

Alternative method to predict the Break-Even oil price for Financial Sustainability Goals: Evidence from Algeria under Black-Scholes model

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Abstract

We aimed to sort-out an alternative method to predict the Break-even oil price using the benchmark model Black-Scholes. The investigation based on daily oil prices data covering the period of 02/01/2013 to 21/09/2020. The main results highlighted a significant and strong correlation between the fiscal breakeven prices based on the Black-Scholes model and the external breakeven price, with a weak correlation with the IMF's fiscal breakeven prices, which means that the Black-Scholes model is outperforming to predict the fiscal oil prices in comparison with the IMF method. The findings also indicated a negative correlation between the B-S and the reference prices indicated in Algeria's public budget.

Keywords:

Financial sustainability;
Break-Even price;
Options contract;
Public budget;
Hedging.

JEL Classification Codes: C02 ; H00 ; H30 ; H61.

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1. INTRODUCTION

Fiscal Breakeven oil prices have becoming popular and important among analysis and making policy decisions for most of the oil-exporting countries. Break-even prices are the oil price at which a government's budget clears. (Ogolo, 2021)

This price appeared in October 2008 by the IMF when it started to calculate it after the global crisis. These countries used the fiscal breakeven oil price (Trejo-Pech & al, 2019) as an indicator to forecast the instability such as Russia and Iran, while Saudi Arabia cut its production to avoid the decline in oil prices under the Fiscal Breakeven oil price (El Mahmah & Kandil, 2019) We can say that this price can be used to shape oil-exporting countries' behaviour and Algeria one of these countries. Oil-exporting countries insist on balancing their budget using the fiscal breakeven oil prices, which can be useful for the geopolitical and market analysts. In addition to the policymakers who are trying to shape oil-exporting countries' behaviour, wherein high oil prices (Ackah & al, 2020) is one of the big factors that may negatively affect the fragile global economy (y .Akira, 2019) In the GCC and North Africa oil-exporting countries proved by (Leando.M, (2012); Brad. W and Cole V.V, (2017), Abdullah.S et al, (2018), Assil.M and Majda, (2018), SelimCakir, (2019).

The oil prices characterized by the high volatility (Łamasz & Iwaszczuk, 2020) in global markets because of many reasons such as the oil production in all of the world, the demand of the importing countries the political crises and other factors which influence the oil prices. (Gillian.M&al, (2014), Arifah.B&al, (2017),), (Focacci.A, 2019) proposed some mathematical method to predict the breakeven prices (Kleinberg & al, 2018).

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The oil prices have known many crises and shocks since the 1970s; when the organization of petroleum exporting countries (OPEC) decided to reduce the production to stabilize the oil prices on high-level in 1982. However, this strategy was not successful because of the instability in oil markets. In 1986 the oil prices have known a remarkable depression, which led to deciding to rob the prices. Since 2014, Algeria is facing a dramatical reduction in the revenues (Brady & Magazzino, 2019) adopted as a result of the decline in oil production and the decline in prices in the same time; which led to a significant decline on the exchange reserves. Despite the recent recovery in oil markets because of the OPEC agreement to cap production, Algeria is concerned about the volatility in oil prices (Gurvich & Sokolov, 2016) because it is setting a reference price that meets the expectations of oil prices. However, Algeria's policy of setting a reference price commensurate with this volatility remains unclear to experts and researchers in this field; besides, the method of the International Monetary Fund in calculating the break-even prices (Assi, Zhakanova Isiksal, & Tursoy, 2021) is not applied by Algerian experts, as well as it does not take into consideration, the global oil prices (Daude & De La Maisonneuve, 2016) and it relied on this method. The collapse of the oil prices and Gas prices has fettered the Algerian economy at the time of degenerating security conditions in Northern Africa. This situation makes Algeria in a weak position because of the absence of diversification in revenue resources. (Chekouri.S.M & al, 2017).

