DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

DROUGHT OPTION CONTRACT PRICE

by
Melih AĞRAZ

June, 2011
İZMİR

DROUGHT OPTION CONTRACT PRICE

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by
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M.Sc THESIS EXAMINATION RESULT FORM

We have read the thesis entitled **"DROUGHT OPTION CONTRACT PRICE"** completed by **MELİH AĞRAZ** under supervision of **ASSOC. PROF. DR. GÜÇKAN YAPAR** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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DROUGHT OPTION CONTRACT PRICE

ABSTRACT

Drought, defined as the relation of the temporary unbalance of moisture content in a region to the water shortage in that region, is one of the most important disasters that influence living things and economy. Drought, now and again, has made its presence felt in our country as well as other parts of the world. Drought, along with its damage to the nature, causes great troubles for economy, especially the agriculture sector. We will be frequently hearing of drought in the near future as a result of global warming.

In this study we aimed at obtaining a drought option price for Harran Plane area. In order to achieve this aim, we used the SPI (Standardized Precipitation Index) values, used in Turkey, instead of the drought index called RDI (Reconnaissence Drought Index), as the drought measurement value in the formula. We generated the missing data for 1977 in the drought measurement values obtained from the General Directorate of Meteorology, using the mean of the data at hand. We tried to evaluate whether cotton is suitable to grow in Harran region, using the drought values of the periods covering the growing-time of cotton. In the light of the results obtained, we interpreted if it is possible to determine an option price for cotton, which is suitable for growing in Harran Region, using the SPI data in a Drought Option Pricing Model instead of RDI values. As a result, we tried to produce a new option price with the data we generated using different distributions.

Keywords: Derivative, Option, RDI, SPI, Drought Option Pricing Model

KURAKLIK OPSİYON FİYATI HESAPLANMASI

ÖZ

Bir bölgede nem miktarındaki geçici dengesizliğin o bölgedeki su kıtlığı ile ilişkisi olarak kabaca tanımladığımız kuraklık canlı yaşamını ve ekonomiyi etkileyen en önemli afetlerden biridir. Kuraklık tüm dünyada olduğu gibi ülkemizde de zaman zaman etkisini göstermektedir. Kuraklık doğaya zarar vermesinin yanı sıra ekonomiye özellikle ekonomide tarım sektörüne ciddi sıkıntılar yaşatmaktadır. Kurak geçen dönemlerde ürün rekoltesinin düşmesi ve dolayısıyla ürünlerin fiyatlarındaki artış ekonomiye ciddi sıkıntılar yaşatmaktadır. Küresel ısınmadan da kaynaklı olarak önümüzdeki dönemlerde kuraklık sözünü sıklıkla duyabileceğiz.

Bu çalışmamızda Harran Ovası bölgesinde bir kuraklık opsiyon fiyatı elde etmeye çalıştık. Bunu yaparken formülde geçen kuraklık ölçüm değeri olan ve RDI (Reconnaissence Drought Index) olarak adlandırılan kuraklık index değeri yerine ülkemizde kullanılan SPI'yı (Standardized Precipitation Index) kullandık. Devlet Meteoroloji İşleri Genel Müdürlüğü'nden aldığımız kuraklık ölçüm değerlerinde 1977 yılına ait eksik veriyi, elimizdeki verilerin ortalamasını kullanarak türetmeye çalıştık. Meterolojiden aldığımız verilerin içerisinde ürünün yetişme döneminde ve ürünün dikimden hasat dönemine kadar olan dönemlerin kuraklık değerlerini bu ürünün Harran Bölgesi'nde yetişmesinin uygun olup olmadığını değerlendirmeye çalıştık. Elimizdeki SPI verilerini Kuraklık Opsiyon Fiyatlama modelinde kullanarak RDI yerine kullandığımız verilerle bir opsiyon fiyatı belirlenip belirlenemeyeceğini yorumladık. Sonuç olarak da farklı dağılımlardan türettiğimiz verilerle yeni opsiyon fiyatı oluşturmaya çalıştık.

Anahtar sözcükler: Türev, Opsiyon, RDI, SPI, Kuraklık Opsiyon Fiyatlama

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CHAPTER ONE
INTRODUCTION

Drought, defined as the relation of the temporary unbalance of moisture content in a region to the water shortage in that region, is one of the most important disasters that influence living things and economy. Insomuch as, it said that the most dangerous disaster of all 31 natural disasters is drought. Drought is a concept almost as old as the history of humanity. According to historians, in every era of history, droughts have appeared and humanity always has had their share of this disaster. Drought, even influencing the establishment of civilizations, has become more complex with the concept of climate change which has made its presence felt in the 20^{th} century. As it is known, as a result of the rapid and widespread development of industry, the temperature rise in the 20^{th} century has been greater than the rise in the previous millennium, and this rise is continuing. The rise of the temperatures in the world due to the changes in the precipitation and the greenhouse gas emission causes us to face the problem of drought more frequently nowadays.

There are various measurement methods to express the drought values. For instance we may mention the Aydeniz method, named after Prof. Aydeniz; the SPI method, frequently used in our country, which gives drought values in terms of only precipitation values; and RDI method which adds the transpiration in plants to the precipitation values. These methods determine their parameters to measure drought. Aydeniz method, for instance, expresses drought with a 7-fold classification on a scale between 0.25 and 2.5; values below 0.25 too humid, and values over 2.5 are desert climates. The General Directorate of Meteorology frequently uses the SPI method which classifies drought on a scale between -2 and 2.

Without doubt, drought affects the agriculture sector and especially the farmers in a different way, along with other sectors and inhabitants. Because the water required in the root of the plant in their growing and developing times is more important than the overall annual precipitation. In this respect the lack of water in earth during the growing and developing times of plants is considered as the agricultural drought.

Drought management is a troublesome task and lots of efforts are made, and will be made in the near future by Turkey and other countries for this issue.

Since 2007 was a drought year and the problems caused by the drought were felt all over the country, the government designated the drought management methods and principles under the name of Drought Management Action Plan by the council of ministers in 2007. Although the methods and principles were designated, drought is a disaster that is difficult to manage since it cannot be estimated. Therefore, countries and people should know how to live with drought and to be prepared for this disaster. One of the economical measures taken in terms of drought is the drought option as a sub-branch of options under the derivative markets. According to this option, the farmers make deals with the buyers of their product taking the drought measurement values of previous years into consideration and thus hedge their products against drought.

In this study, before touching upon the drought option, we mentioned the derivative markets, and the options and types of options as our main subject, first. Later, we tried to determine a drought option price for the cotton farmers in Harran Plane. While doing this, we used the SPI values used in our county instead of RDI values, originally used in the formula. We interpreted the results in terms of the question whether the RDI calculation should be done or not by the General Directorate of Meteorology. Consequently, we generated the data from different distributions and obtained an option price with these data and compared the option prices. Let us know begin with answering the question “What is a derivative?”

CHAPTER TWO
DERIVATIVES

2.1 What is Derivatives?

Derivatives are a particular kind of tradable contract. Their trade value is tied to have of assets, historically bulk commodities but also corporate shares and currencies (Maurer, 2002).

Options, futures and swaps are examples of derivatives. A derivatives is simply a financial instrument (or even more simply, an agreement between two people) which has a value determined by the price of something else (McDonald, 2003).

Options futures are examples of what are derivatives of what are termed derivatives. These are instruments whose values depend on the values of other more basic variables (Hull, 1995).

For example, a bushel of corn has a value determined by the price of corn. However, you could enter into an agreement with a friend that says: if the price of a bushel of corn in one year is grater than $3, you will pay the friend $1. If the price of corn less than $3, the friend will pay you $1. This is a derivative in the sense that you have an agreement with a value depending on the price of something else (corn, in this case) (Mcdonald, 2003).

Commodities traded in Derivatives Markets are:

1. Forward Markets
2. Swap Markets
3. Futures Markets
4. Options Markets

Forward and Swap commodities are traded in non-organized markets, namely the over-the-counter markets, while futures and option commodities are traded in

organized exchanges (Aydeniz, 2008). In Figure 2.1 the classification of derivative markets is presented below.

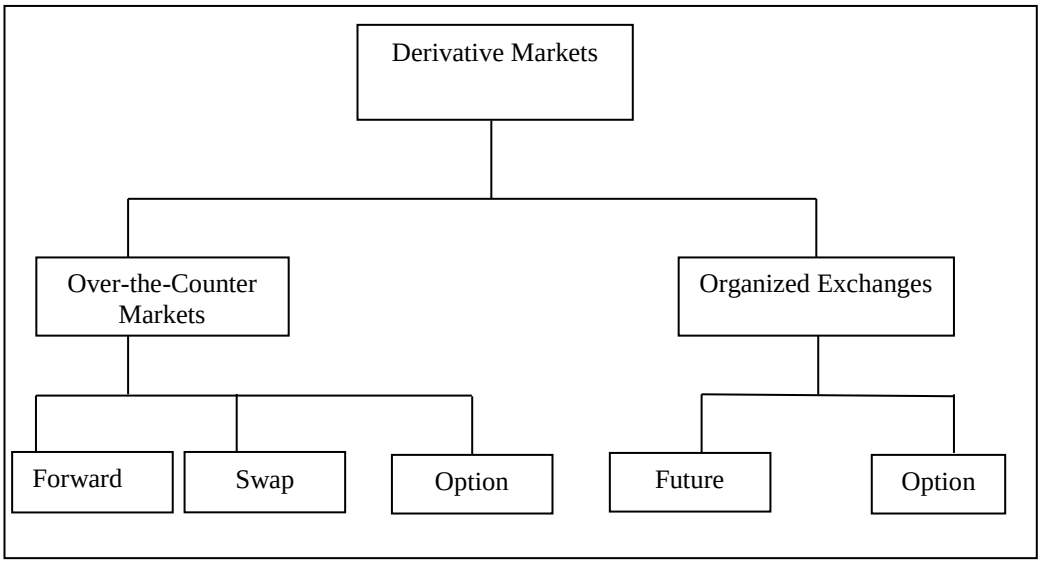


Figure 2.1 Classification of derivative markets

2.2 History of Derivatives

Futures markets can be traced back to the Middle Ages. They were originally developed to meet the needs and merchant consider the position of a farmer in April of a certain year who will harvest grain in June. The farmer is uncertain as to the price he or she will receive for the grain. In years of scarcity, it might be possible to obtain relatively high prices -particularly if the farmer is not in a hurry sell. On the other hand, in years oversupply, the grain might have to be disposed of at fire-sale prices. The farmer and the farmer's family are clearly exposed to great deal of risk.

Consider next a merchant who has an ongoing requirement for grain. The merchant is also exposed to price risk. In some years, an oversupply situation may create favoribe prices; in other years, scarcity may cause the prices to be exorbitant. It clearly makes sense for the farmer and the merchant together in April (even earlier) and agree on a price for the farmer's anticipated production of grain in June. In other words, it makes sense for them to negotiate a type of futures contract. The

contract provides a way for each side to eliminate the risk it faces because of the uncertain price of grain (Hull, 1995).

We explained derivatives history about ancient time but we should mention their recent history. After World War II, the reconstruction of the financial system began with the Bretton-Woods System. States taking part in this system accepted to fix their exchange rates, or at least limiting the rates 1% above or below the determined nominal exchange (Chambers, 2007). Foreign exchange options is an important risk management tool to protect against the risk of foreign exchange faced by both companies performing international transactions and banks and financial institutions (Ersan, 1991; Kırım, 1991).

When the Bretton-Woods system collapsed in 1971, the world entered an era of rapid changes. Within this era, the financial world faced financial risks such as high rates of exchange and interest. As a result of these, financial risk management gained great importance. New financial intermediaries were developed in order to avoid financial risks or at least to minimize them. Derivatives commodities are the most important of these intermediaries (Chambers, 2007).

If we mention the history of options, a group of companies, which defined themselves as commerce brokers and dealers association, created the option markets. If an investor wishes to buy an option, a member of the association finds an option seller. In case the member can not find a seller, the member itself undertakes the sale of the option. Markets created in this way are called “over-the-counter markets”. Because, the seller and the buyer do not meet with each other.

1973 was a milestone for the option markets. In 1973, The Chicago Mercantile Exchange, which is the oldest exchange in the world, established the Chicago Board of Options Exchange to trade options written on stock issues. Thus options were stated to be traded in organized exchanges. After a short time, options written on bonds, foreign exchange, commodities and stock exchanges started to be traded commonly in these organized exchanges (Chambers, 2007). We have made a

mention of the history of derivative markets above; now, let us discuss what the goods subject to the derivative markets are.

2.3 Classification of Assets Subject to Derivatives

In derivatives markets many assets are traded (Aydeniz, 2008). In Figure 2.2, the assets in the derivative markets which are subject to the contract are classified.

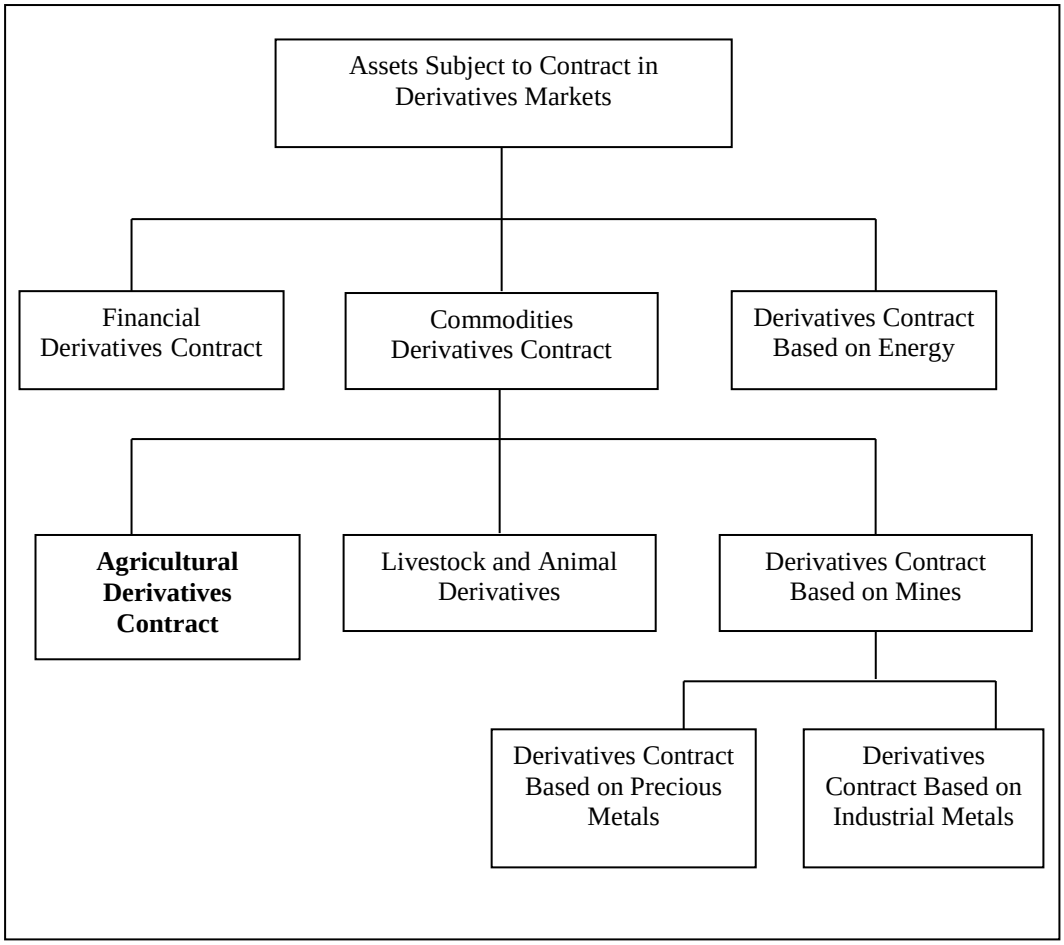


Figure 2.2 Assets subject to contract in derivatives markets

We will explain the “Agricultural Derivatives Contracts”, namely the agricultural options in 2.4.3.11 which is written in bold characters in the chart above.

The derivative transactions performed on agricultural products only before 1972 were started to be used on financial products after this date (Aydeniz, 2008).

Commodities derivatives contracts are the first examples of forward transactions. The derivatives contracts based on commodities are categorized into three groups:

1. Agricultural derivatives contracts: wheat, cotton, corn, sesame, soybeans, coffee, cacao, tobacco, tea, sugar, potatoes, oat, orange juice, olives, etc. are cited as examples of the contracts in this group. Since February 2005, the futures exchange, too, perform transaction on futures contracts based on wheat and cotton.
2. Derivatives contracts based on livestock and animal products: milk, cheese, eggs, butter, livestock, white meat, fish, etc. are cited as examples of the contracts in this group.
3. Derivatives contracts based on mines: These contracts are divided into two groups. Precious metals and Industrial metals. The most known example to precious metals is gold. Gold is used both for investment and as raw material. Gold, silver, platinum and palladium contracts can be given as examples for this group. Zinc, iron and steel, copper, aluminum contracts are cited as examples for the industrial metals group.

2.4 Derivative Markets

Derivative markets are markets in which the trade of any goods or financial instruments, to be delivered or their cash settlement to be done in the future, is done as of today (Usta, 2005). We said that options, futures, forward and swaps are example of derivative markets. Now let us mention Futures, among the Derivatives Products.

2.4.1 Futures

Futures contracts are legal contracts that envisage the delivery of a goods of particular quality and quantity, at a price and date in the future determined as of the date of the contract (Usta, 2005). The buyer/seller of the contracts enters into obligation, and fulfills this obligation is not optionally but as a requirement. The assets treated in futures contracts may be physical commodities as well as indices. The physical commodities contracts are called "Futures contracts based on commodities"; and futures contracts based on indices are called "Financial futures contracts". Futures contracts are traded on organized exchanges **(**Rudolp&Schafer, 2005). According to another definition, futures contracts are traded on an organized exchange, and the terms of the contract are standardized by the exchange (Hull, 1995).

A futures contract is an agreement that involves a standard term and amount, which is traded on organized exchanges, and is dependent on daily offset procedures. In daily offset, after each transaction day, the losing party should make payment to the other party. There are two important advantages of futures contracts. These are, trading speed and liquidity. A futures contract can be rapidly exchanged between parties and can be traded in great amounts without affecting the price.

An investor does not have to have the asset subject to the contract in its possession to sell a futures contract. Put it another way, futures contracts are issued based on some particular financial assets, for instance foreign exchange, stock issues or bonds. Besides, the investor can sell futures contracts without having these financial assets in its possession. Thus, the amount of futures contracts in the world is more than the amount of the financial assets subject to trade.

Futures contracts can be based on physical commodities as rubber, cotton, cocoa, and copper. In addition, they can be traded on transactions such as government bonds, treasury bonds and issues, stock issues, bonds, bank certificates (Chambers, 2007).

2.4.2 Forward

Forward contract are similar to futures contracts in that they are agreements to buy or sell an asset at a certain time in the future for a certain price. However unlike futures contracts, are not traded on an Exchange. There private agreements between two financial institution or between a financial institution an done of its corporate clients (Hull, 1995).

The other explanation about forward is that a forward contract is an agreement signed between seller and buyer, involving the delivery of an asset in a future date, with a determined price as of today (Chance, 1989).

One of the parties to a forward contract assumes a long position and agrees to buy the asset at a certain specified date for a certain price. The other party assumes a short position and agrees to sell the asset on the same date for the same price. Forward contracts do not have to conform to the standarts of a particular Exchange. The delivery date in the contract can be any date mutually convenient to the two parties. Usually, in forward contracts, a single delivery date is specified whereas in futures contracts, there is a range of possible delivery dates.

Forward contracts not marked to market daily like futures contracts. The two parties contract to setle up on the specified delivery date.whereas most to delivery of physical asset to final settlement in cash (Hull, 1995).

