The Impact of the Binomial Option Pricing Model on Designing Hedge Portfolio. Empirical Study on Banking Sector in Amman Stock Exchange

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Abstract

The current study investigates the way of using option pricing according to the Binomial Option Pricing Model (BOPM), and how to design a hedge portfolio for the Jordanian banks in Amman Stock Exchange (ASE) in the years 2015-2016. To Achieve aims of the study, the researcher used Microsoft Office Excel 2007 in order to set pricing, fair value of shares and design hedge portfolio. The study reveals that the BOPM is one of the most significant models for option pricing as appeared in the results of the banking sector in the ASE. The findings also affirm that designing hedge portfolios reduces risks that might occur to non-hedging portfolios; hedge portfolio fulfilled positive results. It expected that shareholders and financial managers working in the Jordanian banking sector gain benefits from this study by providing a way to design hedge portfolio, how to price options using the BOMP and, accordingly, how to reduce the financial risks of the portfolios. The study is considered important as it was implemented for the first time on the banking sector in the ASE which includes varied investment instruments that need awareness and knowledge by the financial managers in the Jordanian banks.

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1. Introduction

The financial derivatives are considered as very important and innovative investment instruments that facilitate the process of transferring and shifting risks to provide the necessary liquidity in the secondary market and to improve its efficiency. One of these financial derivatives is the *Options* which are contracts between two parts: the first part (investor) and the second part (option writer). According to this contract, the investor can purchases, if he wants, financial assets from the option writer, if he wants to sell, with specific price and date; the investor pays amount of money as a reward when holding the contract; this amount is not a part of the contract and will not be redeemed. The options contracts include all securities such as shares, bonds and foreign currency. Moreover, they have a role for speculations in capital gains and for protecting investors against risks of price swings. As well, designing hedge portfolio by using the options contracts might lead to a reduction in the financial risks through a process of risk transferring to other parts which can tolerate.

1.1. Problem of the Study and its Significance

This study explored the impact of the BOPM on designing hedge portfolio in the Jordanian banks listed in the ASE due to the wide expansion of the varied investment opportunities which raise the investors' interest to invest in the current securities as one package, so the process of designing hedge

portfolio through the financial derivatives, mainly the financial options, helps the investors manage their financial risks that related to this portfolio to confront any price fluctuating. Accordingly, this study is an attempt to answer the following questions:

1- *Is there a relationship between the option price and its implicit price and fair value by using the Binomial Option Pricing Model?*

2- *Is there a possibility to reduce the financial risks when designing a hedge portfolio by using the Binomial Option Pricing Model?*

1.2. Aims of the Study

This study aims to clarify how to use the options pricing according to the BOPM and how to design a hedge portfolio.

1.3. Hypotheses of the Study

To answer the questions of the study, the following hypotheses are stated:

1. Hypothesis 1 (H_1): *There is a positive and direct relationship between the option price and its implicit price by using the BOPM.*

2. Hypothesis 2 (H_2): *There is a positive and direct relationship between the option price and its fair value by using the BOPM.*

3. Hypothesis 3 (H_3): *Designing hedge portfolio by using the BOPM reduces the financial risks.*

2. Literature review

Many international and Arabic studies explored the options contracts and their impact. Jerbi (2002) studied the aspects related to the comparison of the evaluation models of the European options and risk management in June 1998 to January 1999 and in January 1998 to December 1999. The results of the study proved that the coefficients of correlation to decide incidental and daily base of contracts are all negative.

Consequently, Prifiti (2002) studied the option pricing in the financial markets according to the main ways of pricing by paying attention to the role of the computer systems and the ways of using the options in trade and hedging. The study found that there is a necessity to apply some statistic and mathematic instruments within the option theory by using *XploRe* program.

Moreover, Smith and Jorge (2012) investigated the role of the financial derivatives in hedging against the risks of investment and enhancing the liquidity of investment in the financial markets. The researcher conducted their study on the financial brokerage companies listed in the ASE in 2012. The findings of the study revealed that there was a relationship between the financial options contracts and the investors' needs in the financial market which were represented in the hedging against the risks of investment, enhancing the level of the financial liquidity and the connection between the investors' needs to the options contracts. In Arabic studies, Al-Aridi (1996) explored the model of the advanced options pricing and their roles in deciding the value of the reward in the option and designing hedge portfolio. The study was conducted as an empirical study in the Iraqi financial sector. The findings of the study showed that the Black-Scholes and the BOPM are used to decide the option price in the Iraqi financial sector.