Talking about the oil prices crises and its role on making the economic stability led us to talk about the financial sustainability. This term has become the most important topic in all the natural resource countries (Humbatova & Hajiyev, 2021). This term related to hydrocarbon revenues in these countries because it

presents the main financial resource of the public budget. Fiscal sustainability based on some important factors to realize it and strengthen it (Yashina.K, & al, 2021), by using the crucial indicators before and after happening to avoid the financial crises, (Mutezo & Mulopo, 2021) .

2. Literature Review

Research papers regarding the fiscal breakeven oil prices have a large increase in the last years. (Leando.M, 2012), focused on the measuring of fiscal risk in hydrocarbon in exporting countries, They conclude that countries; which have large net assets and proven oil reserves are much less vulnerable to the financial risk that, also it indicates by the standard measures based on breakeven prices. While the study of (Gillian M. Nicholls, 2014) shows the breakeven prices volatility for the real option valuation. Where they conclude that industry volatility based on stock prices is not practical for real option as it is in financial options analysis .(Brad.W S and Cole V.V, 2017); try to investigate on the external breakeven oil price to track vulnerabilities in oil-exporting countries. most important of this paper is the lack of exchange rate on the indicator used to calculate the Break-even oil price. It is clear from a discussion that the External breakeven price has more advantages over the fiscal breakeven calculations where it is not difficult to verify the inputs and these required inputs characterized by the consistent across countries which make it easy to make the comparison. Despite all these benefits the IMF and all the oil-exporting countries do not take on account these prices for balancing the budgets(Arifah.B, & al, 2017), aim to forecast model for crude oil price with a structural break, based on GBM and Mean reverting Arnstein

Uhlenbeck process from 1986 to 2016, the main result showed that forecasting crude oil is highly accurate for a short term under GBM

In comparison with Mean reverting Arnstein Uhlenbeck process.(Abdullah.S et A. S. e. al, 2018) The authors try to examine the impact of the oil prices and domestic resource gaps. The main results of this examination show that there is a significant effect on the economic growth in Saudi Arabia, also they find that the fiscal breakeven oil prices are high with 2.35\$/barrel as a marginal. Furthermore, the oil prices have a co-movement with the domestic resource gaps. The contribution of (Assil.M and Majda, 2018), focuses on the fiscal sustainability challenges in the new normal of low oil prices. This paper aims to test the reaction of fiscal sustainability against the augmentation of the public debt after that, the authors compare results of some similar and non-similar groups to understand the effect of the macroeconomic variables on the fiscal policies responses during the fluctuation of the oil prices. This paper also gives some explanations about the results, which are; the GCC countries issue more debts to ensure a fiscal sustainability policy. The variation between the breakeven oil prices has a high impact on the fiscal performance; so, the successive depression of the oil prices and the openness warrant more efforts to reform the budget in the GCC countries. While the discussion paper from the council on foreign relations written by (Jorge de León Miranda and Selim Cakir, 2019); focuses on the fiscal breakeven oil prices; usage, abuse and the opportunities of improvement in 2019. According to the author, the breakeven price can provide the countries by the right political insight. It can also help the decision makers in the oil-exporting countries to control the situation by raising the revenues

or decrease the spending. Aissaoui Ali senior consultant APICORP* shows that according to the official source's governments are thought to have based on the petroleum fiscal revenues to build their budget. In this commentary, he tries to revising and refine a model for calculating the fiscal oil prices in the contest of the changing on the budget and moving to a political vision when we talking about this price which expressed as a "fiscal cost curve" and focusing on the fiscal sustainability in the short term. The second part of this commentary was specialized in talking about the modelling of the fiscal breakeven oil prices; when the author gives a small definition of this price and the main determinants used to predict it; such as the production and export volume. These determinants are the crucial parameters of the revenue's governments receive from royalty and petroleum taxes; the non-hydrocarbon fiscal receipts in addition to the investment income from the current account complement those revenues. According to the author the expenditures should equal the fiscal revenue from the hydrocarbon plus the non-hydrocarbon fiscal revenue plus any transfer from sovereign wealth fund (SWF) and fiscal stabilization fund (FSF). The author focused on an important point in the Fiscal Breakeven price model when the exchange rate are ignored in the construction of the model because the fiscal revenues are generally paid in dollars while the government budget is run in national currency. The study of (Focacci.A, 2019)investigate on multi-breakpoint analysis of crude oil prices, he tries to propose a quite different approach to detect more than a single structural break. The author concludes that the applied method indicates good potential for further empirical investigation within the economics of the commodity markets.

