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Crude Oil Option Market Parameters and Their Impact on the Cost of Hedging by Long Strap Strategy

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ABSTRACT

This study aims to examine the impact of selected market parameters of the European crude oil options on the hedging costs and break-even points (BEPs) in the long strap strategy. The paper analyses the impact of the following market parameters: Volatility and the future price of crude oil, the strike price and time to expiration. The theoretical aspect consisted in using the black model to calculate the value of the option price and the long strap strategy BEP in the condition of ever-changing market parameters. These calculations, by determining implied volatilities of the options, have been adapted to the actual data from the exchange market for the options on WTI futures contract. It was made possible owing to the quik strike platform made available by a CME group exchange. To obtain information about the impact of volatility, time and price of futures on the costs of hedging and BEPs in the long strap strategy, the authors calculated the Greeks (delta, gamma, vega and theta) for the crude oil options. Having done that, not only could they determine the direction but also the power of impact that the parameters had on the final results in the long strap strategy.

Keywords: Commodity Options, Crude Oil Price Risk, Long Strap Option Strategy
JEL Classifications: G13, G32

1. INTRODUCTION

In the era of progressive globalisation, which, among others, results in faster information exchange, market risk, understood as price risk, plays an increasingly important role. The news of economic events is reflected in price fluctuations of financial and non-financial assets. Such an issue can be particularly seen in the commodity market and it has significant consequences for both producers and consumers.

Crude oil undoubtedly belongs to the group of raw materials that are of great importance for the global economy, as it is a raw material which has been an essential energy source in the world for many years. Currently, about 1/3 of primary energy is produced due to the process of oil crude refining. However, there are two basic restrictions regarding the increase in world oil consumption. First of all, it is non-renewable energy source, which means that its resources will run out in the future. Secondly, oil deposits are unevenly distributed around the world and their largest proven reserves are situated in such countries as: Saudi Arabia, Iran, Iraq, Kuwait, United Arab Emirates, Libya, Venezuela and Russia. Some of these countries cannot be classified as economically and politically stable. Moreover, the small number of oil suppliers (especially in the future) is the reason to consider this market oligopolistic.

Accordingly, there is high probability of disturbing the supply of this raw material, which is frequently reflected in significant price fluctuations. Price fluctuations are particularly important for oil producers, as they largely determine the state of the economy of these countries. A prominent example of a country that is dependent on oil crude market is Russia, where export of this raw material and its products constitutes more than a half of Russia's total export (in 2017 it was 60% of total export). Hence, it is claimed that in the long term, fluctuations in world oil prices may have a destructive effect on the stability of the oil industry

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in this country. Chikunov et al. (2019) emphasise that there is a strong need to develop scientific approaches which may lead to the evaluation and diagnosis of financial risk in Russian oil sector.

On the other hand, Arour et al. (2011) and Khamis et al. (2018) revealed that there is a significant impact of oil price fluctuations on the stock market at Gulf Cooperation Council Countries (Qatar, Kuwait, Oman, KSA, Bahrain, UAE). Tabash and Khan (2018) showed a strong interdependence between crude oil price volatility and the gross domestic product of UEA and Saudi Arabia. The impact of oil prices on the economy of Saudi Arabia was also studied by Foudeh (2017).

Also, oil prices fluctuations significantly influence the economic situation of countries that import large quantities of this raw material. These mostly include developing Asian countries, such as China and India. The consequences of oil price fluctuations can be noticed in some of the industries of the above-mentioned countries, as they determine the costs of production. For instance, this appears in the aviation sector. Kathiravan et al. (2019) showed that crude oil price fluctuations (WTI, Brent, Dubai) between 2007 and 2018 had a significant impact on return rates on shares of companies involved in the aviation sector in India. Additionally, changes in crude oil price affect the economic activity of both, developing and developed countries (Cunado and Perez de Garcia, 2005; Hamilton, 2003; Edelstein and Kilian, 2009).

Crude oil prices also affect such aspects of the economy as: the market value of crude oil companies, the inflation rate in oil importing countries, as well as the price of alternative energy sources (An et al., 2019). Following that, it is of crucial importance to search for the hedging methods that may help to avoid negative consequences of the changes of crude oil price on the economy of countries and individual enterprises, especially the refinery sector.

This paper focuses on the commodity (crude oil) options as well as on an option strategy structured with the derivatives. The long strap strategy discussed in the paper, when appropriate used, offers the opportunity of hedging effectively against the risk of crude oil price fluctuation. One of the objectives of the paper is to present the method for structuring the above-mentioned strategy as well as show some patterns for calculating the final result of its application. In addition, for the effective application of the long strap strategy, it is essential to have the skills sufficient to set out successfully the strategy break-even and stop-loss points. These numbers are strongly correlated with the price of the commodity options, which is why more light should be shed on the option pricing model. To this end, the authors decided to use the Black's model.

All the calculations made in the paper are referred to the commodity options in which the price of WTI oil futures contracts (traded on the NYMEX) is the underlying instrument. To determine the implied volatility of options other than ATM (at-the-money), the quikstrike platform available on the CME group website was also used for calculations. The calculated option premiums (option prices) were used to calculate the costs of hedging and break-even points (BEPs) in the long strap strategy and analyse their response to changing values of selected market parameter, which was the purpose of this paper. A more precise determination of the power of impact of these parameters was possible through meticulous calculation and analysis of four Greeks: Delta, gamma, vega and theta. They provided some information about the change in the cost of hedging in the long strap strategy when changing a selected market parameter by a unit. Practical application of the Greeks is manifested in supporting decisions of price risk managers. By calculating the Greeks, they can adjust their option parameters and strategies to the expected directions of changes in the commodity prices.