However, Bousbie (2012) studied the role of the financial engineering in reducing the financial risks of portfolios and analyzing the role of the options strategy in designing hedge portfolio in the Qatari financial market during 2011-2012. The study concluded that following a strategic policy in purchasing the covered purchasing option in managing the portfolio might reduce the potential financial risks.

On other study, Bin Lekhdar (2015) investigated the role of the option contracts in reducing the financial markets risks in Paris Bourse in the years 2009-2014. The findings stated that risks managements mean to analyze and economically control all financial risks that endanger the assets and the administrative capability of the project. The study also proved that the financial derivatives are effective instruments that cover and shift risks form one part to another, and hedging is an instrument that protects projects from any potential risks.

Finally, Reteimy (2014) explored the options pricing using the BOPM and designing hedge portfolios as a case study of the banking sector in Boursa Kuwait during 2012-2013. The study showed that using the financial options within hedging strategy should be subject to many conditions; mainly the options pricing.

2.1. Theoretical Part

This part of study focuses on the significance of the options contracts, the BOPM and the way of designing hedge portfolio; the options contracts appeared as one of the most important instruments that used by investors for their favor to hedge against the risks of price movements, and used by the speculators to gain profits (Hindi, 2007). The options contracts are also useful for the financial leverage; the investor can buy, for example, financial shares in a contract and pay a small amount of money as a reward to the option writer without paying the total value of them. By this, the profits and losses ratio will be greater in comparison with the profits and losses gained by the buyer of the whole shares.

The significance of the options contracts are due to the price standardization of the execution price to be the original price in the financial market which will lasted till the execution date ends. Therefore, many factors might affect the option price which interacted with each other to decide the price or the option premium which is the current price, share price swings, execution price, execution date, interest rate, time remaining for executing the option (Al-Ameri, 2008).

The BOPM states that the option evaluation relies on specific periods with a statistical and mathematic way during each period. This model adapted the risk neutral approach and assumes that the share equity in the option contract, either it goes up or goes down with different ratios, can be predicted. This model is also called the Two-State Model as it postulates that the expected prices of the asset during the contract duration might be used in the option pricing through the philosophy of retracement from the date of execution till the date of conducting the contract.

This model deals with varied sets of conditions mentioned in the options contracts and the fact that the predictions which might occur on the price of asset in the option contract. More to add, this model is widely used as it is easy to apply and could accurately be used to price options especially the longer-term option. Based on the assumption of the BOPM to estimate the fair value of purchasing option through observing the developments and changes that occur for the prices of the initial assets, these considered the most important models that the BOPM is divided into:

1. The Single Period Binomial Model:

This model depends on the price of shares in the financial markets (S), the price of execution (E) and the price of shares at due date (SU); if the price goes up with possibility (P), then SU will be as SU= s (1+U), but if the price goes down with possibility P-, then the price of share will be as the following: Sd= (1+d)
Current share price:

Su = S (1+u)

SD = S (1+d)

Therefore, the value of the option at due date will be:

Cu= Max (0, s (1+u)-E) when rising

Cu= Max (0, s (1+d)-E) when decline

As a result, the value of purchasing option is:

C= PCu+ (1-P) Cd/1+r

Whereas:
P: the possibility to go up in share prices; P-1: the possibility to go down in share prices;
Cu: the value of purchasing option at due date when prices go up;
Cd: value of purchasing option at due date when prices go down;
u: the rate of share prices upward; d: the rate of share prices downward; r: the risk-free rate.