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3. Data and methodology

Our paper aims to predict the fiscal Break-even oil prices using crude oil prices collected from Thomson Reuter's database from 02/01/2013 to 21/09/2020 with daily data. To achieve our hypotheses, we will use the Black-Scholes model as a benchmark model to evaluate the options prices, in addition to the risk-free rate, which is collected from the Federal Reserve Bank, as well as the fiscal-external breakeven oil prices. The rest of the variables will calculate based on our data.

Before to starting our empirical study, we will present the theoretical background of the Black-Scholes model and the most important assumptions, in addition to the presentation of some definition of the Fiscal Breakeven prices and some formulas to calculate it.

4. The Black-Scholes model

The Geometric Brownian Motion process or the B-S model is one of the famous discreet time models; which detects the changes of the theoretical fair value of an option The Geometric Brownian Motion process or the B-S model is one of the famous discreet time models; which detects the changes of the theoretical fair value of an option (Roman, 2004, p. 237). This model is one of the most popular models in mathematical finance, although it's criticism and limits which contravenes with the reality of markets and their characteristics especially the emerging markets known by the high volatility and the rapid changes in their mechanisms. In 1973's the Physicists Black Fisher and Myron Scholes presented a new formula to evaluate the European option type

under some assumptions, which assume the ideal conditions for stock and options.

4.1 The assumptions of the B-S model

- The risk-free rate is known and constant,
- The volatility is constant,
- The stock price follows a random walk-in continuous time;
- The log-Normal distribution of the stock prices;
- The absence of the dividends or other distributions;
- The option is European;
- There are no transaction costs;
- There is no arbitrage opportunity,
- There are no penalties for short selling.

4.2 The Black-Sholes formula

$$C(S,t) = S N(d_1) - Ke^{r(t-t^*)}N(d_2)$$

$$d_1 = \frac{\ln S / K + (r + 0.5v^2)(t^* - t)}{\sigma\sqrt{(t^* - t)}}$$

$$d_2 = \frac{\ln S / K + (r - 0.5v^2)(t^* - t)}{\sigma\sqrt{(t^* - t)}}$$

We can write the put option formula as follow: (Black-Scholes, 1973, pp. 644-642)

$$P(S,t) = Ke^{r(t-t^*)}N(-d_2) - SN(-d_1)$$

To achieve our investigation about the testing of the validity of the Black-Scholes model to predict the fiscal breakeven oil prices we will put the next hypotheses:

4.3 Hypotheses

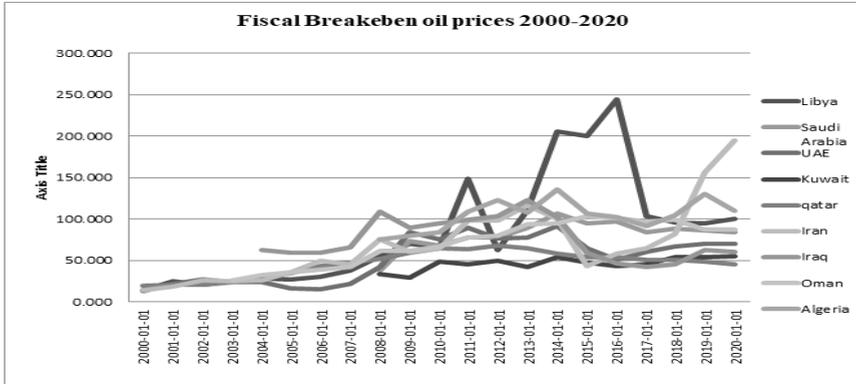
H₁: The Black-Sholes model is valid to predict fiscal break-even prices.

H₂: The Black-Sholes model results converge to the fiscal break-even prices.

