A HEDGING APPROACH FOR COPPER INDUSTRY IN TURKEY

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TÜRK BAKIR ENDÜSTRİSİ İÇİN RİSKTEN KORUNMA YAKLAŞIMI

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ABSTRACT:

The paper provides an extensive copper market analysis detailed as price, basis risk and volatility analysis of copper. E-GARCH test is applied for the daily (close-to-close) copper LME (London Metal Exchange) cash settlement prices from 30th of January, 1985 to 25th of April, 2008 and supply-side asymmetric volatility structure of the market is exposed. Moreover, the importance of the commodity for Turkish Economy is emphasized with explicit economic indicators. And on its purpose, the thesis develops a hedging approach as regards to the copper prices in Turkish Liras under the circumstances of implied volatility orientates the markets as the market based volatility forecast.

Keywords: Hedging, Copper, Volatility, E-GARCH, Turkey

ÖZET:

Bu çalışmada fiyat, baz riski ve oynaklık analizlerinden oluşan kapsamlı bir bakır piyasası analizi yapılmıştır. 30 Ocak 1985'den 25 Nisan 2008'e kadar, günlük LME (Londra Metal Borsası) bakır fiyatları dikkate alınarak E-GARCH testi uygulanmış ve bakır piyasasının tedarikçilerden yana asimetrik bir oynaklık yapısının olduğu tespit edilmiştir. Bununla birlikte; bakır ve ürünlerinin Türk Ekonomisi'ndeki önemi temel ekonomik göstergelerle vurgulanmıştır. Bu bağlamda; tez, piyasa tahmin verisi olarak zımni (öngörülen) oynaklığın piyasayı yönlendirdiği varsayımı altında, bakır Türk Lirası fiyatları için riskten korunma yaklaşımını ortaya koymaktadır.

Anahtar Kelimeler: Riskten Korunma, Bakır, Oynaklık, E-GARCH, Türkiye

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1. INTRODUCTION:

Significant changes in supply, demand, and pricing have touched many of the world's financial and commodity markets during the past 25 years. International politics, war, changing economic patterns, and structural changes within industries have created considerable uncertainty as to the future direction of market conditions. Uncertainty, in turn, leads to market volatility, and the need for an effective means to hedge the risk of adverse price exposure.

The copper market is the one of which has been effected mostly from this global conjuncture. For the last decade, copper prices have been increasing enormously. The reason behind the fact mainly comes from the classic supply and demand principle of economics. With the growing Asian economies, especially Chinese Economy, there has been excess demand for copper which has driven the prices up by five times, from 1.558 USD/ton yearly average price to 7.971 USD/ton yearly average price (LME cash settlement prices), for the last six years.

On the other hand, Turkey's copper reserve is pretty much small in the total world reserves, only 0,03% of the world. The copper reserves of Turkey is generally located in Black-sea and South-east Anatolian Regions; Murgul, Çayeli-Madenköy, Lahanos, Ergani, Siirt-Madenköy, Cerattepe and Küre. These reserves are totally 62.870.000 tons, and contain 2,69% Cu which makes the reserves 1.697.204 copper tons[1]. With these insufficient reserves against its growing consumption, Turkey has been in a shortage which made the trade deficit of the chapter of 'copper and articles thereof' reached to 4% of Turkey's total foreign trade deficit as of 2008[2]. However, this copper shortage is not only risk for the firms in the copper industry of Turkey. Due to the fact that copper is priced in international commodity exchange markets- The London Metal Exchange (LME), the Commodity Exchange Division of the New York Mercantile Exchange (COMEX/NYMEX) and the Shanghai Metal Exchange (SHME), whether it imports or purchases domestically, the firm should also take into consideration the exchange rate risk for the base currency of the market where the copper is quoted. And in accordance with these facts, this study aims to state a hedging approach against to the copper price risk for a value maximizing firm in Turkey.

A rich literature has emerged that explains intensively what the hedge mean, why firms need hedge, how firms should hedge, which financial instruments can be used etc. We differentiate our work from those previous studies on its purpose. First, rather than to focus on hedging as a common risk management tool for the corporate, this thesis proves a hedging approach mainly against to *price fluctuation* and specifically for the corporate in the copper industry of Turkey. And second, as the framework of this hedging approach, instead of modeling which forecasting technique is superior for the

[1] "Maddencilik Özel İhtisas Komisyonu Metal Madenler Alt Komisyonu: Bakır Cevheri ve Pirit çalışma Grubu raporu", Ankara, DPT; www.dpt.gov.tr
[2] Turkish Statistical Institute, www.tuik.gov.tr

approach, we lean our study on the theory that *implied volatility is the market's forecast of future volatility* (Stein, 1989; Zhu and Avellaneda, 1997; Poon and Granger, 2003; Kroner, Kneafsey, and Claessens, 1995) and then establish the approach following the implied volatility of the risk components.

The rest of this paper is organized as follows; section II sets out the widespread literature review covering the basic concepts through the aim of the paper; risk management, main incentives to hedge, determination of optimal hedging strategies, basis risk, significance of volatility and the asymmetry in volatility with E-GARCH econometric model. And section III applies price, basis risk and volatility analysis of copper. In this section, addition to the historical volatility analysis, E-GARCH test is applied to set out the volatility structure of copper. Next, section IV proves the empirical evidence for Turkish copper industry with trading facts, and volatility analysis of the exchange rate ($/TRY). After these intensive analyses, section V establishes the hedging approach for copper in Turkey. Then, section VI realizes a comprehensive conclusion. And finally, section VII is for references while section VIII takes place as appendix.

2. LITERATURE REVIEW:

Hedging can be defined as "….neutralizing, actually offsetting, certain risks in a business" (Stephens, 2000) in the simplest manner. However, in fact it as a multi-dimensional matter which has been a core for the numerous studies during the modern finance era. There are substantial academic researches explain intensively what the hedge mean, why firms need hedge, how firms should hedge, which financial instruments can be used etc. With different point of views, diverse techniques and various theories, all of these studies underline the importance of managing the risk.

According to Güven Sevil (2001), risk, in general, is the possibility of unexpected results, and for financial perspective the definition can be interpreted as the variance between the expected and the realized value. And this variance makes risk management is unavoidable for the corporations in financial industry. The study claims as the main reasons behind the improvement of risk management are that options put on the financial market by Chicago Board of Trade (CBOT) and Black & Scholes option pricing model in 1973, increasing interest rates in USA due to the changing of economic policy in 1979 and also the evolution in international financial markets in 1980's.