2. The Two- Period Binomial Model

The number of results according to this model will increase which means that the outputs of the first period will be inputs to the second period at due date of the option. So, if the share price goes up during the first period to "Su", then goes up again in the second period, the share value will be as the following:

Su2= S (1+u) 2

However, if it goes down in the second period after it goes up at the first period, the value will be as the following:

Sud= S (1+u) (1+d)

But if it goes down in the second period, the value will be:

Sd2= S (1+d) 2

Sud= S (1+u) (1+d)

And the option values for the movements in share prices are:

Cu2 =Max S (1+u) 2 – E

Cud=Max S (1+u) (1+d) – E

Cd2=Max S (1+d) 2 – E

The option prices that might occur at the end of the first period are increasing in the prices towards CU or decreasing in them towards Cd, and in both cases, there are two possible results in the second period; this allows to use the Two-Period Binomial Model for option pricing in both cases rising or droping in prices as follows (Al-Aridi, 1996):

Cu= [PCu2+ (1 - P) CUD]/ (1- r)

Cd= [PCud+ (1 - P) CD2]/ (1+ r)

Consequently, the option price is a function of the variables (Cu, Cd, P, and r), and the value of P could be calculated by this formula (Barneto, 2007):

P= (r-d)/ (u-d)

And the fair theoretical value of the option could be assigned according to the following formula:

C*= [P* Cu+ (1 - P) Cd]/ (1+ r)

After making mathematic compensation of the Cu and Cd values in the previous formula, then the fair value of the options pricing to the two periods could be calculated as follows:

C**= [P2 Cu2 +2P (1 - P) Cud+ (1 – P) 2Cd2]/(1+ r)^2

2.2. Instruments of the Study

To conduct the study, the researcher used Microsoft Office Excel 2007, to assign the share prices and the fair values of the shares; the following points were taken into considerations:

1. The executions price is 95% of the implicit price.
2. The rate of shares volatility is U= 255 upwards, and d= 15% downward.
3. The rate of shares volatility is fixed during one year.

Table 1 below reveals the average of share price and number of the traded shares in banking sector in the ASE. The results are shown as follows:

Table 1. Average of Share Price and Number of the Traded Shares in Banking Sector

Bank	2015		2016	
	Average ST.p	# of share traded	Average ST.p	# of share traded
Arab Bank	6.44	19,310,900	6.13	15,464,772
The Housing Bank	9.28	355,823	9.35	921,537
Capital Bank	1.32	8,440,208	0.91	9,062,760
Bank of Jordan	1.24	10,623,499	2.73	15,377,721
Cairo Amman Bank	2.47	10,402,949	2.12	8,158,859
Jordan Ahli Bank	2.57	5,905,834	1.22	11,415,204
Arab Jordan Investment Bank	2.02	1,906,735	1.72	693,508
Jordan Islamic Bank	3.5	7,405,978	3.55	7,483,311
Bank al Etihad	1.67	3,800,574	1.71	5,636,406
Jordan Commercial Bank	1.14	2,942,963	1.45	6,365,249
Arab Banking Corportation	1.1	3,450,720	1.21	2,649,684
Jordan Kuwait Bank	3.85	1,649,905	3.74	1,045,896

Bank	2015		2016	
	Average ST.p	# of share traded	Average ST.p	# of share traded
Invest Bank	1.21	10,414,167	1.32	4,314,111
Societe Generale Bank Jordan	1.12	263,256	0.96	190,642
Jordan Dubai Islamic Bank	1.01	7,303,25	1.24	13,572,237

3. Methodology of research

First: The options pricing for a single period by using the Two-Period Binomial Model.

This model follows these basic assumptions in pricing the options in a single period:

1. The stocks are traded during a progressive time, so the options pricing would be for each period separately.

2. The implicit prices of shares might only have two values (upward and downward).

Table 2 below presents the results of pricing the options in single period by using the Two-Period Binomial Model in banking sector in the ASE.