Fiscal Break-even price and External Break-even price

Fiscal Breakeven oil price is the minimum price per barrel that the country needs to meet its expected spending needs while balancing its budget. In other word oil prices under this price should result in a deficit in the budget unless government policies change. The figure below represents the development of fiscal oil prices from 2000 to 2020 for nine oil-exporting countries (the Middle East and North Africa). Fiscal break-even has several analytic limits because of the complexity of its formula. In contrast, we have the external Break-even price which is based on a simple formula take on consideration the imports as an analogue of budgetary spending and oil export revenues as the analogue for fiscal revenues.

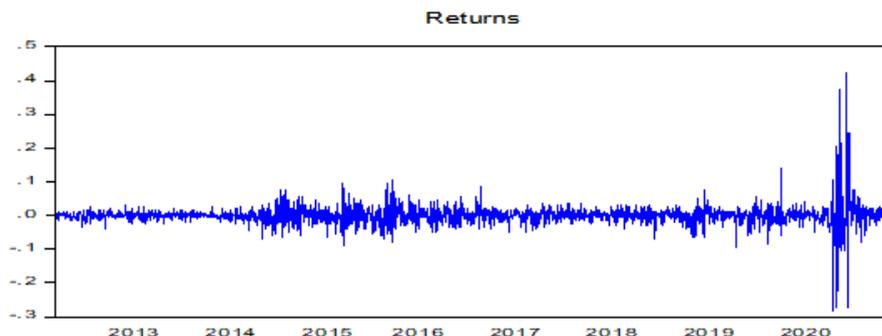
Figure.1. The fiscal Breakeven prices for some oil-exporting countries in the Middle East and North Africa.



Source: Authors using www.fred.stlouisfed.org (IMF).

The figure 01 shows the development of the Fiscal Breakeven prices for the oil-exporting countries from 2000 to 2020. We have chosen this period to highlight the variation of the Break-even price before and after the oil price crash in 2014. The figure shows that Libya's Fiscal Breakeven prices are the higher than the other countries wherein it determined by 244.47 followed by Iraq and Iran, because of the effect of the Arab Spring and the augmentation on risk premium. Besides, we note that during the crisis, the fiscal breakeven prices rose, indicating the significant impact of oil price volatility on the breakeven prices. Since oil prices have a major role in determining the breakeven prices, the following figure shows the volatility of oil prices during the study period.

Figure.2. the volatility of oil returns during the period of study (2013-2020)



Source: Authors.

The figure 02 represents the fluctuation of the oil returns during the study period (2013, 2020), it is clear that the period after 2014 is the beginning of the oil prices crash. The oil prices started to increase at the end of 2016 till the end of 2018 when it reached 74.26\$, but the prices declined dramatically again to 45\$ in December 2018. In 2019 the prices raised again to reached 61.14\$ at the end of the year. The worst scenario of oil prices was in 2020 exactly in April when the prices crashed with negatives value -36.64\$.

We have presented above the breakeven price in general and presented its development during the period 2000-2020 for many oil-exporting countries. Since our study focuses on proposing a model for estimating the breakeven price using the Black-Scholes model used in pricing options, we will provide a simple explanation of breakeven price from the perspective of options contracts.

The Break-even point is the market price that an underlying asset must reach for an option buyer to avoid a loss if they exercise the option contract.

The Break-even price for the call option

$$BEP_c = C + K$$

Where

C: is the call option premium

K: is the strike price.

The Break-even price for the put option

$$BEP_p = K - P$$

Where

P: is the put option premium,

K: is the strike price.

Since Algeria is an oil-exporting country, the appropriate position is to buy the put option contract to take the hedging position against the oil prices dropping.

After presenting the method of calculating the equilibrium price from the perspective of options, we will present the method adopted by the IMF and Middle East Economic Survey as follow:

Break-even price according to the IMF

The International Monetary Fund declared that the determinants of the Break-even price are:

- oil productions volume;
- oil exports;
- global oil prices;
- government expenditures;
- National revenue.

Building on that we can get the Break-even price as follow:

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$$BEP = [(Gov.Ex - Natianal.Revenue) / oil.quantityproduced] + per.barrel.cost.of.production$$

The main limit of this formula is the lack of oil prices and the exchange rate.

