Testing the Binomial-Option Pricing Model and its Impact on Improving a Hedge Portfolio: An Empirical Study

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Abstract

The main purpose of this study is to demonstrate how to use the Binomial-Option Pricing Model (BOPM) to determine the premium of an option by constructing a risk-free arbitrage portfolio consisting of a position in stock and option. Financial derivatives are widely used in a variety of financial markets to manage various risks efficiently and economically. This paper will mainly focus on the pricing and valuation of options by using the Binomial Option Pricing Model (BOPM) to determine the theoretical fair value of options for one or multiple periods. In addition, this study seeks to develop a hedging portfolio consisting of a specific mix of a number of stocks and options for a sample of Jordanian banks listed in Amman Stock Exchange during the period between 2020 and 2021. Appropriate methodologies have been followed to determine the fair value of the option price and to create a hedge portfolio that produces a risk-free return. This study shows that the BOPM model gives acceptable results when applied to the financial sector in the ASE; moreover, it shows that designing a hedged portfolio can reduce risks compared to unhedged portfolios to a significant level. This paper gives a great benefit to portfolio managers in identifying risk management techniques by creating a risk-free hedging portfolio so that the value of the option can be deduced from other variables that can be determined, as well as helping shareholders to reduce risks through the use of option contracts as investment tools. On the other hand, this study points to the need of having sufficient knowledge regarding the fundamentals to understand the nature of this type of derivatives, and how they can be used to avoid risks through an appropriate protective strategy and to achieve reasonable returns.

Keywords: Options, Binomial Model, Hedge Portfolio, Financial Derivatives, Amman Stock Exchange.

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اختبار نموذج تسعير الخيار ذي الحدين وأثره على تحسين محفظة التحوط: دراسة تطبيقية

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ملخص

إن الهدف الرئيس من هذه الدراسة هو بيان كيفية استخدام نموذج تسعير الخيار ذي الحدين (BOPM)، لتحديد علاوة الخيار عن طريق إنشاء محفظة متوازنة خالية من المخاطر تتكون من مركز مؤلف من عدد من الأسهم والخيارات. تستخدم المشتقات المالية على نطاق واسع في الأسواق المالية لإدارة المخاطر المختلفة بكفاءة عالية. ستركز هذه الورقة بشكل أساسي على تسعير الخيارات وتقييمها من خلال استخدام نموذج تسعير الخيار ذي الحدين (BOPM) لتحديد القيمة النظرية العادلة للخيارات لفترة واحدة أو فترات متعددة. وكذلك، تسعى هذه الدراسة إلى تطوير محفظة تحوط تتكون من مزيج محدد من الأسهم والخيارات لعينة من البنوك الأردنية المدرجة في بورصة عمان خلال الفترة بين 2020 و 2021. وقد تم اتباع المنهجيات المناسبة لهذه الغاية لتحديد القيمة العادلة لسعر الخيار وإنشاء محفظة تحوط تنتج عائدًا خاليا من المخاطر. تظهر هذه الدراسة أن نموذج (BOPM) يعطي نتائج مقبولة عند تطبيقه على القطاع المالي في بورصة عمان، علاوة على ذلك، فإنه يظهر أن تصميم محفظة التحوط يمكن أن يقلل من المخاطر مقارنة بالمحافظ غير المتحوطة إلى حد كبير. تقدم هذه الورقة فائدة كبيرة لمديري المحافظ في تحديد تقنيات إدارة المخاطر من خلال إنشاء محفظة تحوط خالية من المخاطر بحيث يمكن استنتاج قيمة الخيار من المتغيرات الأخرى التي يمكن تحديدها، وكذلك مساعدة المساهمين على تقليل المخاطر من خلال استخدام عقود الخيارات كأدوات استثمارية. من ناحية أخرى، تشير هذه الدراسة الى ضرورة توفر المعرفة الكافية فيما يتعلق بالأساسيات لفهم طبيعة هذا النوع من المشتقات وكيف يمكن استخدامها لتجنب المخاطر من خلال استراتيجية وقائية ملائمة وتحقيق عوائد معقولة.

الكلمات الدالة: الخيارات، نموذج ذو الحدين، محفظة التحوط، المشتقات المالية، سوق عمان المالي.

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1. Introduction:

Financial derivatives in general, and options contracts in particular, are important investment topics in the financial markets. Where these tools have received wide attention by the pioneers of financial engineering and researchers in financial management in general, they are considered highly advanced financial tools because of their great impact on the financial markets. Trading this type of investment tools is not limited to traditional tools, such as stocks, bonds and others, but goes beyond that to finding new tools for trading, and the most important of these tools are option contracts of various types and uses (Strong, 2009). The importance of financial options has increased, especially in recent years, as a result of several reasons, the most important of which are developments in the field of information and communication technology and the reflection of these developments affecting daily life, especially capital markets or financial markets (Bodie et al., 2010). The developments that occurred in the financial markets in the eighties and nineties of the last century directed the financial managers of companies and investors to pay attention to these markets and follow the investment methods correctly. Where option contracts occupy an important position in the financial markets, these contracts have obtained a distinguished position because of their great role in reducing the risks resulting from the turmoil and large fluctuations in the prices of various investments due to the circumstances surrounding those investments. Option contracts are among the best financial instruments currently in use as they provide a complete hedge against most of the risks that these investments may be exposed to (Aguilar & Korbel, 2019). Trading in these derivatives is not limited to individual traders, but also to major financial institutions, such as banks, and major companies of all kinds listed in organized markets, in order to hedge their investments against the risks of interest on loans and deposits, as well as against interest rate fluctuations on other debt instruments, such as bonds (CFA Level, Book 5 (2010).

Option contracts have a high level of flexibility to manage and control the risk of price fluctuations. Therefore, it can be defined as securities that are derived from another underlying asset, such as stocks, bonds, commodities or foreign currencies (Bradford, et al., 2009). These instruments can give the investor an opportunity to reduce the risks they are exposed to, by replacing a specific asset with another asset at a specified price on an agreed date. Correspondingly, the main purpose of using derivative contracts is to efficiently manage the risks that may face the business environment and to hedge against these risks by transferring them to other parties (Marroni & Iren 2014). Hence, the uses of options have been greatly expanded to reach other purposes, such as investment and speculation.

Researchers have developed various models for option pricing; these models are varied from simple to complex form. The most important of these models is the Binomial-Option Pricing Model (BOPM), which is considered one of the simplest pricing models. The idea of this model is based on the possibility of building a portfolio that includes a call or put option contract and combined with a financial asset. Their financial flows are similar, but they go in opposite directions. That is, when price fluctuations occur, one component of the portfolio will generate inflows, offset by outflows of the same value from the other component, and this means complete coverage of the investor's position (Hu Y et al.,2020). Option contracts can be defined as agreements between two parties with the aim of trading real or financial assets, foreign currencies and financial market indices, to be executed at a later time at a price agreed upon by both parties called the option price (or delivery price) (Rongda Chen et al.,2021). An option contract gives the buyer the right to buy or sell a financial or real asset at a specified price, called the exercise price, during a specified period of time. In return, the seller (the writer of the contract) is obliged to hand over the stock or the commodity to the buyer if he/she decides to perform the contract and to exercise his right to buy or sell in return for a premium paid to him at the beginning of the contract (Hull, J., 2018). There are several classifications of options and they have rules regulating dealing with them, but the most important type is the call and put option contract.

In this study, I will review the most important theories that are used recently in pricing options, and will examine the extent to which this model is applied to a selected sample of the banking sector in the Amman Stock Exchange. Also, this study will address the issue of establishing a hedged portfolio consisting of stocks and options to obtain a risk-free return.

2. The Problem of the Study and its Significance:

Since Amman Stock Exchange is an emerging financial market, characterized by high levels of market risk, it is the appropriate environment for conducting this type of studies, to demonstrate the impact of applying proper hedging strategies to market fluctuations. Therefore, the problem of the study is represented in the need to answer the following questions: To what extent can we benefited from the application of modern theories (option theories) in an emerging market such as the Amman Stock Exchange? The second question is as follows: Is it possible to apply advanced option strategies in order to hedge the selected portfolio according to the approved technical methods?

The importance of the research appears in shedding light on an advanced and important investment tool that benefits the investor, whether the investor is an individual or an institution. Options act as a hedging tool and an investment method at the same time. The importance of the research is also embodied by showing the role that the option contract can play to hedge against risks, and it plays an important role in removing the fear of using this financial instrument by enriching the investor with the required information through the theoretical aspect. The importance of the research also lies in the practical aspect related to investment in the Amman Stock Exchange, which is characterized by high levels of risks and to meet the need of investors for new approaches to increase investment alternatives and optimal use of capital. Thus, the lack of knowledge still needs renewed research to fill part of this gap. The importance of the research similarly stems from the fact that it is an applied case in Amman Stock Exchange, as the openness of global investment markets in recent years has made it appear as a unified market affected by current events and shares many features, in addition to the increasing global trend towards financial facilities and the removal of restrictions between them with the aim of financial facilitation and acceleration of procedures in order to push the flow of international investments across continents. All this gives importance to open markets for financial derivatives that are increasing day by day.