The remainder of the paper is organized as follows. Section 2 provides a literature review, in section 3 the construction of long strap strategy is presented. Section 4 discusses the used method and data of the study and final results is presented in sector 5. Finally, section 6 concludes the research paper.

2. LITERATURE REVIEW

Options, as derivative instruments with non-symmetric risk distribution, may be used by market participants in many different ways. Speculators trade options to profit from drops, rises or stagnation in prices of the underlying instrument. On the other side of the market there are hedgers, who consider options as tools to protect them against the risk of price fluctuation in financial assets (e.g., stock, bonds, currency exchange rates) or commodities (gold, oil, gas). However, each option market participant tends to focus on two key issues: the price of the base instrument on the last trading day (contract expiration day) and the option price. While the first one is unpredictable and may fluctuate freely in the future, the option price is already known on the date of taking a position in an option contract. This value is the key from the point of view of a success of followed option strategies created by short or long positions in different options.

Calculation of the value of an option (i.e. the option price or option's premium) is the most complicated process, as one may see by comparing valuation methods applied for different types of derivatives. In a nutshell, a valuation of these derivatives is a search for answers to the question: how much should a buyer of an option pay for the option for the price to be fair[1] for each party? The issue is rather complex as it requires setting the value of an option when bought (or sold). In turn, the value should counterbalance the payout to which the option buyer is entitled at a certain moment in the future i.e., on the last trading day. Consequently, many scholars tried to find the most effective options pricing model (2-1) and understand the relationship between market parameters and option's premium (2-2).

2.1. Option Pricing

The first attempts at valuating options date to the turn of 19th and 20th century. They are deemed modelled after Louis Bachelier's doctoral thesis of 1900. The thesis focused also on modelling stock prices and, according to Bachelier, the prices were to move according to the arithmetic Brownian motion. Many years later, in 1960, several papers were published that pushed forward the search for option valuation models. They mostly applied to stock

1 "Fair price" is a price which does not open the door to a potential arbitration on the market.

options. The most important papers devoted to the issue were written by J. Boness and P. Samuelson (Smithson, 1998).

However, the work by Black and Scholes published in 1973 is considered the breakthrough in the search for the model to estimate the option price. They presented a model valuating the European call option in which underlying asset was a dividend-free stock. The solution presented by Black and Scholes is based, as initially assumed, on the structure of a risk-free portfolio, using European options (Black and Scholes, 1973). The model has quickly gained popularity and the scientific circles made regular attempts at its improvement. In consequence, as early as 1973, Merton, using Black and Scholes's line of thinking as the basis, developed a model valuating the European call option in which the underlying asset was a stock with a fixed dividend payable before the expiry date of the option (Merton, 1973).

Continued efforts to improve the option pricing model and expand it by adding more types of underlying assets have led to the discovery of a method for valuating of commodity derivatives. It happened as early as in 1976 and the discovery was made by Black. Also note that the solution presented by Black applied not only to valuation of European commodity options but also to futures and forwards for commodities (Black, 1976).

Apart from the European commodity options, valuation of American options remains important, as their holders have the right to exercise them on any day before their expiration days. Similarly, to the European options, the options are traded on commodity exchanges for raw materials and energy such as NYMEX or ICE and are the most popular among participants of the exchanges. The leading method used to valuate the American option is the analytical approximation method combining solutions proposed in numerical models (including Black's model) and analytical models (such as binominal model (Cox, 1979)). Many research papers describing different approaches to the valuation of the options have been written. One of the first was the solution proposed by Barone-Adasi and Whaley (1987). In reference to Whaley's concepts (1986), they developed both the spot price model to valuate commodity options as well as options for commodity future contracts. In their study, they used Black's model for the European commodity option onto which the early exercise premium was added, arising from the optional early exercising the American option. Structured as described above, the model was discussed in papers published in subsequent years and the subject was further expanded by Bjerksund and Stensland (1993, 2002) as well as other analysts.

The literature offers examples of many other commodity option valuation models (both European and American), based on Black's concepts; however, they have been modified at a rather large scale. Revisions and attempts at improving valuation of these options were made by Schwartz (1997), Shreve (2004) and Clark (2011). However, until now, the solutions proposed by Black come as the most popular valuation model for these options.