The formula is given by the Middle East Economic Survey taking on account the oil prices written as follow:

$$BEP = \alpha^{-1}(EXP - OFR + yC)/(xQ + yE)$$

Where:

α : is price-differential adjustment factor relative to the value of OPEC basket of crudes.

EXP : is budget an extra-budget expenditure.

OFR : Non-hydrocarbon fiscal revenue.

y : is the average rate of hydrocarbon taxation.

C : Is the hydrocarbon industry's full-cycle cost.

x : Hydrocarbon production-weighted royalty rate.

Q : Marked production of hydrocarbon.

E : Hydrocarbon exports.

The main critic of this formula is ignoring if the exchange rate, and focusing on the intern approach.

After the brief presentation of the definition of the breakeven oil price; and the most important models proposed for its calculation; in addition to the most important criticism. We will start our study based on the proposed model used in the pricing of options contracts, which allows us through the results to make a comparison with the results obtained by relying on models of international resources.

5. Results and discussion

The first table presents five prices according to the results of the Black-Scholes model, which we calculated based on the variables of the model that take into account market prices and prices' volatility; the prices determined by the International Monetary Fund, external breakeven prices and for comparison, we used reference prices based on Algeria, In addition to the average oil prices during the study period. While table two highlights the correlation between the prices.

Table.1 The presentation of the different breakeven oil prices types

Year	B-S/BE	BE/(IMF)	EBE	BE Price In Algeria	AV/Price
2013	105,059(*)	108,135	108,092	37	108,704
2014	95,423	135,327	115,489	37	99,449
2015	48,587	106,825	96,598	45	53,598
2016	39,684	102,506	89,081	45	45,131
2017	50,548	91,394	90,034	50	54,737
2018	67,226	98,933	101,684	50	71,692
2019	62,253	116,446	106,672	50	64,444
2020	12,95	157,23	112,20	45	24,18

Source: Authors.

(*), is the fiscal breakeven prices based on the B-S's variables; rf: the free-risk rate, S: market oil pieces, K: the Strike price, σ : the volatility. Exp: $BEP_{2013} = \frac{K_{2013} - P_{2013}}{P_{2013}} = 105.059$.

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The second table represents the correlation coefficient between the B-S results and the different type of breakeven prices.

Table.2 The correlation between different break-even oil prices.

Correlations	B-S/BE	IMF/BE	E/BE	BE In Algeria
B-S/BE	100,00%	56,59%	85,95%	-74,15%
IMF/BE	56,59%	100,00%	83,02%	-61,73%
E/BE	85,95%	83,02%	100,00%	-57,30%
BE In Algeria	-74,15%	-61,73%	-57,30%	100,00%

Source: Authors

The tables 02 shows the different types of breakeven oil prices and the correlation between these prices respectively. We can explain the high correlation between the Black-Scholes breakeven prices and the external breakeven prices (85.95%) by the convergence of the determinants used to make the calculation; wherein the external breakeven prices taking on account the oil prices which are determined in global markets; in contrast, the IMF formula does not take on consideration the external factors such as the oil prices; which explain the weak correlation 56.59% between the Black-Scholes model prices and the IMF breakeven prices. We observe from the result the strong correlation between the IMF breakeven prices and the external breakeven oil prices, the explanation of this result can be returned on the calculation of the external prices when the imports can be considered as the analogue of the government expenditures and the hydrocarbons revenues as the analogue of the fiscal revenues, on the other hand, the breakeven oil prices under the Black-Sholes model are closed to the oil prices average which covers the limit of the big gap between the Algerian referential prices and the oil prices on the global markets.

These factors one of the main important keys used to calculate the breakeven prices according to the IMF formula. We can say that the external breakeven prices would not cause external pressure on the public budget or the currency peg for the countries that are committed to a currency peg and Algeria one of these countries.

The prices we get through the model are very close to the external breakeven prices, which is required. In another word, it should not be a big difference between the breakeven price and the price set in the international markets because this gap will open the door to manipulation of the revenues obtained, whereas oil revenues were channelled to the Revenue Control Fund to finance the budget deficit. In Algeria, for example, a reference price has been determined by 37 dollars per barrel, while oil prices have exceeded 100 dollars in some years. Despite all this, Algeria has continued to suffer from a budget deficit due to high import costs, where nearly 75% of the enterprises import raw materials from abroad.