3. Aims of the study:

The main purpose of this study is to conduct an analytical study on the basis of financial theories to test it on a sample of banks listed on the Amman Stock Exchange in order to determine the impact of options contracts on the shares of these banks, as well as to know the ability of these banks to hedge against market risks. This study also aims to encourage investors in the Amman Stock Exchange, individuals or institutions, to trade this instrument after creating a market dedicated to dealing in options. This study also explains the mechanism of pricing options using the Binomial Model for one period or more, which leads to increasing investment awareness among those interested in this aspect of investment and to introducing them to the available investment opportunities offered by this tool.

4. Research Hypotheses:

To answer the research questions presented, the following alternative hypotheses can be formulated:

(H1) The relationship between the option price and the implied stock price using the binomial options pricing model is positively correlated.

(H2) The relationship between the option price and its fair value using the binomial-option pricing model is a positive direct relationship.

(H3) Creating a hedge portfolio using the binomial options pricing model contributes to reducing risk.

5. Literature Review:

Witzany (2020) showed that options are comparable to forward contracts, where one party must pay a premium to have the choice of whether to settle the contract or not. Both the OTC and formal exchange markets have seen a rise in the popularity of options, although their valuation is more difficult to determine than it is for forwards. The study indicates that inputs for valuation models must now include the volatility of the underlying asset price, which has also emerged as a new market variable. Hence, the study described how options are valued both within the theoretically more complex framework of stochastic asset price modeling and within the conceptually simpler setting of binomial trees. The topic of option portfolio hedging utilizing the so-called Greek concept has been examined. The size of the trading share and widespread acceptance of the various financial instruments, including derivatives, according to a study by Mostafa & Kamal (2020), make the evaluation of options an important subject of study. The theory of option valuation has significant applications in financial management as a tool of hedging against market risks. In order to calculate the premium on the call option of BNP Paribas Bank over 7 partial periods, that study applied one of the most significant quantitative techniques, the binomial distribution, which enables traders to track the evolution of the prices of financial assets through potential distributions offered by the model. Wang (2018) indicated that the binomial-option pricing model is relatively simple and more suitable for explaining the basic concept of option pricing. The binomial-option pricing model is based on the basic assumption that there are two possible directions for the price of a security over a given period of time: up or down. Although this assumption is very simple, the binomial-option pricing model is suitable for dealing with more complex options because they can be broken down into smaller time units for a given time period. Oshaibat (2018) examined the method of using option pricing according to the Binomial-Option Pricing Model (BOPM) and how to design a hedge portfolio for Jordanian banks on the Amman Stock Exchange (ASE) in the years 2015-2016. That study revealed that the BOPM model is one of the most important options pricing models as it appeared in the results of the banking sector in the Amman Stock Exchange. The results also confirm that the design of hedging portfolios reduces the risks that may occur for non-hedged portfolios. The hedge portfolio has achieved positive results. Echenim & Peltier (2017) documented that the binomial-pricing model is a method for evaluating an option based on a discrete time model of stock market development. It allows to determine the fair price of the derivative from the gains it generates on its expiration date. They formalize basic concepts in finance, such as the non-arbitrage principle, and prove that the market, under the assumptions of the model, is complete, which means that any European derivative can be replicated by creating a portfolio that generates the same payoff regardless of the evolution from the market. Hassan (2017) demonstrates that the function of the option contract in addressing the needs of investors in capital markets and assesses the relationship between hedging against investment risks and lowering financial risks so that the investor is not exposed to financial losses. The simple regression model was used in the study to assess the nature of the link between the dependent variable and the study's independent variables. The study employed the simple linear correlation coefficient (Pearson) to assess the strength of the association between its variables. One of the study's most significant findings is that options are a tool for hedging against financial risks and can provide benefits for investors. The study suggested that there is a need to increase awareness of the role. In a study by Bouziane & Jabouri (2017), a model to price banking sector options was used on the Kuwait Stock Exchange between 2013 and 2014. Based on the results, they discovered that the CRR model's appealing feature is that the binomial tree of geometric Brownian motion (multi-periods) corresponds to the standard formula Black-Scholes proposed for European options. The benefit of this model is that it allows the user to see how asset prices vary over time and evaluate options based on decisions made at various periods in time. In accordance with research done in the Paris market by Esawi (2016), this paper aims to use one of the options pricing models, a Binomial Model for one period and two periods to determine the prices of options contracts traded in the financial markets, through the theoretical and applied aspects on some shares of companies listed in Euronext Paris. By assembling a risk-free investment portfolio out of a diversified mix of stocks and options contracts, this tool primary goal is to hedge and reduce the risk of price swings. Reteimy (2014) explored the option pricing using the BOPM and designing hedge portfolios as a case study of the banking sector in Kuwait Stock Exchange during 2012-2013. The study showed that using the financial options within hedging strategy should be subject to many conditions; mainly the options pricing. Finally, in a study by Sunday Emmanuel et. al. (2014), the researchers made a comparison between the Binomial Model of European options and Black-Scholes evaluate options and conclude that the Binomial Model is more flexible compared to the Black-Scholes Model. The Binomial Model is also used to price a wide range of options.

This study is distinguished from previous studies in that it used the hedging portfolio for multiple periods, and it shows how the risks facing investors can be reduced through financial derivative contracts.

6. Theoretical Framework and Method:

An option pricing model is a mathematical formula or computational procedures that employs factors to determine the option price as inputs. The output is the theoretical fair value of the option (Chance & Brooks, 2016). If the model performs as it should, the option market price will be equal to the theoretical fair value.

6.1 One-Period Binomial Model

This model was developed by William Sharpe (1978) for option pricing, and it is considered one of the simplest options pricing models, as it does not depend on complex mathematical formulas in calculating the option price. This model is used to calculate the fair value of European put-and-call options. The use of this model is based on several assumptions: first, the prices of stocks that have options either rise or fall at different rates at random. Moreover, the option is of the European type, meaning that the option right can only be exercised at the end of the date specified in the option contract. Furthermore, this model assumes that no dividends are distributed to shareholders throughout the life of the option. Finally, this model assumes that the invested assets achieve a risk-free return and that the rate of lending and borrowing is at a risk-free rate of return.

Generating the equations of the options pricing model for one period depends on the stock price in the stock market at the beginning of the contract is (S), during a specific period of time that can be days until it reaches months, and at an execution price (E). Thus, at the expiry of the agreed-upon period, the share price on the maturity date can take one of the two values (Su) if the share price moves up at a rate (u) and with a probability (q), meaning that the share price will be:

$$S_u = S(1+u) \tag{1}$$

But if the stock price moves down at a rate of (d) and with a probability of (1-q), then the stock price will be as follows:

$$S_d = S(1+d) \tag{2}$$

where $u > d \geq 0$

The final component of the model is to assume that a risk-free asset with return r is also available. Defining the gross return, R, on the risk-free asset by $R \cong 1 + r$, it must be a case that returns on the risk-free asset and satisfies $u > R > d$, and this must hold since it $R > u$, and the risk-free asset would constantly provide a higher return than the underlying stock (Chance & Brooks, 2016). The value of the option at expiration is denoted C_u when the underlying stock price is S_u , and C_d when it is S_d, so its value can be calculated through the following two equations:

$$C_u = Max[0, S(1+u) - E], \quad (3)$$

$$C_d = Max[0, S(1+d) - E] \quad (4)$$

These both equations represent the value of the option when the price moves up or down, where Cu and Cd are the values of the call option after one period, and E is the exercise price.

