In a strangle, one anticipates a very important movement on the underlying or an increase in the implicit volatility[4]. For example, an investor buys a put at $4 with an strike price $K_1 = 50$ $ and a call at 6 $ with an strike price $K_2 = 67$ $ of the same maturity date. Graph 7 presents this strategy.

[4]One can also be led to sell a Strangle for reasons strictly inverse to those which would push to buy it, for example in the case of the anticipation of a stagnation of the underlying or a decrease of the implicit volatility. However, selling a Strangle is more expensive than buying it. In fact, since the sale of options is riskier than the purchase, the margin required by the broker will be higher.

Figure 7. Strangle Maturity Gains



Source: Made by the authors

At the maturity date, June 30, 2020, the price of Sahara Blend is $40 on the market. Table 14 shows the flows generated at maturity with a strangle. The oil price is lower than the strike priceK_1. The investor then exercises his call option by buying a put at the market price. He wins $10. However, the two premiums cost a total of $10. The transaction is then null for the investor. For a holder of a barrel of Sahara Blend the implementation of the strangle strategy is not appropriate because it does not reduce the loss of -$27.

Table 14. Gains at maturity of the strangle strategy

Value of underlying asset	Gain of buy put	Gain of buy call	Gross result	Buy put	Buy call	Net result
ST ≤ K1	10	0	10	4	6	0

Source: Made by the authors

6- DISCUSSION OF RESULTS

Under the pricing assumptions used for European-type options, we noted that the valuation models for call and put options used allowed us to obtain relatively close premium amounts, which enabled us to set these values in the part dedicated to the implementation of options trading strategies, namely $ 6 for the call and $ 5.5 for the put ; the premium of the call being higher than that of the put predicted a priori an anticipation or forecast of an increase in the Sahara Blend barrel price, and therefore suggested the implementation of trading strategies instead of hedging ones ; this was subsequently reversed, as the price of the underlying asset experienced a significant drop in the order of 40% after 6 months.

The implementation of options exchange strategies on the Sahara Blend barrel price requires an initial investment, which can only be amortized by a favorable evolution of the price of the underlying asset at maturity, this leads us to believe that hedging strategies have more arguments for their implementation than trading strategies, given the appetite shown by decision-makers for this sector of great strategic importance, which most situations are manifested by aversion to risk. In addition, we have demonstrated through this paper the real usefulness of such an approach, to effectively cushion an oil shock occurring over a short period of time (less than a year). We have also found that the position taken becomes more efficient when two or more options are combined, depending on the exercise prices, whether they are equal or different, this not only reduces the investment cost, but also to improve the results of the strategy in targeted price intervals in advance, unlike a single position on the option, where the acquisition cost is higher, with a result that is less controllable. Regardless of the results obtained according to each strategy, it should be specified that the latter are not static, and can therefore be subject to adjustment according to the future evolution of the price of the underlying asset.

Our results indicate that given the price of the barrel at maturity and the exercise prices used, some strategies give conclusive results (buy put, bear spread, straddle) and others have proven to be of little use (buy call, strangle). The contributions of our study are threefold. First, as far as we know, no study has looked at the consequences of the use of options on the course of the Sahara Blend. Second, our study contributes to the academic literature on the use of derivatives in the energy market following a major health crisis. Finally, this paper allows to choose between several hedging methods to limit the risks related to a sharp fall in oil prices.

CONCLUSION

In this article, we question the use of options as a hedge against the risk of a violent drop in the price of Sahara Blend caused by a health crisis. We use three major models used for the valuation of options, the binomial tree model, the Black & Scholes model and the Monte Carlo simulation valuation. These three models give very similar results for both call and put option valuation estimates.

Based on the call and put valuation results, a few option trading strategies were selected according to a result profile that is more assimilated to hedging behavior than speculation. Our results allow us to classify the different strategies into two main categories. Taking into account the price of the barrel at maturity and the chosen strike prices, some strategies give interesting results such as the buy put, the bear spread and the straddle, while other strategies prove to be less effective (buy call, strangle). For a value of $40 per barrel of Sahara Blend on June 30, 2020, the purchase of the put reduces the loss by about 79%, the bear spread reduces it by 57%. The straddle gives a similar result to the bear spread unlike the strangle. For the latter, in spite of management fees and commissions that are supposed to be zero, the strategy has proven to be ineffective. Beyond the categorization of applicable strategies, our results suggest some complementary elements. First, options represent a reliable alternative to hedging a long position taken on the price of Sahara Blend. Second, the acquisition cost of an option is not an obstacle to the implementation of an optimal hedging strategy. Finally, stock option valuation models do not take into account all the characteristics of the Sahara Blend share price, but nevertheless give usable results because the value of the option has only a minor impact on the cash flows generated by the exchange transaction itself.

This article also provides implications for professional investors such as portfolio managers, traders and dealers as well as for holders of barrels of Sahara Blend or academics. Future research could focus on the comparison between cash settlement and physical settlement as well as on the introduction of American options.

REFERENCES

Abdesselam B., (1989). *Le gaz algérien : stratégies et enjeux*. Éditions Bouchène. Algérie.

Abosedra S., & **Baghestani H., (2004)**. On the predictive accuracy of crude oil futures prices. Energy policy, 32(12), 1389-1393.

Alizadeh A. H., Nomikos N. K., & Pouliasis P. K., (2008). A Markov regime switching approach for hedging energy commodities. Journal of Banking & Finance, 32(9), 1970-1983.

Alvarez-Ramirez J., Alvarez J., & Rodriguez E., (2008). Short-term predictability of crude oil markets: a detrended fluctuation analysis approach. Energy Economics, 30(5), 2645-2656.