2.4.3 Options

Options, as a general term, is a type of agreement that originates the right to buy or sell an asset from a fixed price in a determined term. The application of the option is not an obligation but a matter of choice (Seyidoğlu, 2003).

Options are fundamentally different from forwad and futures contracts. An option gives the holder of the option right to do something. The holder does not have to

exercise this right. By contrast, in a forwad or futures contract, the two parties have commited themselves to doing something. Whereas it costs nothing to enter into a forward or futures contract, the purchase of an option requires an up-front payment (Hull, 1995).

As we mentioned above, the most important difference that distinguishes options from other derivatives is the use or nonuse of the given right. The deficit is limited to the premium paid only, in case the option is not treated. Therefore, limited deficit potentiality and high leverage potential is among the advantages of options transactions (Güven, 2001).

A simple contract for example is to sell a commedity at the market price at the moment of the contract's origination within a specified time period in the future. If the market price of the underlying comodity goes up during the term of the contract, the value contract decreases, since owner would then have the essentialy worthless right to sell the commodity at a price lower than price (Maurer, 2002).

One of the main reasons that option markets to make a great progress is their property of reducing risks. As options markets are an important part of the world's financial markets, it is a basic requirement for the investors to comprehend the mechanism of options (Chambers, 2007). Many people, from stockborkers to farmers, or many companies may protect themselves against the risks in the market using options. Thus they can freely make investments and trade.

The option contracts realized in financial markets, in the widest sense, is an instrument, which gives the individual or institutional investor holding the contract, the right to buy or sell an asset from a particular price at a determined date in the future or before (Yılmaz, 1998).

If we are to add a new definition at this point, an option contract is the right to buy or sell a particular amount of asset from a particular price at a determined date in the future or before this date. This right in question is entitled only to the buyer of the

contract (holder). As for the party writing or selling the option, it is under a contingent liability (Ersan, 1998).

An option is a special contract. The buyer of the option has the right to choose whether he/she wants to deal to happen. With this contract, they will set a maturity date and an agreed price level, which is called strike price (Stampfi, 2001; Goodman, 2001). And also options are traded both on Exchanges and in the over-counter market (Hull, 1995).

After these brief and different definitions of options, we may give examples of options. A newspaper, which distributes coupons to its readers in order to buy a product of a particular price until a determined date in the future, in fact sells an option to purchase to its readers. A similar example may be given with respect to the practices of airline companies. For instance, an airline company can give its customer the right to change the ticket at the last moment just for $75, although the customer bought the ticket at a highly discounted price and feared that his plans would change and he could not be able to refund the ticket. If the customer pays $75 and buys the right to cancel the ticket anytime he wishes, this would be equal to buying an options contract in the financial markets (Yılmaz, 1998).

2.4.3.1 Options Markets

As we previously touched upon, the Chicago Board Options Exchange is the first option exchange which realized the trade of options by bounding option transactions to a procedure. Later, in addition to this exchange, American Philadelphia and New York exchanges started to perform options transactions. As it is known, an exchange is a legal institution where the trade of financial instruments such as options and futures contracts is done. For the transactions to be performed, the exchange provides various regulations, procedures and a physical space.

Not all of he options are treated in exchanges. Some options are traded in over-the-counter markets. These markets are the ones that are formed between two

financial institutions or between a financial institution and an individual investor (Stampfi & Goodman, 2001). Another market that options are traded is the organized markets in which the form requirements are standardly determined. In other words, options markets are divided into two as organized markets (stock exchanges) and over-the-counter markets.

2.4.3.2 Over-the-Counter Options Markets

In over-the-counter markets, factors such as using prices of options, their terms are determined by mutual agreements. The monetary amounts of the options traded in over-the-counter markets are notably higher than the ones traded in the stock exchanges. Besides, the types of the foreign exchanges traded are more wide-ranging. While membership to a stock exchange requires various conditions, in over-the-counter markets trade and investment banks, institutions, and individual investors can easily perform transactions. However, the most important drawback of over-the-counter markets against stock exchanges is their being open to risks. When there is a credit risk for one of the parties, this risk is laid on the other party. There is not any exchange institution to undertake the risk. Another drawback is that the transactions in over-the-counter markets are more expensive than the ones in the stock exchanges (Chambers, 2007).

These options, apart from the stock exchanges, are realized between the banks or financial institutions and customers. The contract sizes of options, their application prices and terms are not standard, but determined completely in terms of the requirements of the bank and its customer. Similarly, the option premium is determined only by the parties in the option. There is not a need for an assurance apart from the premium (Yılmaz, 1998).

Over-the-counter markets have some benefits, such as;

- The options conditions traded in these markets are determined with respect to the specific needs of the parties.

- Over-the-counter markets are private markets without the necessity that neither public, nor other investors in the market, including competing companies, to know that the transactions are performed. In organized markets, buying a great amount of sell option gives a signal to the market that any investor received bad news. This, in turn, may cause the market, as a result of the market's getting uneasy about potential information, to stumble. This is not the case in over-the-counter markets.

Over-the-counter markets are not legally regulated. Their rules are determined with respect to honesty and respect based on commercial common sense. The persons who do not obey these general rules would have difficulty in finding parties to perform transactions in the market. These markets, not having a legal infrastructure, do not require a formal permissive authority for new option types. The contracts are formed and traded between parties that see common benefit in making business together. In this respect there are not any limitations and red tapes that increase the costs (Yılmaz, 1998).

The most important drawback of the over-the-counter markets is their being open to risks. If there is a possibility of risk for one party, this risk is laid on the other party.

2.4.3.3 Organized Option Markets

Organized option markets emerged in order to establish the trading venue, legal infrastructure, rules, the standardization of contracts and liquidity which are missing in over-the-counter markets; by this means, they sped up and enabled the trading of options contacts like stock issues, and provided the emergence of a spot market in which the options contracts can easily exchanged.

In this system, when any investor holding the options contract wishes to sell the option before the end of its term, or when any investor who wrote the options contract aims at a relief from obligation of the trade of the stock issue, both investors

have the opportunity to perform a transaction towards closing the positions they are holding by taking inverse positions in organized markets (Yılmaz, 1998).

The basic properties of the options traded in stock exchanges are as below:

- All trading transactions are performed with respect to the rules set in the stock exchange.

- The contract sizes are standardized. For instance, in Philadelphia Exchange (PHLX) the size of foreign exchange or exchange contracts are € 31.250.

- The terms or validity expirations of the options are standard also. For instance, in exchange options, the terms are the third Wednesdays of March, June, September and December.

- Only the seller or writer of the option makes down a margin or an assurance, of a percentage of the option value determined by the stock exchange, to the stock exchange where trading takes place.

- These options may depend on cash or spot prices and also the contracts traded in the stock exchanges (Ersan, 1998).

CBOE, being the first organized option exchange in the world, also lead the beginning of options trading transactions in American Stock Exchange (AMEX), the Philadelphia Stock Exchange (PHLX), the Pacific Stock Exchange (Pacific SE) and New York Stock Exchange (NSE) in the USE. As for the first options exchange in Europe, it was established in 1978 in Amsterdam under the name of European Options Exchange (EOE) (Seyidoğlu, 2003). We can see country and stock market table below. We provided table from Euroclear IFR, Handbook of World Stock and Commodity Exchanges, 1996. Later, many option exchanges were established in the world and list of these options are given in Table 2.1.

Table 2.1 States and markets in which option contracts are realized on stock issues

State	**Exchange**
Australia	Australian Options Market (Sydney)
Austria	Austrian Futures and Options Exchange (ÖTOB) (Vienan)
Belgium	Belgian Futures and Options Exchange (BELFOX)
Brasil	Rio de Janerio Stock Exchange Sao Paulo Stock Exchange (BOVESPA)
Canada	Montreal Exchange (ME) The Toronto Stock Exchange (TSE) Vancouver Stock Exchnange (VSE)
Chile	Santiago Stock Exchange
Denmark	The Copenhagen Stock Exchange
Finland	Finnish Options Market (SOM)
France	Marche des Options Negociables de Paris (MONEP)
Germany	German Stock Exchange Deutche Terminboerse (DTB) (Frankfurt)
Netherlands	European Options Exchange (EOE) (Amsterdam)
Italy	Italian Deriavatives Market (IDEM)
New Zealand	New Zealand Futures and Options Exchange (Auckland)
Norway	Oslo Stock Exchange (OB)
Singapore	Stock Exchange of Singapore Ltd.
South Africa	The Johannesburg Stock Exchange
Spain	MEFF Renta Variable SA (Madrid)
Sweden	The Swedish Futures and Options Market (OM Stockhom AB)
Switzerland	Swiss Options and Financial Futures and Options Exchange (SOFFEX) (Dietikon)
United Kingdom	London International Financial Futures and Options Exchange (LIFFE) OMLX The London Securities and Derivatives
USA	Chicago Board Options Exchange (CBOE) Philadelphia Stock Exchange (PHLX) New York Stock Exchange (NYSE) Amerikan Stock Exchange (AMEX) Pacific Stock Exchange (Pscific SE)

2.4.3.4 Types of option

The options are classified according to their expiry dates. While performing this classification, the options' possibilities to be transacted before or after the end of the maturity period and to be transacted in a particular amount are taken into consideration. This classification is called American, European or Bermuda.

2.4.3.4.1 European Options. These are options used only when the terms expires; the investor has to wait the expiration of the term even though he makes profit.

2.4.3.4.2 American Options. These are options that can be treated before the term. In other words, if the investor is in money before the expiration of term, he can treat the option or if he is at loss or thinks that his loss would increase he can treat the option.

2.4.3.4.3 Bermudan Options. These are options that can be treated limited times including the end of the term. Although the weight is on the American options in the organized markets that treat options contracts all over the world, most of the option contracts traded in over-the-counter markets are European options.

2.4.3.5 Kinds of Option

There are mainly two kinds of options. These are call options and put options. Also, there are two parties as buyer and seller in each option (Yüksel, 1997).

A call option gives the holder the right to buy an asset by a certain day for a certain price (Hull, 1995). Put another way, the owner or buyer of the call option is the party who has the right to use the option contract he bought for a certain price or premium in a period determined in the contract or at the end of this period (Ceylan, 2001).

As for put option, it the option that gives its buyer the right to sell a certain amount of assets for a certain price or premium until a certain date or at a certain date. Put option is a financial instrument that companies, that want to protect themselves from decreases in the prices, or speculators, who aims at profiting from these decreases may benefit (Bolak, 2004).

In other words, put options works as the opposite of call options. A put option buyer has the right to sell an asset for the determined price until a certain date. Put option seller, though, has to buy the asset when the buyer wishes. The table below shows the rights and obligations of the buyer and seller in call and put option (Stigum, 1990).

2.4.3.5.1 Basic Positions Taken in Option Transactions. There are four basic positions in option transactions

1) call opsiyon

    a) long call b) short call

2) put option

    a) short put b) long put

The four positions used in options transactions are summarized in Table 2.2 (Peridon& Steiner, 2002).

Table 2.2 The four basic positions in option transactions

Kind of Option	**Buyer**: Pays premium, has the right to decide actively.	**Seller**: Takes premium, is in a passive condition and has to fulfill his obligation.
Call Option	**Call Option Buyer**: Has the right to buy the asset	**Option Writer**: Lliable to sell the asset in question
Put Option	**Put Option Buyer**: Has the right to sell the asset in question	**Option Writer**: Liable to buy the asset in question

As it can bee seen from the table above, an option buyer, buys the right to buy the asset on which the contract is written for call option and buys the right to sell for put option. Option buyer has to pay a premium or price to the seller when the option contract is made. Option seller (the party writing the option) is liable to sell the asset in call option and buy the asset in put option. Seller of the option has to deliver or sell the asset in question when the buyer treats the option. Seller accepts the payment of a premium in exchange for writing the contract and expects the option is treated in its expiry date (Foley&Orlin, 1991).

2.4.3.5.1.1 Call Options. We said that call option gives the holder the right to buy an asset by a certain date for a certain price (Hull, 1995). As we have mentioned before, call option is the option that gives to the holder the right to buy an asset for a price determined as of today, of a certain amount in a certain term (Call option buyer, long call). The option holder may wish to use the option at the end of the term. In this case, his loss is limited to the premium paid in the beginning only; however his profit is theoretically unlimited (Ceylan, 2001). In call option, option seller (writer, short call), in case the option buyer uses his option rights has to sell the asset the contract is based on. In this case, the profit of option writer is limited to the premium collected in the beginning; however his loss is theoretically unlimited (Aydeniz, 2008)

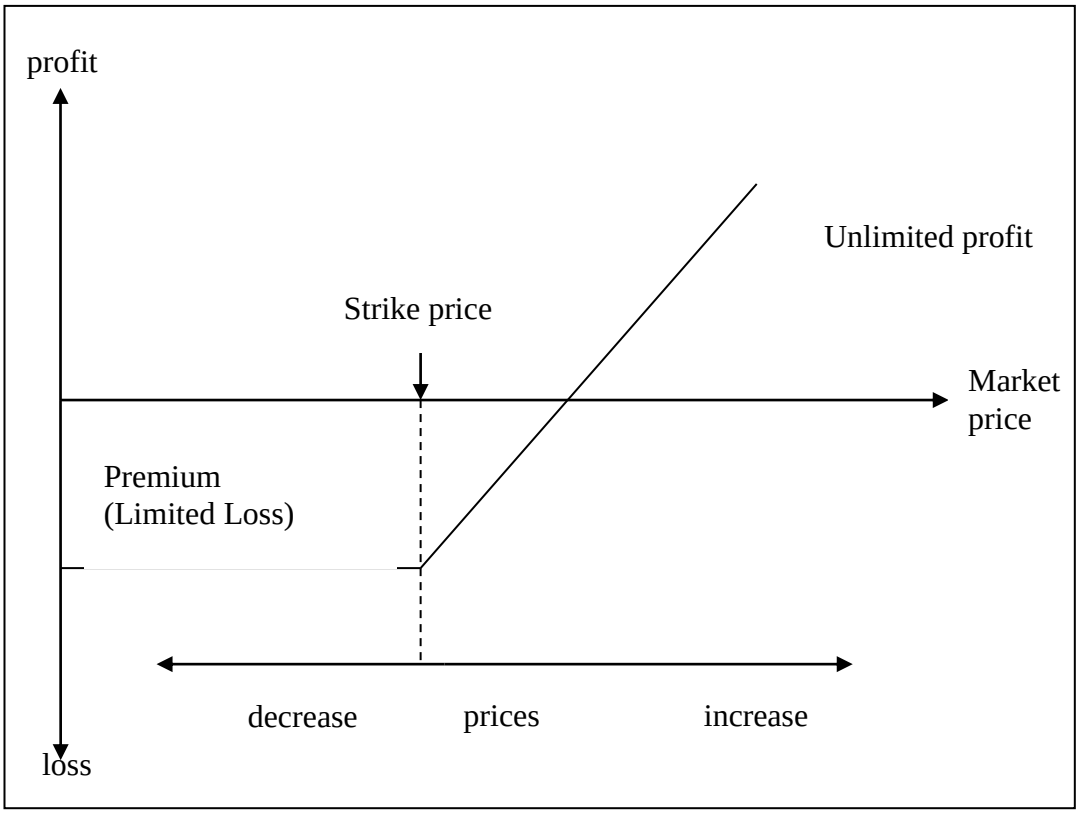


Figure 2.4 Profit-loss status of long call/put option (Aydeniz, 2008)

As it can be seen above, the holder treats the option when the increase in the price of the asset in question is above the premium he paid. However, if the spot price of the asset decreases instead of increasing, the holder will not treat the option and when the term of the contract expires, his loss will be limited to the premium he paid (Aydeniz, 2008).

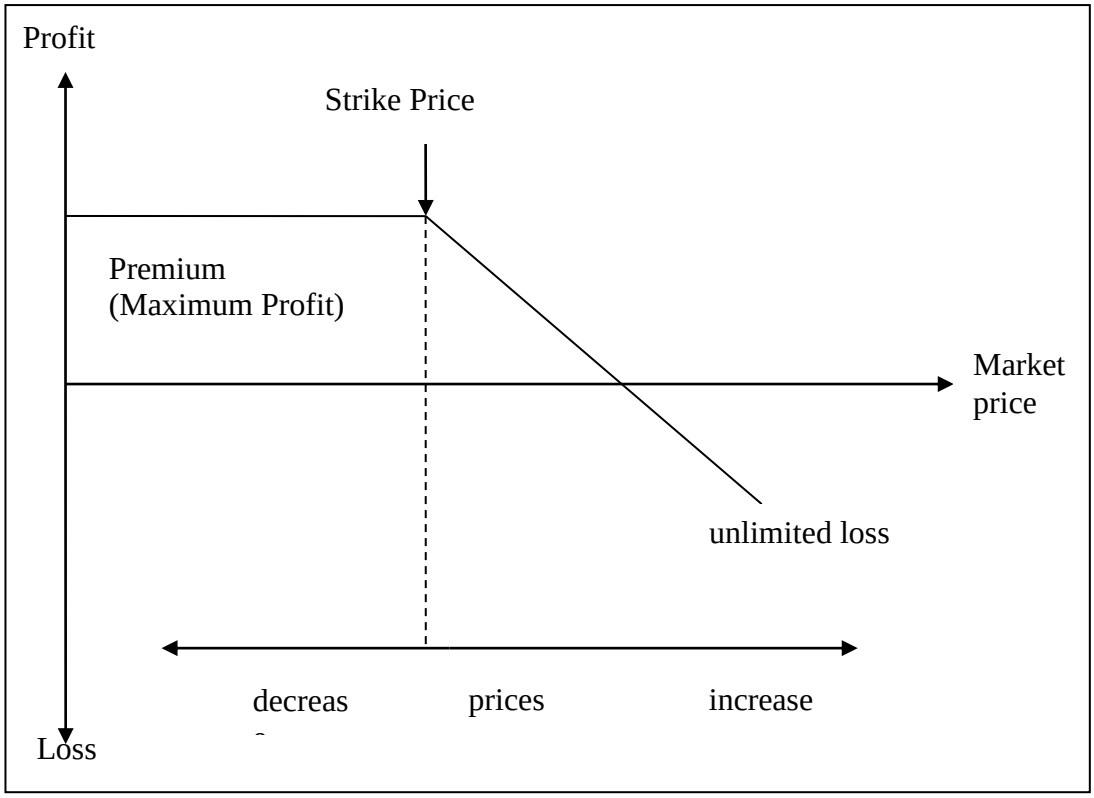


Figure 2.5 Profit-loss status of option writer in call option (Aydeniz, 2008)

In a call option, the expectation of the writer is that there would be a decrease in the price of the asset. When the price of the asset increases above its strike price, the option is treated and option writer can not make profit. When the market price of the asset decreases the writer will get a profit equal to the option premium. When the market price of the asset increases, the loss of the writer would be theoretically unlimited (Aydeniz, 2008).

Consider the situation of an investor who buys a European call option to purchase 100 IBM shares with a strike price of $40. Suppose that the current stock price is $38, the expiration date of the option is in four months, and the price of an option to purchase to share is $5. The initial investment is $500. Since the option is Europian, the investor can exercise only on the expiration date. If the share price on this date is less than $40 he or she will clearly choose not to exercise (there is no point in buying for $40). In these circumstances, the investor loses the whole of the initial investment of $500. If the share price above $40 on the expiration date, the option will be

exercised. Suppose, for example, that the share price is $55. By exercising the option, investor is able to buy 100 shares for $40 per share. If the shares are sold immediately, the investor makes a gain of $15 per share, or $1500 ignoring transactions costs. When the initial cost of the option is taken into account, the net profit to the investor is $1000.