The Binomial Model's purpose is to create a formula for the theoretical fair value of the option, which is represented by the variable C. The theoretical fair value is then compared to the actual price to see if the option is overpriced, underpriced, or fairly priced. The formula for C is created by putting together a risk-free stock and option portfolio that should earn the risk-free rate. A hedged portfolio is a risk-free investment strategy. Knowing the value of the stock and the return on the risk-free portfolio helps to derive the option price formula from other variables. The risk-free portfolio is called the hedge portfolio, and it consists of h of common stock and a short-call option, and the model provides the hedge ratio. The present value of the portfolio (V) is the value of the number of shares (h) minus the value of the short call (C), so the value of the portfolio is as follows:

$$V = hS - C \quad (5)$$

Upon execution, the value of the portfolio is either of these:

$$V_u = hS_u - C_u \quad \text{when the stock price arises} \quad (6)$$

$$V_d = hS_d - C_d \quad \text{when the stock price decreases} \quad (7)$$

If the outcome is the same, regardless of whether the stock price is moving up or down, it means that there are no risks (Chance & Brooks, 2016); therefore,

$$hS_u - C_u = hS_d - C_d \quad (8)$$

From solving the previous equation, we calculate the hedge ratio (h):

$$h = \frac{C_u - C_d}{S_u - S_d} \quad (9)$$

Since we know how to identify the stock price S and the factors u and d, the value of the option can be determined when the stock of Cu arises, besides its value when it falls C_d, and the number of shares h. The risk-free portfolio should generate a return equal to the risk-free interest rate (Jules, et al.,2022). Therefore, the value of the portfolio after one period must equal the value of the current portfolio multiplied by the risk-free interest rate. If the value of the portfolio grows at a risk-free rate of return, in this case the value of the portfolio at the expiration of the option will be as follows:

$$(hS - C)(1 + r) \quad (10)$$

Based on the values V_u, V_d, we will choose one of them to derive the original equation for the portfolio on the expiration of the option period:

$$(hS - C)(1 + r) = hS_u - C_u \quad (11)$$

We substitute the value of h into this equation to find the price of the call option C, which expresses the theoretical value of the call option:

$$C = \frac{1}{R}[qC_u + (1 - q)C_d] \quad (12)$$

Where,

Cu: the value of purchasing option at the due date when prices go up;

Cd: value of purchasing option at the 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.

q: the possibility to go up in share prices; q-1: the possibility to go down in share prices; which can be calculated by the following equation

$$q = \frac{1+r-d}{u-d} \quad (13)$$

R: the gross return of the risk-free rate , $R \cong 1 + r$;

6.2 Two-Period Binomial Model

The price of the call option, according to this model, is the discounted value at a risk-free rate of return for the weighted average of two possible prices in the subsequent period, provided that these two prices are calculated on the basis of one period. Therefore, the model has three time points: time 0, time 1, and time 2. During the second one-period, the price could go either up or down, in which case it would end up at either S_u^2 or S_{ud}. If the stock price has gone down in the first period to S_d, during the second period , it will either go down again or go back up, in which case it will end up at either S_d^2 or S_{ud}. Thus, the option prices at expiration should be one of the following possible prices:

$$C_u^2 = Max(0, S_u^2 - E) \quad (14)$$

$$C_{ud} = Max(0, S_{ud} - E) \quad (15)$$

$$C_d^2 = Max(0, S_d^2 - E) \quad (16)$$

Based on the definition of one-period Binomial Model, we can obtain the value of C_u and C_d:

$$C_u = \frac{qC_u^2 + (1-q)C_{ud}}{1+r} \quad (17)$$

$$C_d = \frac{qC_{ud} + (1-q)C_d^2}{1+r} \quad (18)$$

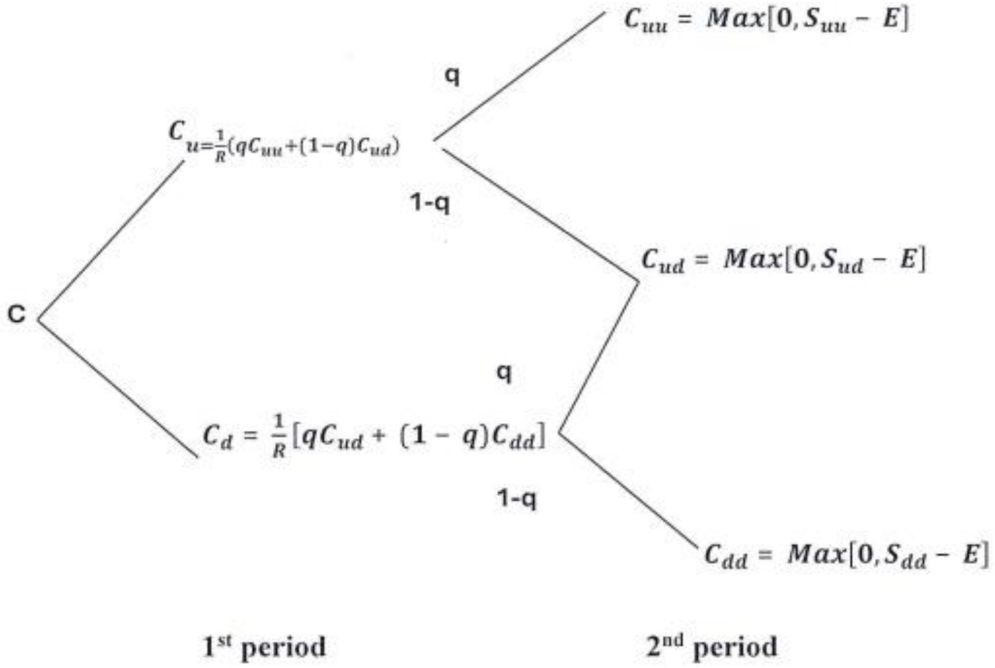
First, we find the values of Cu, and Cd, then we substitute these into the preceding formula for C.

Based on these grounds,

$$C = \frac{q^2 C_{u^2} + 2q(1-q)C_{ud} + (1-q)^2 C_d^2}{(1+r)^2} \quad (19)$$

This formula illustrates that the value of the call is a weighted average of its three possible values at expiration of two periods later. The denominator, $(1+r)^2$ or R^2 , discounts this figure back two periods to the present (Chance & Brooks, 2016).

Figure (1) the possible values of the call option according to the Binomial Model



7 Hedge portfolio

The hedge is constructed by initially holding h shares of stock for each call issued. At the end of first period, the stock price is either Su or Sd. Accordingly, a hedge ratio should be adjusted. If the stock is at Su, let the new hedge ratio be designated as h_u; if the stock is at S_d, then the new hedge ratio will be designated as h_d. Hence,

$$h = \frac{C_u - C_d}{S_u - S_d}, \qquad h_{u} = \frac{C_u^2 - C_{ud}}{S_u^2 - S_{ud}}, \qquad h_d = \frac{C_{ud} - C_d^2}{S_{ud} - S_d^2} \qquad (20)$$

Where this formula captures all of the possible stock paths over the n periods until the option expires.

$$V_0 = hS - C \qquad (21)$$

$$V_u = hS_u - C_u, \qquad r_h = \frac{V_u}{V_0} - 1 \qquad (22)$$

$$V_d = hS_d - C_d, \qquad r_h = \frac{V_d}{V_0} - 1 \qquad (23)$$

Where,

V_0: represents the value of the portfolio at time 0

Vu: represents the value of the portfolio after one period when prices are rising

Vd: represents the value of the portfolio after one period when prices are declining

Hedging a portfolio using a single-period Binomial Model is a combination of buying a certain number of shares and selling another number of options. This combination is designed to provide protection for stocks and options from risks (Muroi, 2022). That is, the value of the portfolio that consists of stocks and options achieves a return on investment equivalent to the risk-free return, and this return is not affected by the change in the market price of the share.

8 Sample selection:

This study relied on the stock prices of the banking sector in the financial market, where the number of banks reached 15 banks within this sector. The main justification for choosing this sector can be laid in light of several considerations, including i) the shares of this sector are traded regularly, and ii) this sector is the most vulnerable to financial risks in successive financial crises, especially the economic impact of the Covid-19 virus, which has had a significant impact on various economic sectors, including the banking sector. The study is based on the following assumptions:

- The study period extends to two years
- The strike price of the options contracts is 95% of the current share value
- The percentage of rise and fall in stock prices is 20% and 10%, respectively
- The interest rate for the risk-free return is 4.5%.
- The term of the contract is one year

Table (1) The following table shows the listed banks in Amman Stock Exchange

			2020-01-03 - 2020-12-30		2021-01-03 - 2021-12-30		
Company	Ticker	Avg. price	No of shares	% of shares	Avg price	No of shares	% of shares
ARAB BANK	ARBK	4.43	18455598	15.44%	4.69	21000528	15.50%
HOUSING BK TRD FIN	THBK	5.06	1861499	1.56%	3.49	3231199	2.38%
JORDAN AHLI BANK	AHLI	0.82	10911953	9.13%	0.9	17067259	12.59%
BANK OF JORDAN	BOJX	1.93	5196989	4.35%	1.98	5193738	3.83%
JOR ISLAMIC BANK	JOIB	2.71	8352270	6.99%	3.24	13668555	10.09%
CAPITAL BANK	CAPL	0.95	39445625	32.99%	1.49	36054017	26.61%
CAIRO AMMAN BANK	CABK	1	9336958	7.81%	1.29	17095992	12.62%
BANK AL ETIHAD	UBSI	1.56	1645396	1.38%	1.65	6462078	4.77%
JOR KUWAIT BANK	JOKB	2.08	894474	0.75%	1.43	5556738	4.10%
ARAB JOR/INV/BANK	AJIB	1.08	1401507	1.17%	1.24	1620252	1.20%
JCBANK	JCBK	0.78	15744558	13.17%	0.83	596701	0.44%
ARAB BANKING CO.	ABCO	0.71	852632	0.71%	0.78	1759271	1.30%
SAFWA ISLAMIC BANK	SIBK	1.34	4539183	3.80%	1.7	5106971	3.77%
INVESTBANK	INVB	1.29	904244	0.76%	1.38	1072100	0.79%
SOCGEN BK - JORDANIE	SGBJ	1.43	22391	0.02%	1.43	25286	0.02%

Source: Prepared by the researcher.