2.2. Black's Model in Commodity Options and the Greeks

Black's solutions dating back to 1976 is a fairly easy method of valuating European commodity prices. The model is based on the assumption that the underlying instrument prices move as particles in the Brownian movement, which is a particular case of a stochastic Wiener process. In turn, calculation of the option premium concentrates on searching for a value balancing the payout for the option buyer on the contract expiry date. Eventually, with the respective initial assumptions, prices of European commodity call and put options are expressed with the following formulas (Clark, 2014; Hull, 2012):

$$V_0^C = e^{-r^d T}\left[f_0 N(d_1) - KN(d_2)\right] \tag{1}$$

$$V_0^P = e^{-r^d T}\left[KN(-d_2) - f_0 N(-d_1)\right] \tag{2}$$

Where

$$d_1 = \frac{\ln\left(\frac{f_0}{K}\right) + \frac{\sigma^2}{2}T}{\sigma\sqrt{T}} \tag{3}$$

$$d_2 = \frac{\ln\left(\frac{f_0}{K}\right) - \frac{\sigma^2}{2}T}{\sigma\sqrt{T}} \tag{4}$$

And
V_0^C – Price of the commodity call option,
V_0^P – Price of the commodity put option,
f_0– The future price of the underlying instrument,
K– Strike price of the option,
r^d– Continuously compounded riskless interest rate,
T– Time left until the option expiration,
σ^2– Yearly variance rate of return for the underlying instrument,
N– The standard normal cumulative distribution function.

The impact of some of the option parameters is analysed by using the Greeks. They provide information on how the option may change as a result of a changing a parameter by a unit. In this paper, four different Greeks were used: delta, gamma, vega and theta. Their mathematical interpretation and formulas which can be used to calculate the value based on Black model, are presented in Table 1.

The first of the presented coefficients, the delta, shows the option price response to a change in the future price of the underlying instrument (a commodity) by a unit. Delta is also identified with the proxy for the probability that an option will expire in the money (Hull, 2012). In turn, by calculating the gamma, one can learn about the impact of the future price of the underlying asset on the change in the delta. Mathematically, the delta is a partial second derivative of the option price against the price of the underlying asset. Another Greek, vega, is a partial first derivative of the option price calculated against price volatility of the underlying asset. Its value indicates how and by how much the option price is going to change given a 1% p.p. increase (or a decrease) in volatility of the underlying assets for which the option was sold. Theta offers some crucial information on the impact on the number of days to the last trading day on the option price. Theta shows a potential change in the value of the option when reducing the time to the last trading day by a time unit. the structure of the Black's model

Table 1: Mathematical interpretation and equations for selected Greeks

The Greeks	The Greeks as a derivative	Calculating the value of a coefficient based on Black's model
Delta	$\delta = \frac{\partial V}{\partial f}\theta$	$\delta = \omega e^{-r^d T} N(\omega d_1)$
Gamma	$\gamma = \frac{\partial \delta}{\partial f}$	$\gamma = \frac{e^{-r^d T} N'(d_1)}{f\sigma\sqrt{T}}$
Vega	$v = \frac{\partial V}{\partial \sigma}$	$v = e^{-r^d T} f N'(d_1)\sqrt{T}$
Theta	$\theta = -\frac{\partial V}{\partial T}$	$\theta = \omega\left[r^d e^{-r^d T} f N(\omega d_1) - r^d e^{-r^d T} K N(\omega d_2)\right] - \frac{e^{-r^d T}\sigma f N'(d_1)}{2\sqrt{T}}$

Source: own study based on (Węgrzyn, 2013), (Alexander, 2008), (Hull, 2012)

V–unit price of an option; ω=1 for the call option ω= –1 for the put option; N'(x) – standard normal probability density function, calculated from $N'(x) = \frac{e^{-x^2/2}}{\sqrt{2\pi T}}$; other symbols and in the black's model

would indicate a year as the unit but the typically considered unit is a day instead. Such analysis provides therefore more precise information on the impact of theta on the option price (Bittman, 2009; Hull, 2012).

Works by Taleb (1996), Hull (2012) or Węgrzyn (2013) offer some information on the Greeks covered in this paper and the method for their shaping depending on the type of the analysed options. In this paper, the Greeks have been used to analyse the power of the impact of some selected market parameters on the level of costs and BEPs in the long strap strategy. However, before they were determined, the method of structuring the strategy had been described briefly as well as equations helpful to determine the BEP points in the strategy were presented in more detail.

3. LONG STRAP STRATEGY – STRUCTURE AND BEP POINTS

The long strap strategy is formed by a combination of long positions in call and put options for the same underlying asset and the same time to expiration. Furthermore, the strike prices of these options are set at an identical level. It is also assumed that the number of positions taken in the call option is twice as high as the number of position in the put option. Therefore, in order to calculate the final result achieved in the long strap strategy, it is necessary to set out the final results in long positions of both put and call options with the right parameters and, subsequently, placing them in a manner appropriate for the strategy.

Assuming that K is the strike price of an option, *c* is a unit option premium for the call option and p is a unit option premium for the put option and F_T is the future price of a commodity on the expiration day, the profit function of long position in n call options (C(K)) is,

$$C(K) = \begin{cases} -nc & \text{if} \quad F_T < K \\ n(F_T - K - c) & \text{if} \quad F_T \geq K \end{cases} \tag{5}$$

and the profit function of long position in m put options (P(K)) is

$$P(K) = \begin{cases} m(K - F_T - p) & \text{if} \quad F_T < K \\ -mp & \text{if} \quad F_T \geq K \end{cases} \tag{6}$$

Applying the symbols used in the equation (5) and (6) and taking into account the structuring of the long strap strategy (i.e. assuming that n=2m), its final result R(K) is described by the following equation:

$$R(K) = \begin{cases} m(K - F_T - p - 2c) & \text{if} \quad F_T < K \\ 2m\left(F_T - K - c - \frac{1}{2}p\right) & \text{if} \quad F_T \geq K \end{cases} \tag{7}$$