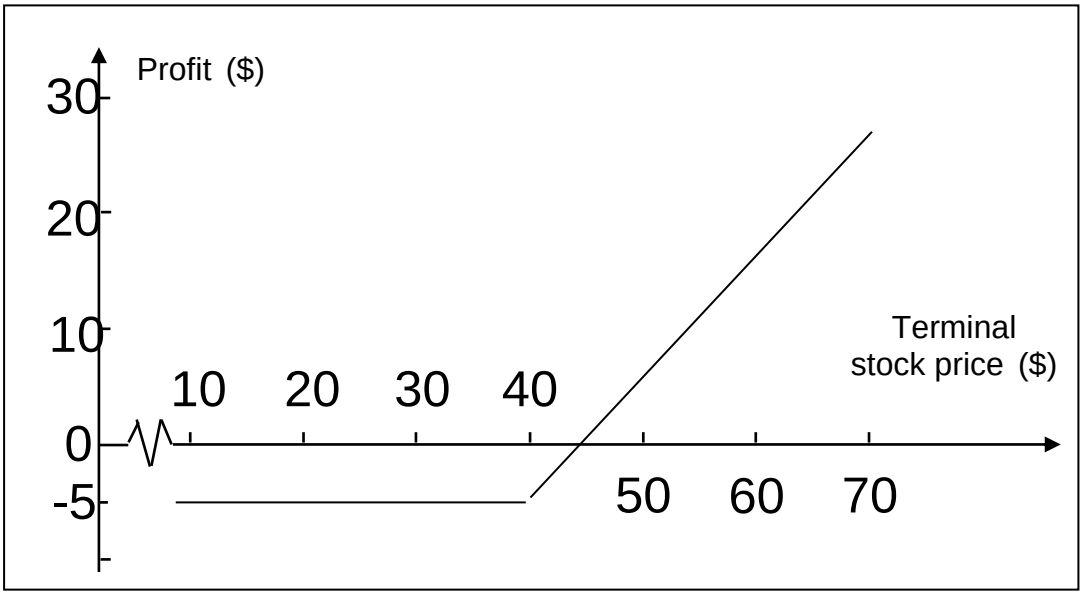


Figure 2.6 Profit from buying a European call option on one IBM share

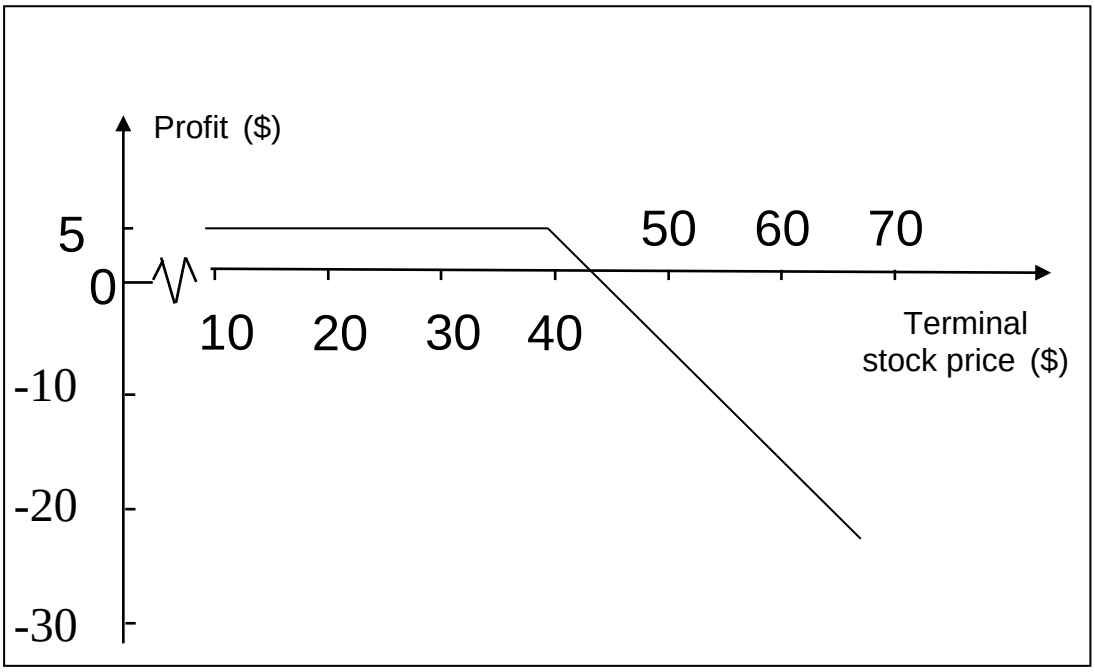


Figure 2.7 Profit from writing a European call option on one IBM share.

Figure 2.6 shows the way in which teh investor's net profit /loss on a option to purchase one share varies with the terminal share price in this example. It is important to realize that an investor sometimes exercises an option and makes a loss over all. Suppose that in the example the stock price of IBM is $42 at the expiration of the option.The investor would exercise the option for a gain of 100*($42-$40)=$200 and realize a loss overall of $300 when the initial cost of the option is taken into account. It is tempting to argue that the investor should not exercise the option in these circumstances. However, not exercising would lead to an overall loss of $500- which is worse than $300 loss when the investor exercise. In general, call options should always be exercised at the expiration date if the stock price above the strike price (Hull, 1995).

2.4.3.5.1.2 Put Options. Put option is the option that gives its buyer the right to sell an asset for a price fixed as of today in a certain term or at the end of a certain term. Option writer has to fulfill the liability he undertook by the option contract (Ceylan, 2001).

Any person or institution that may suffer a loss due to the decrease in the price of an asset in the future and that wish to protect themselves against this risk buy the long put position.

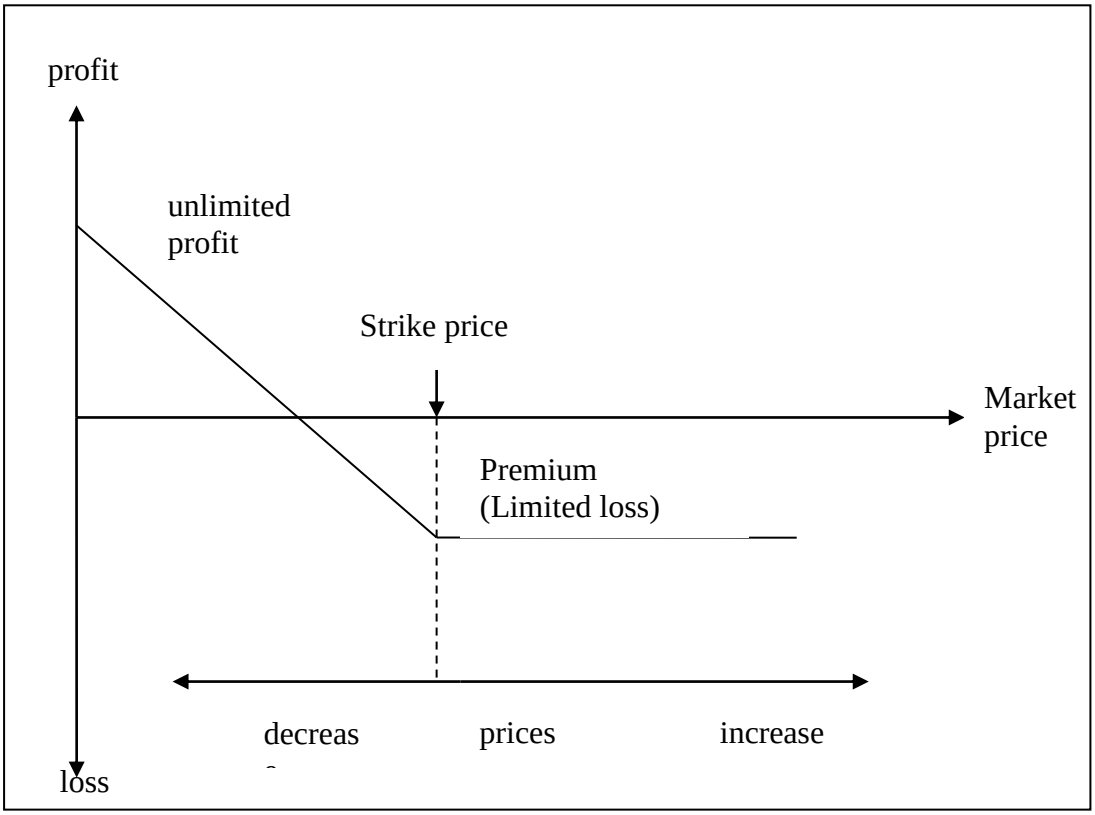


Figure 2.8 Put option with regards to holder and profit-loss status

Since the option holder has the expectation of a decrease in the future, when the prices exceed “strike price + premium”, he would use the option right over any market price. However, if the market price proceeds contrary to expectations, he would wait and if the situation goes on like this at the end of the term, he would not use the option right and his loss would be limited to the premium he paid.

Put option writer (seller) has to buy the asset at the determined amount for the determined price, when the short put option contract is treated by the buyer. The expectation of the writer is that the prices would increase. The maximum profit of the writer is the premium he took from the option holder, and his loss is theoretically unlimited.

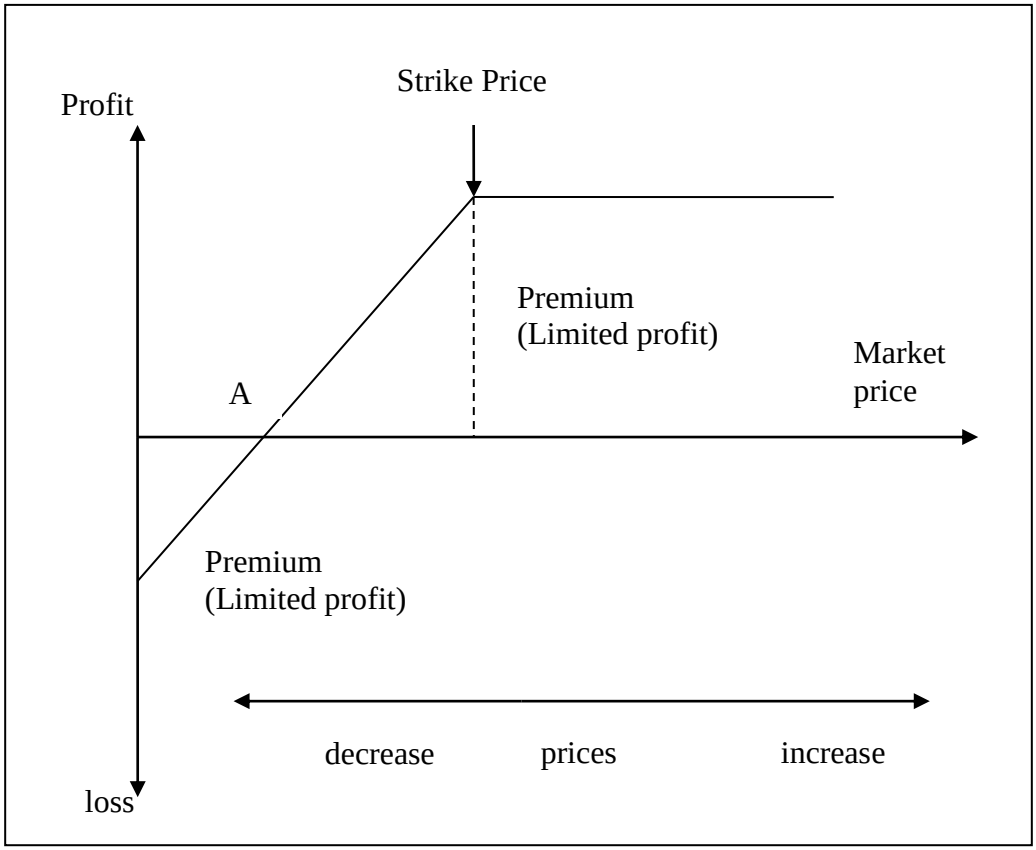


Figure 2.9 Put option with regards to option writer and profit-loss status

As it is seen in Figure 2.9, option writer's profit would increase as the market price of the asset increases; however, in this case, the holder would not use his rights. When the market price of the asset drops below point A, the holder would use his rights and this will be disadvantage to the writer (Aydeniz, 2008).

Lets give an example of the put option wheras the purchase of a call option is hoping that the stock price will increase, the purchase of a put option is hoping that it will decrease. Consider an investor who buys a European put option to sell 100 Exxon shares with a strike price of $70. Suppose that the current share price is $65, the expiration date of the option is in three months, and the price of an option to sell one share is $7. The initial investment is $700. Since the option is Eurepean, it will be exercised only if the share pice is below $70 at the expiration date. Suppose that the share price is $55 on this date. The investor can buy 100 shares for $55 per share and, under the terms of the put option, sell the same shares for $70 to realiz a gain of $15 pe share or $1500. When the $700 initial cost of the option is taken into account,

the investor net profit is $800. Of course there is no guarantee that the investor will take a gain. If the stock price is above $70 the put option expires worthless and the investor loses $700.

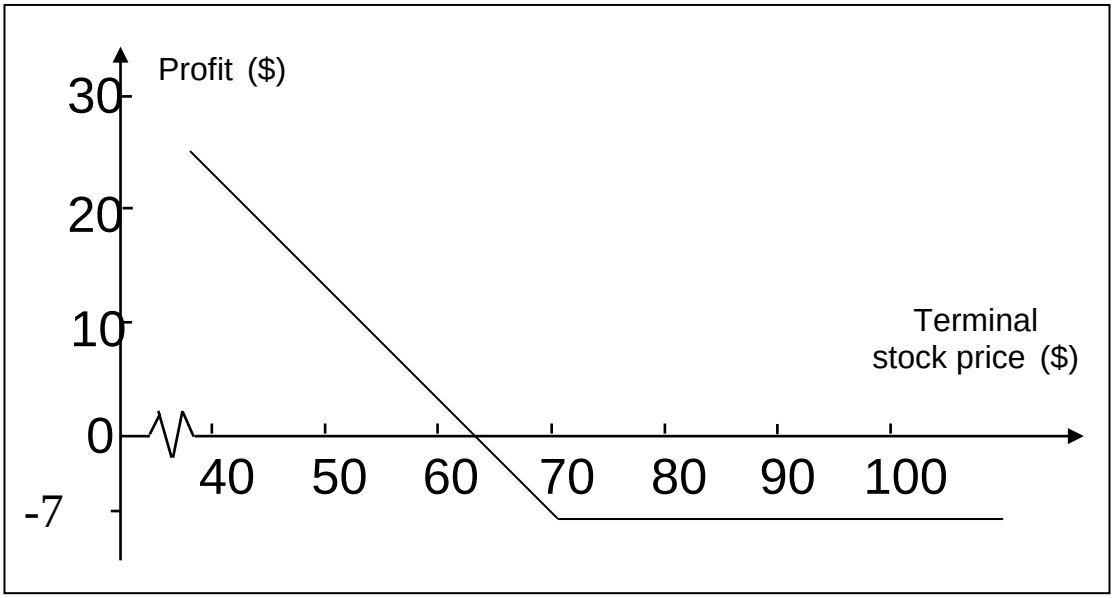


Figure 2.10 Profit from buying a Eurepean put option on one Exxon share

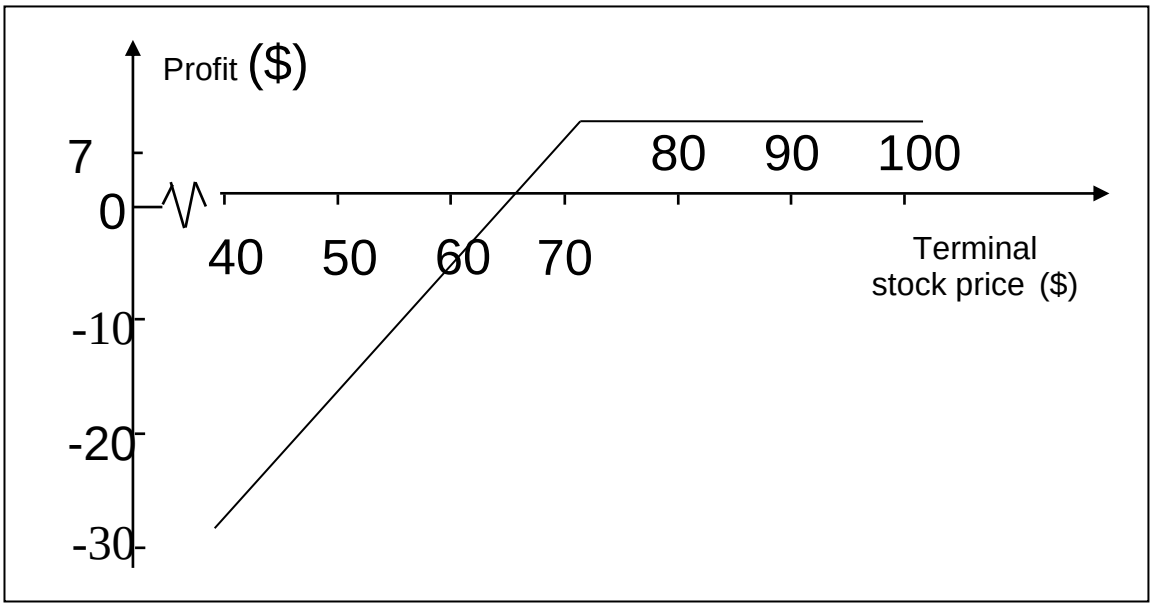


Figure 2.11 Profit from writing a European put option on one exxon share (Hull, 1995).

2.4.3.6 Properties of Option Contracts

Although option contracts has many properties specific to the organized markets they are treated, we will mention four basic properties (Gemmill, 1993) in this section.

Quoteing Conditions

Organized option exchanges determine the asset that option contracts will be written on. In option contracts to be written on stock issues, the stock exchange determines the minimum listing requirement that an issue should fulfill and the minimum standard that the issue should maintain in case an option contract is written on it.

During the selection of the stock issues, the companies do not have any effect, as well as the individuals or institutions that do not want option contracts to be written on the issues of the companies they own. The best example for this is the Golden Nugget company, which does not want any option contracts to be written on the stock issues it owns. The company sued the stock exchange, but it losed the case after two years (Chance, 1989).

Size of the Contract

A standard option contracts treated in the stock exchange and written on stock issues, provides the right to buy or sell only a certain amount (i.e. 100) stock issues.

The strike price is determined in a standard way in option exchanges. The stock exchange determines on which strike prices the option contract will be written on. Therefore, investors agree to buy or sell their option contracts for the option price determined by the stock exchange. However, the transactions in over-the-counter markets are performed at a strike price that the parties agreed upon.

Expiry of Term Dates

In over-the-counter markets the expiry of term dates are shaped according to the requirements of the option buyers and sellers. In organized option exchanges, though, each stock issue is classified according to a certain term cycle. The term cycles are divided into three. (1) January, April, July and October; (2) February, May, August, and November; (3) March, June, September and December. These classes are shortly called as January, February and March cycles. Current end of terms are realized as current month, next month, or the last two months of January, February or March cycles.

Positions and Strike Limits

In many countries, in which the financial markets are developed, commissions or institutions, making legal regulations about capital markets, force the option exchanges to bring position limits on the maximum number of the option contracts that an investor can have on one side of the market. Option exchanges periodically declare their position limits determined as 3000, 5000 or 8000 contracts for each stock issue. The purpose of determining position and strike limits is to prevent a certain individual or group to have an important effect on the market (Yılmaz, 1998).

2.4.3.7 Option Premium and Strike Price

The price that the option buyer pays to the seller according to the status of the trade is called "option premium" (Schmidt, 2006). Option premiums may change according to the distance of the option to its expiry of term, to the difference between the market price of the goods or financial product subject to option and its strike price, to the size of the volatility, to the rate of risk-free interest rate and to the benefits other than capital profit (vob, http://www.vob.org.tr/vob/turkish/egitim/piyasa/faq.rtf).