Actually these reasons support the idea that risk management is a purely financial transaction. It therefore follows from Miller and Modigliani (1958). According to the Modigliani-Miller paradigm, buying and selling option contracts cannot alter the company's value; in perfect financial markets, with fixed investment policy and with no contracting costs or taxes, corporate financing policy is irrelevant. The argument implies that if a firm chooses to change its hedging policy, investors who hold claims issued by the firm can change their holdings of risky assets to offset any change in the firm's hedging policy, leaving the distribution of their future wealth unaffected.

Smith and Stulz (1985) rephrase the argument that if the hedging policy affects the value of the firm, it must do so through taxes, contracting costs, or the impact of hedging policy on the firm's investment decisions. If hedging reduces the variability of pre-tax firm values, then the expected corporate tax liability is reduced and the expected post-tax value of the firm is increased, as long as the cost of the hedge is not too large. And also, by reducing the variability of the future value of the firm, costless hedging lowers the probability of incurring bankruptcy. However, if the tax function of income is non-linear, the hedging may have no impact on the after-tax income, due to the costs of hedging instruments. With costly hedging, corporate must account for hedging costs when deciding among alternative hedging strategies.

Similarly with Smith and Stulz, Bessembinder (1991) also contend that by reducing the variability of cash flows, risk management decreases the expected costs of bankruptcy and underinvestment. In this study, ‘the two-date state preference model’ identifies two main reasons of risk hedging by corporations can increase firm value; first hedge reduces agency costs and thus reduces incentives for equity holders to underinvestment and second hedging provides net cash inflows in those states where the firm’s cash flows are low, bonding its ability to meet commitments in additional states.

Besides these, David Haushalter (2000) emphasizes that the cost of financial distress is another component that influences value-maximizing firms do hedge. This study examines the hedging policies of oil and gas producers between 1992 and 1994 and documents that the part of production that oil and gas producers hedge against price risk is positively related to the ratio of total debt to total assets and is greater for companies having little financial flexibility, measured by the relative amount of debt outstanding and cash holdings. That is to say, all else equal, the more difficulty a company has in obtaining outside financing, the more costly a shortfall in cash flow will be and the greater is the value hedging provides (Haushalter, 2000).

On the other hand, even the value maximizing firm takes its economic value into consideration primarily, Smith & Stulzs (1985) reveals that the value maximizing firm also concerns its accounting earning due to the fact that bond covenants use accounting numbers to define states where the firm's activities are restricted. It is thus possible for a value-maximizing firm to choose to reduce the variance of its accounting earnings, even if this increases the variance of economic earnings.

Another important incentive why the corporate hedges, comes from its managerial compensation structure. Managers' private preferences seem to affect corporate risk management choices (Tufano, 1996). According to Tufano's empirical research of risk management practices in the gold mining industry; firms whose managers own more stock options manage less gold price risk, and those whose managers have more wealth invested in common stock manage more gold price risk. This statement is parallel with the study of Smith and Stulzs (1985); depends on the convexity of the managers' end-of-period utility function of the end-of-period firm value, managers will choose the appropriate hedging policy in order to maximize their own wealth. Thus, in order to create managerial risk aversion, the managerial compensation contracts must be design as an increasing function of the firm value.

Another dimension of hedging literature has been presented as regards how firms do state their optimal hedging strategy. Risk management strategies can be characterized as either linear, hedging strategies (which eliminate all exposure to price fluctuations) or nonlinear, insurance strategies (which protect firms against falling prices only.) Firms employing forwards, futures contracts and swaps use linear strategies, while firms purchasing put options use nonlinear strategies.

There are explicit debates about the determinants of optimal hedging strategies. Peter Tufano (1996) demonstrates that choices among instruments are determined by their relative costs (including transaction costs), interim liquidity requirements, accounting and tax implications, and the ability to customize the contract terms.

Froot, Scharfstein and Stein (1993), argue that the optimal choice of strategies is determined by whether the sensitivity of cash flows and investment costs relative to changes in the underlying macro-variable. If the sensitivities are equal, linear or hedging strategies will be optimal, otherwise firms would prefer to use non-linear or option strategies. However, Tufano (1996) finds this theory unreliable due to the short time series of annual observations.

On the other hand, Brown and Toft (2002) do not concentrate on the investment and/or capital structure of the firm as a determinant of optimal hedge strategy. First of all, they retype the derivatives as vanilla (such as forwards and simple options) instead of linear and as exotic (derivatives and options) instead of non-linear. According to the theory set on how firms should hedge, price and quantity correlation, the degree of price and quantity volatility, and the ratio of these risks are the primary determinants of the optimal hedge strategy for the firm. When the produced quantity is known with certainty and price-quantity correlation is negligible forward contracts are typically very effective hedging tools. It is called naïve forward hedge. In contrast, when the correlation between price and quantity is negative, firms can benefit most from nonlinear exotic payoffs. Additionally, as price risk increases relative to quantity risk, the hedge becomes more linear, since the un-hedgable risk is less important. But as price risk decreases, the un-hedgable component of total risk increases and the "optionality" (convexity)[3] of the optimal hedge increases.

Another important component that influences the decision of corporate whether should hedge or not is the basis risk factor. The risk a company encounters when the settlement price of the hedging instrument is different from the price of the underlying asset being hedged is termed *basis risk.* This risk can be measured as the correlation between the change in the price of the asset being hedged and the change in the price of the asset underlying the financial instruments available for hedging: the lower this correlation, the greater the basis risk from hedging. David Haushalter (2000) examines the hedging policies of oil and gas producers if basis risk reduces the effectiveness of hedging in reducing risk. According to the financial model, the coefficient on the variable indicating basis risk is significantly proves the fact that basis risk is an important determinant of risk management of the corporate and furthermore the higher the basis risk the less effective hedging in reducing risk and consequently the less extensively a firm should hedge to minimize risks. It is the reasonable fact that explains the variation of hedging policies within

[3] Convexity can be defined as the second derivative of the pay-off function (Brown and Toft, 2002).

industries. Thus, empirical studies of corporate hedging policies should not only consider a firm’s need to hedge but also its ability to do so.

Above all, with no doubt, the most important constituent for hedging is the volatility. Volatility, by the mean of its definition -a measure of the degree of price movement in a stock, futures contract or any other market- creates risk that is the core of hedging concept. However, Jain (2001) states that volatility is a significantly important sense due to the fact that corporations can make practical use of volatility-based hedging strategies by understanding and even forecasting the volatility. However, price volatility of most option-able securities varies considerably over time, and accurate prediction is far from easy. The two basic approaches are either to compute the realized volatility over the recent past from historical price data or to calculate the implied volatility from option price.