From the point of view of a successful application of each option strategy, the BEP is a very important component. A BEP is a price level of the underlying asset giving the final result equal to 0 in a strategy. Therefore, the BEP indicates the necessary change in the price to avoid losses on the strategy. In case of a two-sided hedges i.e. protecting both against price increases and price drops (with the long strap strategy as a good example of such hedging), there are two BEPs. The first one informs about the minimum price drop (against the expiration price). When reached, the BEP will compensate for the losses resulting from paid option premiums. In the paper, it is recorded as BEP_D. The price of the underlying asset above which the long strap strategy (in case of an increase in prices) will be profitable is the second BEP, recorded as BEP_U. Their calculation method is closely related to the equation (7) and described as follows:

$$BEP_U = K + \frac{p}{2} + c \tag{8}$$

$$BEP_D = K - p - 2c \tag{9}$$

Since in the long strap strategy the number of positions occupied in the call option is twice as high as in the put option, the difference (K–BEP_D) will be always twice bigger than the (BEP_U–K) difference. Accordingly, the strategy must be applied predominantly when expecting rises in the prices of the underlying asset. Since the long strap strategy also uses a long position in the put option, earnings are possible also in case of drops in the prices of the underlying assets. However, the price must fall below BEP_D.

When analysing the equations (8) and (9), one may also notice that the BEP_D distance from the option price K is equal to the total cost (TC) of hedging which is equal to the sum of paid option premiums. In turn, the distance between BEP_D and the strike price K is twice shorter. In consequence, when TC stands for the TCs paid in the long strap strategy (TC = p + 2c), (8) and (9) equations may look as follows:

$$BEP_U = K + \frac{TC}{2} \quad (10)$$

$$BEP_D = K - TC \quad (11)$$

and when subtracted, give the dependency:

$$BEP_U - BEP_D = \frac{3}{2} TC \quad (12)$$

The equation (12) shows that the distance between the BEPs is strictly connected with the costs borne in the long strap strategy and is always 1.5 times higher. Consequently, a change in the value of BEP_U and BEP_D will result from a change in prices of options (option premiums) used in the strategy. For this reason, further on, when analysing the impact of individual market parameters, the notion of the costs of the strategy and the distance between the BEPs will be substituted.

4. DATA AND METHODOLOGY

As argued above, the BEPs in the long strap strategy (which also represent the TCs) are also dependent on the set strike price of an option. To analyse the dependence, the authors decided to analyse different situations, depending on the value of market parameters necessary to calculate prices of commodity options.

Market parameters of commodity options are based on the following initial assumptions:

- A 2% annual risk-free interest rate
- The future price of a commodity upon taking a position in the option contract for the commodity was 66 monetary units
- Volatility of the future price of the underlying asset (a commodity) expressed for the year, reached one of the three levels: 25%, 35% or 45%
- The last trading day of an option is 30, 20 or 10 days
- The strike price equal to 64, 65, 66 (ATM options), 67 or 68 monetary units.

The market parameters used in the equations have been selected carefully to offer the best reflection of the situation prevailing on the real market of WTI oil future option prices. The annual volatility of the commodity price typically oscillates within a 0.2-0.5, which prompted the authors' decision to use three different values from the range (0.25, 0.35 and 0.45) in the analyses. The future price of oil set at 66 USD/b is, in turn, a WTI price of June 01, 2018 and refers to an option with the delivery date falling in July (its expiration date is June 15, 2018 and a potential sale of the commodity takes place in July). In addition, these analyses also took into account periods of 30, 20 and 10 days since the number of option transactions on NYMEX or ICE is clearly the highest in the last month of the option activity. Accordingly, it was concluded that such option (and, consequently, option strategies) were the most interesting from the point of view of an exchange trading participant.

From the perspective of matching a theoretical valuation of options with their real (market) parameters, problematic is the relationship between volatility and the strike price. In the literature, it is referred to as the volatility smile. The name comes from the shape (curve) of the graph of the function where the strike price is an argument and values are equal to the volatility implied in the option. In this case, the graph of the function is a U-shaped parabole whose minimum is around the ATM strike price.

Therefore, the occurrence of this phenomenon differentiates the level of volatility of the implied options for the same instrument, having the same strike prices. To determine volatility of the implied options issued for WTI oil with their strike price different that the ATM option strike price, the authors used quikstrike platform. The platform is available on the CME Group website and offers many embedded tools which can be used also (apart from its capability to determine the above-mentioned volatility) to valuate the option by using different models (using the Black models as well as other models, see: (CME Group, 2018a, b)) or checking the effectiveness of a strategy by simulating the future prices of the underlying asset.

5. RESULTS

The tools available on quickstrike platform helped to determine the implied volatility for the options which strikes price are different that the price of the ATM option (in this case option with K=66 USD/b). The results of their application are presented in Figure 1. Values of other market parameters required for option valuation were assumed at the level identical to the level in section 4. The option strike price was changed every 1 USD and ranged between 64 and 68 USD/b.