Experts in Algeria in the preparation of the budget estimate the hydrocarbon revenues required to balance the budget on three indicators; the amount of the expected hydrocarbon productions, the reference price of the barrel of oil approved for the preparation of the budget in addition to the exchange rate of the dinar against the dollar.

The exchange rate is among the most important criticisms of the IMF's method of calculating the breakeven price because of its negligence of the impact of the exchange rate on its calculation. Although Algeria takes into account this indicator, the reference price still far from the price determined in global markets.

Estimates of the equilibrium price calculation by the International Monetary Fund may be overpriced because it

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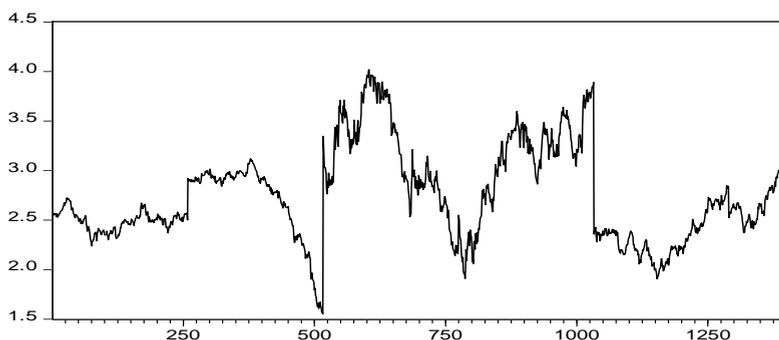
depends on the volume of exports that are subject to sudden differentiation. State expenditures, which can be altered by political decisions, such as coping with emergency conditions, are also vulnerable to unexpected inflation crises that increase spending.

In the aftermath of the global financial crisis in 2008, the world entered a period of an economic slowdown that led to the emergence of huge problems that have taken root in various countries of the world, including Africa. Algeria is facing the greatest economic challenges since the civil war in the nineties of the last century. Where the repercussions of the global financial crisis showed a creep in the decline in oil prices, which led to the weakening of the local economy. This decline in export revenues translated into a current account deficit. For the first time in more than 15 years; and worsened the situation is the decline in domestic production of energy resources such as oil and gas, due to the weak institutional base of the Algerian state and its dependence on the rent economy without creating an investment environment. That is saturated to meet the different needs of the state and society; there is a need to support local energy allocations. Thus, to promote economic diversification by encouraging the non-oil sector and a more effective management policy of oil wealth on the future of Algeria (Short, medium and long term) This is a challenge and a crisis in itself in the face of the Algerian economy as it depends on more than 75% of oil revenues.

The government has lowered the reference price of a barrel of oil in its preparation of the draft fiscal law for 2020, and adopted the price of \$ 45 per barrel instead of \$ 50, due to the instability of the oil market and the decline in prices. The government was forced to revise the reference price of the barrel of oil adopted in

its estimates in the preparation of the draft financial law for the coming year, but this time the reduction, not the increase, after the last review in 2016, and was included in a tripartite scheme for the preparation of financial laws for the years 2019, 2020 and 2021, as it was the government is likely to raise, we talked before about the high volatility of oil prices in the recent period. We will present the first and second figures, which represent the cost of using Algeria to put option contracts as an oil-exporting country where we tested two cases; the first in the case of the breakeven price based on the Black Scholes model is equal to the strike price. The second case is the market price (underlying price) equal to the strike price. This is based on the proposed model, which enables us to calculate the cost of the contract.