Actually, implied volatility is widely believed to be informationally superior to historical volatility, because it is the market's forecast of future volatility (Stein 1989). Similarly, Zhu and Avellaneda (1997) construct a statistical model for the term-structure of implied volatilities of currency options and show that the movements of the term-structure are explained to more than 95%.

In contrast, Canina and Figlewski (1993), find implied volatility to be a poor forecast of subsequent realized volatility for S&P 100 index options, most actively traded contract in the United States.

All these debates, whether implied volatility forecast approach is superior to historical volatility forecast approach or not, are examined intensively in the study of Poon and Granger (2003). By carefully reviewing the methodologies and empirical findings in 93 papers published so far, the study provides bird's-eye view of the whole volatility forecasting literature and some recommendations for the practice and future research[4]. And a general conclusion is stated; option implied volatility is perceived as a market's expectation of future volatility and hence it is a market based volatility forecast. However, since option model based forecast requires a number of assumptions to hold for the option theory to produce a useful volatility estimate, option implied also suffers from many market driven pricing irregularities. Nevertheless, this study strictly proves that option implied volatility appears to have superior forecasting capability, outperforming many historical price volatility models and matching the performance of forecasts generated from time series models that use a large amount of high frequency data.

[4] The paper, "Forecasting Volatility in Financial Markets: A Review", categorized the forecast approaches under four main methodologies- HISVOL (Historical Volatility models), GARCH (members of ARCH, GARCH, E-GARCH and so forth families), ISD (Implied standard deviation based on the Black-Scholes model) and SV (stochastic volatility). ISD is rank as the best methodology among the previous volatility forecasting literature. The detailed information about the structure of the research and a brief summary of the conclusion of this study has been illustrated in the Appendix part.

Another important dimension of the volatility constituent is time-varying volatility which demonstrates the volatility structure of the market. To capture the property of time-varying volatility, Engle (1982) introduced the ARCH (Autoregressive Conditional Heteroskedasticity) model. Bollerslev's (1986) extension of this model, the GARCH (Generalized Autoregressive Conditional Heteroskedasticity) model, has gained widespread acceptance in the literature and is often used for modeling stochastic volatility in financial time series. Since GARCH models assume that there is a symmetric response between volatility and returns, Nelson (1991) introduced the EGARCH (Exponential GARCH) model in order to model asymmetric variance effects.

The EGARCH specifies conditional variance in logarithmic form, which means that there is no need to impose estimation constraint in order to avoid negative variance. With appropriate conditioning of the parameters, this specification captures the stylized fact that a negative shock leads to a higher conditional variance in the subsequent period than a positive shock would (Poon and Granger, 2003). In other words, volatility tends to rise in response to “bad news” and tends to fall in response to “good news”, and EGARCH is the best in the ARCH family in order to model this asymmetry (Lindner and Meyer, 2003).

3. VOLATILITY ANALYSIS OF COPPER MARKET:

Of all the materials used by humans, copper has had one of the most profound effects on the development of civilization. From the dawn of civilization until today, copper has made, and continues to make, a vital contribution to sustaining and improving society. Copper's chemical, physical and aesthetic properties make it a material of choice in a wide range of house, industrial and high technology applications. And also, alloyed with other metals, such as zinc (to form brass), aluminum or tin (to form bronzes), or nickel, for instants, it can acquire new characteristics for use in highly specialized applications. In fact, society's infrastructure is based heavily on copper. For example; copper is used for conducting electricity and heat; communications; transporting water and gas; construction and making statues and other forms of art.

3.1. Copper in the Exchange Markets:

The role of a commodity exchange is to facilitate and make transparent the process of settling prices. Three commodity exchanges provide the facilities to trade copper: The London Metal Exchange (LME), the Commodity Exchange Division of the New York Mercantile Exchange (COMEX/NYMEX) and the Shanghai Metal Exchange (SHME). In these exchanges, prices are settled by bid and offer, reflecting the market's perception of supply and demand of a commodity on a particular day. On the LME, copper is traded in 25 ton lots and quoted in US dollars per ton; on COMEX, copper is traded in lots of 25,000 pounds and quoted in US cents per pound; and on the SHME, copper is traded in lots of 5 tons and quoted in Renminbi per ton. More recently, mini contracts of smaller lots sizes have been introduced at the exchanges (ICSG, 2007).

Exchanges also provide for the trading of futures and options contracts. These allow producers and consumers to fix a price in the future, thus providing a hedge against price variations. In this process the participation of speculators, who are ready to buy the risk of price variation in exchange for monetary reward, gives liquidity to the market. A futures or options contract defines the quality of the product, the size of the lot, delivery dates, delivery warehouses and other aspects related to the trading process. Contracts are unique for each exchange. The existence of futures contracts also allows producers and their clients to agree on different price settling schemes to accommodate different interests.

3.2. Price Analysis of Copper:

For the last decade, copper prices have been increasing enormously. The reason behind the fact mainly comes from the classic supply and demand principle of economics.

Global copper consumption increased steadily over the past century[5]. While in 1980s Europe was the region that was superior to other regions in consuming copper, in 2000s Asia has been ranked as the first in copper consumption in the world. And further, Asia countries, especially China, have driven the overall consumption growth in the world[6]. And from supply side, in order to meet this increased demand in the world, also copper mine production has been increased[7]. However, there has been still demand surplus which has force the price of the copper rises[8]. Especially, in 2004 since the world stocks sharply decreased and thus the demand could not be met, the price instantaneously multiplied its value more than twice in the beginning of 2006.

On the other hand, the depreciation of USD Dollar versus EURO is another component that influences the increase of copper price in terms of USD Dollar (Tamzok, 2006).

3.3. Basis Risk Analysis of Copper:

Basis risk is identified as the risk that the price of a future will vary from the price of the underlying cash instrument as expiry approaches. As more comprehensive definition, it is the risk a company encounters when the settlement price of the hedging instrument is different from the price of the

[5] Figure-1: World Copper Usage from 1900 to 2006 has been illustrated in the Appendix.
[6] Figure-2: Refined Copper Usage by Region has been illustrated in the Appendix.
[7] Figure-3: Copper Mine Production from 1990 to 2006 has been illustrated in the Appendix.
[8] Figure-5: Trends in World Refined Copper Stocks and Price has been illustrated in the Appendix.

underlying asset being hedged. The lower this correlation, the greater the basis risk from hedging. It is the reasonable fact that explains the variation of hedging policies within industries (Haushalter, 2000). Thus, while hedging by using futures and options, the hedger should deal with the movement of basis as it is a very important element that has to be taken into account at all time.