BekirosS. D., & **Diks C. G., (2008)**. The relationship between crude oil spot and futures prices: Cointegration, linear and nonlinear causality. Energy Economics, 30(5), 2673-2685.

Black F., & **Scholes M., (1973).**The pricing of options and corporate liabilities. Journal of political economy, 81(3), 637-654.

Boness A. J., (1964). Elements of a theory of stock-option value. Journal of Political Economy, 72(2), 163-175.

Bopp A. E., & **Sitzer S., (1987)**. Are petroleum futures prices good predictors of cash value? The Journal of Futures Markets (1986-1998), 19(4), 705.

Bopp A. E., & **Lady G. M., (1991)**. A comparison of petroleum futures versus spot prices as predictors of prices in the future. Energy Economics, 13(4), 274-282.

Boyle P. P., (1977). Options: A monte carlo approach. Journal of financial economics, 4(3), 323-338.

Bühler W., Korn O., & **Schöbel R., (2004).** Hedging long-term forwards with short-term futures: a two-regime approach. Review of Derivatives Research, 7(3), 185-212.

Chen K. C., Sears R. S., & **Tzan D. N., (1987)**. Oil prices and energy futures. BEBR faculty working paper; no. 1344.

Coppola A. (2008). Forecasting oil price movements: Exploiting the information in the futures market. Journal of Futures Markets: Futures, Options, and Other Derivative Products, 28(1), 34-56.

Cotter J., & **Hanly J., (2006)**. Reevaluating hedging performance. Journal of Futures Markets: Futures, Options, and Other Derivative Products, 26(7), 677-702.

Cotter J., & **Hanly J., (2012)**. A utility based approach to energy hedging. Energy Economics, 34(3), 817-827.

Cox J. C., Ross S. A., & Rubinstein M., (1979). Option pricing: A simplified approach. Journal of financial Economics, 7(3), 229-263.

Crowder W. J., & **Hamed A., (1993).** A cointegration test for oil futures market efficiency. Journal of Futures Markets, 13, 933-933.

Deaves R., & **Krinsky I., (1992).** Risk premiums and efficiency in the market for crude oil futures. The Energy Journal, 13(2).

Fleming J., & **Ostdiek B., (1999).** The impact of energy derivatives on the crude oil market. *Energy Economics*, 21(2), 135-167.

Fujihara R. A., & **Mougoué M., (1997).** An examination of linear and nonlinear causal relationships between price variability and volume in petroleum futures markets. *Journal of Futures Markets*: Futures, Options, and Other Derivative Products, 17(4), 385-416.

Gülen S. G., (1998). Efficiency in the crude oil futures market. *Journal of Energy Finance & Development*, 3(1), 13-21.

Kim A., (2015). Does futures speculation destabilize commodity markets? *Journal of Futures Markets*, 35(8), 696-714.

McDonald R. L., Cassano M., & **Fahlenbrach R., (2006).** *Derivatives markets* (pp. 503-542). Boston: Addison-Wesley.

Merton R. C., (1976). Option pricing when underlying stock returns are discontinuous. *Journal of financial economics*, 3(1-2), 125-144.

Merton R. C. (1998). Applications of option-pricing theory: twenty-five years later. *The American Economic Review*, 88(3), 323-349.

Metropolis N., & **Ulam S., (1949).** The Monte Carlo method. *Journal of the American statistical association*, 44(247), 335-341.)

Moosa I. A., & **Al-Loughani N. E., (1994)**. Unbiasedness and time varying risk premia in the crude oil futures market. *Energy econom*ics, 16(2), 99-105.

Peroni E., & **McNown R., (1998)**. Noninformative and informative tests of efficiency in three energy futures markets. *Journal of Futures Markets*: Futures, Options, and Other Derivative Products, 18(8), 939-964.

Quan J. (1992). Two-step testing procedure for price discovery role of futures prices. The Journal of Futures Markets (1986-1998), 43(1), 139.

Ripple R. D., & **Moosa I. A., (2007)**. Hedging effectiveness and futures contract maturity: the case of NYMEX crude oil futures. *Applied Financial Economics*, 17(9), 683-689.

Shambora W. E., & **Rossiter R., (2007)**. Are there exploitable inefficiencies in the futures market for oil? *Energy Economics*, 29(1), 18-27.

Shrestha K., Subramaniam R., Peranginangin Y., & Philip S. S. S., (2018). Quantile hedge ratio for energy markets. *Energy Economics*, 71, 253-272.

Shiraya K., & **Takahashi A., (2012).** Pricing and hedging of long-term futures and forward contracts by a three-factor model. *Quantitative Financ*e, 12(12), 1811-1826.

Switzer L. N., & **El-Khoury M., (2007)**. Extreme volatility, speculative efficiency, and the hedging effectiveness of the oil futures markets. *Journal of Futures Ma*rkets: Futures, Options, and Other Derivative Products, 27(1), 61-84.

Veld-Merkoulova Y. V., & **De Roon F. A., (2003)**. Hedging long-term commodity risk. *Journal of Futures Mark*ets: Futures, Options, and Other Derivative Products, 23(2), 109-133.

Wang, Y., Geng Q., & **Meng F., (2019)**. Futures hedging in crude oil markets: A comparison between minimum-variance and minimum-risk frameworks. *Energy*, 181, 815-826.

Yun W. C., & **Kim H. J., (2010)**. Hedging strategy for crude oil trading and the factors influencing hedging effectiveness. *Energy Polic*y, 38(5), 2404-2408.