The researcher used the descriptive analytical method to determine the relationship between the independent variable and the dependent variable to achieve the objectives of the study and to test its hypotheses. The researcher applies option pricing theories using a Binomial Model of option pricing in one or two periods.

9 Hypothesis Testing and Analysis:

The first hypothesis examines the extent to which the option price is affected by the stock price by applying the Binomial Model for a single time period.

(H1): The relationship between the option price and the implied stock price using the binomial-options pricing model is positively correlated.

The results presented in the tables below (2) and (3) show that whenever the stock price (S) moves up or down, the option price (C) also moves in the same direction. The percentage change in the option price depends on the change in the share price. This means that the relationship between the stock price change and the option price is a relatively positive relationship.

Table (2) Pricing one-period call options using a Binomial Model 2020-01-03-2020-12-30

Bank	S	E	u	d	Su	Sd	Cu	Cd	R	q	1 − q	C
ARAB BANK	4.43	4.21	1.2	0.9	5.32	3.99	1.11	0	1.045	0.483	0.517	0.51
HOUSING BK TRD FIN	5.06	4.81	1.2	0.9	6.07	4.55	1.27	0	1.045	0.483	0.517	0.59
JORDAN AHLI BANK	0.82	0.78	1.2	0.9	0.98	0.74	0.21	0	1.045	0.483	0.517	0.09
BANK OF JORDAN	0.95	0.90	1.2	0.9	1.14	0.86	0.24	0	1.045	0.483	0.517	0.11
JOR ISLAMIC BANK	1.93	1.83	1.2	0.9	2.32	1.74	0.48	0	1.045	0.483	0.517	0.22
CAPITAL BANK	2.71	2.57	1.2	0.9	3.25	2.44	0.68	0	1.045	0.483	0.517	0.31
CAIRO AMMAN BANK	1	0.95	1.2	0.9	1.20	0.90	0.25	0	1.045	0.483	0.517	0.12
BANK AL ETIHAD	1.56	1.48	1.2	0.9	1.87	1.40	0.39	0	1.045	0.483	0.517	0.18
JOR KUWAIT BANK	2.08	1.98	1.2	0.9	2.50	1.87	0.52	0	1.045	0.483	0.517	0.24
ARAB JOR/INV/BANK	1.08	1.03	1.2	0.9	1.30	0.97	0.27	0	1.045	0.483	0.517	0.12
JCBANK	0.78	0.74	1.2	0.9	0.94	0.70	0.20	0	1.045	0.483	0.517	0.09
ARAB BANKING CO.	0.71	0.67	1.2	0.9	0.85	0.64	0.18	0	1.045	0.483	0.517	0.08
SAFWA ISLAMIC BANK	1.34	1.27	1.2	0.9	1.61	1.21	0.34	0	1.045	0.483	0.517	0.15
INVESTBANK	1.29	1.23	1.2	0.9	1.55	1.16	0.32	0	1.045	0.483	0.517	0.15
SOCGEN BK - JORDANIE	1.43	1.36	1.2	0.9	1.72	1.29	0.36	0	1.045	0.483	0.517	0.17

Source: Prepared by the researcher. The prices of (S) and (C) are in Jordanian Dinars (JD).

Table (3): Pricing one-period call options using a Binomial Model 2021-01-03 - 2021-12-30

Bank	S	E	u	d	Su	Sd	Cu	Cd	R	q	1-q	C
ARAB BANK	4.69	4.456	1.2	0.9	5.63	4.22	1.17	0	1.045	0.483	0.517	0.54
HOUSING BK TRD FIN	3.49	3.316	1.2	0.9	4.19	3.14	0.87	0	1.045	0.483	0.517	0.40
JORDAN AHLI BANK	0.90	0.855	1.2	0.9	1.08	0.81	0.23	0	1.045	0.483	0.517	0.10
BANK OF JORDAN	1.98	1.881	1.2	0.9	2.38	1.78	0.50	0	1.045	0.483	0.517	0.23
JOR ISLAMIC BANK	3.24	3.078	1.2	0.9	3.89	2.92	0.81	0	1.045	0.483	0.517	0.37
CAPITAL BANK	1.49	1.416	1.2	0.9	1.79	1.34	0.37	0	1.045	0.483	0.517	0.17
CAIRO AMMAN BANK	1.29	1.226	1.2	0.9	1.55	1.16	0.32	0	1.045	0.483	0.517	0.15
BANK AL ETIHAD	1.65	1.568	1.2	0.9	1.98	1.49	0.41	0	1.045	0.483	0.517	0.19
JOR KUWAIT BANK	1.43	1.359	1.2	0.9	1.72	1.29	0.36	0	1.045	0.483	0.517	0.17
ARAB JOR/INV/BANK	1.24	1.178	1.2	0.9	1.49	1.12	0.31	0	1.045	0.483	0.517	0.14
JCBANK	0.83	0.789	1.2	0.9	1.00	0.75	0.21	0	1.045	0.483	0.517	0.10
ARAB BANKING CO.	0.78	0.741	1.2	0.9	0.94	0.70	0.20	0	1.045	0.483	0.517	0.09
SAFWA ISLAMIC BANK	1.70	1.615	1.2	0.9	2.04	1.53	0.43	0	1.045	0.483	0.517	0.20
INVESTBANK	1.38	1.311	1.2	0.9	1.66	1.24	0.35	0	1.045	0.483	0.517	0.16
SOCGEN BK – JORDANIE	1.43	1.359	1.2	0.9	1.72	1.29	0.36	0	1.045	0.483	0.517	0.17

Source: Prepared by the researcher. The prices of (S) and (C) are in Jordanian Dinars (JD).

It should be noted here that;

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

E: The exercise price for the option contract (E=95%)

u: The expected rate of increase in the share price in the market 20%

d: The expected rate of decline in the share price in the market 10%

S_u, S_d represent the value of the stock in case of rising or falling, respectively.

The result of tables (1) and (2) can be interpreted as shown below by taking one of the banks that formed the study sample (The Arab Bank):

$$\begin{cases} S_u = S(1+u) = 4.43(1+0.20) \quad = 532 \\ S_d = S(1+d) = 4.43(1+(-0.10) = 3.99 \end{cases}$$

Cu and Cd indicate to the price of the option in cases of rise and fall in the implied price of the shares based on equations (3) and (4):

$$\begin{cases} C_u = Max[S_u - E, 0] = Max[5.32 - 4.21 \ ,0] \ = 1.11 \\ C_d = Max[S_d - E, 0] = Max[3.99 - 4.21 \ ,0] \quad = 0 \end{cases}$$

As for the last column in the table, it represents the fair value of the call option in one period, weighted by increases and decreases in the stock price based on the Binomial Model of asset pricing, derived from equation (12):

$$C = \frac{1}{R}[qC_u + (1-q)C_d], \text{ where } \left[q = \frac{R-d}{u-d}\right], R = 1 + r, \ (r = 0.045)$$

$$\left[q = \frac{1.045 - 0.90}{1.20 - 0.90} = 0.483\right], and\ 1 - q = (1 - 0.483 = 0.517)$$