Table 2. The Options Pricing for a Single Period by Using the Two-Period Binomial Model

Bank	S	E	U	D	Su	Sd	Cu	Cd	C*
Arab Bank	6.44	6.12	0.25	0.15	8.05	5.47	1.93	0.00	0.600
The Housing Bank	9.28	8.82	0.25	0.15	11.60	7.89	2.78	0.00	1.817
Capital Bank	1.32	1.25	0.25	0.15	1.65	1.12	0.40	0.00	0.258
Bank of Jordan	1.24	1.18	0.25	0.15	1.55	1.05	0.37	0.00	0.243
Cairo Amman Bank	2.47	2.35	0.25	0.15	3.09	2.10	0.74	0.00	0.484
Jordan Ahli Bank	2.57	2.44	0.25	0.15	3.21	2.18	0.77	0.00	0.503
Arab Jordan Investment Bank	2.02	1.92	0.25	0.15	2.53	1.72	0.61	0.00	0.395
Jordan Islamic Bank	3.5	3.33	0.25	0.15	4.38	2.98	1.05	0.00	0.685
Bank al Etihad	1.67	1.59	0.25	0.15	2.09	1.42	0.50	0.00	0.327
Jordan Commercial Bank	1.14	1.08	0.25	0.15	1.43	0.97	0.34	0.00	0.223
Arab Banking Corportation	1.1	1.05	0.25	0.15	1.38	0.94	0.33	0.00	0.215
Jordan Kuwait Bank	3.85	3.66	0.25	0.15	4.81	3.27	1.16	0.00	0.754
Invest Bank	1.21	1.15	0.25	0.15	1.51	1.03	0.36	0.00	0.237
Societe Generale Bank Jordan	1.12	1.06	0.25	0.15	1.40	0.95	0.34	0.00	0.219
Jordan Dubai Islamic Bank	1.01	0.96	0.25	0.15	1.26	0.86	0.30	0.00	0.198

* **Source:** Done by the researcher

Whereas:

S: the average price of bank shares during the study.

E: the rate of the execution price for the option contract (E=95%)

u, d: rate of rising prices (u=25%) and drop prices (d=15%)

Sd and Su: represent the shares values in both rising and drop prices respectively. They can be calculated as follows:

Su= S (1+u) (1)

Sd= S (1+d) (2)

As it was in Arab Bank:

Su=6.44 (1.25). = 8.05

Sd=6.44 (.85) = 5.47

Cu, Cd: the options prices in both rising and drop implicit prices of shares. They are calculated as follows:

Cu= Max (Su-E, 0) (3)

Cd= Max (Sd-E, 0) (4)

When they are implemented on Arab Bank, the results are:

Cu=Max (8.05-6.12, 0) =1.93

Cd=Max (5.47-6.12, 0) =0

The fair value of the purchasing option for single period is calculated as follows:

C*= [P* Cu+ (1 - P) Cd]/ (1+ r) (5)

And the value of P is:

P= r-d/u-d (6)

And by assuming that the free- risk rate is (r= 4.5%), and applying the formula number 5 on the Arab Bank, the fair value of the purchasing option is:

C*= (0.45x1.93+ (1-0.45)0/1.45=0.600

Table 2 above states illustrates that the highest theoretical fair value of the purchasing option was for the Housing Bank (0.864 JD), while the lowest one was for Jordan Dubai Islamic Bank (0.094 JD).

Second: The options pricing to periods 2015 and 2016 by using the Two-Period Binomial Model.

Table 3. Options Pricing for Two Periods

Bank	R	E	Su2	Sud	Sd2	Cu2	Cud	Cd2	C**
Arab Bank	0.03	6.12	10.0625	9.2575	8.5169	3.94	3.14	2.40	3.036825
The Housing Bank	0.03	8.82	14.5	13.34	12.2728	5.68	4.52	3.46	4.376046
Capital Bank	0.03	1.25	2.0625	1.8975	1.7457	0.81	0.64	0.49	0.622455
Bank of Jordan	0.03	1.18	1.9375	1.7825	1.6399	0.76	0.60	0.46	0.58473
Cairo Amman Bank	0.03	2.35	3.859375	3.550625	3.266575	1.51	1.20	0.92	1.164745
Jordan Ahli Bank	0.03	2.44	4.015625	3.694375	3.398825	1.57	1.25	0.96	1.211901
Arab Jordan Investment Bank	0.03	1.92	3.15625	2.90375	2.67145	1.24	0.98	0.75	0.952544
Jordan Islamic Bank	0.03	3.33	5.46875	5.03125	4.62875	2.14	1.71	1.30	1.650448
Bank al Etihad	0.03	1.59	2.609375	2.400625	2.208575	1.02	0.81	0.62	0.7875
Jordan Commercial Bank	0.03	1.08	1.78125	1.63875	1.50765	0.70	0.56	0.42	0.537575
Arab Banking Corportation	0.03	1.05	1.71875	1.58125	1.45475	0.67	0.54	0.41	0.518712
Jordan Kuwait Bank	0.03	3.66	6.015625	5.534375	5.091625	2.36	1.88	1.43	1.815493
Invest Bank	0.03	1.15	1.890625	1.739375	1.600225	0.74	0.59	0.45	0.570584
Societe Generale Bank Jordan	0.03	1.06	1.75	1.61	1.4812	0.69	0.55	0.42	0.528143
Jordan Dubai Islamic Bank	0.03	0.96	1.578125	1.451875	1.335725	0.62	0.49	0.38	0.476272