2.4.3.8 The Pricing Properties of Option Contracts

There some factors that affect the pricing of options. These are:

- The current stock price
- The strike price
- The time to expiration
- The volatility of the stock price
- The risk free interest rate
- The dividents expected during the life of the option (Hull, 1995)

1. Stock price and strike price

As the price of the asset subject to option changes, the option price would change too. For a call option provided that other factors, especially strike price, remain fixed, the price of the option increases as the price of the asset increases. On the other hand, the price of the put option decreases as the price of the asset increases. Strike price is fixed during the term of the option. Provided that other factors remain the same, when the strike price decreases the price of the call option will increase. But in put option, the price of the put option will increase if the strike price increases (Chambers, 2007).

The profit of a call option, treated in a time in the future, will be equal to the amount of proportion of the stock issue's ruling price that exceeds the option strike price. This situation can be presented as below:

Profit Collected from Call Option	=	The Ruling Price of the Stock Issue	-	Strike Price

According to this, if the price of the stock issue increases, the value of the option will increase too. Because, the profit collected will increase. However, the value of

the option will decrease as the strike price increases, since the profit collected decreases.

Speaking of put options, the collected profit will be equal to the amount of proportion of the strike price that exceeds the stock issue's ruling price. This situation can be presented as below:

Profit collected from Put Option	=	Strike price	-	The ruling price of the stock issue

As it can be understood, put options are treated contrary to call options. The value of the put option decreases as the price of the stock issue increases. Because, the collected profit becomes negative. On the other hand, the value of the put option increases as the strike price increases. Because the collected profit becomes positive (Chambers, 2007). If we are to graph these;

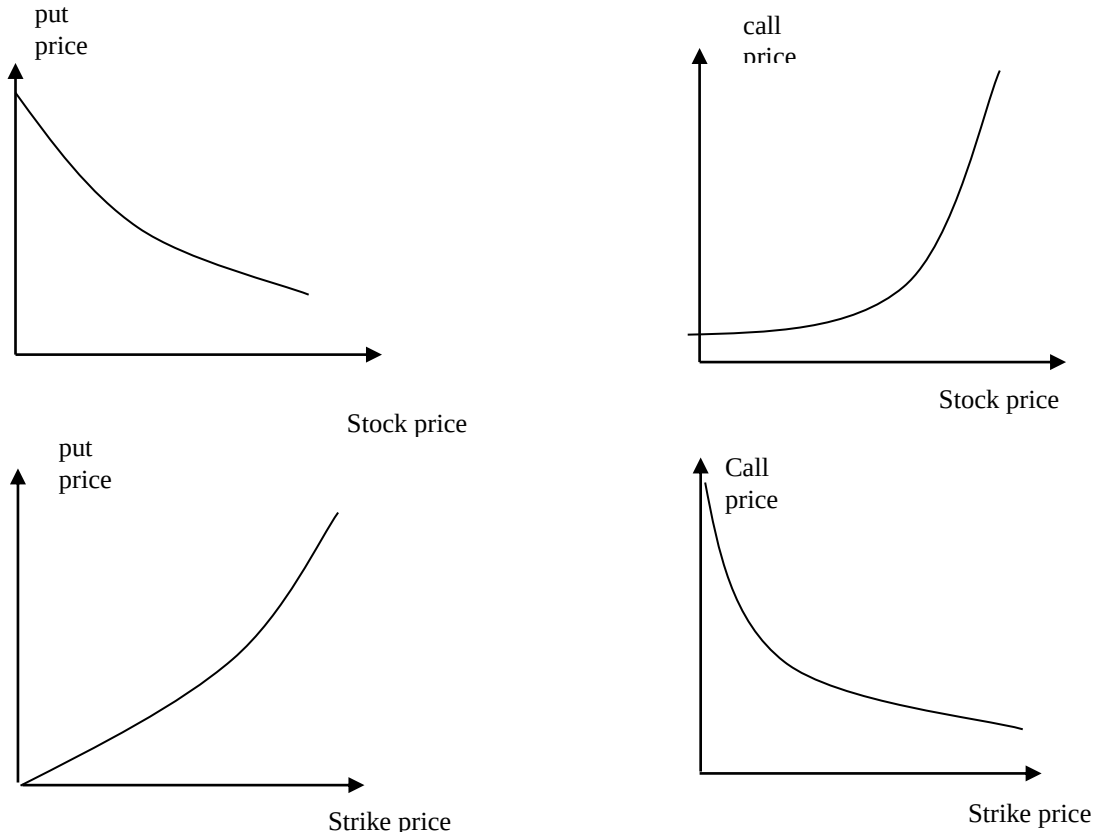


Figure 2.13 Effect of changes in stock price, strike price, and expiration date on options prices (Hull, 1995)

2. Time to expiration

Generally speaking, if the time of operation is long date, the value of the option increases. One of the reasons for this is that the option can find the chance to increase its value. Another reason is, due to options' nature. As it is known, a call option provides its holder the flexibility of buying or not buying. Let us assume that the strike price and the stock issue's ruling price is $10. Theoretically, this option does not have value. However, if the stock issue price exceeds $10 in the day of operation of before, the option will be of positive value. This will give the buyer to treat the option profitably. Therefore, the time that the option is valid increases the chance that the value of the option increases (Van&James, 1995). If we are to graph these;

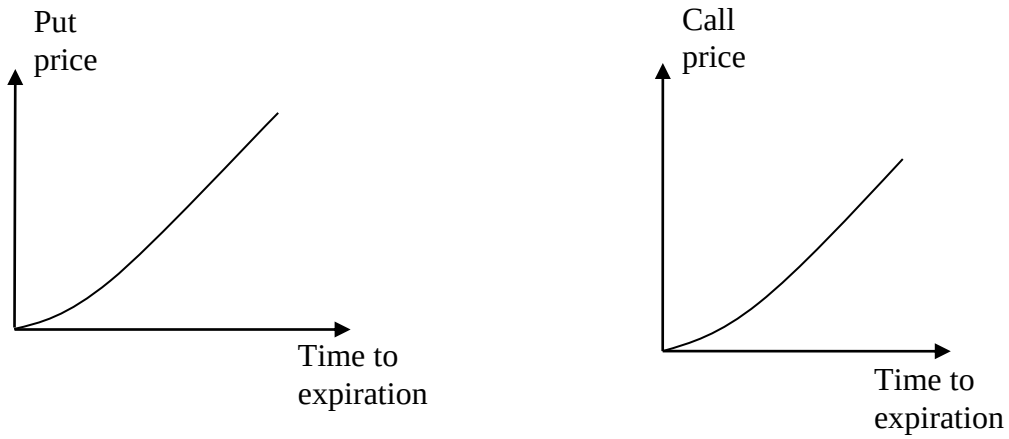


Figure 2.14 Efect of changes in stock price, strike price and expration date on option prices (Hull, 1995)

3. Volatility

The most important factor that affects the price of an option is the volatility of the stock issue's price. In other words, when all other factors remain fixed, the change in the issue's price causes extraordinary results. The market value of the option increases as the volatility increases. If there is not a possibility of change in the issue's price, one should not expect a great change in the value of the option. Volatility increases the value of the option

The volatility of an issue's price is an approach that is used to measure the liveliness that an issue's price will show in the following years. The probability of the issue to move negatively or positively increases as the volatility increases. These movements will not cause great changes for the holder of the issue, since these positive and negative movements will compensate each other. However, this is not the case for call or put option holder. While the call option holder profits from increases in the price, he will lose if the price decreases, but his loss will be limited. Because the amount he will lose will be the premium price he paid in the beginning only. Similarly, a put option holder will profit from the decreases. But he will lose the amount equal to the premium if the prices increase. Put another way, in option contracts, losses are limited while profits are pretty much. Therefore, the price of call or put options increase as the volatility increases (Chambers, 2007). If we are to graph these;

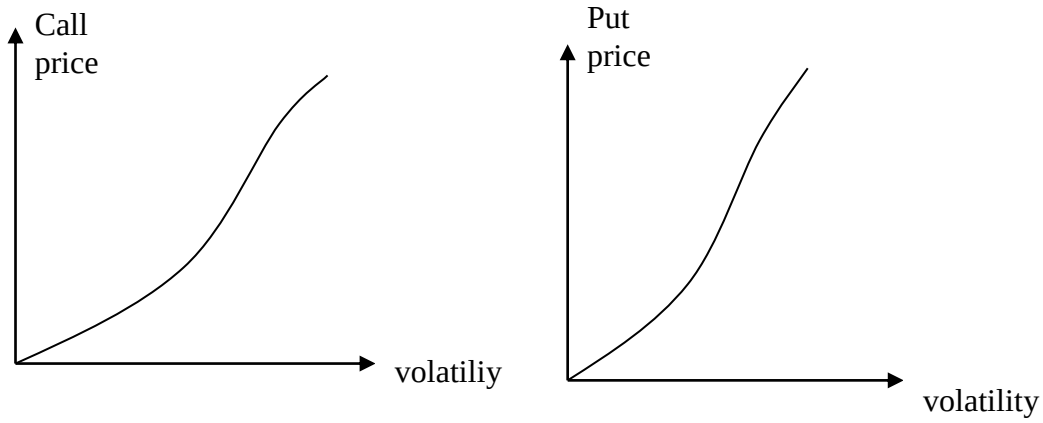


Figure 2.15 Efect of changes in stock price, strike price and expration date on option prices (Hull, 1995)

4. Risk Free Interest

The risk free interest rate affects the price of an option in a less clear cut way. As interest rates in the economy increase, the expected growth rate of the stock price tends to increase. However, the present value of any future cash flows received by the holder of the option decreases. These two effects both tend to decrease the value

of a put option. Hence, put option prices decline as the risk free interest rate increases. In the case of calls, the first effect tends to increase the price while second effect tends to decrease it. It can be shown that the first effect always dominates the second effect; that is, the prices of calls always increase as the risk free interest rate increases.

It should be emphasized that these results assume all other variables remain fixed. In practice when interest rise (fall), stock prices tend to fall (rise). The net effect of an interest rate change and the acompanying stock price change may, therefore, be the opposite of that just given (Hull, 1995). If we are to graph these;

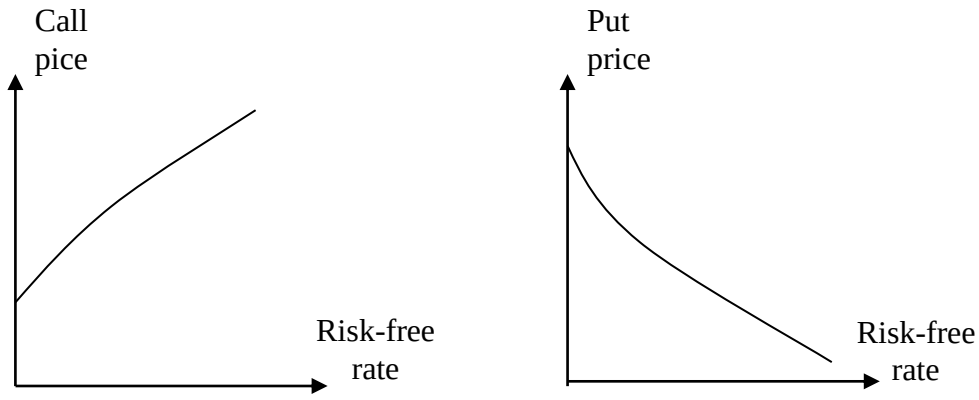


Figure 2.16 Efect of changes in stock price, strike price and expration date on option prices (Hull, 1995)

5. Dividens

A profit sharing operation on a stock issue decreases the value of the option written on that stock issue. Because, dividend payments make attractive to buy stock issues instead of options. Put it differently, provided that all other factors remain the same, the value of the option decreases as the dividend increases. In fact, dividend distribution decreases the liquidity of the stock issue holder. But, it is not the situation for the option holder. The price of the stock issue will decrease when the dividend distributions are completed, as a result the value of the option bought will decrease.

While call options are effected negatively from dividend distribution, it is the opposite for the put options. Because, as call option holder expect that the issue's price will increase, when the prices decrease due to dividend distribution, he will not want to buy the issue which is cheaper in the market for a higher price by the option he bought, and he will loose the premium he paid by not treating the option. However, put option holder has the chance to sell the issue at a higher price by the nature of the option he bought (Chambers, 2007). If we are to graph these;

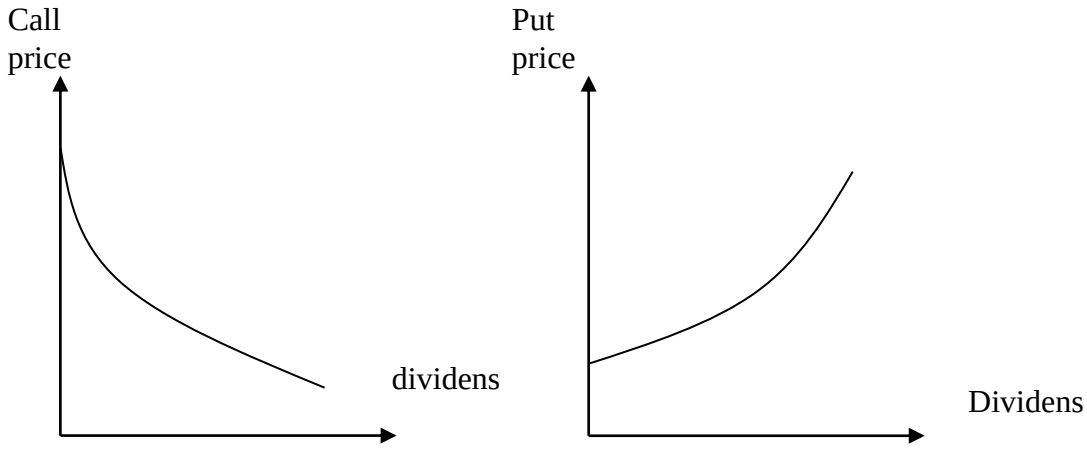


Figure 2.17 Effects of changes in volatility, risk free interest rate, and dividens on option prices (Hull, 1995)

We examined the factors that affect the option price above; for option price we may argue that effect of each factor can be presented as below, provided that all other factors we mentioned, affecting option price remain the same (Edwards& Ma, 1992).

Table 2.3 Effect of each factor on option price

Price Factors	Value of Call Option	Value of Put Option
when the issue price increases	increase	decrease
strike price increases	decrease	increase
expiration of term increases	increase	increase
volatility increases	increase	increase
interest rate increases	increase	decrease
dividends increase	decrease	increase

2.4.3.9 Option Pricing Models

There are lots of option pricing model but I explained two from all model which are the most important.

2.4.3.9.1 Binomial Model. Binominal model is the easiest methods in determining the price of an option. This model assumes a discrete timed process. In this one-step process, the price of the stock issue follows an inert binominal stochastic process. To be more precise, it is suggested that a variable follows a stochastic process if its price changes in an uncertain way through time. One type of stochastic processes is the discrete timed process. Variable values that can change only in definite fixed points in time follow a discrete timed stochastic process.

A portfolio is created in order to implement the one-step binominal option pricing model to a call option. A certain amount of stock issue in a long position will provide an interest rate in short position, in this portfolio (Fabozzi&Modigliani, 1996). Some assumptions are made for this portfolio. One of these assumptions is that the investor does not have the chance to arbitrage. Another one is that there is not any uncertainty, while creating the portfolio on stock issue and options, about the value of the portfolio after a certain period. Because the portfolio does not carry any risk. The profit collected from the portfolio should be equal to the risk-free interest rate. In this case, the value of the portfolio after a single-step will be compounded with the current value of the portfolio and the risk-free interest rate for one-step, and arbitrage opportunities will appear (Chambers, 2007).

We can generalize the argument that has just been presented by considering a stock whose price is S and an option on the sock whose current price is f. We suppose that the option lasts for time T and that during the life of the option the stock price can either move up from S to a new level S_u or down from S to a new level S_d ($u>1$; $d<1$). The proportional increase in the stock price when there is an up movement is u-1 ; the proportional decrease when there is a down movements is 1-d.

If the stock price moves up to S_u, we suppose that the pay off from the option is f_u; if the stock price moves down to S_d, we suppose that the pay off from the option is f_d. The situation is illustrated down (Hull, 1995).

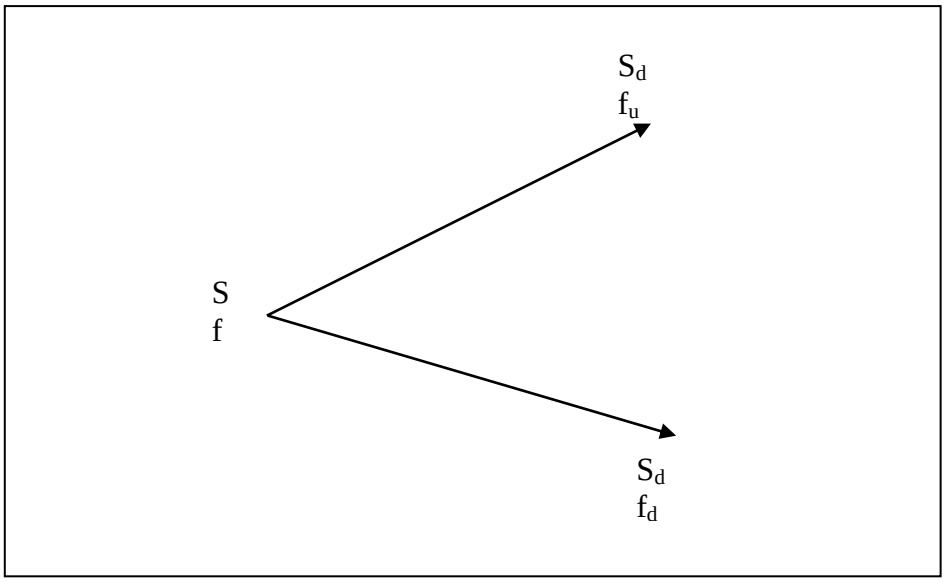


Figure 2.18 The one step binomial tree

The one-step binominal tree above can be expanded as a two-step binominal tree.

As the portfolio is risk-free, the current value of the portfolio can be found by discounting the expected value by the risk-free interest rate (Blake, 1990).

$$f = e^{-rt}(pf_u + (1-p)f_d) \tag{2.1}$$

here p is,

$$p = \frac{e^{rt} - d}{u - d} \tag{2.2}$$

The formula above enables the option pricing using single-step binominal model.

We start by considering a very simple situation where a stock price is currently $20 and it is known that at the end of three months the stock price will be either $22

or $18. We suppose that we are interested in valuing a European call option to buy the stock for $21 in three. This option will have one of two values at the end of three months. If the stock price turns out to be $22, the value of the option will be $1 ; if the stock price turns out to be $18, the value of the option will be zero (Hull, 1995).