We analyzed the cash settlement LME prices of copper versus three-month settlement LME prices of copper, from 2002 to 2008. Although basis risk is at around 0,8% of cash settlement price for the last two years, the uncertainty comes after the price exposure in 2004, makes the overall average up to 1,9% for this six year period. In 2005, the basis risk reached to 8% of cash settlement[9].

3.4. Volatility Analysis of Copper:

For risk management, the change itself is more important than the reason behind the price change. Thus, in order to manage these price changes- as the basic logic of hedging- it is essential to understand the price volatility. In this part, the structure of copper price volatility has been mapped.

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[9] Figure-7: Basis Risk: Cash Settlement Prices vs. 3-Month Settlement Prices of LME and Figure-8: Basis Risk in %: Cash Settlement Prices vs. 3-Month Settlement Prices of LME are illustrated in the Appendix.

3.4.1. Historical Volatility of Copper:

Historical volatility, the measure of a stock's price movement based on historical prices, is often referred to as *actual volatility* or *realized volatility*. It measures how active the stock price characteristically is over certain period of time (Jain, 2001).

We analyzed daily (close-to-close) copper LME cash settlement prices from 17th of October, 2002 to 25th of April, 2008. The annualized volatility is calculated with the standard deviation volatility formula[10];

$$HV = \sqrt{\frac{\sum_{n}(Rt - Rm)^2}{n-1}} \qquad \text{(equation 1)}$$

where the Rt is the day-to-day price changes in a market and calculated with the formula below;

$$R_t = LN\left(\frac{S_t}{S_{(t-1)}}\right) \qquad \text{(equation 2)}$$

S_t is the stock price on day t and the Rm in equation-1 is the average day-to-day price changes over a certain period;

$$Rm = \frac{\sum_{n} Rt}{n} \qquad \text{(equation 3)}$$

[10] This equation is widely used as a consistent estimator of volatility.

In order to get the annualized volatility for the six year period, we need to convert these daily observations by multiplying the result by the square root of 252 (the average number of trading days in a year).

The observations ranged between 1.489 USD/ton as the lowest value and 8.885 USD/ton as highest value - almost six times of the lowest value. And the annualized volatility is 27,64% that is significantly important to hedge.

The Figure-8 in the appendix shows the volatility of daily cash settlement LME prices for the period, 2002-2008. According to the figure, while the biggest daily variance occurred as price decrease in 2003, the daily volatility has been more intensive for the last two years.

3.4.2 Implied Volatility Analysis of Copper:

Implied volatility is the current volatility of a stock, as estimated by its option price. The volatility is the most important variable in the pricing of these derivative securities, whose trading volume has quadrupled in recent years (Granger and Poon, 2003). Actually, the importance of implied volatility does not only come from these extremely growing trading volume, but also comes from the fact that it is the market's forecast of future volatility (Stein, 1989; Zhu and Avellaneda, 1997; Poon and granger, 2003). Furthermore, Kroner, Kneafsey, and Claessens (1995) have proved that implied dominates time series (historical) forecast specifically in metal markets.

And Figure-9 confirms the fact. In the figure, ATM (At the Money) implied volatility of copper is illustrated versus the spot price volatility of copper. On the 26^{th} of September, 2005, the implied volatility jumped from %18 to %25, while the spot price was following its upward trend on those days. And within one month, the spot market reflected to this implied volatility rise with an increase from %175 to more than %400. Moreover, the implied volatility was going on to guide the spot market with an adjustment after the extreme rise. Until the 7^{th} of November 2005, the spot prices progressed in flat as evidence to the adjustment in implied volatility side.

3.4.3. E-GARCH: Volatility Asymmetry of Copper:

In order to capture the structure of the volatility of copper market, the historical price changes will be analyzed more intensively in this part. Our data is daily (close-to-close) copper LME cash settlement prices from 30^{th} of January, 1985 to 25^{th} of April, 2008.

First of all, we demonstrate our price change "mean equation" model with the Least Square Estimation Methodology as below;

$$DLP_t = a_0 + \sum_{i=1}^{n} a_i DLP_{t-i} + \varepsilon_{DLP_t} \qquad \text{(equation 4)}$$

In the equation; DLP_t refers the percentage change of price (return), and ε refers the stochastic error term.

After estimating the model with LSM, by exercising Akaike Information Criterion (AIC) we decided to continue with 5 lags throughout the analysis. Table-3[11] shows that the five-lag model has been estimated significantly.

Secondly, in order to control if the constructed model is stationary or not, we test the model with GARCH. We apply GARCH (2,1) and conclude that the series are stationary, we do not need any adjustment for the data. In the

[11] In this study, we use E-Views5 econometrics program to estimate and test our model.

appendix, Table-4 illustrates that the sum of alphas and beta is less than one (RESID(-1) + RESID(-2) + GARCH(-1) < 1).

Since the series is stationary, we can apply E-GARCH in order to set out the volatility structure of copper prices. The EGARCH (Nelson 1991) specifies conditional variance in logarithmic form, which means that there is no need to impose estimation constraint in order to avoid negative variance. The general E-GARCH estimation equation is quoted below.

$$\log(\sigma_t^2) = \exp\left[\alpha_0 + \sum_{i=1}^{q} \alpha_i g(z_{t-1}) + \sum_{i=1}^{p} b_i \log(\sigma_{t-1}^2)\right] \quad \text{(equation 5)}$$

σ^2_t is the conditional variance term and z_t is the standardized error term. The error terms are assumed that have zero means and normally distributed.

With appropriate conditioning of the parameters, this specification captures the stylized fact that a negative shock leads to a higher conditional variance in the subsequent period than a positive shock would. The equation 6 discloses this asymmetry with θ parameter. In the equation, the second term $\left[|z_t| - E|z_t|\right]$ refers ARCH effect and the θ parameter lets the ARCH effect be asymmetry.

$$g(z_t) = \theta z_t + \left[|z_t| - E|z_t|\right] \quad \text{(equation 6)}$$

We test our data with E-GARCH and the test results that the estimated θ parameter is significantly negative for copper prices. It is to say that a negative shock prompt the volatility more than a positive shock.

With numerical results demonstrated in Table-5 in the appendix; while 1 unit of positive shock affects the volatility by 0,189516, 1 unit of negative shock affects the volatility by 0,227788. This information indicates that the copper market is a supply controlled market.