Source: Done by the researcher

Whereas:

r: Assuming the average of risk free rate is 4.5% in 2015.

Su2: rising share in the first period in 2015 and the second period in 2016.

Sud: the prices of shares when the prices rise in the first period and go down in the second period.

Sd2: drop shares in the first period in 2015, then in the second period 2016.

Cu, Cu2, Cd2: the fair values of options in care of rising or drop shares.

It is noticed that Table 3 above shows that the highest theoretical fair value of the purchasing options was in the Housing Bank which arrives 4.376046 JD due to the rising in the share value in the market in comparison with other banks. While the lowest value was with Jordan Dubai Islamic Bank which arrives 0.476272 JD because of the drop share prices of this bank in the market.

Third: Designing Hedge Portfolio

The Hedge Portfolio is purchasing shares and selling purchasing options provided that it achieves a similar return of the free-risk rate (r) for the assets, and its value equals the value of the held shares subtracted by the value of the released options.

Table 5. Related Data of Hedge Portfolio Account

Bank	S	C*	h	n	V0	V1	Rh
Arab Bank	6.44	1.26063	0.75	800	2845.51	3529.519	0.194
The Housing Bank	9.28	1.81656	0.75	800	4100.36	5086.016	0.194
Capital Bank	1.32	0.25839	0.75	800	583.24	723.4419	0.194
Bank of Jordan	1.24	0.24273	0.75	800	547.89	679.5969	0.194
Cairo Amman Bank	2.47	0.4835025	0.75	800	1091.37	1353.713	0.194
Jordan Ahli Bank	2.57	0.5030775	0.75	800	1135.55	1408.519	0.194
Arab Jordan Investment Bank	2.02	0.395415	0.75	800	892.54	1107.085	0.194
Jordan Islamic Bank	3.5	0.685125	0.75	800	1546.47	1918.217	0.194
Bank al Etihad	1.67	0.3269025	0.75	800	737.89	915.2636	0.194
Jordan Commercial Bank	1.14	0.223155	0.75	800	503.71	624.7907	0.194
Arab Banking Corportation	1.1	0.215325	0.75	800	486.03	602.8682	0.194
Jordan Kuwait Bank	3.85	0.7536375	0.75	800	1701.12	2110.039	0.194
Invest Bank	1.21	0.2368575	0.75	800	534.64	663.155	0.194
Societe Generale Bank Jordan	1.12	0.21924	0.75	800	494.87	613.8295	0.194
Jordan Dubai Islamic Bank	1.01	0.1977075	0.75	800	446.27	553.5426	0.194

Whereas (h) represents the calculated value to hedge out from the total shares in the portfolio; it is the total sum of the purchased shares for the numbers of the released options in the current price (c) and rate of coverage.

$$h=(Cu-Cd)/S(1+u)-S(1+d)=(Cu-Cd)/(Su-Sd)=(1.93-0)/(8.05-5.47)=0.75$$

As (n) refers to the number of options for sale (800), and the value of the hedge value (v) is (ns) which refers to the total sum of the shares values subtracted by the value of the released options. In Arab Bank, for example, the process of hedging portfolio includes taking short centers for 800 purchasing options and long centers for 600 shares. Therefore, the current value of the portfolio is:

$$V0=0.75X800(6.44)-800X (1.26) =2845.51$$

Consequently, the return of this portfolio is the current value of the portfolio at the beginning of the period (V0) for its value at the end of the period (V1):

$$Rh=1-V0/V1=1-2845.51/3529.519=0.194$$

And this represents the risk- free return which means that the investment in banks will grow up with rate of interest estimated at 19.4%.