Then

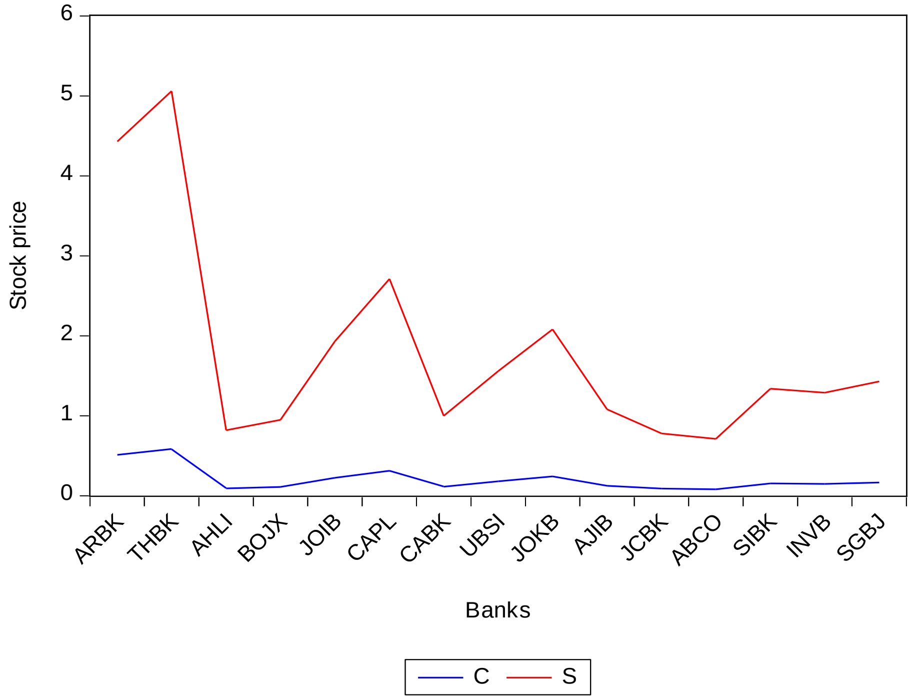
$$C = \frac{1}{1.045}[0.483(1.11) + 0.517(0)] = 0.51$$

It is noted from Table (2), which represents the outcomes of the study conducted on the sample during the period (2/1/2020 to 30/12/2020), that the largest theoretical fair value for the option price belongs to the Housing Bank, which amounted to (0.59 JD), while it the lowest theoretical fair value for the call option price for the Arab Corporation Bank (0.08 JD).

By comparing these results with the corresponding stock values, it is evident that the Housing Bank had the highest market value per share, unlike the Arab Corporation Bank, which had the lowest stock values compared to other banks. Also, by looking at the results presented in table (3), which report the results of the study for the year 2021, it is obvious that the relationship between the stock price movement up or down and the call option price is a direct proportional relationship according to the market price change and its volatility according to market variables. Figure (1) shows the relationship between the share price and call option price for the sample during one period.

Figure (2)

The relationship between stock price and call option price for a one-period by using binomial pricing model



9.1 Pricing Two-Period Options Using the Binomial Model

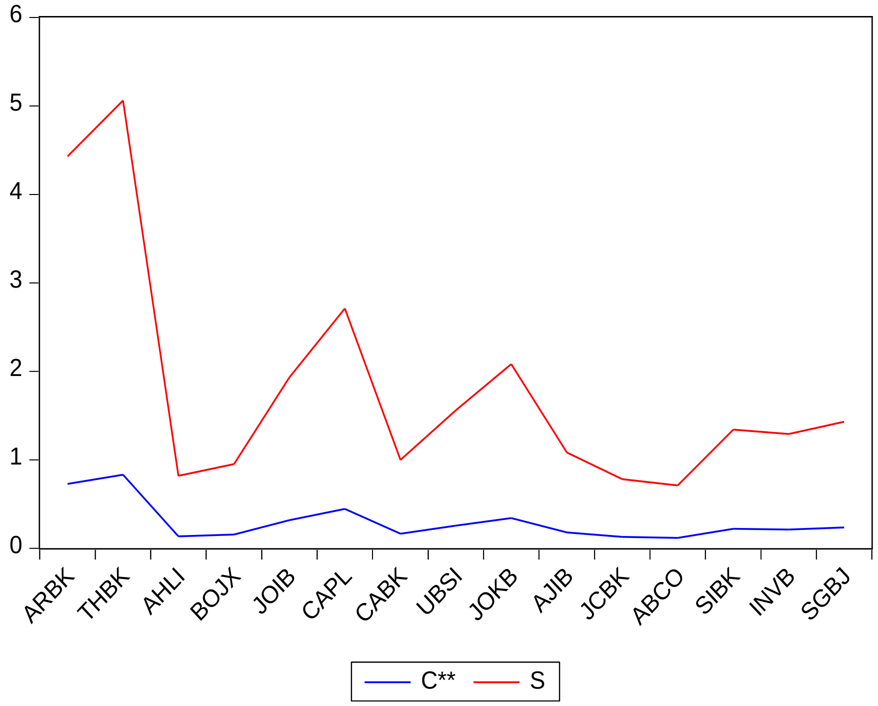
Table (4) shows the values of the variables that were used in the binomial asset pricing model to achieve at the theoretical fair value of options pricing during more than one-time period (2020 and 2021).

Table (4) Pricing two-period call options using a Binomial Model 2020-01-03 - 2021-12-30

Bank	*S*	*E*	*u*	**d**	Su^2	S_{ud}	Sd^2	Cu^2	C_{ud}	Cd^2	*R*	*q*	**C** (JD)**
ARAB BANK	4.43	4.21	1.2	0.9	6.38	4.78	3.59	2.17	0.57	0	1.045	0.48	0.72
HOUSING BK TRD FIN	5.06	4.81	1.2	0.9	7.29	5.46	4.10	2.48	0.66	0	1.045	0.48	0.83
JORDAN AHLI BANK	0.82	0.78	1.2	0.9	1.18	0.89	0.66	0.40	0.11	0	1.045	0.48	0.13
BANK OF JORDAN	0.95	0.90	1.2	0.9	1.37	1.03	0.77	0.47	0.12	0	1.045	0.48	0.16
JOR ISLAMIC BANK	1.93	1.83	1.2	0.9	2.78	2.08	1.56	0.95	0.25	0	1.045	0.48	0.32
CAPITAL BANK	2.71	2.57	1.2	0.9	3.90	2.93	2.20	1.33	0.35	0	1.045	0.48	0.45
CAIRO AMMAN BANK	1	0.95	1.2	0.9	1.44	1.08	0.81	0.49	0.13	0	1.045	0.48	0.16
BANK AL ETIHAD	1.56	1.48	1.2	0.9	2.25	1.68	1.26	0.76	0.20	0	1.045	0.48	0.26
JOR KUWAIT BANK	2.08	1.98	1.2	0.9	3.00	2.25	1.68	1.02	0.27	0	1.045	0.48	0.34
ARAB JOR/INV/BANK	1.08	1.03	1.2	0.9	1.56	1.17	0.87	0.53	0.14	0	1.045	0.48	0.18
JCBANK	0.78	0.74	1.2	0.9	1.12	0.84	0.63	0.38	0.10	0	1.045	0.48	0.13
ARAB BANKING CO.	0.71	0.67	1.2	0.9	1.02	0.77	0.58	0.35	0.09	0	1.045	0.48	0.12
SAFWA ISLAMIC BANK	1.34	1.27	1.2	0.9	1.93	1.45	1.09	0.66	0.17	0	1.045	0.48	0.22
INVESTBANK	1.29	1.23	1.2	0.9	1.86	1.39	1.04	0.63	0.17	0	1.045	0.48	0.21
SOCGEN BK – JORDANIE	1.43	1.36	1.2	0.9	2.06	1.54	1.16	0.70	0.19	0	1.045	0.48	0.23

Source: prepared based on the study sample, C** indicates to the call option price after two-periods. The prices of (S) and (C**) are in Jordanian Dinars (JD).

Figure 3: The relationship between stock price and call option price for two-periods



Here the value of R (1+r) appears, which represents the risk-free return according to the data of the Central Bank of Jordan for the year 2020, which is 0.045. As for the value of Suu, it indicates the rise in the share price in the first and second periods (2020 and 2022), while the value of S_{ud} shows the prices of the banking sector shares if they increased in the first period, then it fell in the second period. The Sd^2 value indicates a decline in the stock in the first period and then a continuous weakening in the second period. The columns with the variables (C_{uu}, C_{ud}, C_{dd}) denote to the fair prices of the option (high, high; high, low; low, low) stock prices during 2020 and 2021. The prices are calculated according to the following equations:

If the share price arises in the first period (2020) to (Su) and arises again in the second period (2021), the value of the share becomes (for The Arab Bank) like this:

$$\begin{cases} Su^2 = S(1+u)^2 = 4.43(1+0.20)^2 = 6.38 \\ S_{ud} = S(1+u)(1+d) = 4.43(1+0.20)(1-0.10) = 4.78 \\ Sd^2 = S(1-d)^2 = 4.43(1-0.10)^2 = 3.59 \end{cases}$$

As for the changes in the option price, the call option price can be calculated according to equations, 14, 15, and 16 as follows:

$$\begin{cases} Cu^2 = Max(Su^2 - E, 0) = Max(6.38 - 4.21, 0) = 2.17 \\ C_{ud} = Max(Sud - E, 0) = Max(4.78 - 4.21, 0) = 0.57 \\ Cd^2 = Max(Sd^2 - E, 0) = Max(3.59 - 4.21, 0) = 0 \end{cases}$$

Thus, the value of the call option based on the Binomial Model for two periods is as follows (equation 19):

$$C^{**} = \frac{[(0.48)^2(2.17) + 2(0.48)(1-0.48)(0.57) + (1-0.48)(0)]}{(1+0.045)^2} = 0.72$$

The fair value of the options prices after two periods reached the maximum in the Housing Bank (0.83 JD), and the reason for this is due to the high average value of the stock price in the market for this bank compared to other banks in the sample. The value of the option was at its lowest in the Arab Corporation Bank, as it reached (0.12 JD), and this is due to the low market value of this bank. It is noted by comparing the results of the study presented in Tables (3) and (4), which calculate the value of the option over one period and two periods, that the option values increase as the number of time periods increases (Chance & Brooks 2016).