With the help of the formula above (2.2), the value of the option is calculated as below:

$$p=\frac{e^{rt}-d}{u-d}$$

$$p=\frac{e^{0.12.0.25}-0.9}{1.1-0.9}$$

$$p=0.6523$$

and formula (2.1)

$$f=e^{-rt}(pf_u+(1-p)f_d)$$

$$f=e^{-0.03}(0.6523*1+0.3477*0)$$

$$f=0.633$$

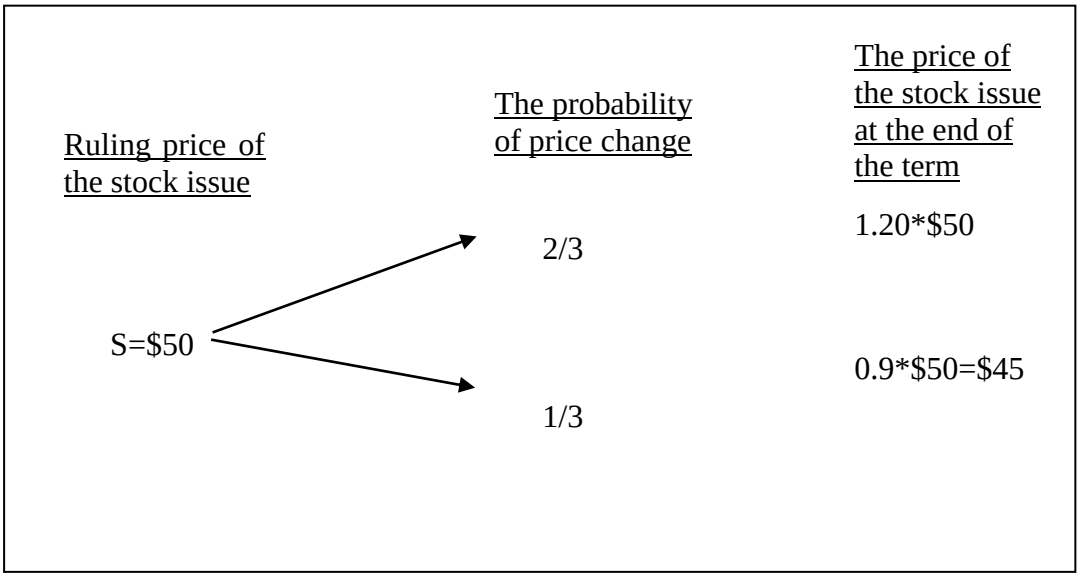
the value of the option is 0.633.

The formula $f=e^{-rt}(pf_u+(1-p)f_d)$ shows that the price of the option is a function of variables such as fu, fd, p and r. Here the variables fu and fd are determined by the variables S, u, d and X. In this case the variable that determine the price of an option are, ruling price of stock issue S, strike price X, risk-free interest rate r, and the u and d parameters that determine the potential price of stock issue in a future trading day. Here it is worthy of notice that down and up movements of stock issues are not included in the model. The price of the option widely depends on the price of the stock issue. Therefore, when the stock issue price is known, the price of the option can be obtained. The price of the stock issue is determined independently from the option. In this case, the probabilities of the movements in the stock issue prices should be taken into consideration as a factor (Chance, 1989).

Let us assume that the probability of up movement of stock issue prices is p and the probability of down movement is 1-p; and let us assume that the probability of a 20% increase in the stock issue price is 2/3 and the probability of a 10% decrease is 1/3. At the end of the step, the expected value of the stock issue is $55. This implies a 10% increase of a $50 investment. The price of the option is assumed $50 and the risk-free interest rate for a 6-months term is assumed 5%. According to these information, it is seen that the option price at the end of the term is $10 or 0 in the b section of the figure below. This result emerges as an effect of an increase or a decrease in the stock issue price (Van&James, 1995).

a) The price of the stock issue at the end of the term

Table 2.4 End of period stock issue value



The expected value of the stock issue at the and of the term can be calculated as (2/3)*($60)+(1/3)($45)= $55.

b) Option value at the end of the term

Table 2.5 End of period option value

The price of the stock issue at the end of the term	The probability of price change	Option value at the end of the term
$60	2/3	Max($60-$50)
$45	1/3	Max($45-$50)=0

The expected value of the option at the end of the term can be calculated as (2/3)*($10)+(1/3)(0)= $6,667

In this case, while the value of p, which is the probability of up movement, the expected value of the stock issue at a certain T time can be formulated as below:

$$E(St)=pSu+(1-p)Sd \quad (2.3)$$

or

$$E(St)=Se^{rt} \quad (2.4)$$

According to these equations, it can be understood that the stock issue price can increase in as much as the risk-free interest rate. In other words, the profit of the stock issue will be equal to the risk-free interest rate (Chambers, 2007).

2.4.3.9.2 Black –Scholes Model. In the beginning of 1970's, Fischer Black and Myron Scholes developed a new model, characterized as a milestone in option pricing. This model is widely used by option traders. The most important advantage of this model is the ease of use. Theoretically this model is used in pricing all the contracts that are dependent on unexpected situations in the future (Bowe, 1988). This model, in fact, was developed for pricing the European options which are based

on stock issues without dividend distribution. By the studies conducted later, it became possible to adapt the model to American options and to futures options based on other instruments (Ersan, 1998).

There are two major assumptions that Black–Scholes model depends on. One of these is the stock issue price which is also called random walk model. According to this model, the proportional change in the price of a stock issue is normally distributed in the short run. According to the other assumption, the price of the stock issue is distributed lognormally in any time in the future.

Under the non-normal distribution assumption, the movements in stock issue prices can be explained by two important parameters. These are the expected profit from the issues and the volatility measures for the stock issue prices. These parameters will be detailed in the following sections (Chambers, 2007).

2.4.3.9.2.1 Expected Profit. The expected profit is the average profit an investor assumes to collect in a short period. The expected profit of an investor from a stock issue (φ) is dependent on the risk-status of that issue. The profit will increase as the risk increases. The value of the expected profit also depends on the interest rate in the market. The expected profit will increase as the risk-free interest rate increases. The expected profit rate in a short time is indicated with φ. The annual profit rate, which is compounded for a longer time is expressed as $\varphi-\sigma^2/2$. Here σ is the volatility parameter.

2.4.3.9.2.2 Volatility Measures. In all of the option pricing models, the expected volatility in the profit of the asset is of great importance. Such a volatility reflects the potential movement of a put or call option towards being in money. Accordingly, the seller of the option demands a higher option premium. And the option buyer accepts to pay a higher premium if the expected volatility is high (Edwards & Ma, 1992).

The volatility of a stock issue (σ) is the standard deviation of the profit returned by the stock issue, if the profit is expressed by continuous compounding. As it is not

possible to measure the volatility of a stock issue before the end of the term, it is necessary to make estimations on volatility.

Two basic methods were developed about volatility measurement. These are the historical volatility and the impled volatility. These two methods are explained below.

a) Historical Volatility

Historical volatility is a method that inverstors use to measure the volatility. This method is implemented taking into consideration the price movements a stock issue displayed in a period of time in the past (Bowe, 1988).

The volatility is calculated by historical volatility by using the formula below:

$$\sigma^2 = \frac{\sum_{t=1}^{N}(X_t - \overline{X})^2}{N-1} \qquad (2.5)$$

Here in this formula

$$X_t = S_i \qquad (2.6)$$

N= number of examined periods

S_i= the stock issue price at the end of interm i (i=0,1,….,n)

b) Implied Volatility

Implied volatility is an important parameter that creates a model for option pricing. This model depends on the implied market price of the option. The said volatility enables the investor to decide about whether the price of the stock issue would increase or decrease. The investor may believe that the expected price of the option will be relatively higher or lower than the current price. When the ruling price

of the stock issue changes in time, the term of the option will change too. In such a case, there is not any reason that requires the option price to remain the same. Here, the question to be asked is that whether the volatility in the price of the option is an incidence of the changes in the market elements such as ruling price and term. The answer to the question is no, if the implied volatility has not changed; yes, if it has. (Bowe, 1988).

In cases, where different volatility estimations are done for options with the same strike price, there emerges the problem to choose which volatility estimation method in estimating the price volatility in the future. In such cases, the overall approach is obtaining the weighted mean of the volatility estimations. However, this weighted mean should be calculated in a way that would represent the investors own opinions (Edwards& Ma, 1997).

2.4.3.9.2.3 Analysis of Black-Scholes Model. Black-Scholes option pricing model have the characteristics of a basic analysis in academic and professional environments. The basic tenet of this model is the pricing of call and put options, when the capital markets are in an equilibrium, and thus enabling the expected profit from the portfolio to be equal to the risk-free interest rate (Chambers, 2007). Put it differently, the main support of the model is the idea to create a portfolio that returns a profit at the amount of risk-free interest rate by having a short position in put option and by having a long position in call option (Samuels&Wilkes, 1995). In other words, the model in its basic status depends on a risk-free portfolio. The portfolio comprises of long call option and the short positions of the stock issues based on the options that the customer collects a profit equal to risk-free interest rate (Ersan, 1998).

The assumptions that Black and Scholes depend on while developing their option pricing model are listed below (Stigum, 1990; Chance, 1989).

1. The movements of stock issue prices follow a lognormal distribution
2. There is not any transaction cost or tax payment

3. The stock issue that the option is written on shall not pay dividend during the term of the option
4. Stock issue trading is continuous
5. There is not any opportunity for risk-free arbitrage
6. The short run risk-free interest rate r is fixed
7. Investors may loan or lend money at the same risk-free interest rate

With respect to these assumptions, the following formulas were developed for Black-Scholes pricing:

$C=SN(d_1)-X e^{-rt} N(d_2)$ (2.7)

$P=X \quad e^{-et} \quad N(- \quad d_2 \quad)-SN(- \quad d_1 \quad)$ (2.8)

In these formulas:

$$d_1 = \frac{\ln(S/X) + (r + \sigma^2/2)T}{\sigma\sqrt{T}} \quad (2.9)$$

$$d_2 = \frac{\ln(S/X) + (r - \sigma^2/2)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T} \quad (2.10)$$

In the formula above;

σ^2 = the annual variance of the continuously compounded profits of the stock issue

$N(d_1)$, $N(d_2)$ = the cumulative probability distribution function for standard normal variable (from $-\infty$ to $d_{1,2}$)

ln=logarithm

e = exponential current value factor (2.7183)

In the solutions of the formula above, 4 out of 5 variables is known. These are the current stock issue (S), option term (T), strike option (S_t) and short run interest rate (r). The unknown variable is the standard deviation of the stock issue price (σ). The reason for this is the difficulty to directly observe the expected volatility in the stock issue profit. In order to perform this observation, the historical volatility method can be used. In order to use this method, the volatility of the stock issue in the near past is taken into consideration and the volatility that may occur during the term of the option is tried to be estimated (Van& James, 1995). We have mentioned of options above; now, let us look what option commodities are.

4.3.10 Option Commodities

Commodities are used by the companies in two ways:

1. Companies that grow agricultural goods, livestock and animal products, companies that search and hoist precious metals, industrial metals and energy products.
2. Companies that use the commodities in 1 as raw material.

Due to these commodities having great importance in the reel economy and their supply being limited, their markets are dynamic and volatile. For the commodities, the operation of protecting from price risks in futures and option exchanges is of great importance, because of selling price uncertainty for producers and cost uncertainty for users. If the share of the raw material used in production in the input cost is high, and thus if the operation of protecting from raw material price risk cannot be conducted:

1. If there are high fluctuations in the market price of the raw material the raw material cost will increase. This increase is utterly dangerous for the company, since raw material comprises a considerable part of the input costs.
2. Stock costs may occur.
3. The company will not be able to determine a healty sale price.

4. Raw material costs under a fierce competition causes the profit margin of the company to drop.
5. Successful investment calculations, planning and budgeting cannot be realized.

Due to these reasons and for Turkey is integrated into international markets, the raw material price fluctuations soar. In this case, management of raw material price risk becomes crucial for the companies.

Option transactions on the following commodities can be seen in option markets:

Table 2.6 Commodities in option markets

Option contracts based on Agricultural products
Cotton, wheat, barley, oat, soybeans, corn, sugar, coffee, cocoa, orange juice, lumber, tea
Option contracts based on livestock and animal products
Milk, cheese, eggs, butter, livestock, poultry, white and red meat, fish
Option contracts based on Energy
Petroleum, natural gas, electricity, coal, ethanol, diesel oil, uranium, lignite
Option contracts written on precious metals and industrial metals
Copper, aluminum, gold, platinum, palladium, zinc, iron and steel, chrome, mercury

2.4.3.11 Agricultural Options Contracts

The extreme fluctuations in the agricultural product prices caused the emergence of the futures markets. For over a century, only futures contracts on agricultural products have been traded in the futures markets. In agricultural products, supply and demand is not only dependent on the price but also the climate conditions are effective on production. The quantity and quality of the product is affected by the climate conditions. For instance, while in a wet period, wheat production is

abundant, in a drouthy year the crop will be lower. In the volatility of production amount, the product choices by the farmers is another important factor. A company that carries business in one area of production can not shift to another area suddenly while producing different versions of the same product. However, a farmer who sows potatoes to his field may decide on sowing cotton or wheat next year. While a farmer's concentration on one product in his choices increases the supply in that product, it can cause short supply in another product (Vadeli İşlemler ve Opsiyon Eğitim Kitabı, 2003).

Another important issue about agricultural products is that the production exhibits a seasonal characteristic. Certain agricultural products are sold in the market in some particular seasons. For instance, melons are sold in the summer, while it is hard to find melons in the winter. Agricultural products should be placed in the market when they become ripe, or else the product will rot. The same situation is not valid for a white appliances factory; because the capacity related to production can remain the same and product can be kept without rotting. Another feature that distinguishes agricultural products from, for instance, white appliances is that in agricultural products a period of time should pass in order the product to ripen. It is not possible for the farmer to ripen them in a shorter time by increasing the imput quantity. So, agricultural products have different features than other financial assets. Therefore, in hedging operations, these issues are taken into consideration. Also, it should be kept in mind that each agricultural product exhibits diverse features (Aydeniz, 2008).

The drought options step in right at this point. By using drought options during the droughts happen from time to time, the hedging operation the farmer will be realized. Before defining drought in detail, we may now mention the agricultural policies of the states and the importance of option exchanges.

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2.4.3.12 Agriculture Policies that the States Determine and the Importance of Futures and Option Exchanges

There are three basic feaure of agricultural production (Ulusoy, AB'ne adaylık sürecinde AB ve Türkiye tarım politikaları, www.dpt.gov.tr):

1. The demand/income of agricultural products is not flexible.
2. The presentation of agricultural products is not flexible and is phased. Here, the natural conditions hold sway. The production decision is not affected by the spot market signals, the prices of the products are evaluated according to the previous market signals.
3. Despite the prices of agricultural products tend to decrease, the raw material prices and other industrial prices that farmers ought to buy increase.

Today, agriculture all over the world, including the developed countries, is a sector that faces an extreme wave of state intervention. Agriculture sector has an important place in national economy with its share in national income, employment and consumption expenditures and as a sector that produces strategic staple products. In our country, as in other countries, agriculture is supported in various ways. Some of these supports are, intervention by price, enabling the use of cheaper input by intervening input prices, protectionism in foreign trade, providing low-interest loans, supporting production via incentive and premium applications.

In our county to, the state make options contracts with farmers. We can give as an example the contract the state made with farmers previously, on the price of nut in Black Sea Region.

Futures and option transactions concersn especially the agriculture markets. Therefore, the opportunity to make an agricultural planning becomes possible by using the production movements of the farmers who think about planting according to the emerging prices.

Futures and options exchange brings about many advantages in terms of agricultural prices. The ease and speed in the operations of the markets can enable more stability in agricultural prices. Futures and option exchanges will decrease the

financial burden the state undertakes by resolving the structural problems caused by the discrete nature of supply and continual nature of demand. Cotton, especially, is an agricultural product that has strategic importance for Turkey. By the help of futures and options exchanges, the textile and confection industrialist will find an opportunity to offset their risks by transferring their risk, caused by the bidirectional fluctuations in the prices, over to financial sector.

The producers, at the same time, will obtain the possibility to make sales and production connections in the long term. The industrialist can obtain input at a stable price, by evaluating the price signals he gets from the exchange; and he can fullfil his liabilities to domestic and foreign markets in time, by planning his production costs and sales prices realistically by checking the prices emerged in the exchange.

Again, savings can be provided in financial expenditures based on storing costs and stocks after production, and thus the cost factor here can be transferred to other areas as resource. On the other hand, forward transactions facilitate making unerring estimations for the future. By this way, producers can make their production plans, production choices and production replacement possibilities more effectively. Because, in an environment with product exchanges, the sensitiveness of the producer to the market conditions will increase. Apart from all these, the producer will increase his competitive force in international markets by having the opportunity to trade with world prices as an importer and exporter.

Also, the importer will find the possibility to enter into long term connections and to fullfil these connections without undertaking risks. Exporter, protected from the price risks will obtain stable income and will want to increase his market share. (Arısoy, 2001).

In short, the advantages that option and futures exchanges bring about are:

1. The exchanges constitute a security system used to eliminate the uncertain price risk for an industrialist who processes agricultural products and who sells the processed product.
2. They prevent sharp and shocking rise and drops in prices.
3. They protect the producer from the price risk of the future, since the prices emerged in the market constitutes a dependable indicator for agriculture sector and since the exchanges orientate the production changes.
4. They enable the industrialist and exporters to make long term connections in foreign markets and to fullfil their liabilities by thickening supply and demand as the most important function of the option and futures markets.

2.4.4 Weather Derivatives

The purpose of weather derivatives is to allow business and other organisations to insure themselves against fluctuations in the weather. For example, they allow natural gas companies to avoid the negative impact of a mild winter when no one turns on the heating, they allow construction companies to avoid the losses due to a period of rain when construction workers cannot work outside and they allow ski resorts to make up for the Money they lose when there is snow.

The weather derivatives market, in which contracts that provide this kind of insurance are traded, first appeared in the US energy industry in 1996 and 1997. Companies accustomed to trading contracts based on electricty and gas prices in order to hedge their electricity and gas price risk realised they could trade contracts based on the weather and hedge their weather risk in the same way. The market grew rapidly and soon expanded to other industries and to Europe and Japan. Volatility in the financial markets has meant that not all of the original participants are still trading, but the weather derivatives market has steadily grown and there are now a number of companies, insurance companies, reinsurance companies, banks and hedge funds that have groups dedicated purely to the business of buying and selling weather derivatives. The Weather Risk Management Association (WRMA), the

industry body that represents the weather market, recently reported a total national value of over $10 billion for weather derivative trades in the year 2002/2003 (Jewson, S. & Brix, A., 2007, 1).

2.4.4.1 Drought

In looking for the answer to questions about droughts and deserts we must assume that their causes are much the same in all parts of the world. Every continent has a desert in each hemisphere. Surrounding every desert are areas where crops cannot be grown profitably except by irrigation. It takes large quantities of water to irrigate. We must have rain.

In times of drought on every continent people think of the deserts with alarm. Learned men write of our expanding deserts, our “deserts on the march”. These alarming reports can be found in many rainfall and, like our high plains and western ranges, is suitable grazing under proper controls but suffers from overstocking. Increasing dryness in South Africa culminated in a great drought in 1919. In 1920 the governor-general appointed a drought commission which gathered the opinions of experts in all matters relating to the drought and its terrible consequences, with particular emphasis on the possibility that a more or less permanent change to a drier climate was taking place. The commissioner said in their final report in 1923 that “this drying out of extensive areas of the Union is stil proceeding with great rapidity in many portions of the country”. The logical outcome of it all is that this country will become The Great South African Desert” uninhabitaly by man.

In 1919 the Pacific Coast States also had a severe drought, but the remainder of the United States had a wet year. Fifteen years later we were in the depths of drought and depression. There followed the President’s report on “The Future of the Great Plains” which paralled the South African report in many respects. Indeed, the same thing already had been done in this country after the great drought of the nineties. In these miserable times we ask the same old questions: What is a drought? What causes drought? Do they expand in time of drought; and if so, are they likely to take

up a new or more extended position permanently? Are the forces that produce the deserts the same that cause widespread droughts? Can drought be predicted? Are we experiencing a permanent trend toward a drier climate? These are questions of tremendous importance (Tannehill, 1947).

What is drought? When a region's precipitation drops dramatically for an extended period of time, drought may result. The word drought refers to a period abnormally dry weather that produces a number of negative consequences, such as crop damage or an adverse impact on a community's water supply. Prolonges drought, especially when a accompanied by high temperatures, can lead to a shortage of food and, in some places, widespread starvation. While many extreme or unusual weather events are short- lived, drought is a more gradual phenomenon, slowly taking hold of an area and tightening its grip with time. In severe cases, drought can last for many years and have devastating effects on people and animals (Ahrens, C. & Samson, P. 2010).