Supply-side asymmetry also proves the fact that the copper market is subject to speculative trades (Working, 1962). In that type of markets, both speculators and hedgers trade the volatility (Anderson and Danthine, 1981). Yet the hedging and speculative behavior are distinguished by the kind of risk accepted in the two cases; speculators take price-level risk, while hedgers take price difference (basis) risk (Working, 1962).

4. EMPIRICAL EVIDENCE FOR TURKISH COPPER INDUSTRY

The copper reserves of Turkey is generally located in Black-sea and South-east Anatolian Regions; Murgul, Çayeli-Madenköy, Lahanos, Ergani, Siirt-Madenköy, Cerattepe and Küre. These reserves are totally 62.870.000 tons, and contain 2,69% Cu which makes the reserves 1.697.204 copper tons, only 0,03% of the world copper reserves[12].

Since 1980s, privatization of mining sector has been subject to many debates in Turkey. On this issue, in order to create a competitive market and improve the efficiency of the sector, there have been numerous actions; such as separation by sectors, commercialization and syndication. For example, Etibank A.Ş. has been divided by sectors into seven different corporations in 1998. And as one of the seven corporations Eti Bakır A.Ş. with Karadeniz Bakır İşletmeleri (KBI) A.Ş., which are the two major copper mining companies in Turkey, were privatized in 2004 (Arslan, 2006).

However, due to the insufficient reserves, unfortunately these privatization actions could not make the performance of the companies meet even the domestic demand. Figure-10 shows the trade balance of Turkey for the chapter of 'copper and articles thereof'. Since 2003, the gap between

[12] "Maddencilik Özel İhtisas Komisyonu Metal Madenler Alt Komisyonu: Bakır Cevheri ve Pirit çalışma Grubu raporu", Ankara, DPT; www.dpt.gov.tr

import and export has started to rise increasingly. This exposure in import relative to export creates a deficit that is almost 4% of Turkey's total foreign trade deficit in 2008[13]. This percentage makes copper significantly important commodity for Turkey.

In addition to this, the gap also proves the fact that Turkey is strictly in shortage for copper and thus from macroeconomics point of view, the country must be a long position hedger.

On the other hand, since copper is priced in exchanged markets globally, Turkey has to take into account the base currency exchange rate of the market where the copper is quoted. For this study, LME copper settlement prices have been focused and thus USD Dollar over Turkish Liras has been shown as empirical evidence in this section.

4.1. Historical Volatility Analysis of USD Dollar over TRY:

The annualized historical volatility of the exchange rate ($/TRY) is calculated for the same period with the copper volatility calculation; selling exchange rates of Central Bank of the Republic of Turkey, from 17th of October, 2002 to 25th of April, 2008. The same methodology explained in the "historical volatility of copper" part is applied and the annual volatility of

13 Fgure-11 "Copper Trade Deficit as Percentage of Total Trade Deficit of Turkey" is illustrated in the appendix.

$/TRY is computed as 13,58%. The volatility graph of Exchange Rate USD Dollar over Turkish Liras is illustrated in the appendix.

This volatility is not negligible and is even quite important for our hedging approach, and on this issue it is going to be emphasized in the following section.

4.2. Implied Volatility Analysis of USD Dollar over TRY:

The strong forecasting power of implied volatility is again confirmed in the currency markets. Most studies find implied volatility to contain information about future volatility for up to a six-to-nine month horizon (Poon and Granger, 2003).

According to the figure 13, which is illustrated in the Appendix, the one month implied volatility USD Dollar over TRY is obviously seen as pre-determinant of spot USD Dollar over TRY. One-month volatility of the exchange rate ($/TRY) has been decreased from I to II, and the spot of USD/TRY has reflected this decline as from A to B with eight-month lag. And again the upward move in one-month volatility from II to III has been met with an increase in spot USD/TRY from B to C.

5. A HEDGING APPROACH FOR COPPER IN TURKEY:

Hedging is more than taking a position in a futures market that is equal in size and opposite to a predetermined position in the cash market (Anderson and Danthine, 1981). Effective hedging needs an ability of prediction, understanding structure of the market and being aware of outside effects to the market.

Our hedging approach relies on the theory that option *implied volatility* is perceived as a market's expectation of future volatility and hence it is a market based volatility forecast (Poon and Granger,2003; Stein,1989; Zhu and Avellaneda,1997). And we focus on the *price risk*[14].

On the other hand, since its copper reserve is pretty much small in the total world reserves, only 0,03% of the world[15], Turkey is a *price taker* in the global copper market. And due to the fact that the copper price is settled in the exchange markets globally, Turkey must take into consideration also the exchange rate of the base currency for the copper prices. In this study, as LME settlement prices have been observed, through our hedging approach we just focus on *exchange rate of USD Dollar over Turkish Liras ($/TRY).*

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[14] While focusing on only price risk exposure, we want to simplify our hedging approach. In the real world, demonstrating hedging strategy is more complex with quantity risk exposure (Brown and Toft, 2002).

[15] Again "Maddencilik Özel İhtisas Komisyonu Metal Madenler Alt Komisyonu: Bakır Cevheri ve Pirit çalışma Grubu raporu", Ankara, DPT; www.dpt.gov.tr

The annualized historical volatility of the exchange rate ($/TRY) is calculated for the same period with the copper volatility calculation; selling exchange rates of Central Bank of the Republic of Turkey, from 17th of October, 2002 to 25th of April, 2008. The same methodology explained in the "historical volatility of copper" part is applied and the annual volatility of $/TRY is computed as 13,58%[16] which is significantly risky for copper prices in Turkish Liras even the copper price volatility- annually 27,64% - would have been ignored. These volatilities create cash flow variance risk that is the main incentive of hedging (Smith & Stulz, 1985 and Bessembinder, 1991). And the cash flow variance disturbs a value maximizing firm on both its economic value and its accounting earnings (Smith & Stulz, 1985). Nonetheless, since copper price in Turkish Liras has also FX risk in its composition, the corporation in Turkey faces much more financial distress which makes the value hedging provide greater (Haushalter, 2000).

Aforementioned implied volatility is the volatility implied by the market price of the option based on an option pricing model. Thus, implied volatility is a forward-looking measure and differs from historical volatility, the latter is calculated from known past prices of a security. And if implied volatility is greater than historical volatility, the market expects more volatile price movements in the near future. In other words, implied volatility orientates the markets with different degrees of lags according to the structure of the

[16] The volatility graph of Exchange Rate USD Dollar over Turkish Liras is illustrated in the appendix.

markets. For example, Li (2002) and Scott and Tucker (1989) find implied forecasts well for up to six-to-nine months horizon for exchange rate markets. And figure-12 has shown the horizon has also been satisfactory for the exchange rate of USD Dollar to Turkish Liras. For that reason, as to the conjecture of the market, whether it implies negative or positive price changes, corporations do hedge in the case of *greater implied volatility*.