When calculated the implied volatility for options which are not ATM options (K ≠ 66), three cases were analysed. The first one assumed volatility of the ATM option at 0.25, the second one at 0.35 and the third one at 0.45. According to Figure 1, a decrease in the strike price (K = 64 or K = 65) resulted in an increasing volatility of the option. For an option with the strike price K = 67 or K = 68, the volatilities were lower than the volatility of a respective ATM option. The number of days to expiration of an option did not have any major impact on the changes in the volatility parameter in the analysed options.

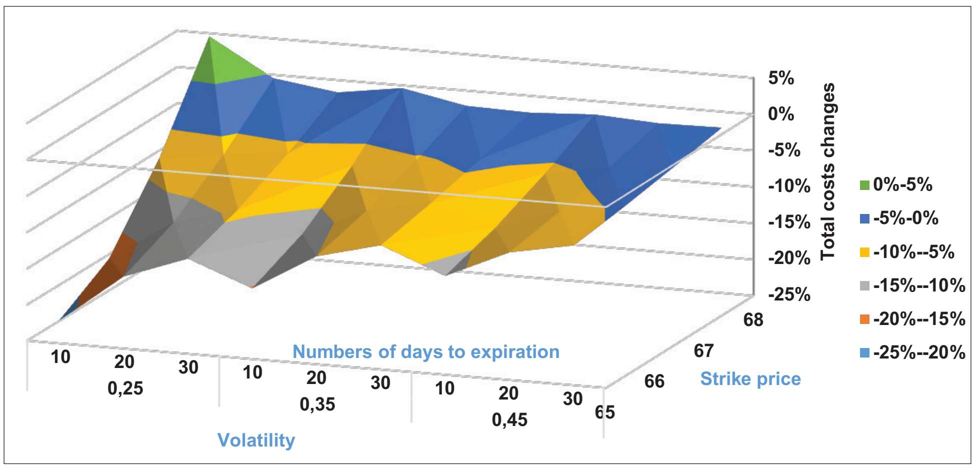
The value of implied volatilities obtained by using the quikstrike platform will allow to determine the prices of the European call and put options for the future WTI oil price. Black's model was used to calculate the price of the option. Obtained values allowed to determine the level of BEPs and the TC in the long strap strategy. To analyse how the TCs respond to a variable strike price, percentage changes in the BEPs were calculated while increasing the strike price by a unit. All results are presented in Table 2.

Figure 1: Changes in volatility implied for the future price of WTI oil options at set market parameters of ATM options

	64	65	66	67	68
ATM (σ=0,25;T=30)	0.2661	0.2569	0.25	0.246	0.2419
ATM (σ=0,25;T=20)	0.2653	0.2572	0.25	0.2464	0.2423
ATM (σ=0,25;T=10)	0.2666	0.2567	0.25	0.2454	0.2436
ATM (σ=0,35;T=30)	0.3663	0.3575	0.35	0.3452	0.3425
ATM (σ=0,35;T=20)	0.3664	0.3561	0.35	0.3456	0.343
ATM (σ=0,35;T=10)	0.3667	0.3562	0.35	0.3459	0.3425
ATM (σ=0,45;T=30)	0.4655	0.4561	0.45	0.445	0.443
ATM (σ=0,45;T=20)	0.4654	0.4572	0.45	0.4454	0.4428
ATM (σ=0,45;T=10)	0.4649	0.456	0.45	0.4466	0.4433

Source: Own analysis

Figure 2: Percentage changes in total cost with a strike price changed by a unit



Source: Own analysis

The calculations led to formulation of the following conclusions connecting the costs of hedging by the long strap strategy with the strike price and other market parameters of an option:

1. Increased volatility (with other option parameters remaining unchanged) increases the TCs in the long strap strategy. it is a consequence of a growth in the strike price both for the put and the call option
2. A reduction in the number of days to expiration (of the option strategy), with other option parameters unchanged, reduces the strike price both for the put and the call option. The dependence translates into a reduction of the TCs of the long strap strategy
3. By increasing the strike price, the put option price goes down and the call price goes up. Since in the long strap strategy twice as many positions are taken in call options than in put options, a higher strike price (with other parameters unchanged) limits the TCs of the long strap strategy.

These dependencies are derived directly from the Black's model as well as from the method underlying the long strap strategy structuring. Furthermore, they also affect the rate of changing the total strategy costs in case of a growing strike price (Figure 2).

As presented above, an increase in the strike price would typically result in decreasing distance between BEP_U and BEP_D (TCs). The rate of the decreases is slower when setting increasingly higher strike prices. Therefore, a reduction in the TCs of the long strap strategy will become the most intensive when changing the strike price from 64 to 65 units and hardly perceptible (usually below 2%) when "moving" from 67 to 68 units. Taking the impact of other market parameters into account, note that the rate of reduction of distances between BEPs in the long strap strategy is going down when volatility of the underlying asset is increasing. On the other hand, limitation of the number of days to expiration increases the rate of the reduction, with the only exception being a change in the strike price from 67 to 68 units. In that case, as a result of a shorter time to expiration (with other parameters remaining unchanged), the reduction rate of the TCs remains unchanged. Taking the lowest of the volatilities used (about 0.25), an increase in the TCs as a