What causes drought? Weather experts have not given a satisfactory answer. Books on weather and climate mention droughts briefly or skip the subject altogether. Climate refers to average weather, or typical weather, but droughts in the United States are not average or typical conditions except in the Pacific States in summer and in certain other western areas where the climate is arid or semi-arid.

For these reasons we may consider drought as a stepchild in the weather family a sort of meterological black sheep. At times it seems to violate te law of averages, the theory of probability, and all other rules. We might explain it as a change of climate but we have evidence that it has always been only a temporary condition. We are not sure about it untill the crops have withered and died. There is nothing much that can be done until it is recognized as a bad drought, and then we come forward with goverment relief.

When a great drought proceeds day by day until it becomes a catastrophe, we speculate on the same old subjects. Maybe the ocean currents have shifted. Perhaps the climate is changing. During the war time we talk about the effects of high

explosives. Maybe the growth of radio broadcasting has affected the climate by putting too much electricity in the air! It may be due to the destruction of forests and plowing of fields. Maybe we have built too many airports. Some scientists say that storm tracks have changed. Others think that it may be caused by too many sunpots or not enough.

What are the effects of drought? We can explain this with an example. The unparalleled drought of 1934 greatly reduced water levels in rivers and lakes, and navigation was impeded. Lightened cargoes resulted in losses. Lakes Michigan and Huron reached the lowest levels known. Communuties were forced to extend water works farther into lakes due to recession of shore lines. Sewer outlets were left high and dry and became a menace to health. There were extensive relief works in twenty-four states. There was a 40 % reduction in corn and wheat yields. The government purchased seven million cattle and five million sheep. It was estimated that this drought (1934) and the conditions preceding it did direct damage to agriculture amounting to five billion dollars (Tannehill, 1947).

2.4.4.1.2 Some Notable Droughts

Extensive drought has afflicted at some point almost every major continent. In fact, drought has occurred in all areas at one time or another. Drought and its related famine account for more deaths worldwide than any other weather-related disaster. One continent especially hard hit by drought is Africa.

African Drought

One region in Africa that has had its share of drought is the Sahel is bounded on the North by the dry Sahara Desert and on the South by the grassland of the Sudan. The Sahel is a semi-arid region of variable rainfall where precipitation totals may exceed 20 inches in the southern portion and less than 5 inches in the North.

During the winter, the Sahel is dry, but as summer approaches, the rains usually begins. The inhabitants of the Sahel are mostly nomadic people who migrate to find grazing land for their cattle and goats. In the late 1960s, the annual rains did not reach as far North as usual, marking the begining of a seies of dry years and severe drought.

The decrease in rainfall, along with over-grazing, turned thousands of square miles of pasture into barren wasteland. By 1973, when the severe drought reached its climax, rainfall totals were 50 percent of the long-term average, and perhaps 50 percent of the cattle and goats had died. The sahara desert had migrated southward into the northern fringers of the region, and a great famine had taken the lives of more than 100.000 people. Although low rainfall years have been followed by wetter ones, relatively dry conditions have persisted over the region for the past 40 years or so. The overall dryness of the region has created many problems, including the shrinking of many of the larger lakes, such as Lake Chad. Severe drought has plagued other parts of Africa, including Somalia, Kenya, Ethiophia and Morocco. In fact, a terrible drought during 1984 and 1988 in the Horn of Africa led to a famine that killed more than 750.000 people.

North American Drought

There have been a number of severe droughts in North Ameriaca, too. In fact, probably the worsth weather related disaster to hit the United States during the twentieth century was the great drought of the 1930s. That drought, which tragically coincided with the Great Depression, actually began in the late 1920s and continued into the late 1930s. It not only lasted a long time, but it extended over a vast area. The drought, coupled with poor farming practices, left the top soil of the Great Plains ripe for wind eroison. As a result, wind storms lifted millions of tons of soil into the air, creating vast dust storms that buried whole farm houses, reducing millions of acres to an unproductive wasteland, and finally ruining thousands of families. Because of the infamous dust storms, the 1930s are often referred to as “ the Dust

Bowl years." To worsen an already bad situation, the drought was accompanied by extreme summers heat that was most severe during the summers of 1934 and 1936.

One misconseption of this great drought is that "the rains never came." Actually, over most areas it did rain. In fact, some areas experienced above-normal rainfall totals for several months, and in some places for an entire season. But unfortunately, the wet spells were unable to migrate the extended dry periods that progressively became more and more severe, and eventually affected the lives of millions of people. Many were left destitute and moves elsewhere, especially to California.

More normal rainfall patterns returned to the Plains in the 1940s, and agriculture began to recover. But severe drought has returned to the region on several occasions in the 1950s and again in 1988. The worst drought in 50 years affected at least 35 states during the long, hot summer of 1988. Rainfall totals over the Midwest, Northern Plains, and the Rockies were 50 to 85 percent below normal. In some areas, the lack of rainfall dated back to 1984. Crops and livestock died, and the region suffered greatly. Nationwide losses from the drought exceed $40 billion, exceeding the losses caused by the San Francisco earthquake in 1989, Hurricane Andrew in 1992, and the Missisippi River floods of 1993.

The northeastern United States suffered through a drought from 1963 to 1965, and in the west California had a severe drought during the mid-1970s, causing water rationing to be imposed statewide. A more recent drought occured in the west and the southwest during 2002. In this region, extremely dry vegetation turned into roaring wildfires that burned over a million acres in California, Arizona, and Colorado. The southeast is not immune to severe drought, as a terrible drought afflicted the area from Alabama to North Carolina during 2007 and 2008 (Ahrens, C. & Samson, P. 2001).

Drought Sample in Turkey

If we are to investigate the drought situation in Anatolian land from past to present, it is seen that the driest years were between 1845 and 1874. The study will briefly mention what had happened during the drought in 1874.

Drought 1874 in Anatolia

The drought which had happened in this year was caused by aridity of the weather and high temperatures. Long periods of aridity and high temperatures had brought the drought; and due to this situation's combining with heavy snow in the winter, new crops could not be produced and the people of Anatolia had faced a perennial famine.

Although the drought had had influence on vast regions, it has been sad that Ankara and Konya provinces had been the most affected regions.

Although the people had requested a grant in aid, the government failed to realize the drought, due to the blockage of the road in winter; and the effect of the drought had been vehement.

The fall in the production in 1874 due to dry weather had caused a general famine. In Ankara and Konya provinces, people had started to starve to death because of the famine caused by the drought, diseases had increased, and perturbation had arisen. For this reason, the locals of the region had started to immigrate to other places with more convenient conditions.

18.000 people had been reported dead because of famine in Ankara between 1874 and 1875. However, the number of the people who had lost their lives during or after the immigration was not included in these casualty tolls due to imprecise reports. That is to say, more people had lost their lives for the reasons such as the famine conditions brought by the drought which had made its presence felt since 1869, high temperatures (1869-1874) and the extreme cold (1874-1875), famine, malnutrition, and epidemics.

It is understood that, it had rained very little in 1873 in Konya, and grass and crops had not vegetated therefore there had not been any harvest. Following the dry summer, the heavy winter had ruled out all means of transportation. The famine condition, which had been continuing for over three years, caused the deaths of over a thousand people until 27 March 1874.

There had been reports that almost 10.000 people affected from the drought in the villages around Nevşehir had become unable to ensure their daily food and starved to death.

In Ankara, children had been reported wretched and wandering in the streets since they had lost their parents because of the famine.

The public order had been disturbed because of the famine which was the result of the drought, epidemics had broken out, and many people had lost their homes and land and had lost many relatives. Unfortunately, none other than these vexing examples could reveal the vehemence of the effects the drought caused (Erler, 2010).

2.4.4.2 Drought Option

For a drought option, as the underlying item is the measure of drought, the strike level should be also changed to some specific value of drought index. When the holder warns to buy a drought option contract, first of all the buyer and the seller should decide whether it is a call opption and when the buyer could exercise the contract. Then they should set up strike level, the period of this contract. Another item called tip should be brought in the contract, which reflects the relationship between the value of drought index and the loss of farmer's income.

This drought option can be used by the goverment to help the farmers. Right now under existing crop insurance policies, farmers are paid only after there has been a claim. That is, only after there has been a complete or partial crop failure. For small

farmers in developing countries, such as subsistence farmers, this might occur only after they have lost their livelihood or are starving. However, drought option contract is more sensitive than the insurence contract. For example, a put option contract is bought by the agriculture agency. The profit from this contract is kept as a funding assist farmers. They need to choose a drought index the underlying item, a specific value of the index, K, as the strike level, the tip S, and the period of the contract. The value of this asset will increase before the crops fail because it only depends on the severity of drought. Another difference with drought options is that, even thought the drough is not so serious to destroy almost all the crops and trigger the insurance payout, the agency can stil get a payback by exercising the deal as long as the real value of drought index I smaller that the strike level K, which means the profit will be S.(K-I) (Zhu, 2009).

2.4.4.3 Drought Index Methods

Drought indices assimilate thousands of bits of data on rainfall, snowpack, streamflow, and other water supply indicators into a comprehensible big picture. A drought index value is typically a single number, far more useful than raw data for decision making.

There are lots of methods for value of drought index methods, some of them are; Palmer Drought Severity Index (PDSI), Crop Moisture Index (CMI), Surface Water Supply Index (SWSI), Reclamation Drought Index (RDI), Standardized Precipitation Index (SPI).

There are several indices that measure how much precipitation for a given period of time has deviated from historically established norms. Although none of the major indices is inherently superior to the rest in all circumstances, some indices are better suited than others for certain uses. For example, the Palmer Drought Severity Index has been widely used by the U.S. Department of Agriculture to determine when to grant emergency drought assistance, but the Palmer is better when working with large areas of uniform topography. Western states, with mountainous terrain and the

resulting complex regional microclimates, find it useful to supplement Palmer values with other indices such as the Surface Water Supply Index, which takes snowpack and other unique conditions into account.

The National Drought Mitigation Center is using a newer index, the Standardized Precipitation Index, to monitor moisture supply conditions. Distinguishing traits of this index are that it identifies emerging droughts months sooner than the Palmer Index and that it is computed on various time scales.

Most water supply planners find it useful to consult one or more indices before making a decision. What follows is an introduction to each of the major drought indices in use in the United States and in Australia (http://drought.unl.Edu/whatis/indices.htm#refs)**.**

2.4.4.3.1 Reconnasissance Drought Index (RDI). The reconnaissance drought index was first itroduced by Tsakiris 2004. It was used measure the severity of drought in the Mediterranean region.

This index has three expressions. The first one is called the initial value of RDI, α_0. If we use α_o^i to stand for the initial RDI for ith year, we can calculate it by the following formula

$$\alpha_o^i = \frac{\sum_{j=1}^{12} P_{ij}}{\sum_{j=1}^{12} PET_{ij}}, \quad \text{i=1…N and j=1…12} \tag{2.11}$$

where P_{ij} and PET_{ij} are the precipitation and potential evapotranspiration of the j th month in the ith year with the unit mm(m^2. month), N is the number of the years of the available data. Potential evapotranspiration reflects the upper limit of evapotranspiration in the region. Based on this formula, we know that lower the RDI is, more serious drought will be.

The second one is called normalized RDI, which is used to reflect the abnormality of the drought in this region. The normalized RDI in the ith year can be calculated by the following formula:

$$RDI_n^i = \frac{\alpha_0^i}{\overline{\alpha_o}} - 1 \ , \tag{2.12}$$

where $\overline{\alpha_o}$ is called aridity index, reflecting the aritmetic mean of all α_0 for N years. In this expression, when RDI_n is negative, the value of RDI is lower than the aridity index, which means the drought serious in this place.

The third one, Standardized RDI (RDI_{st}), is the standardized of the second one. If we use y^i to stand for $\ln(\alpha_0^i)$, the RDI_{st} can be shown to be

$$RDI_{st}^i = \frac{y^i - \bar{y}}{\sigma_y^{'}}, \tag{2.13}$$

where $\bar{y}$ is the arithmetic mean of all y^i, and $\sigma_y^{'}$ is the standart deviation. The important assumption for this expression is that the α_0 follows the lognormal distribution.

From Tsakiris (2005), we can see some advantages of the RDI:

1. It can be actually calculated for any period of time, even thoogh the equation 2.1.4 is used for whole year.
2. It can be used for measurement of the agricultural drought, as it considers the relationship of water supply as precipitation and water demand of the crop, which we use potental evapotrasnpiration to stand for.

3. This index actually includes more climate factors than PDI or SPI, such as day hour and crop coefficients. Both of them are included in potential evapotranspiration, which may lead to a more accurate measurement.

The value of RDI for any period in one year can be calculated by the following formula:

$$RDI^{i} = \frac{\sum_{j=1}^{m} P_{ij}}{\sum_{j=1}^{m} PET_{ij}}, \quad i = 1 \ldots N \text{ and } j = 1 \ldots m \tag{2.14}$$

where j=1 stands for begining day of the period we need, and m is the number of days for this period (Zhu, 2009).

2.4.4.3.2 Standardized Precipitation Index (SPI). Standardized Precipitation Index (SPI) method, is a drought index that can recognize the volatility of lack of fall in different time scales (1,3, 6, 9,12, 24 and 48 months). For this method, monthly fall arrays are prepared for at least 30 years period. As a result of normalizing the SPI value, the drouthy and humid seasons in a certain timescale are determined.

The necessity to express quantitatively the lack of fall in different timescales emerge in terms of observing drought. In the analysis 1, 3, 6, 9, 12 or 24 month timescales can be chosen according to the logic of how long later the effect of lack of fall to the water resources can be perceived. For instance, although a drop in fall affects the humidity in the soil immediately, it affects ground waters, rivers and lakes later. A drought situation in 6, 9 and 12 months timescales is preferred to observe the effect on rivers and lakes, and a drought situation in a 24 months timescale is preferred to observe the effect on ground waters. Here, 3 months drought data represents seasonal droughts, and 12 months data represents annual droughts.

We can see value of SPI below and we have provided SPI index value Table 2.7 from http://www.ncdc.noaa.gov/oa/climate/research/prelim/drought/spi.html

Table 2.7 Index values and classification in terms of SPI method

SPI İNDİS VALUE	CLASSIFICATION
2.0 and more	Exceptionally Moist
1.60 and 1.99	Extremely Moist
1.30 and 1.59	Very Moist
0.80 and 1.29	Moderately Moist
0.51 and 0.79	Abnormally Moist
0.50 and -0.50	Near Normal
-0.51 and -0.79	Abnormally Dry
-0.80 and -1.29	Moderately Dry
-1.30 and -1.59	Severely Dry
-1.60 and -1.99	Extremely Dry
-2.0 and less	Exceptionally Dry

The understanding that a deficit of precipitation has different impacts on groundwater, reservoir storage, soil moisture, snowpack, and streamflow led McKee, Doesken, and Kleist to develop the Standardized Precipitation Index (SPI) in 1993. The SPI was designed to quantify the precipitation deficit for multiple time scales. These time scales reflect the impact of drought on the availability of the different water resources. Soil moisture conditions respond to precipitation anomalies on a relatively short scale. Groundwater, streamflow, and reservoir storage reflect the longer-term precipitation anomalies. For these reasons, McKee et al. (1993) originally calculated the SPI for 3–, 6–,12–, 24–, and 48–month time scales.

McKee et al. (1993) used the classification system shown in the SPI values table to define drought intensities resulting from the SPI. McKee et al. (1993) also defined the criteria for a drought event for any of the time scales. A drought event occurs any time the SPI is continuously negative and reaches an intensity of -1.0 or less. The event ends when the SPI becomes positive. Each drought event, therefore, has a duration defined by its beginning and end, and an intensity for each month that the event continues. The positive sum of the SPI for all the months within a drought event can be termed the drought's "magnitude".

There is Historical Burn Analysis Method; by this method, people who want to calculate the price of the option need neither complicated mathematical knowledge nor special software (Zhu, 2009). In summary, Historical Burn Analysis means the operations we will perform on the data from the past.

2.4.4.4 The Description of the Model

The basic assumption of this method is that all the historical data can cover all the possibilities in the future, which means the price of the option only depends on the data we already have.

The option for drought is given by

$$\Pr = \frac{1}{N} e^{-rt} \left[\sum_{i=1}^{N} \max(K - I_i, 0) \right] \tag{2.15}$$

Where T is the maturity, r is the interest rate, I_i is the Reconnaissence Drought Index Value (RDI), for the i^{th} year during that specific period, N is the number of years of data, K is the strike value for grought indices at drought option contract price model (Zhu, 2009).

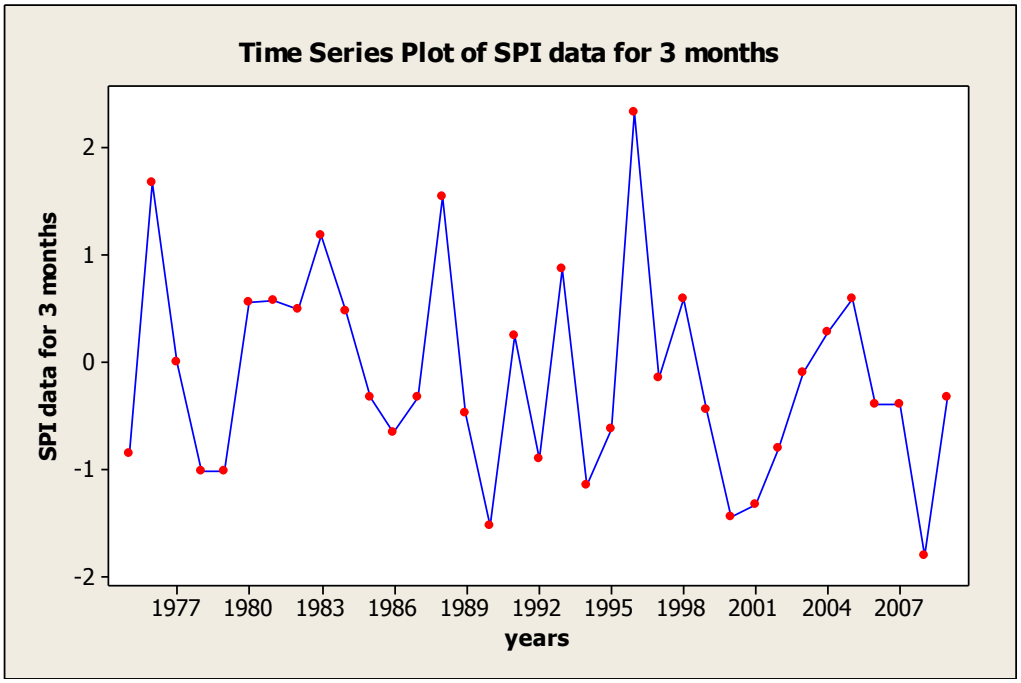
CHAPTER THREE
APPLICATION

We obtained the data presented in Appendix 1 from the General Directorate of Meteorology. As it can be seen in this data, Appendix 1 is separated into columns of 3 months, 6 months, 9 months and 12 months. We can explain this separation as such; for instance, in the 7^{th} month (July) of 1977, the 0.17 drought value corresponding to the 3 months column represents the 3 months mean drought value of May, June and July. Let us give another example; the 0.93 drought value corresponding to the 12 month column of the 5^{th} month (May) of 1980 represents the drought value measured during 12 months before the 5^{th} month.

The sowing of cotton in Harran plane is done in March and April; its harvest is done in August. In other words, cotton become ready for harvest in 6 months after sowing. The water requirement of cotton is 400 to 600 cubic millimeters. Since the annual precipitation in cotton growing countries and especially in Harran region of Turkey is insufficient, the water required for cotton to be well developed should be provided through irrigation. Irrigation is one of the leading factors that influence productivity in cotton.