However; for our approach, the correlation between the volatilities of the two basic price change risk factors is also important to state the optimal hedging strategy for copper in Turkish Liras. If the correlation between $/TRY and copper prices on the stock exchanges is positive, then the price change risk is multiplied for copper price in Turkish Liras (Copper/TRY); we say that the corporations must do hedge. Yet, if the correlation is negative, the opposite price vectors offset partially the price change risk, which is called natural hedge (Brown and Toft, 2002); and we say that in this case the corporations must determine the *residual risk* and then state the hedging policy. The residual risk can be referred as the risk left over at the end of offsetting process of these exposures each others, meanwhile the greater implied volatility of the two risk component dominate the residual risk

In the appendix, table-6 summarizes the hedging approach for a value maximizing firm in Turkey under the assumption of 'implied volatility orientates the markets'. Depending on whether the firm is buyer or seller, the hedging policy should be set up. For example, the cases when the copper prices in Turkish Liras increase create opportunity of extra gain for a seller. Then the seller is better of preferring not to hedge in order to avoid hedging costs or over-hedging loss (Gay, Nam, and Turac, 2001). However, in these cases, a buyer should take a long hedge position. While determining the optimal hedging strategy, the correlation between price and quantity should be analyzed. If the firm faces with negligible price and quantity correlation, then naïve forward hedge with forward contracts (linear or vanilla) is an effective hedging method for the buyer. In contrast, when the correlation between price and quantity is not negligible and especially is negative with dominant effect of quantity, the firm can benefit most from *call options* as nonlinear exotic payoffs (Toft and Brown, 2002).

On the other hand, in the case of price decrease of copper in Turkish Liras, the buyer is better of not to hedge, while the seller should take a short hedge position. Again after establishment of the price and quantity correlation, the seller should decide to use whether forward as naïve hedge or *put options* as nonlinear exotic hedge.

In addition to this, the corporations also have to concern the volatility structure of copper as well. The structure of copper volatility is supply-side asymmetry. This characteristic makes the market react more aggressively to the price decreases than to the price increases. Thus this asymmetric characteristic is important in order to explicate the *historical volatility* throughout constructing the optimal hedging strategy. From hedging point of view, when the prices start to come down, the value maximizing corporations must dynamically control their hedging positions. Whether the corporation is in short position, there is a possibility of increasing loss risk, or the corporation is in long position, there is a possibility of over-hedging and/or unnecessarily transaction costs of hedging risk.

6. CONCLUSION:

This thesis aims to reveal the magnitude of hedging copper commodity in Turkish Liras. We are interested in this subject because copper prices have been significantly increased for the last decade; from 1.558 USD/ton yearly average of 2002 to 7.971 USD/ton yearly average of 2008 for the first four month. Additionally to this dramatic price exposure, Turkey's demand has also been increased. Yet, it has negligible copper production of its own; as of the end of 2007, Turkey's copper trade deficit is more than 3,5% of its total foreign trade deficit. This percentage makes copper considerably important commodity for Turkey.

According to our findings, for the period from 2002 to 2008, basis risk of three-month settlement LME prices of copper is less than 1% which is a notably slight risk relative to 27,64% of annualized price volatility risk for the same period. Thus, we conclude that basis risk of copper market is not an obstacle to an effective hedging for corporations. Besides, again for the same period, we test the volatility structure of copper market with E-GARCH (Nelson, 1991) and prove that as expected a negative shock prompt the volatility more than a positive shock. This supply-side asymmetric characteristic, which also confirms the fact that the copper market is subject to speculative trades (Working, 1962), is important in order to explicate the *historical volatility* throughout constructing the optimal hedging strategy.

Furthermore, our hedging approach is settled for copper prices in Turkish Liras and thus also covers the foreign exchange rate risk of base currency. Under the circumstances of implied volatility orientates the markets both for copper prices and the exchange rate of base currency over Turkish Liras, the correlation between the volatilities of the two basic price change risk factors has to be taken into consideration before setting the optimal hedging strategy. If the correlation is positive, then the price change risk is multiplied for copper price in Turkish Liras (Copper/TRY); we say that the corporations must do hedge. Yet, if the correlation is negative, the opposite price vectors offset partially the price change risk and we say that in this case the corporations must determine the *residual risk* and then state the hedging policy.

On the other hand, there are several problems in the implementation of hedge accounting in terms of taxation that seriously discourages Turkish corporate from hedging. Because of dissimilar approaches of Turkish accounting standards and Turkish tax procedure law, under the current legislation there is no specific taxation treatment for hedging transactions in Turkey (Phillips, 2006). Further researches should focus on Turkish tax procedure law in order to revise and modify according to the new accounting standards, but this is outside the scope of this thesis.

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8. APPENDIX

"Forecasting Volatility in Financial Markets: A Review"; Poon & Granger; 2003:

By analyzing 93 published papers on volatility forecasts, Poon and Granger classified the approaches as below;

*** HISVOL**; for historical volatility models, which includes random walk, historical averages of squared returns, or absolute returns. Also included in this category are time series models based on historical volatility using moving averages, exponential weights, autoregressive models, or even fractionally integrated autoregressive absolute returns. All models in this group model volatility directly omitting the goodness of fit of the returns distribution or any other variables such as option prices.

* **GARCH;** any members of the ARCH, GARCH, EGARCH, and so forth families are included.

* **ISD;** for option implied standard deviation, based on the Black-Scholes model and various generalizations.

* **SV;** for stochastic volatility model forecasts.

And Poon and Granger conclude that the overall ranking suggests that ISD provides the best forecasting with HISVOL and GARCH roughly equal, although possibly HISVOL does somewhat better in the comparisons. The success of the implied volatility should not be surprising, as these forecasts use larger, and more relevant, information set than the alternative methods as they use option prices. Among the 93 papers, seventeen studies compared alternative versions of GARCH. It is clear that GARCH dominates ARCH. In general, models that incorporate volatility asymmetry such as EGARCH and GJR-GARCH perform better than GARCH.