Table 2: TC, BEP and final results for long strap option strategy

Parameters			Option premium		BEP and TC			BEP and TC changes (%)		
σ	T	K	Call	Put	D	U	TC	D	U	TC
0,2661	30	64	3,13	1,13	56,6	67,7	7,40			
0,2569	30	65	2,46	1,46	58,62	68,19	6,38	3,57	0,72	−13,78
0,25	30	66	1,88	1,88	60,35	68,83	5,65	2,95	0,94	−11,39
0,246	30	67	1,41	2,41	61,77	69,62	5,23	2,35	1,15	−7,43
0,2419	30	68	1,02	3,02	62,94	70,53	5,06	1,89	1,31	−3,31
0,2653	20	64	2,80	0,80	57,6	67,2	6,40			
0,2572	20	65	2,12	1,12	59,64	67,68	5,36	3,54	0,71	−16,25
0,25	20	66	1,54	1,54	61,38	68,31	4,62	2,92	0,93	−13,81
0,2464	20	67	1,08	2,08	62,76	69,12	4,24	2,25	1,19	−8,23
0,2423	20	68	0,72	2,72	63,84	70,08	4,16	1,72	1,39	−1,89
0,2666	10	64	2,41	0,41	58,77	66,61	5,23			
0,2567	10	65	1,68	0,68	60,96	67,02	4,04	3,73	0,62	−22,70
0,25	10	66	1,09	1,09	62,73	67,63	3,27	2,90	0,91	−19,14
0,2454	10	67	0,65	1,65	64,05	68,48	2,95	2,10	1,26	−9,59
0,2436	10	68	0,36	2,36	64,92	69,54	3,08	1,36	1,55	4,29
0,3663	30	64	3,83	1,83	54,51	68,75	9,49			
0,3575	30	65	3,20	2,20	56,41	69,3	8,59	3,49	0,80	−9,48
0,35	30	66	2,64	2,64	58,09	69,95	7,91	2,98	0,94	−7,99
0,3452	30	67	2,15	3,15	59,54	70,73	7,46	2,50	1,12	−5,65
0,3425	30	68	1,74	3,74	60,78	71,61	7,22	2,08	1,24	−3,22
0,3664	20	64	3,36	1,36	55,92	68,04	8,08			
0,3561	20	65	2,71	1,71	57,86	68,57	7,14	3,47	0,78	−11,63
0,35	20	66	2,15	2,15	59,54	69,23	6,46	2,90	0,96	−9,52
0,3456	20	67	1,68	2,68	60,96	70,02	6,04	2,38	1,14	−6,50
0,343	20	68	1,29	3,29	62,13	70,94	5,87	1,92	1,31	−2,76
0,3667	10	64	2,77	0,77	57,69	67,16	6,31			
0,3562	10	65	2,09	1,09	59,73	67,64	5,27	3,54	0,71	−16,47
0,35	10	66	1,52	1,52	61,43	68,29	4,57	2,85	0,96	−13,27
0,3459	10	67	1,07	2,07	62,79	69,1	4,21	2,21	1,19	−8,02
0,3425	10	68	0,72	2,72	63,84	70,08	4,16	1,67	1,42	−1,11
0,4655	30	64	4,54	2,55	52,37	69,81	11,63			
0,4561	30	65	3,93	2,93	54,21	70,4	10,79	3,51	0,85	−7,17
0,45	30	66	3,39	3,39	55,83	71,08	10,17	2,99	0,97	−5,81
0,445	30	67	2,90	3,90	57,3	71,85	9,70	2,63	1,08	−4,59
0,443	30	68	2,48	4,48	58,56	72,72	9,44	2,20	1,21	−2,68
0,4654	20	64	3,93	1,93	54,21	68,9	9,79			
0,4572	20	65	3,32	2,32	56,04	69,48	8,96	3,38	0,84	−8,51
0,45	20	66	2,77	2,77	57,69	70,15	8,31	2,94	0,96	−7,29
0,4454	20	67	2,29	3,29	59,13	70,94	7,87	2,50	1,13	−5,22
0,4428	20	68	1,88	3,88	60,36	71,82	7,64	2,08	1,24	−2,96
0,4649	10	64	3,15	1,15	56,55	67,73	7,45			
0,456	10	65	2,51	1,51	58,47	68,27	6,53	3,40	0,80	−12,34
0,45	10	66	1,96	1,96	60,12	68,94	5,88	2,82	0,98	−10,00
0,4466	10	67	1,50	2,50	61,5	69,75	7,40	2,30	1,17	−6,46
0,4433	10	68	1,12	3,12	62,64	70,68	6,38	1,85	1,33	−2,55

Source: Own analysis σ: Volatility, T: Number of day to expiration, K: Strike price, D=BEP_D, U=BEP_U, TC: Total cost

result of changing the strike price from 67 to 68 units may be also observed for a 10-day strategy.

The dependencies presented so far did not show the power of impact of individual market parameters onto costs in the long strap strategy. For this reason, the final stage of the analysis consisted in calculating Greek coefficients delta, gamma, vega and theta for options for the future prices of WTI oil. Such approach made it also possible to calculate the Greeks for strategies built on the basis of the above-mentioned options.