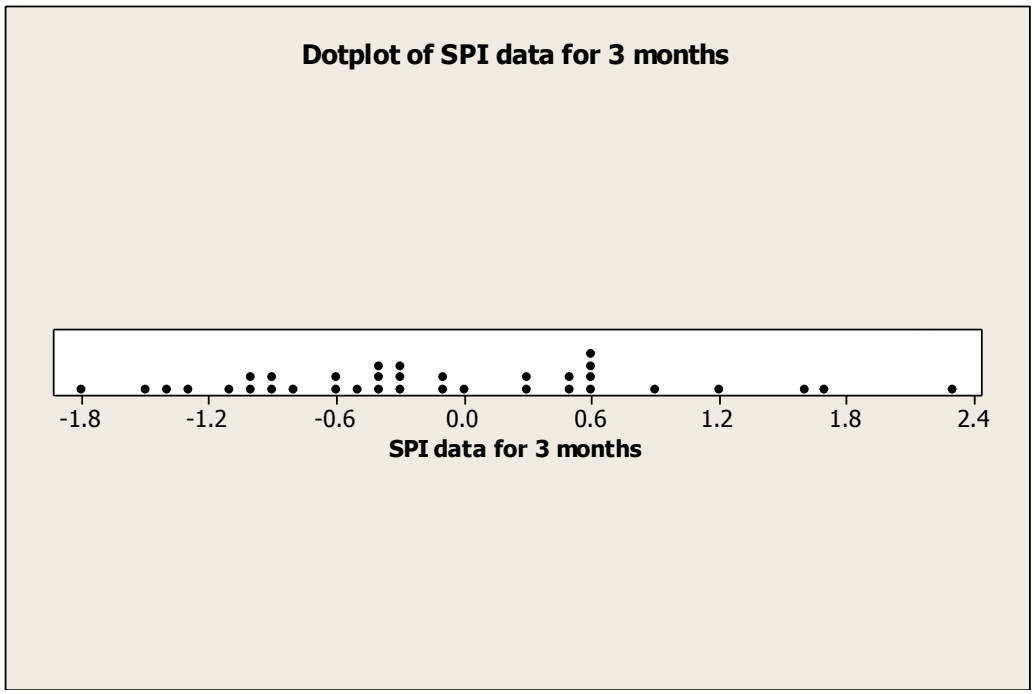
The sowing-time of cotton is determined according to the climatic conditions. The temperature of the soil should be over 15° C for sowing. As it can be understood from this, cotton is a plant that does not like drought or humidity. Although sowing-time differs with respect to regions and from year to year, March-April in Harran Plane, and April-May in Aegean Region and Antalya region are suitable periods for sowing. According to this, if we chart the time series of the 3 months drought periods including March-April-May (Appendix 3), which are the sowing and growing times of cotton in Harran Plane;

Table 3.1 Time series for 3 months SPI data betwen March-May



When we examine the graph, we see that 1996 was quite moisty, and we presume that this situation influenced the development of the product negatively and thus the crop for 1996 was low. We see rapid rises and falls between the years 1975- 1976-1977, 1987-1988-1989, and 1995-1996-1997. According to this data, drought presented great variations in these years. It is seen that 1996 is the moistiest year during growing-time of cotton, among the data at hand. It can be seen that 2008 is the most dry year.

Table 3.2 Dotplot for 3 months SPI data betwen March-May



If we put down the drought data between March and May, which is the growing period of cotton, to a dot plot as above, we can say that these periods pass without drought and without too much rain. As it is seen, there is bunching in the 0.6 and -0.3 drought values; in other words Harran plane passes March-May period with low rain and barely droughty

If we perform computations such as mean and standard deviation for the 3 months data in Minitab;

Descriptive Statistics: SPI data for 3 months

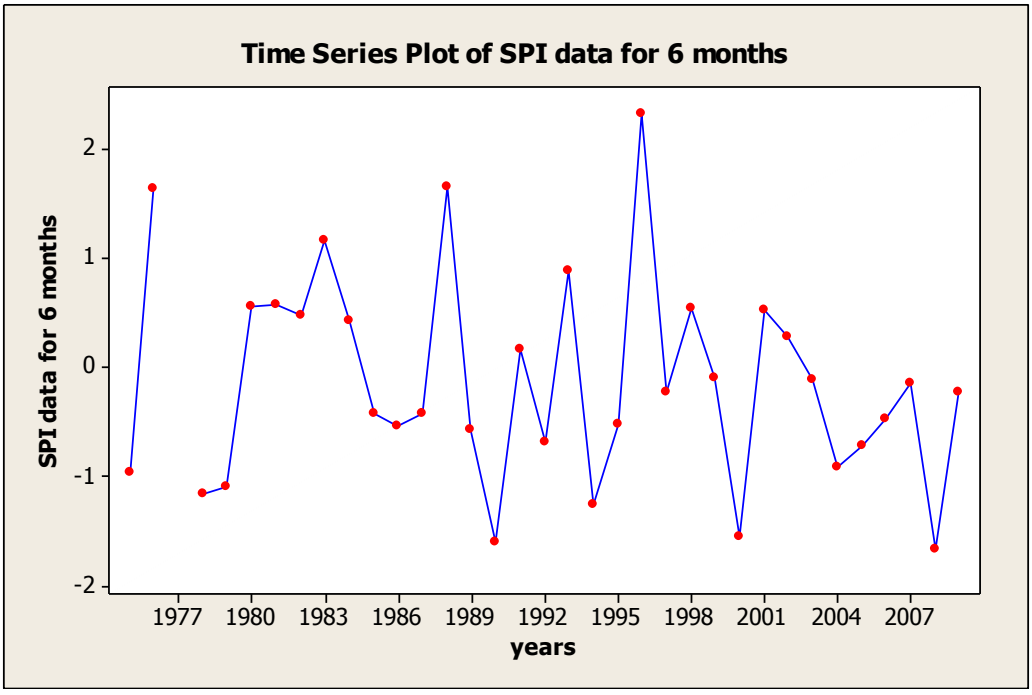
Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median
SPI data for 3 m	35	0	-0.131	0.161	0.955	-1.800	-0.860	-0.330

Variable	Q3	Maximum
SPI data for 3 m	0.560	2.330

According to the results obtained, we can argue that we can see in more detail that the lowest drought value -1.80 as it was presented in Time Series. We can see that this value is in 2008 using Time Series. According to this finding, this year has the droughtiest March–May period and thus the productivity of cotton might be decreased due to over-drought. We can also argue that the maximum drought value is 2.330 and this value is for 1996 from Time Series. With respect to this finding, we can say that this year is the rainiest. As a result of our investigations on the three-month drought values during the growing-time of cotton, we may assert that Harran Region is suitable for the growing conditions of cotton.

We can see the drought data for the 6 months period, including the growing-time of cotton, between 1975 and 2009 in Appendix 2. If we chart these data;

Table 3.3 Time Series for 6 months SPI data betwen March-May

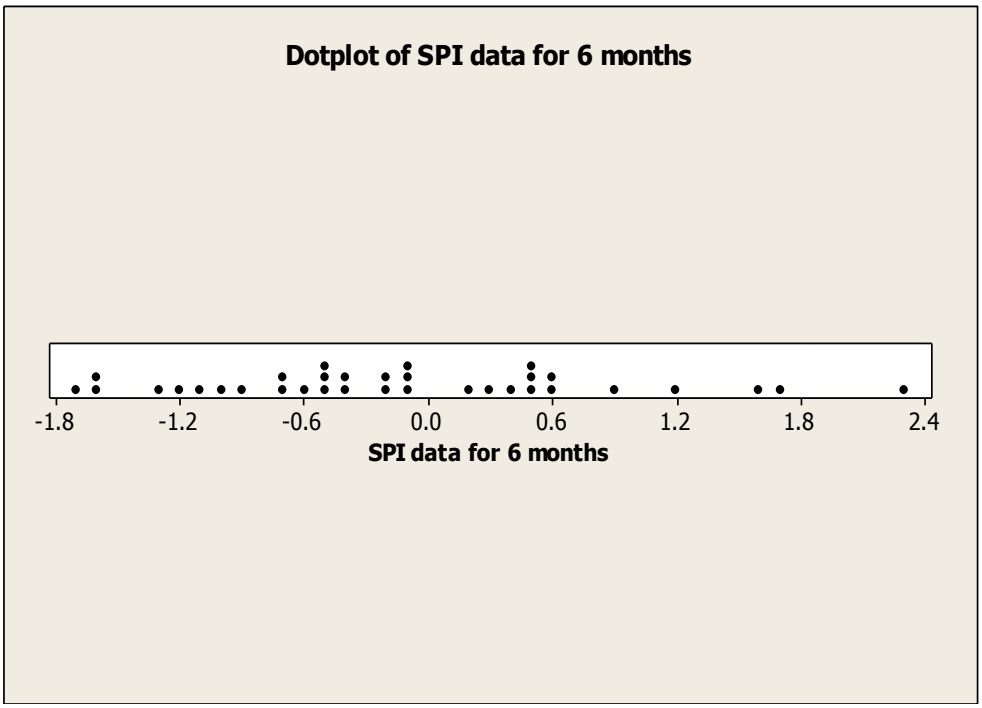


As we have mentioned before, the SPI values for 1977 were missing in the data obtained from the General Directorate of Meteorology for this graph. We could not

know what happened that year, but if we consider other years, we see rapid rises and falls between 1987-1988-1989, and 1995-1996-1997. In other words, while 1988 was quite rainy, 1990 was quite drought. We can also argue that in 1996 there was a humid at the level of top and this situation influenced cotton farmers negatively. We can say, from the data, that 1990 and 1994 were quite dry, and since this situation is negative for cotton, we may argue that the crop for those years were low.

If we put the data in Appendix 2 down to a dot plot;

Table 3.4 Dotplot for 6 months SPI data betwen March-May



We can see that the drought values in Harran region are bunched below the value 0.6; this situation shows that Harran region has a climate which is not too droughty and too rainy during the growing-time and harvest-time of cotton, and thus this region is suitable for cotton farming.

If we perform computations such as mean and standard deviation for the 6 months data in Minitab;

Descriptive Statistics: SPI data for 6 months

```
Variable           N  N*    Mean  SE Mean  StDev  Minimum      Q1  Median
SPI data for 6 m  34   1  -0.125    0.165  0.962   -1.670  -0.768  -0.230

Variable             Q3  Maximum
SPI data for 6 m  0.525    2.330
```

According the results obtained; and using -0.125, the mean value of our data instead of the missing data of 1977, we see that the maximum drought value is 2.33, and it accrued in 1996 from Time Series. With respect to this finding, we can argue that 1996 was a mishap for the cotton farmers in the region and the crop was very low. In Time Series we see that the lowest drought value is -1.670 in 2008. We can argue, for this year, that it was too dry, which was bad for cotton, during the growing-time of cotton and thus there occurred a decrease in crop.

- **Result of the drought option price**

Now let us try to determine the drought option price for cotton using the formula in 2.15, which is used for the RDI value, after adding the data of 1977 we generated. We will have determined the option price for the cotton farmers in the region to perform hedge operations against the risk of drought. As it is seen in the formula, we will use the 2009's strike price, 2.21 TL for the strike price K. While conducting the calculation we will accept the interest rate as r = 0.1 and the term as 6 months. When the data is considered for six-months periods annually, in 34 years t would correspond to 34 periods and the calculations would be made in accordance with this.

$$\text{Pr} = \frac{1}{N} e^{-rt} \left(\sum_{i=1}^{N} \max(K - I_i, 0) \right) \qquad (2.15)$$

r	t	(-rt)	e^(-rt)	max(K-I,0)	Pr
0.1	17	-1.7	0.182684	81.735	0.439166

According to this result, while RDI calculations are not used in our country, the SPI calculations are made by the General Directorate of Meteorology. We see that we can determine the drought option price by using these SPI data in the formula in 2.15.

We calculated the drought option price for Harran Region using real drought data Let us now try to calculate the option prices with the data generated by using different distributions:

The data sets, pertaining to the distributions we generated by setting the Location and Scale parameters of Laplace Distribution and Cauchy Distibution as -0.125 and 0.962, the values obtained from the real data, are as below:

Table 2.13 Generated Numbers for Laplace and Cauchy Distributions

Laplace Distribution			Cauchy Distribution	
0.1948	-0.32433		-0.18939	0.34096
1.15931	-1.92737		-0.06156	-0.6322
0.3469	0.05638		-1.63275	0.0699
-0.43986	-4.84718		-0.36474	-4.4602
0.06995	0.10481		0.29247	-0.08181
-1.07801	-0.65706		-0.49895	-1.11842
-1.7707	-1.50316		-0.53713	-0.59782
-2.92577	-2.10557		-4.83994	-9.69588
-0.24237	-0.42265		-1.5992	0.4081
-0.02767	-0.21675		0.4716	-4.64521
1.36772	-2.35303		1.67015	0.60748
0.36814	1.61723		-0.04868	-5.80486
1.21934	0.82759		0.05903	-7.49062
-1.07607	0.01856		-5.52206	0.66483
-0.46425	-0.05061		1.88108	-2.11901
-0.01589	-2.59665		-0.57225	2.78166
0.45726	-0.63483		-1.59225	-2.33866

If we calculate the premium with these data for Laplace Distribution:

r	t	(-rt)	e^(-rt)	max(K-I,0)	Pr
0.1	17	-1.7	0.182684	81.79445	0.439485

If we calculate the premium with these data for Cauchy Distribution:

r	t	(-rt)	e^(-rt)	max(K-I,0)	Pr
0.1	17	-1.7	0.182684	67.00894	0.360039

The premium calculation, generated from real values, was as below:

r	t	(-rt)	e^(-rt)	max(K-I,0)	Pr
0.1	17	-1.7	0.182684	81.735	0.439166

CHAPTER FOUR
CONCLUSION

We generated the missing data for 1977, among the 34 years SPI values we obtained from the General Directorate of Meteorology, by accepting it as the mean of our data. We saw that cotton is an appropriate plant for Harran region, by analyzing the drought values for both March-May period, the growing-time of cotton, and March-August period, the whole product-time of cotton.

Later, we obtained an option premium. Then, we compared this option premium to other premiums we obtained using the data exhibiting different distributions. In order this comparison to be done; we generated 34 years SPI values suitable for Laplace and Cauchy distributions. We calculated the cotton option premiums for these data by pegging the time-frame, interest rate and strike price. We made a comparison of these premiums in the conclusion part of the study.

In conclusion, it is seen that we obtained resulted in close values with our real data and Laplace Distribution for option premium, Cauchy distribution resulted in lower values. However, we may argue that, whatever distribution we chose, the premiums we obtained yielded very close results to each other.

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APPENDICES

Appendix 1 Drought data of Şanlıurfa

Year	Month	3 Months	6 Months	9 Months	12 Months
1975	1	-1.12	-1.25	-1.64	-0.75
1975	2	0.41	-0.24	-0.21	0.16
1975	3	-0.24	-0.75	-0.68	-1.16
1975	4	0.56	-0.31	-0.46	-0.78
1975	5	-0.86	-0.21	-0.71	-0.7
1975	6	-0.07	-0.34	-0.74	-0.69
1975	7	-1.22	0.19	-0.52	-0.68
1975	8	-0.71	-0.97	-0.27	-0.76
1975	9	0.05	-0.13	-0.39	-0.80
1975	10	-0.79	-1.70	-0.08	-0.71
1975	11	0.20	0.05	-0.73	-0.26
1975	12	0.90	0.87	0.52	0.15
1976	1	1.02	0.70	0.35	0.53
1976	2	0.86	0.78	0.74	0.07
1976	3	0.52	0.88	0.87	0,66
1976	4	1.21	1.40	1.27	1.06
1976	5	1.68	1.58	1.57	1.57
1976	6	1.73	1.36	1.54	1,55
1976	7	1.45	1.55	1.62	1.54
1976	8	-0.71	1.64	1.56	1,53
1976	9	-0.21	1.67	1,36	1.56
1976	10	1.43	1.77	1.85	1,87
1976	11	0.84	0.76	1.69	1,69
1976	12	1.23	1.19	2.02	1.63
1977	1	1.02	-0.37	1.48	1.23
1977	2	-2.01	0.96	1.03	-1.58
1977	3	0.59	-1.23	0.78	0.01
1977	4	-0.11	-1.45	0.25	0.74
1977	5	0.00	0.52	-1.12	0.00
1977	6	0.06	-0.17	1.95	1.10
1977	7	0.17	-0.15	1.10	-0.66
1977	8	*	*	*	*
1977	9	*	*	*	*
1977	10	*	*	*	*
1977	11	-1.78	*	*	*
1977	12	0.29	*	*	*
1978	1	0.62	*	*	*
1978	2	1.03	0.37	*	*
1978	3	-0.05	0.05	*	*

1978	4	-0.45	0.09	*	-*
1978	5	-1.01	0.22	-0.27	*
1978	6	-0.57	-0.41	-0.26	*
1978	7	-0.45	-0.65	-0.08	*
1978	8	0.03	-1.07	0.20	-0.29
1978	9	-.0.37	-0.65	-0.47	-0.30
1978	10	-0.34	-0.83	-0.84	-0.22
1978	11	-2.10	-2.24	-1.90	-0.32
1978	12	-0.83	-0.92	-1.26	-0.85
1979	1	-0.18	-0.42	-0.67	-0.83
1979	2	0.31	-0.43	-0.48	-1.04
1979	3	0.14	-0.47	-0.52	-0.85
1979	4	-0.65	-0.61	-0.82	-1.06
1979	5	-1.02	-0.36	-0.94	-0.99
1979	6	-1.48	-0.52	-0.94	-1.00
1979	7	-0.69	-0.89	-0.76	-0.98
1979	8	-0.20	-1.10	-0.40	-0.97
1979	9	0.19	-1.51	-0.57	-1.00
1979	10	1.27	0.6	-0.27	-0.36
1979	11	1.60	1.61	0.25	0.30
1979	12	1.33	1.32	0.43	0.30
1980	1	0.18	0.66	0.36	-0.17
1980	2	0.08	0.92	0.90	0.15
1980	3	0.39	1.09	1.09	0.50
1980	4	0.91	0.67	1.02	0.83
1980	5	0.56	0.33	0.94	0.93
1980	6	0.26	0.32	0.94	0.94
1980	7	0.34	0.80	0.61	0.94
1980	8	0.41	0.56	0.33	0.93
1980	9	0.31	0.22	0.31	0.95
1980	10	-1.07	-0.40	0.51	0.41
1980	11	-1.52	-1.54	-0.13	-0.12
1980	12	-0.17	-0.21	-0.13	0.10
1981	1	-0.08	-0.42	-0.41	0.28
1981	2	0.54	-0.09	-0.10	0.20
1981	3	0.55	0.24	0.22	0.21
1981	4	0.45	0.19	-0.05	-0.07
1981	5	0.58	0.64	0.22	0.22
1981	6	0.30	0.46	0.24	0.23
1981	7	1.04	0.72	0.41	0.21
1981	8	0.36	0.57	0.64	0.21
1981	9	-0.37	0.23	0.43	0.21
1981	10	-0.12	0.57	0.54	0.30
1981	11	0.12	0.08	0.43	0.57
1981	12	0.51	0.45	0.40	0.53
1982	1	0.07	-0.12	0.24	0.38
1982	2	-0.42	-0.43	-0.45	-0.04
1982	3	-1.19	-0.57	-0.63	-0.53
1982	4	-0.26	-0.2	-0.34	-0.07
1982	5	0.50	-0.03	-0.07	-0.08