Forth: Returns of Hedge Portfolio

Table 6. Returns of Portfolio in Hedging and Non-hedging Cases

Bank	Shares prices in 2015	Shares prices in 2016	Return of non-hedging shares	Return or hedging shares
Arab Bank	6.44	6.13	-0.05	0.194
The Housing Bank	9.28	9.35	0.01	0.194
Capital Bank	1.32	0.91	-0.45	0.194
Bank of Jordan	1.24	2.73	0.55	0.194
Cairo Amman Bank	2.47	2.12	-0.17	0.194
Jordan Ahli Bank	2.57	1.22	-1.11	0.194
Arab Jordan Investment Bank	2.02	1.72	-0.17	0.194
Jordan Islamic Bank	3.5	3.55	0.01	0.194
Bank al Etihad	1.67	1.71	0.02	0.194
Jordan Commercial Bank	1.14	1.45	0.21	0.194
Arab Banking Corportation	1.1	1.21	0.09	0.194
Jordan Kuwait Bank	3.85	3.74	-0.03	0.194

Bank	Shares prices in 2015	Shares prices in 2016	Return of non-hedging shares	Return or hedging shares
Invest Bank	1.21	1.32	0.08	0.194
Societe Generale Bank Jordan	1.12	0.96	-0.17	0.194
Jordan Dubai Islamic Bank	1.01	1.24	0.19	0.194
Returns of Portfolio			-0.98	2.907

Table 6 reveals that the returns of portfolio in non-hedging case were -0.98 which mean the portfolio incurred losses based on this rate, while the shares of hedge portfolio made profits and positive return with rate 19.4% which is the risk-free rate; it gained a total return estimated at 290.

4. Testing Hypotheses

1. Hypothesis 1: *"There is a positive and direct relationship between the option price and its implicit price by using the BOPM."*

The results in Tables 2 and 3 refers that the option pricing by using the Single-Period Binomial Model and Two-Period Binomial Model shows a positive relation between the price of purchasing option and its implicit price; when the price of purchasing option goes up, the current prices of the shares go up. Hence, this hypothesis is accepted.

2. Hypothesis 2: *"There is a positive and direct relationship between the option price and its fair value by using the BOPM."*

It is observed in Tables 2 and 3 that the option pricing by using the Single-Period Binomial Model and Two-Period Binomial Model shows a positive relation between the price of purchasing option and its fair value; when the price of purchasing option goes up, the current prices of the shares go up. Hence, the second hypothesis is also accepted.

3. Hypothesis 3: *"Designing hedge portfolio by using the BOPM reduces the financial risks."*

According to Tables 4 and 5, it is noticed that designing hedge portfolio played a crucial role toward risk aversion that some banks were exposed to because of being in non-hedging case, so the third hypothesis is accepted.

5. Results and conclusions

This study comes out with the following results:

1. The Binomial Option Pricing Model (BOPM) is regarded as one of the most important models to price the purchasing option which was ensured in the case of banking sector in Amman Stock Exchange (ASE).

2. The return of non-hedging shares equals 19.4%

3. It is considered that the return of hedge portfolio equals the current value at the end of the period, which means that the investment will grow at rate 19.4%; this result is refers to the risk free rate. Consequently, investing amount of 466258.71 Kuwaiti Dinar (rh=11.7) will grow up to 528000 Kuwaiti Dinar at rate of 11.7% which differs from the rate of the free risk interest in the Jordan fund market. This is comparatively different from the assumptions of the financial engineering and the BOPM which assumes equality between the return of risk and the rate of free- risk interest in the fund market; this might be because of the weakness of the ASE, additionally the side effects of the global financial crisis on banking sector. The researcher believes that designing hedge portfolio participates in reducing the risks that might occur to the non-hedge portfolio which formed from the same stocks. Moreover, the hedge portfolio achieved absolutely positive results.

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