The results presented in the Table 3 show that, in the long strap strategy using options with strike prices set below the present future price of a commodity (66 USD/b), an increase in any parameter: the strike price, volatility or the days to expiration (while other parameters remain unchanged) reduces the delta. In case when the strategy structure plans to use options with strike prices above the ATM option strike price, the impact of volatility and time to expiration onto delta is reversed while the direction of the strike price impact does not change. Accordingly, the TC of the long strap strategy with a lower strike price (K = 64 or K = 65/b) will be growing quite rapidly in case of increasing future prices of WTI. This outcome will be particularly noticeable in case of 10 days to expiration strike days when a growth in the price of an oil barrel by 1 USD translates into an increase in the sum of paid option prices by approximately 1.3 USD (for K = 64 USD/b). However, the cost response to changes in the future price of the commodity at higher strike prices (K = 67 or K = 68 USD/b) will be significantly less intensive. Even more so, given short periods

Table 3: The value of Greeks for single options and long strap strategy

Parameters			Options						Long Strap			
σ	T	K	Delta C	Delta P	Gamma	Vega	Theta C	Theta P	Delta	Gamma	Vega	Theta
0,2661	30	64	0,67	−0,33	0,07	0,068	−0,03	−0,03	1,01	0,22	0,205	−0,09
0,2569	30	65	0,60	−0,40	0,08	0,073	−0,03	−0,03	0,79	0,24	0,219	−0,09
0,25	30	66	0,51	−0,49	0,08	0,075	−0,03	−0,03	0,54	0,25	0,226	−0,09
0,246	30	67	0,43	−0,57	0,08	0,074	−0,03	−0,03	0,29	0,25	0,223	−0,09
0,2419	30	68	0,35	−0,65	0,08	0,070	−0,03	−0,03	0,04	0,24	0,209	−0,08
0,2653	20	64	0,70	−0,30	0,08	0,054	−0,04	−0,04	1,10	0,25	0,161	−0,13
0,2572	20	65	0,61	−0,39	0,10	0,059	−0,05	−0,05	0,84	0,29	0,177	−0,14
0,25	20	66	0,51	−0,49	0,10	0,062	−0,05	−0,05	0,54	0,31	0,185	−0,14
0,2464	20	67	0,41	−0,59	0,10	0,060	−0,05	−0,04	0,22	0,31	0,180	−0,14
0,2423	20	68	0,31	−0,69	0,09	0,054	−0,04	−0,04	−0,07	0,28	0,163	−0,12
0,2666	10	64	0,76	−0,24	0,11	0,034	−0,07	−0,07	1,29	0,32	0,101	−0,20
0,2567	10	65	0,65	−0,35	0,13	0,041	−0,08	−0,08	0,94	0,40	0,122	−0,24
0,25	10	66	0,51	−0,49	0,15	0,044	−0,08	−0,08	0,52	0,44	0,131	−0,25
0,2454	10	67	0,36	−0,64	0,14	0,041	−0,08	−0,08	0,09	0,42	0,123	−0,23
0,2436	10	68	0,24	−0,76	0,12	0,034	−0,06	−0,06	−0,29	0,35	0,101	−0,19
0,3663	30	64	0,64	−0,36	0,05	0,071	−0,04	−0,04	0,91	0,16	0,213	−0,13
0,3575	30	65	0,58	−0,42	0,06	0,074	−0,04	−0,04	0,74	0,17	0,222	−0,13
0,35	30	66	0,52	−0,48	0,06	0,075	−0,04	−0,04	0,56	0,18	0,226	−0,13
0,3452	30	67	0,46	−0,54	0,06	0,075	−0,04	−0,04	0,38	0,18	0,225	−0,13
0,3425	30	68	0,40	−0,60	0,06	0,073	−0,04	−0,04	0,20	0,18	0,219	−0,12
0,3664	20	64	0,66	−0,34	0,06	0,057	−0,06	−0,06	0,97	0,19	0,170	−0,19
0,3561	20	65	0,59	−0,41	0,07	0,060	−0,06	−0,07	0,77	0,21	0,180	−0,20
0,35	20	66	0,52	−0,48	0,07	0,062	−0,07	−0,07	0,55	0,22	0,185	−0,20
0,3456	20	67	0,44	−0,56	0,07	0,061	−0,07	−0,06	0,33	0,22	0,183	−0,19
0,343	20	68	0,37	−0,63	0,07	0,058	−0,06	−0,06	0,11	0,21	0,175	−0,18
0,3667	10	64	0,70	−0,30	0,09	0,038	−0,10	−0,11	1,11	0,26	0,113	−0,31
0,3562	10	65	0,61	−0,39	0,10	0,042	−0,11	−0,11	0,84	0,29	0,125	−0,34
0,35	10	66	0,51	−0,49	0,10	0,044	−0,12	−0,12	0,53	0,31	0,131	−0,35
0,3459	10	67	0,41	−0,59	0,10	0,042	−0,11	−0,11	0,22	0,31	0,127	−0,34
0,3425	10	68	0,31	−0,69	0,09	0,038	−0,10	−0,10	−0,07	0,28	0,115	−0,30
0,4655	30	64	0,62	−0,38	0,04	0,072	−0,05	−0,06	0,85	0,13	0,216	-0,16
0,4561	30	65	0,57	−0,43	0,05	0,074	−0,05	−0,06	0,72	0,14	0,222	−0,17
0,45	30	66	0,53	−0,47	0,05	0,075	−0,06	−0,06	0,58	0,14	0,226	−0,17
0,445	30	67	0,48	−0,52	0,05	0,075	−0,06	−0,05	0,44	0,14	0,226	−0,17
0,443	30	68	0,43	−0,57	0,05	0,074	−0,05	−0,05	0,30	0,14	0,223	−0,16
0,4654	20	64	0,63	−0,37	0,05	0,058	−0,08	−0,08	0,90	0,16	0,175	−0,25
0,4572	20	65	0,58	−0,42	0,06	0,060	−0,08	−0,09	0,73	0,17	0,181	−0,25
0,45	20	66	0,52	−0,48	0,06	0,061	−0,08	−0,08	0,56	0,17	0,184	−0,25
0,4454	20	67	0,46	−0,54	0,06	0,061	−0,08	−0,08	0,39	0,17	0,184	−0,25
0,4428	20	68	0,41	−0,59	0,06	0,060	−0,08	−0,08	0,22	0,17	0,180	−0,24
0,4649	10	64	0,67	−0,33	0,07	0,040	−0,14	−0,14	1,01	0,21	0,119	−0,42
0,456	10	65	0,59	−0,41	0,08	0,042	−0,15	−0,15	0,78	0,23	0,127	−0,44
0,45	10	66	0,51	−0,49	0,08	0,044	−0,15	−0,15	0,54	0,24	0,131	−0,45
0,4466	10	67	0,43	−0,57	0,08	0,043	−0,15	−0,15	0,30	0,24	0,129	−0,44
0,4433	10	68	0,36	−0,64	0,08	0,041	−0,14	−0,14	0,07	0,23	0,122	−0,41