1982	6	0.93	-0.31	-0.05	-0.08
1982	7	0.96	0.1	0.04	-0.08
1982	8	0.29	0.48	-0.04	-0.08
1982	9	0.32	0.89	-0.34	-0.07
1982	10	-0.58	0.35	-0.14	-0.12
1982	11	-0.75	-0.82	0.01	-0.34
1982	12	-1.04	-1.09	-0.13	-0.83
1983	1	-0.40	-0.69	-0.29	-0.44
1983	2	0.04	-0.38	-0.41	-0.07
1983	3	0.83	0.05	0.03	0,43
1983	4	0.67	0.16	-0.04	0.18
1983	5	1.18	0.73	0.45	0.45
1983	6	0.97	1.05	0.44	0.43
1983	7	1.49	1.14	0.58	0.43
1983	8	0.08	1.16	0.72	0.43
1983	9	-0.37	0.91	1.04	0.42
1983	10	-1.26	0.81	0.84	0.38
1983	11	-0.48	-0.59	0.73	0.48
1983	12	-0.90	-1.00	-0.04	0.45
1984	1	-0,83	-1.20	-0.29	0.18
1984	2	-1.56	-1.75	-1.83	-0.40
1984	3	-0.07	-0.68	-0.74	-0.18
1984	4	0.11	-0.51	-0.81	-0.24
1984	5	0.48	-0.69	-0.93	-0.98
1984	6	-0.70	-0.47	-0.93	-0.99
1984	7	-0.84	-0.20	-0.69	-0.99
1984	8	-0.57	0.42	-0.75	-0.98
1984	9	-0.37	-0.78	-0.53	-1.01
1984	10	-0.56	-1.27	-0.44	-0.85
1984	11	0.59	0.49	0.54	-0.52
1984	12	-0.08	-0.16	-0.69	-0.53
1985	1	0.44	0.15	-0.17	-0.13
1985	2	0.23	0.40	0.35	0.48
1985	3	0.34	0.12	0.08	-0.32
1985	4	0.31	0.42	0.24	0.00
1985	5	-0.33	-0.10	0.05	0.01
1985	6	0.07	0.19	0.04	0.00
1985	7	-0.92	-0.02	0.18	0.01
1985	8	-0.71	-0.43	-0.15	0.01
1985	9	-0.37	-0.01	0.15	0.00
1985	10	-0.10	-0.9	-0.17	0.08
1985	11	-0.37	-0.57	-0.65	-0.34
1985	12	0.11	0.04	-0.07	0.11
1986	1	-0.17	-0.34	-0.67	-0.32
1986	2	1.00	0.69	0.65	0.24
1986	3	0.39	0.27	0.24	0.13
1986	4	0.41	0.11	-0.02	-0.29
1986	5	-0.65	0.34	0.14	0.09
1986	6	0.19	0.29	0.22	0.19
1986	7	0.94	0.63	0.30	0.19

1986	8	1.10	-0.54	0.39	0.19
1986	9	-0.15	0.12	0.25	0.19
1986	10	0.38	0.71	0.59	0.29
1986	11	-0.07	0.07	-0.58	0.27
1986	12	-0.35	-.0.42	-0.35	0.02
1987	1	0.20	0.18	0.44	0.50
1987	2	-0.20	-0.32	-0.26	-0.68
1987	3	0.43	0.04	0.00	-0.03
1987	4	-0.58	-0.30	-0.32	-0.09
1987	5	-0.33	-0.41	-0.51	-0.47
1987	6	-1.79	-0.31	-0.52	-0.57
1987	7	-2.12	-0.93	-0.54	-0.57
1987	8	-0.71	-0.43	-0.47	-0.56
1987	9	-0.05	-1.87	-0.36	-0.58
1987	10	1.33	0.55	-0.26	-0.13
1987	11	1.38	1.35	0.45	0.12
1987	12	1.56	1.54	0.60	0.59
1988	1	1.14	1.52	1.16	0.50
1988	2	0.72	1.28	1.26	0.75
1988	3	0.91	1.62	1.63	1.00
1988	4	1.46	1.65	2.02	1.83
1988	5	1.55	1.40	1.81	1.83
1988	6	1.24	1.28	1.83	1.84
1988	7	0.46	1.33	1.54	1.89
1988	8	1.46	1.66	1.48	1.88
1988	9	1.16	1.30	1.35	1.92
1988	10	1.92	1.62	1.93	2.00
1988	11	1.62	1.85	2.09	1.93
1988	12	1.30	1.38	1.78	1.67
1989	1	-1.22	0.18	0.21	1.06
1989	2	-2.31	-0.62	-0.49	0.71
1989	3	-1.73	-0.18	-0.13	0.52
1989	4	-1.16	-1.65	-0.64	-0.61
1989	5	-0.47	-1.85	-0.81	-0.72
1989	6	-2.97	-2.43	-0.82	-0.78
1989	7	-1.49	-1.47	-1.80	-0.86
1989	8	-0.65	-0.57	-1.93	-0.86
1989	9	-0.37	-3,09	-2.55	-0.89
1989	10	1.64	0.91	-0.37	-0.99
1989	11	1.59	1.58	0.52	-0.86
1989	12	0.85	0.81	-0.25	-1.19
1990	1	-0.25	0.59	0.23	-0.53
1990	2	-0.29	0.63	0.59	0.12
1990	3	-0.53	0.12	0.08	-0.66
1990	4	-0.68	-0.68	-0.04	-0.33
1990	5	-1.52	-1.04	-0.22	-0.28
1990	6	-0.66	-0.84	-0.22	-0.26
1990	7	-0.95	-0.96	-0.85	-0.26
1990	8	-0.18	-1.60	-1.09	-0.26
1990	9	-0.15	-0.74	-0.91	-0.27

1990	10	-1.40	-1.86	-1.28	-1.06
1990	11	-0.92	-1.11	-1.89	-1.42
1990	12	-1.8	-1.92	-2.09	-1.63
1991	1	-1.23	-1.61	-1.96	-1.83
1991	2	-1.04	-1.50	-1.59	-2.22
1991	3	0.16	-0.88	-0.95	-1.30
1991	4	0.04	-0.79	-1.11	-1.43
1991	5	0.25	-0.58	-0.96	-1.02
1991	6	-0.31	-0.13	-0.96	-1.02
1991	7	0.32	0.04	-0.71	-1.01
1991	8	-0.71	0.17	-0.64	-1.01
1991	9	-0.21	-0.39	-0.18	-1.03
1991	10	-0.27	-0.16	-0.16	-0.82
1991	11	0.00	-0.17	0.04	-0.68
1991	12	0.42	0.36	-0.04	0.01
1992	1	-0.20	-0.42	-0.41	-0.33
1992	2	0.78	0.61	0.57	0.50
1992	3	-0.18	0.04	0.00	-0.26
1992	4	-0.04	-0.23	-0.41	-0.44
1992	5	-0.90	0.06	-0.03	-0.08
1992	6	0.33	-0.07	0.09	0.06
1992	7	1.36	0.53	0.20	0.06
1992	8	1.39	-0.69	0.15	0.06
1992	9	0.50	0.31	-0.,08	0.08
1992	10	-0.68	0.74	0.27	0.02
1992	11	-0.15	0.08	-0.75	0.01
1992	12	-0.67	-0.69	-0.43	-0.45
1993	1	0.22	-0.08	0.49	0.26
1993	2	-0.02	-0.20	-0.09	-0.66
1993	3	0.19	-0.34	-0.36	-0.27
1993	4	-0.32	-0.13	-0.36	0.10
1993	5	0.87	0.47	0.34	0.43
1993	6	1.28	0.82	0.35	0.35
1993	7	1.79	0.64	0.51	0.35
1993	8	0.57	0.88	0.48	0.35
1993	9	-0.15	1.22	0.80	0.33
1993	10	-1.19	1.14	0.34	0.31
1993	11	-0.25	-0.25	0.56	0.31
1993	12	-0.82	-0.91	0.32	0.26
1994	1	0.50	0.15	0.99	0.49
1994	2	0.41	0.16	0.17	0.62
1994	3	0.33	-.0.29	-0.34	0.37
1994	4	-0.83	-0.21	-0.48	0.26
1994	5	-1.14	-0.33	-0.50	-0.50
1994	6	-0.43	-0.04	-0.50	-0.55
1994	7	-0.08	-0.87	-0.29	-0.55
1994	8	-0.71	-1.26	-0.38	-0.54
1994	9	0.83	-0.36	-0.02	-0.50
1994	10	0.90	0.43	-0.51	-0.10
1994	11	1.58	1.57	0.16	0.30

1994	12	1.19	1.23	0.67	0.58
1995	1	0.60	0.8	0.62	-0.06
1995	2	-0.69	0.34	0.28	-0.44
1995	3	-1.66	-0.25	-0.24	-0.53
1995	4	-1.46	-0.44	-0.24	-0.38
1995	5	-0.63	-0.93	-0.14	-0.19
1995	6	0.40	-1.02	-0.11	-0.10
1995	7	0.71	-0.95	-0.26	-0.09
1995	8	0.98	-0.53	-0.87	-0.09
1995	9	0.19	0.35	-1.08	-0.14
1995	10	-0.51	0.12	-1.17	-0.42
1995	11	0.07	0.17	-0.50	-0.87
1995	12	-1.37	-1,44	-0.85	-1.60
1996	1	0.68	0.40	0.53	-0.41
1996	2	0.5	0.38	0.45	-0.08
1996	3	3.11	2.14	2.16	2.07
1996	4	2.49	2.17	2.11	2.22
1996	5	2.33	1.87	1.83	1.91
1996	6	0.15	2.5	1.80	1.81
1996	7	-0.70	2.06	1.85	1.80
1996	8	-0.11	2.33	1.86	1.80
1996	9	1.08	0.24	2.58	1.88
1996	10	0.93	0.24	2.12	1.92
1996	11	0.37	0.29	2.12	1.84
1996	12	0.85	0.93	0.700	2.48
1997	1	-0.31	0.01	-0.29	1.59
1997	2	-0.39	-0.26	-0.32	1.52
1997	3	-1.26	-0.33	-0.28	-0.30
1997	4	-0.17	-0.39	-0.19	-0.43
1997	5	-0.14	-0.44	-0.36	-0.4
1997	6	-0.15	-1.14	-0.43	-0.39
1997	7	-0.79	-0.45	-0.57	-0.39
1997	8	-0.49	-0.23	-0.48	-0.4
1997	9	0.74	-0.11	-1.15	-0.43
1997	10	1.25	0.56	0.06	-0.19
1997	11	1.56	1.55	0.70	0.21
1997	12	1.45	1.48	1.03	0.02
1998	1	1.14	1.47	1.16	0.700
1998	2	0.38	1.12	1.10	0.71
1998	3	0.25	1.09	1.12	0.87
1998	4	-0.06	0.69	1.03	0.83
1998	5	0.6	0.55	1.11	1.10
1998	6	0.55	0.38	1.06	1.09
1998	7	0.80	0.18	0.76	1.08
1998	8	-0.46	0.54	0.51	1.07
1998	9	-0.37	0.48	0.35	1.06
1998	10	-1.89	0.05	-0.14	0.55
1998	11	-1.37	-.1.64	-0.12	0.10
1998	12	-0.91	-1.01	-0.45	-0.18
1999	1	-1.06	-1.46	-1.04	-0.81

1999	2	-0.40	-1.02	-1.12	-0.48
1999	3	-0.57	-1.12	-1.19	-0.85
1999	4	0.14	-0.62	-0.93	-0.75
1999	5	-0.44	-0.62	-1.10	-1.18
1999	6	-0.15	-0.64	-1.08	-1.15
1999	7	-1.29	-0.21	-0.82	-1.14
1999	8	2.03	-0.1	-0.42	-0.88
1999	9	1.95	0.25	-0.41	-.0.9
1999	10	0.52	-0.33	-0.14	-0.73
1999	11	-2.27	-1.05	-0.95	-0.98
1999	12	-2.11	-1.47	-1.36	-1.27
2000	1	-0.51	-0.41	-0.78	-0.51
2000	2	-0.25	-1.04	-0.78	-0.97
2000	3	-0.13	-1.28	-1.04	-1.15
2000	4	-1.35	-1.26	-1.23	-1.59
2000	5	-1.45	-0.98	-1.63	-1.43
2000	6	-1.26	-0.71	-1.63	-1.42
2000	7	-1.10	-1.62	-1.41	-1.41
2000	8	-0.43	-1.56	-1.04	-1.68
2000	9	0.37	-1.26	-0.75	-1,70
2000	10	-0,37	-1.23	-1.77	-1.53
2000	11	0.27	0.15	-1.05	-0.93
2000	12	0.29	0.27	-0.53	-0.48
2001	1	-0.45	-0,69	-1.05	-1.63
2001	2	-0.44	-0.36	-0.43	-1.19
2001	3	-0.52	-0.29	-0.32	-0.87
2001	4	0.51	0.01	-0.17	-0.45
2001	5	0.59	0.02	0.04	-0.01
2001	6	0.68	-0.08	0.01	0.00
2001	7	0.78	0.64	0.15	0.00
2001	8	-0.71	0.52	-0.03	-0.01
2001	9	-0.37	0.62	-0.13	-0.03
2001	10	0.70	0.78	0.71	0.24
2001	11	0.38	0.25	0.52	0.04
2001	12	1.50	1.47	1.47	0.70
2002	1	0.56	0.65	0.79	0.81
2002	2	0.25	0.3	0.25	0.47
2002	3	-0.63	0.58	0.55	0.73
2002	4	0.14	0.39	0.50	0.63
2002	5	0.28	0.26	0.31	0.27
2002	6	-0.27	0.74	0.3	0.27
2002	7	-0.38	-0.09	0.21	0.31
2002	8	0.35	0.27	0.26	0.31
2002	9	0,73	-0.23	-0.74	0.31
2002	10	-0.54	-0.91	-0.33	0.05
2002	11	-0.6	-0.66	-0.14	-0.01
2002	12	-0.71	-0.69	-0.88	-1.02
2003	1	-0.29	-0.57	-0.80	-0.53
2003	2	1.01	0.62	0.63	0.57
2003	3	1.48	0.79	0.81	0.53

2003	4	1.24	0.66	0.50	0.32
2003	5	-0,10	0,60	0.34	0.34
2003	6	-0.70	0.85	0.36	0.38
2003	7	-0.20	0.97	0.49	0.34
2003	8	0.38	-0.12	0.59	0.34
2003	9	-0.21	-0.78	0.83	0.34
2003	10	0.20	-0.25	0.85	0.44
2003	11	-0.15	-0.20	-0.28	0.45
2003	12	-0.31	-0.39	-0.89	0.48
2004	1	0.47	0.37	0.17	0.88
2004	2	0.76	0.53	0.54	0.27
2004	3	0.27	-0.07	-0.12	-0.51
2004	4	-0.42	0.00	-0.07	-0.23
2004	5	-0.80	0.09	-0.05	-0.06
2004	6	0.20	0.20	-0.06	-0.10
2004	7	0.20	-0.41	-0.04	-0.10
2004	8	-0.71	-0.91	0.04	-0.10
2004	9	-0.37	0.12	0.16	-0.10
2004	10	-0.91	-0.50	-0.69	-0.23
2004	11	1.95	1.97	0.63	0.86
2004	12	0.78	0.73	0.56	0.47
2005	1	0.71	0.38	0.30	-0.10
2005	2	-1.19	0.32	0.26	-0.31
2005	3	-0.76	-0.09	-0.14	-0.15
2005	4	-0.88	-0.08	-0.32	-0.39
2005	5	-1.32	-1.66	-0.43	-0.50
2005	6	-0.03	-0.71	-0.18	-0.22
2005	7	0.57	-0.61	0.00	-0.22
2005	8	2.32	-0.72	-1.33	-0.20
2005	9	0.37	-0.07	-0.75	-0.20
2005	10	0.08	0.24	-0.68	-0.06
2005	11	0,13	0.68	-0.6	-1.26
2005	12	-0.52	-0.57	-0.62	-0.93
2006	1	-0.10	-0.22	-0.11	-0.66
2006	2	-0.37	-0.37	-0.06	-0.82
2006	3	-0.65	-0.94	-0.99	-1.03
2006	4	-0.43	-0.42	-0.53	-0.46
2006	5	-0.39	-0.57	-0.58	-0.35
2006	6	0.52	-0.28	-0.59	-0.62
2006	7	-0.12	-0.54	-0.49	-0.61
2006	8	-0.46	-0.48	-0.62	-0.62
2006	9	-0.09	0.45	-0.33	-0.64
2006	10	0.71	0.23	-0.34	-0.36
2006	11	0.07	-0.08	-0.46	-0.63
2006	12	-0.90	-0.99	-0.46	-0.77
2007	1	-1.52	-1.14	-1.27	-1.22
2007	2	-0.69	-0.69	-0.78	-0.95
2007	3	-0.06	-0.68	-0.74	-0.49
2007	4	0.28	-0.74	-0.63	-0.79
2007	5	-0,.40	-0.69	-0.73	-0.80

2007	6	-0.80	-0.25	-0.73	-0.78
2007	7	-0.14	0.10	-0.79	-0.71
2007	8	1.06	-0.15	-0.64	-0.67
2007	9	1.20	-0.04	-0.19	-0.69
2007	10	0.38	-0.07	0.09	-0.75
2007	11	-0.65	-0.50	-0.54	-0.90
2007	12	-1.01	-0.87	-0.96	-0.69
2008	1	-1.30	-1.18	-1.31	-0.73
2008	2	-1.37	-1.68	-1.62	-1.47
2008	3	-1.83	-2.15	-2.08	-2.08
2008	4	-2.68	-2.54	-2.54	-2.73
2008	5	-1.80	-2.03	-2.31	-2.28
2008	6	-0.72	-1.89	-2.19	-2.14
2008	7	0.43	-1.99	-2.17	-2.23
2008	8	0.81	-1.67	-1.98	-2.25
2008	9	3.65	0.76	-0.83	-1.32
2008	10	1.72	1.42	-0.61	-1.22
2008	11	1.32	1.41	-0.25	-1.09
2008	12	-0.83	0.47	-0.14	-1.15
2009	1	-1,60	-1.27	-0.23	-1.50
2009	2	-1.50	-0.42	-0.39	-1.29
2009	3	-1.01	-1.41	-0.50	-0.89
2009	4	-0.22	-1.19	-0.43	-0.42
2009	5	-0.33	-1.27	-0.58	-0.57
2009	6	-0.10	-0.93	-1.30	-0.55
2009	7	-0.16	-0.36	-1.21	-0.52
2009	8	1.09	-0.23	-1.20	-0.52
2009	9	1.12	0.01	-0.88	-1.28
2009	10	1.42	0.90	0.24	-0.66
2009	11	0.99	1.13	0.30	-0.70
2009	12	1.18	1.26	0.85	0.00

Appendix 2 Drought data for S.Urfa for 6 months

Year	SPI
1975	-0.97
1976	1.64
1977	*
1978	-1.17
1979	-1.10
1980	0.56
1981	0.57
1982	0.48
1983	1.16
1984	0.42
1985	-0.43
1986	-0.54
1987	-0.43
1988	1.66
1989	-0.57
1990	-1.60
1991	0.17
1992	-0.69
1993	0.88
1994	-1.26
1995	-0.53
1996	2.33
1997	-0.23
1998	0.54
1999	-0.10
2000	-1.56
2001	0.52
2002	0.27
2003	-0.12
2004	-0.91
2005	-0.72
2006	-0.48

2007	-0.15
2008	-1.67
2009	-0.23

Appendix 3 Drought data for 3 months

Year	**SPI**
1975	-0.86
1976	1.68
1977	0.00
1978	-1.01
1979	-1.02
1980	0.56
1981	0.58
1982	0.50
1983	1.18
1984	0.48
1985	-0.33
1986	-0.65
1987	-0.33
1988	1.55
1989	-0.47
1990	-1.52
1991	0.25
1992	-0.90
1993	0.87
1994	-1.14
1995	-0.63
1996	2.33
1997	-0.14
1998	0.6
1999	-0.44
2000	-1.45
2001	-1.32
2002	-0.80
2003	-0,10
2004	0.28
2005	0.59
2006	-0.39
2007	-0.40
2008	-1.80