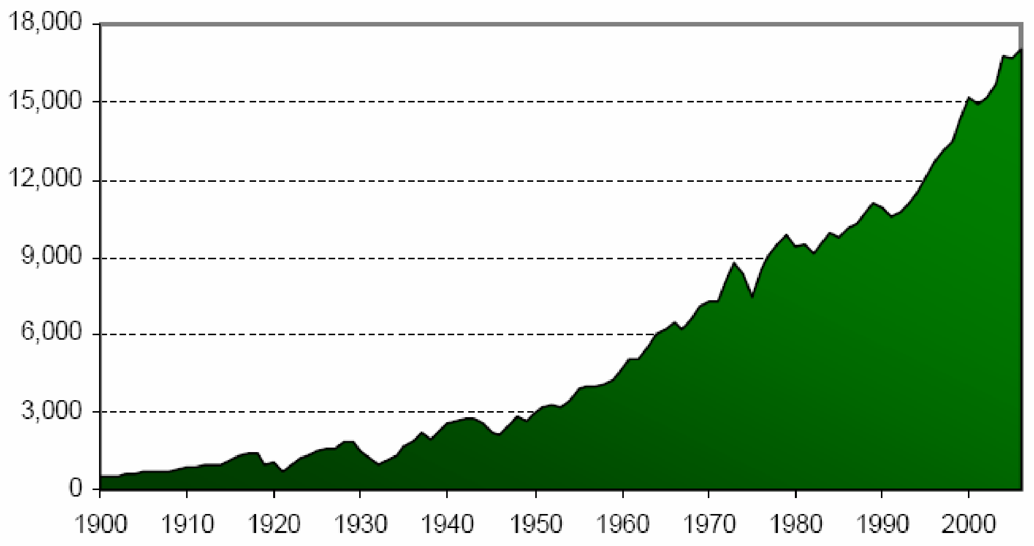
The option implied volatility being a market based volatility forecast has been introduced to contain most information about future volatility.

Table-1: Summary of Published Papers on Volatility Forecast Approaches

	Number of Studies	Studies Percentage
HISVOL > GARCH	22	56%
GARCH > HISVOL	17	44%
HISVOL > ISD	8	24%
ISD > HISVOL	26	76%
GARCH > ISD	1	6%
ISD > GARCH	17	94%
SV > HISVOL	3	
SV > GARCH	3	
GARCH > SV	1	
ISD > SV	1	

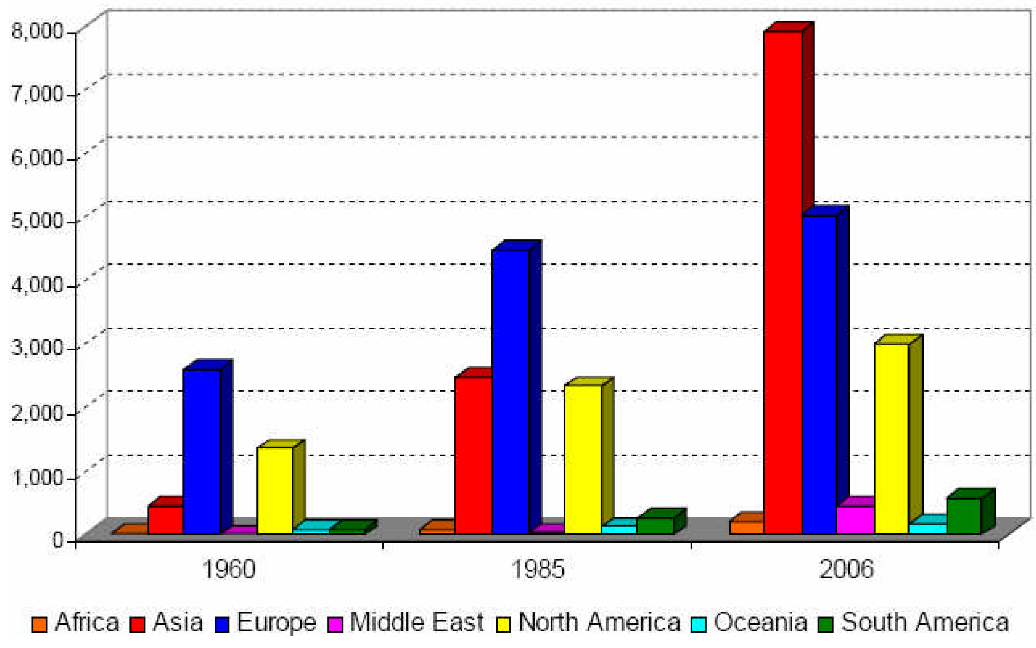
Source: Ser-Huang Poon and Clive W. J. Granger, "Forecasting Volatility in Financial Markets: A Review."

Figure-1: World Copper Usage from 1900 to 2006



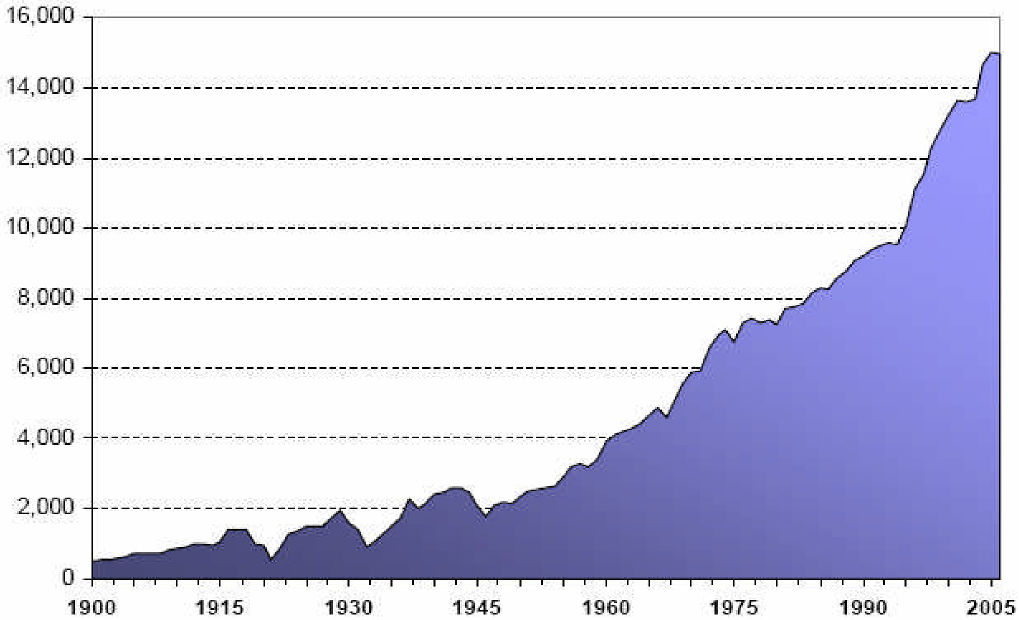
Source: ICSG (International Copper Study Group) – www.icsg.org (Thousand metric tons).