Source: Own analysis

of strategy delivery and low volatility (0.25), an increase in the future prices of oil may result in a reduced sum of the option prices. Volatility, a strike price and days to expiration do not have a major impact on the delta for the strategy with ATM options and typically oscillates between 0.54 and 0.58.

The value of the gamma which, in turn, informs about the response of the delta to fluctuations in the future price of a commodity reaches the highest value in long strap strategies with ATM options. By reducing the time to expiration, gamma is increased. In turn, higher volatility limits the level of the gamma.

A change in the strike price has a rather similar way of affecting the value of the two latter Greeks, vega and theta (its absolute value). Each reaches it highest level (assuming that other parameters are not volatile) for the ATM option. It means that the long strap strategies using such options are the most sensitive to volatility of the underlying instrument (as indicated by vega) and time to expiration (theta). Vega and theta also increase when influenced by volatility of options used. Strategies involving ATM options were an exception hereof as their vega is not dependent on volatility of the underlying instrument, observed on the market at the time. In turn, a reduction in the time to strike limits the vega and increases theta.

Accordingly, costs in the long strap strategies with ATM options, realised within 30 days from the moment of taking a position in such strategy, will be the most sensitive to shifts in volatility. The impact of the change of time on the sum of the paid out option premiums will be then the most observable in strategies with the shortest strike date (10 days), the highest anticipated volatility (0.45) for which ATM options may be also used.

6. CONCLUSION

The method used to structure the long strap strategy and setting the BEPs presented in the paper showed that the strategy should be used largely in case of anticipated increases in the prices of the underlying asset. Apart from the long put option, the strategy also uses a long position in the call option and, as a result, it offers the opportunity of generating a profit also with dropping prices of the underlying asset. From the point of view of a successful application of the long strap strategy, the levels of the BEPs are important (BEP_D, BEP_U), they are directly related to the TCs i.e. with the sum of paid option premiums.

The key objective of the paper was to present the manner in which the costs will be changing in the long strap strategy when influenced by fluctuations of such parameters as the future price of a commodity and its volatility (non-elective parameters) as well as the strike price and the time to expiration (elective parameters). The analyses are based on the data from the WTI market for oil futures. For this reason, the results of the study are particularly valuable to entities actively participating in oil trading and exposed to the risk of oil price fluctuations.

Calculations underlying the conclusions showed that an increase in the strike prices reduces the costs. Their drop rate is particularly intensive when put option-based strategies are created which are effectively out-of-the-money options (in consequence, the call options used are in-the-money options, which results from the manner in which the long strap strategy is structured). Furthermore, note that an option with the strike price used in the structure of the strategy was different from the ATM strike price by not more than 2 USD per barrel. Among the key conclusions from the analysis the way in which the implied volatility for such options is formed. The coefficient is higher for options with lower strike prices and lower for options with higher strike prices than the ATM option. The phenomenon contributes to some intensified reductions in the TCs while increasing the strike prices used in the long strap strategy. Also, a cost increase was also observed when increasing volatility and extending the time to expiration.

By calculating the Greeks for the long strap strategy, one could learn about the difference in the strike price when a market parameter changes by a unit. It turned out that an increase in the TC caused by a growth in the WTI oil future prices was particularly intensive when using options with lower strike prices. In turn, gamma, vega and theta were the highest for ATMs.

Consequently, the Greeks contributed some important knowledge about the dependence between the strike price and market parameters which affect the option. The coefficients may be then considered important tools supporting the decision-making process when selecting an option in the process of building strategies hedging against the price risk. These decisions may also concern a change in option positions when responding to some received values of the Greeks calculated for the strategy (a dynamic hedging). Therefore, one may conclude that the above-mentioned tools improve the decision-making flexibility and, consequently, give an opportunity for generating improved results by reducing the costs of hedging or obtaining a higher amount from an option payout function.

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