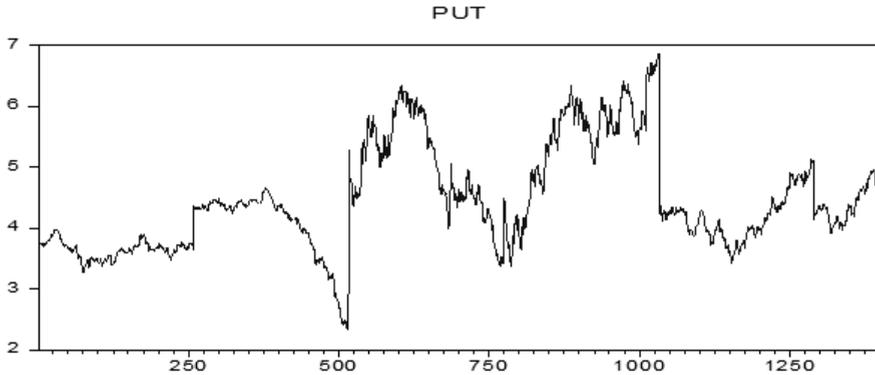
Figure.3. The cost of the put option in the case $BEP_{BS} = K$
PUT



Source: Authors.

According to our data; which are used to calculate the option premium based on the Black-Sholes model. Alternatively, the cost the put option we can observe that the average of the cost is 2.68 for the put option contract, in another word we can say that Algeria will pay 2.86\$ to take a position of the buyer of the put option; when the Fiscal Breakeven oil price is the strike price.

Figure.4. The cost of the option in the case $S=K$

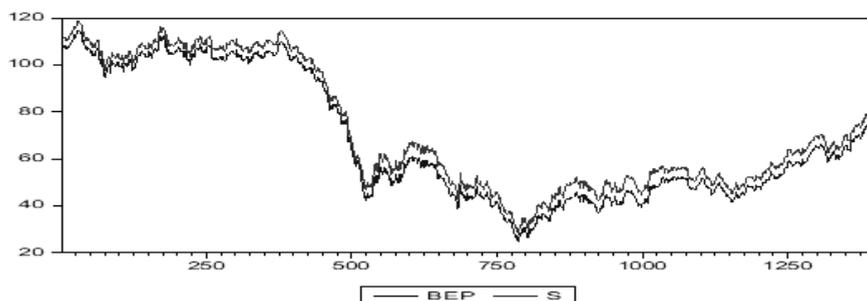


Source: Authors.

Figure 04 highlights the cost of the put option when the strike price is equal to the underlying price, we can observe that the cost augmented with an average of 4.36\$ in comparison by the previous figure (2.68\$). That is mean, if the strike price is higher than the market price, the cost of the option increases, which is logical because in the position of buying a put option, the executive price should be larger than the market price and therefore the cost is higher because it will be an executive option for the contract holder.

The cost estimate allows the contract to hedge against oil price volatility. According to the results obtained from the two figures above, when the strike price is higher than the underlying price the possibility to execute the contract will be higher; which corresponds to the philosophy of the option holder, who expects oil prices to fall below the markets prices, enabling him to achieve unlimited returns Leading to higher option cost. This mechanism can allow the government to take a hedging position and reducing risk.

Figure.5. The performance of the Fiscal Breakeven price against the market prices



Source: Authors.

The figure 05 shows the logical relationship between the market prices, and the Break-even prices, which should be lower than the markets prices.

6. Conclusion

Fiscal sustainability, or public finance sustainability, is the possibility of the governments to sustain its current spending, tax and other policies in the long term without threatening government solvency or defaulting on some of its liabilities or promised expenditures.

We aimed in our investigation to propose a new approach for calculating the fiscal breakeven oil prices in the oil-exporting countries in general and in Algeria especially. The fiscal breakeven oil prices are now broad and well researched in public finance; as an important tool to achieve financial sustainability, especially for countries that rely heavily on oil revenues, including Algeria (75%). The main result of our paper indicates that the Black-Scholes model is valid to predict the fiscal breakeven prices in Algeria rather than the oil-exporting countries.

This result has proved by the strong correlation between the Black-Scholes prices and the External breakeven prices that is mean the Black-Scholes model is more closely related to external prices because it takes on consideration the oil prices as well as the volatility; while it has a small correlation with the IMF prices, which confirms the main critics for the IMF formula. Another finding indicates that Algeria can manage its situation against the oil price volatility in markets by taking the position of the holder of the put option; this position allows knowing the cost of each decision taking to make the hedging position.

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