9.2 Hedging a Portfolio Using a One-Period Binomial Model

In this part of the study which is devoted to building a protected portfolio of stocks and options by testing the third hypothesis for one period:

(H3a): Creating a hedge portfolio using the binomial-option pricing model contributes to reducing risk.

A hedged portfolio consists of owning shares and selling call options at a rate of return similar to the risk-free rate of return. It can be calculated so that its value is equal to the value of the shares held, minus the value of the options sold, depending on the equations (21) related to the creation of the approved hedge portfolio as follows:

Table (5): Hedged portfolio calculation for one- period 2020-01-03 to 2020-12-30

Bank	Ticker	S	E	u	d	Su	Sd	Cu	Cd	R	q	$1-q$	C	h	V_0	Vu	rhu	Vd	rhd
ARAB BANK	ARBK	4.43	4.209	1.2	0.9	5.32	3.99	1.11	0	1.045	0.48	0.52	0.51	0.83	317.94	332.25	0.045	332.25	0.045
HOUSING BK TRD FIN	THBK	5.06	4.807	1.2	0.9	6.07	4.55	1.27	0	1.045	0.48	0.52	0.59	0.83	363.16	379.5	0.045	379.5	0.045
JORDAN AHLI BANK	AHLI	0.82	0.779	1.2	0.9	0.98	0.74	0.21	0	1.045	0.48	0.52	0.09	0.83	58.85	61.5	0.045	61.5	0.045
BANK OF JORDAN	BOJX	0.95	0.903	1.2	0.9	1.14	0.86	0.24	0	1.045	0.48	0.52	0.11	0.83	68.18	71.25	0.045	71.25	0.045
JOR ISLAMIC BANK	JOIB	1.93	1.834	1.2	0.9	2.32	1.74	0.48	0	1.045	0.48	0.52	0.22	0.83	138.52	144.75	0.045	144.75	0.045
CAPITAL BANK	CAPL	2.71	2.575	1.2	0.9	3.25	2.44	0.68	0	1.045	0.48	0.52	0.31	0.83	194.50	203.25	0.045	203.25	0.045
CAIRO AMMAN BANK	CABK	1	0.95	1.2	0.9	1.20	0.90	0.25	0	1.045	0.48	0.52	0.12	0.83	71.77	75	0.045	75	0.045
BANK AL ETIHAD	UBSI	1.56	1.482	1.2	0.9	1.87	1.40	0.39	0	1.045	0.48	0.52	0.18	0.83	111.96	117	0.045	117	0.045
JOR KUWAIT BANK	JOKB	2.08	1.976	1.2	0.9	2.50	1.87	0.52	0	1.045	0.48	0.52	0.24	0.83	149.28	156	0.045	156	0.045
ARAB JOR/INV/BANK	AJIB	1.08	1.026	1.2	0.9	1.30	0.97	0.27	0	1.045	0.48	0.52	0.12	0.83	77.51	81	0.045	81	0.045
JCBANK	JCBK	0.78	0.741	1.2	0.9	0.94	0.70	0.20	0	1.045	0.48	0.52	0.09	0.83	55.98	58.5	0.045	58.5	0.045
ARAB BANKING CO.	ABCO	0.71	0.675	1.2	0.9	0.85	0.64	0.18	0	1.045	0.48	0.52	0.08	0.83	50.96	53.25	0.045	53.25	0.045
SAFWA ISLAMIC BANK	SIBK	1.34	1.273	1.2	0.9	1.61	1.21	0.34	0	1.045	0.48	0.52	0.15	0.83	96.17	100.5	0.045	100.5	0.045
INVESTBANK	INVB	1.29	1.226	1.2	0.9	1.55	1.16	0.32	0	1.045	0.48	0.52	0.15	0.83	92.58	96.75	0.045	96.75	0.045
SOCGEN BK - JORDANIE	SGBJ	1.43	1.359	1.2	0.9	1.72	1.29	0.36	0	1.045	0.48	0.52	0.17	0.83	102.63	107.25	0.045	107.25	0.045

S, represents the current stock price, E is the exercise price; u = 1 + return if stock goes up, d = 1 + return if stock goes down, R= 1+risk-free rate; Value of European call at expiration one period later (Cu = Max (0, Su – E), Cd = Max (0, Sd – E)); h represents hedge ratio (Cu-Cd)/(Sd-Sd); q represents the probability that prices will move upward and can be derived by(R-d)/(u-d); (C) is the value of option price at time 0 ;V_0 is the value of the portfolio at the current time; V_u describes the value of the portfolio when the stock price goes up;V_d describes the value of the portfolio when the stock price goes down;r_{hu}, r_{hd} they both describe the return of a hedged portfolio in cases where prices move up or down.

Column (h) represents the calculated hedging value of the total shares in the portfolio, i.e. it represents the total shares purchased relative to the number of options issued at their current price (C). The coverage ratio (h) is calculated by the following relationship:

$$h = \frac{C_u - C_d}{S_u - S_d} = \frac{1.108 - 0}{5.32 - 3.99} = \frac{4.33}{5.20} = 0.833$$

A hedging portfolio consists of selling call options and buying a number of shares. Thus, the value of the current portfolio, based on the hedge ratio, is 0.833, which requires the investor to buy 833 shares at the share price of each bank and to sell 1,000 call options at the option price for each bank. Hence, the portfolio achieves a return on investment equal to the risk-free return. Consequently, the following table shows the portfolio value for one component of the sample (The Arab Bank selected to show calculations):

Table (6): The value of a hedged portfolio

Current value of the portfolio	$V_0 = 833 \times 4.43 - 1000 \times 0.512 = 3178.19$
The value of the portfolio when the price rises	$V_u = 833 \times 5.32 - 1000 \times 1.11 = 3321.56$ $r_u = \frac{3321.56}{3178.19} - 1 \approx 4.5\%$
The value of the portfolio when the price declines	$V_d = 833 \times 3.99 - 1000 \times 0 = 3323.67$ $r_d = \frac{3323.67}{3178.19} - 1 \approx 4.5\%$

The above table shows that the financial portfolio achieved a return equal to the risk-free return of 4.5%, meaning that the investment of 3178.19 dinars will grow to 3321.56 dinars in the event that the share price rises to 32.5 dinars or decreases to 3.99 dinars To achieve a return estimated at 4.5%, which represents the risk-free return if the hedging process is carried out according to the method described above, so the cash flows generated in the case of a decrease or increase in the present value of the underlying shares are equal, bearing in mind that during the hedging process, the investor has a long position consisting of buying 554 shares for every 665 call options (554/665 = 0.833).

9.3 Hedging A Portfolio Using a Two-Period Binomial Model:

This section of the study also focuses on creating a protected portfolio of stocks and options by evaluating the third hypothesis when the portfolio is built using data from two different time periods:

(H3b): Creating a hedge portfolio using the binomial options pricing model contributes to reducing risk.

Figure (4) illustrates a hedging portfolio process for one element of our sample. It would be very helpful to keep an eye on the figure as we move through an example. We will consider the data analyzed for the Arab Bank, which is presented in table (7) as an example for hedging its portfolio. Let the call be trading in the market at its theoretical fair value of 0.73 JD. The hedge will consist of 1000 short calls. The number of shares purchased at time 0 is given by the formula (20) for h:

$$h = \frac{0.58 - 0.58}{5.32 - 3.99} = 0.769$$

Thus, the Arab Bank should buy 769 shares of stock and write 1000 calls; the transaction can be summarized as follows:

Buy 769 shares at 4.43 JD = 3406.67 JD (assets);

Write 1000 calls at 0.73 JD = -728 JD (liabilities)

Net investment = 2678.67 JD (net worth)

Stock goes to ($S_u = 5.32$): Table (5) shows that the hedge portfolio consists of 769 shares at 5.32 JD and 1000 calls at 1.289 JD. The value of the hedge portfolio is

$$V_u = 769\ (5.32\,JD) - 1000(1.289\,JD) = 2802.08\,JD$$

then,

$$r_h = \frac{2802.08}{2678.67} - 1 \approx 4.45\%$$

Consequently, the investment has grown from 2678.67 JD to 2802.06 JD, it should be able to verify that this is a 4.5% return, the risk –free rate. To maintain a hedge through the next period, we need to revise the hedge ratio. The new hedge ratio, h_u, is

$$h_u = \frac{2.17 - 0.58}{6.38 - 4.78} = 1$$

9.4 The new hedge ratio will be one share of stock for each call.

To establish the new hedge ratio, we need either 769 calls or 1000 shares of stock. We can either buy back 231 calls, leaving us with 769, or buy 231 shares, giving us 1000 shares. Because it is less expensive to buy the calls, the Arab Bank should buy back 231 at 1.289 JD each for total cost of 297.76 JD. To avoid putting out more funds, the Arab Bank should borrow the money at the risk-free rate.

Stock goes to ($S_d = 3.99$): The hedge portfolio consists of 769 shares valued at 3.99 JD and 1000 calls valued at 0.266 JD. The value of the hedge portfolio is

$$V_d = 769\ (3.99\,JD) - 1000(0.266\,JD) = 2802.31\,JD$$

So,

$$r_h = \frac{2802.31}{2678.67} - 1 \approx 4.45\%$$

which differs from the outcome at stock price of 5.32 JD only by a round–off error. Because the return is the same regardless of the change in the stock price, the hedge portfolio is riskless. To maintain the hedge through next period, we adjust the hedge ratio h_d, formula to

$$h_d = \frac{2.17 - 0.00}{4.78 - 3.59} = 0.487$$

Stock goes from ($S_u = 5.32\,JD\ \ to\ S_{uu} = 6.38\,JD$) (second period): The Arab Bank sell the 769 shares, the calls are exercised at ($C_{uu} = 2.17\,JD$) each, and repay the loan of 297.76 JD ($(1000 - 769) \times 1.289 = 297.76$) plus the 4.5% interest. The value of the hedge portfolio is

$$V_{uu} = 769\ (6.38) - 769(2.17) - 297.76(1.045) = 2926.75$$

This indicates that the return for the portfolio in the second period is riskless, as it satisfies the rate of risk-free rate:

$$rh_{uu} = \frac{2926.75}{2800.72} - 1 \approx 4.5\%$$

Stock goes from ($\boldsymbol{S_u = 5.32\,JD\ \ to\, S_{ud} = 4.78\,JD}$) **(second period):** The Arab Bank has 769 shares valued at $(4.78\,JD)$, 769 calls, which is worthy of 0.58 JD for each, and the repayment of the loan of 297.76 JD plus interest for a total hedge portfolio value of

$$V_{ud} = 769\ (4.78) - 769\ (0.58) - 297.76\ (1.045) = 2918.64$$

Also this shows that there is a return of 4.5% from the previous period:

$$rh_{ud} = \frac{2918.64}{2800.72} - 1 \approx 4.5\%$$

Stock goes from ($\boldsymbol{S_d = 3.99\,JD\ \ to\, S_{ud} = 4.78\,JD}$) **(second period):** The hedge ratio of the portfolio consists of 487 shares,

$$h_{ud} = \frac{C_{ud} - C_{dd}}{S_{uu} - S_{dd}} = \frac{0.58 - 0}{4.78 - 3.59} = 0.487$$

Thus, we need 487 shares of stock for the 1000 calls. We currently hold 769 shares, so we can sell off 282 shares at 3.99 JD and receive 1125.18 JD. Then, we invest this money in riskless bonds paying the risk-free rate.

$$V_{ud} = 487\ (4.78\,JD) - 1000(0.58\,JD) + 1125.18(1.045) = 2923.49\,JD$$

So,

$$r_{hud} = \frac{2923.49}{2802.31} - 1 \approx 4.5\%$$

Stock goes from ($\boldsymbol{S_d = 3.99\,JD\ \ to\, S_{dd} = 3.59\,JD}$) **(second period)**: There are no shares traded at 3.59 JD, 1000 calls expiring worthless, and principal and interest on the risk-free bonds. The value of this hedge portfolio is

$$V_{dd} = 0\ (3.59\,JD) + 1000\ (0) + 2800.72\ (1.045) = 2926.75$$

This is essentially the same amount received as in the other cases; the difference is due only to a round-off error. Hence, regardless of which path the stock takes, the hedge will produce an increase in wealth of 4.5% in each period.

Table (7): Hedged portfolio calculation for Two- period 2020-01-03 to 2020 -12-30

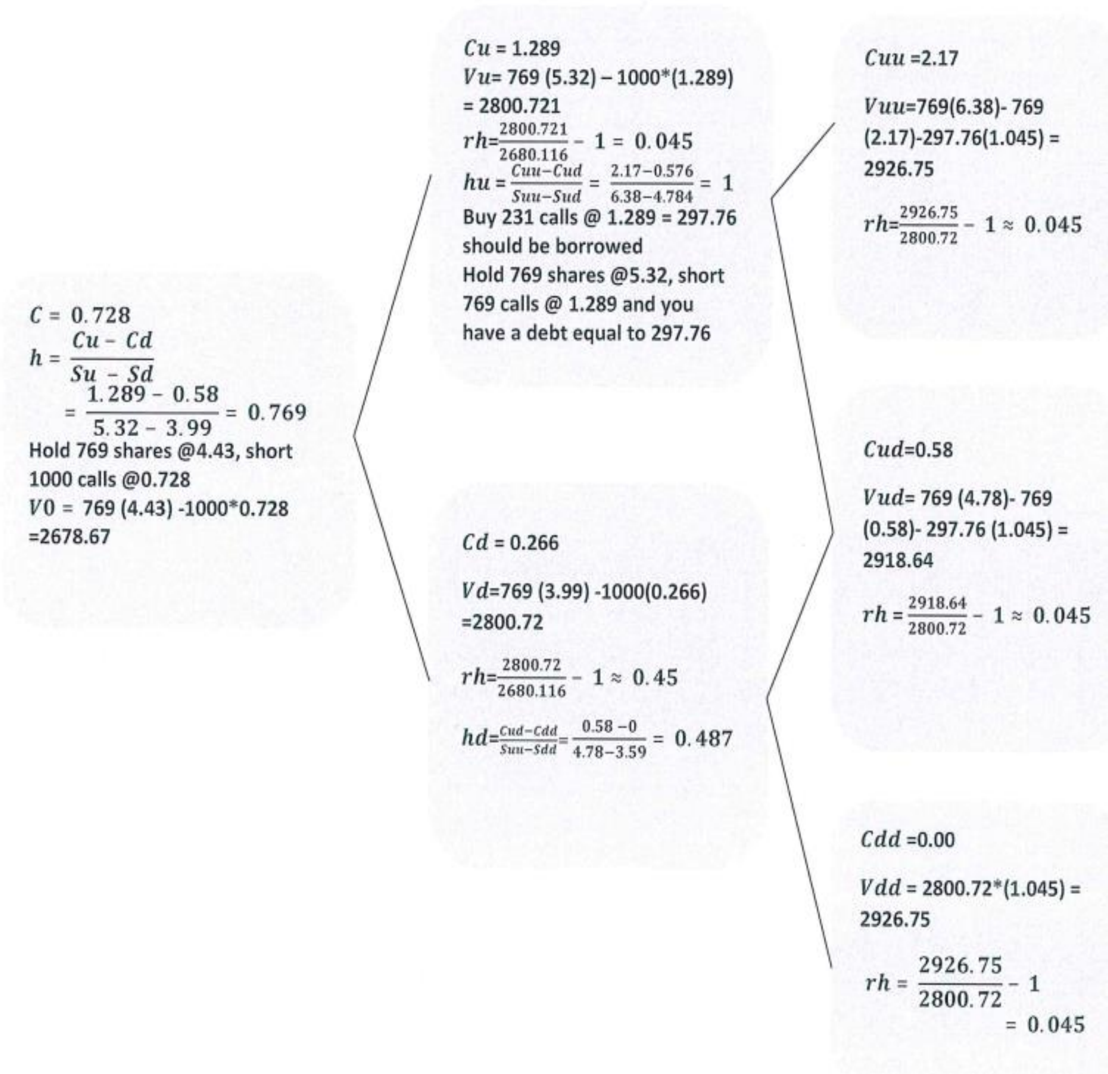
Bank	Ticker	h	V_0	Vu	Vd	rhu	rhd	hu	hd	Vuu	rhuu	Vud	rhud	Vdd	rhdd
ARAB BANK	ARBK	0.769	2680.12	2800.72	2800.72	0.045	0.045	1	0.481	2926.75	0.045	2926.75	0.045	2926.75	0.045
HOUSING BK TRD FIN	THBK	0.769	3061.26	3199.02	3199.02	0.045	0.045	1	0.481	3342.97	0.045	3342.97	0.045	3342.97	0.045
JORDAN AHLI BANK	AHLI	0.769	496.09	518.42	518.42	0.045	0.045	1	0.481	541.75	0.045	541.75	0.045	541.75	0.045
BANK OF JORDAN	BOJX	0.769	574.74	600.61	600.61	0.045	0.045	1	0.481	627.63	0.045	627.63	0.045	627.63	0.045
JOR ISLAMIC BANK	JOIB	0.769	1167.64	1220.18	1220.18	0.045	0.045	1	0.481	1275.09	0.045	1275.09	0.045	1275.09	0.045
CAPITAL BANK	CAPL	0.769	1639.53	1713.31	1713.31	0.045	0.045	1	0.481	1790.41	0.045	1790.41	0.045	1790.41	0.045
CAIRO AMMAN BANK	CABK	0.769	604.99	632.22	632.22	0.045	0.045	1	0.481	660.67	0.045	660.67	0.045	660.67	0.045
BANK AL ETIHAD	UBSI	0.769	943.79	986.26	986.26	0.045	0.045	1	0.481	1030.64	0.045	1030.64	0.045	1030.64	0.045
JOR KUWAIT BANK	JOKB	0.769	1258.38	1315.01	1315.01	0.045	0.045	1	0.481	1374.19	0.045	1374.19	0.045	1374.19	0.045
ARAB JOR/INV/BANK	AJIB	0.769	653.39	682.79	682.79	0.045	0.045	1	0.481	713.52	0.045	713.52	0.045	713.52	0.045
JCBANK	JCBK	0.769	471.89	493.13	493.13	0.045	0.045	1	0.481	515.32	0.045	515.32	0.045	515.32	0.045
ARAB BANKING CO.	ABCO	0.769	429.54	448.87	448.87	0.045	0.045	1	0.481	469.07	0.045	469.07	0.045	469.07	0.045
SAFWA ISLAMIC BANK	SIBK	0.769	810.69	847.17	847.17	0.045	0.045	1	0.481	885.29	0.045	885.29	0.045	885.29	0.045
INVESTBANK	INVB	0.769	780.44	815.56	815.56	0.045	0.045	1	0.481	852.26	0.045	852.26	0.045	852.26	0.045
SOCGEN BK - JORDANIE	SGBJ	0.769	865.14	904.07	904.07	0.045	0.045	1	0.481	944.75	0.045	944.75	0.045	944.75	0.045

Where h describes the hedged ratio; V_0 expresses the value of the portfolio at time 0, V_u describes the value of the portfolio when the stock price goes up;V_d describes the value of the portfolio when the stock price goes down;r_{hu}, r_{hd} both describe the return of a hedged portfolio in cases where prices move up or down.h_u *and* h_d

Represents the hedge ratio when the price moves up or down.V_{uu} , V_{ud} ,and V_{dd} all describes the portfolio's value during period two, when prices change in each state.rh_{uu} , rh_{ud} , and rh_{dd} demonstrates the hedged portfolio return in each c

The binomial-option pricing model for two periods is used in detail in figure (4) (4). The figure also displays the value of the portfolio, which is a combination of a specific number of shares and a specific number of options according to the hedging ratio. It shows the value of the option in each situation, whether prices have increased or fallen. As appears in the table, with the portfolio in each instance, the risk-free return (4.5%) is attained, resulting in a decrease in risk.

Figure (3)



10 Results discussion

Amman Stock Exchange is considered one of the emerging markets that seeks to keep pace with developments and simulate the rules of governance, but the performance of the financial markets fluctuates according to the prevailing economic conditions. Therefore, the study sample was chosen to represent the banking sector, since this sector is considered one of the most affected by economic activity and interest rate fluctuations. Financial derivatives provide portfolio managers with a new tool for managing risks that will significantly reduce the effects of systematic market risks, increase liquidity, and transfer risks to other parties. The study showed that the return of the hedged portfolio of a selected sample gives a risk-free return equal to 4.5%. While we see in a similar study for Reteimy (2014) the return of a portfolio represents banking sector in the Kuwaiti market reaches to 11.7%, this large difference is due to the modest performance of Amman Stock Exchange during the study period as a result of its being affected by the Covid-19 pandemic. When applying the binomial-option pricing model, the researcher finds that the option prices move in a harmonious way with the stock prices. In addition, it should be noted that if stock prices move below the exercise price in options contracts, the value of the option becomes zero in the case of buying a *call option,* and the trader's loss is only the value of the premium. On the other hand, when the contract is a *put option*, the holder of the option will make a decision of exercising the contract only when the prices drive down; otherwise, the option value will be zero.

The other thing we can observe in the option markets is that when prices are increased to a higher level over the time period of the contract, the option prices will be called *deeply in the money* if it is a call option. Similarly, if prices fall below the contract’s exercise price to a significant level, the net worth is called *deeply out of the money*. These two cases did not occur in Amman Stock Exchange for the sample shares through this simulated study. This can be explained by the fact that prices move up and down progressively, and there are no outliers in market prices.

This study reveals that during the tested period, the Capital Bank traded the highest proportion of shares in Amman Stock Exchange, making up around 26.6% of the total volume of shares listed in the market with an overall value of approximately 53,720,485; however, the price of each option per share is 0.17 JD when the Binomial Model is used to price the options for the two-period approach, whereas the Arab Bank, with a market value of 98,492,476 JD, held approximately 15.5% of the sector's shares with an option price equal to 0.54 JD after two periods in 2021. When examining the option prices for each share, we find that the Housing Bank for Trade and Finance option is the highest in 2020 (0.59 JD), even though the market's share of trading is only 2.4% higher than the share price of the other shares listed in this sector. The explanation for all these differences in option prices is due to the price effect of each share, which confirms the direct relationship between the share price and the option price.

Another thing that can be documented in this study is that the option price per share increases with the number of time periods. To illustrate, the option price of the Arab Bank share during one-time period was (0.51) JD, while the option price became (0.72) JD after two periods of time (Table 4). These results are consistent with the findings of a study conducted by Issawi (2016) in Paris Stock Exchange and Aguilar & Korbel (2019).

11 Conclusion

The concept of an option pricing model—a mathematical formula or mathematical procedure that establishes the theoretical fair value of an option—is put forth in this paper because options pricing refers to the practice whereby options must be traded at their theoretical fair value. The Binomial Model, a formula for estimating the cost of an option, is the subject of this study.

This study started with creating the model in a single period to expiration to determine the option value. A period is defined as a predetermined time during which the underlying stock may move in one of two directions—up or down to a specific price— bearing in mind that the binomial does not require the actual probabilities of up and down moves, which is documented that it is possible to create a risk-free portfolio by combining a long position of investing in shares combined with a short position in a call option. Thus, it is possible to solve via the theoretical option price given the other input parameters, since the return on a risk-free portfolio should be the risk-free rate. Henceo, it is expected to profit from an arbitrage at the absence of risk if the option is not trading at its theoretical price. Then, the researcher extended the concept to a two-period scenario, where it showed that the combination of long stock and short calls must be altered throughout each period to retain the hedge portfolio's risk-free status. Therefore, if the option is mispriced, then it is still possible to make an arbitrage benefit. Furthermore, the study demonstrated that when using the Binomial Model to price options contracts, the relationship between the stock price and the option price is always direct, meaning that any increase in the stock price may be followed by a corresponding increase in the price of options contracts.

This reasearch further indicated that financial options are of great importance in the process of covering and protecting the investment portfolio from the risks of price fluctuations. This study also concluded that when pricing options for one period using the Binomial Model, the relationship between the stock price and the price of the call or put option in the financial markets is a direct proportional relationship, and we can reach the same conclusion when pricing options for two periods using the same model, but adjusted to reflect the theoretical fair value of the option, according to the number of option periods.

The study concluded that several hedging strategies could be applied. The most important of these are featured in this study, which aims to form an investment portfolio consisting of the purchase of shares and the sale of call option contracts for the same shares to achieve accurate returns analogous to the risk-free rate return. The value of the hedge portfolio is equal to the value of the shares held minus the value of the options issued but equal to the risk-free return. It is obvious that a computer, including web-based applications, software programs, and spreadsheets, is required to perform the binomial-option pricing calculations for a large number of periods.

Finally, we can outline the advantages of the Binomial Model by simply stating that it is a very effective tool for illuminating key ideas when exploring option valuation models. The ability of the model to show users how the creation of a dynamic risk-free hedge results in a formula for the option price is perhaps its most valuable feature.

To sum up, this study is an empirical simulation to forecast potential outcomes in the options market and how these financial models can be used to control risks, build a hedged financial portfolio, and offer opportunities for managers and investors to generate creditable returns when using these investment tools.

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