Figure-2: Refined Copper Usage by Region



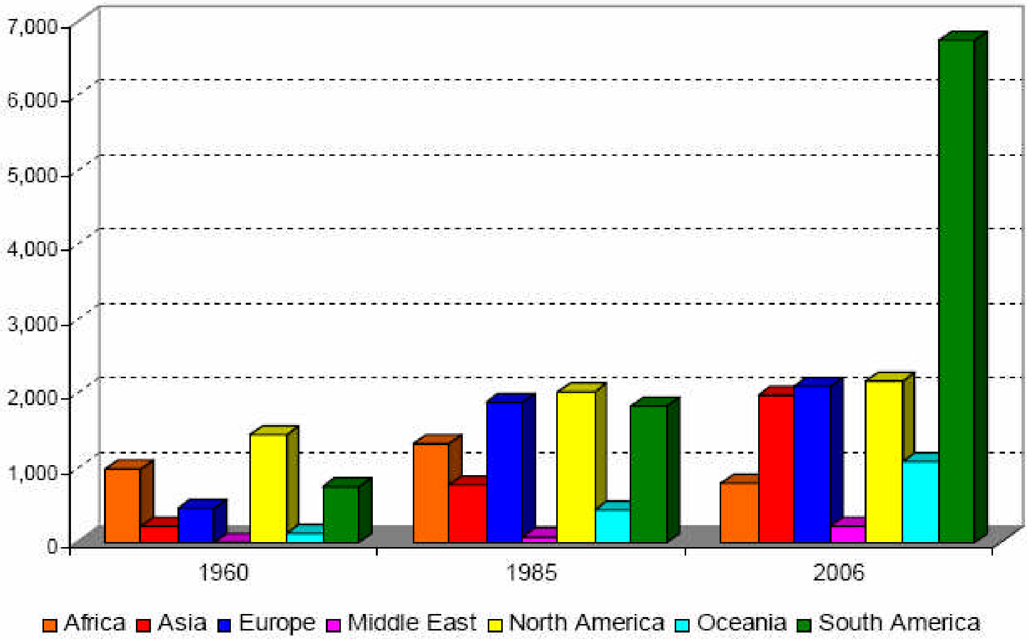
Source: ICSG (International Copper Study Group) – www.icsg.org (Thousand metric tons)

Figure-3: Copper Mine Production from 1990 to 2006



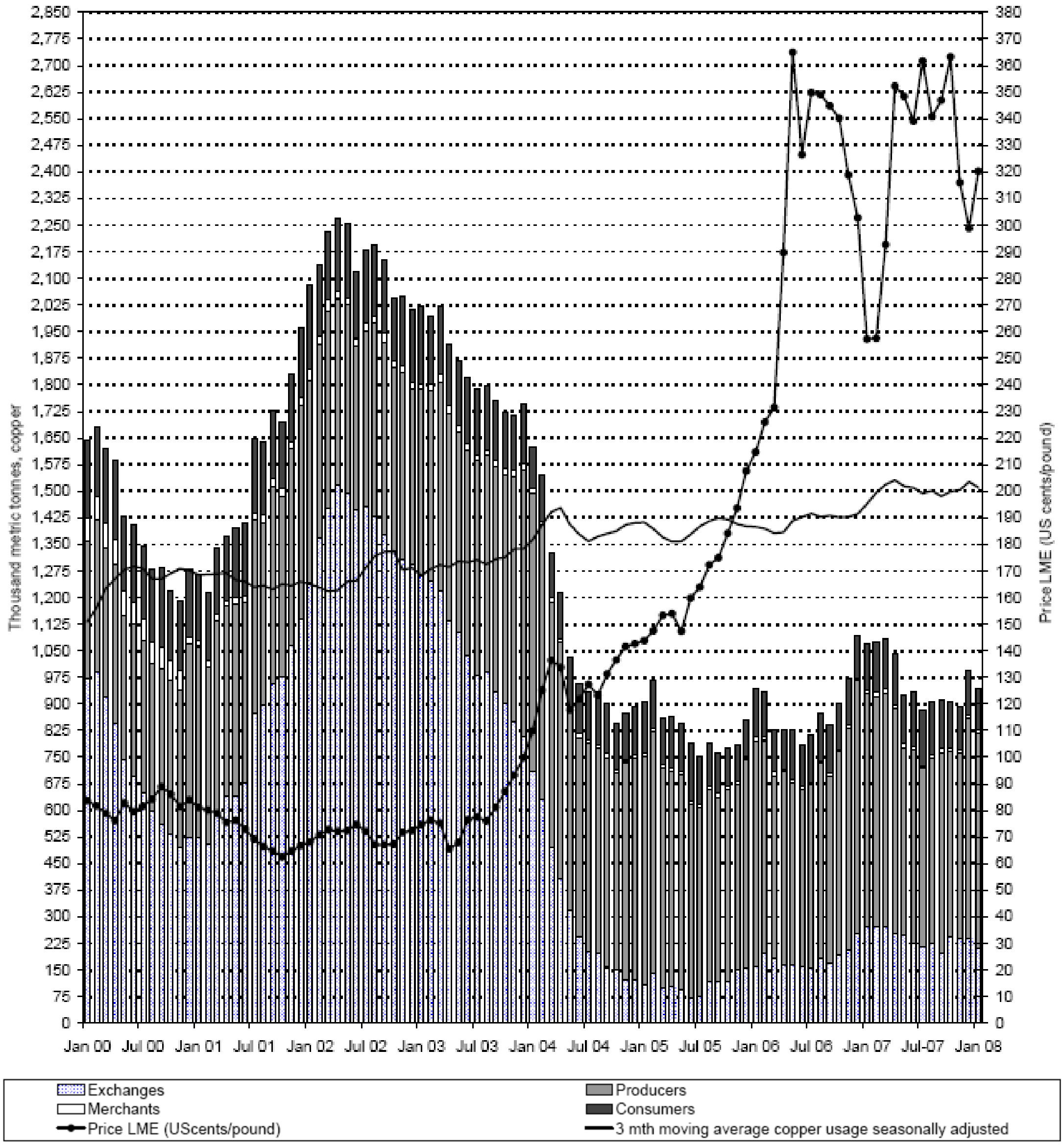
Source: ICSG (International Copper Study Group) – www.icsg.org (Thousand metric tons, copper content).

Figure-4: Copper Mine Production by Region



Source: ICSG (International Copper Study Group) – www.icsg.org (Thousand metric tons)

Figure-5: Trends in World Refined Copper Stocks and Price



*Stocks are end of period. Prices are average for the period.

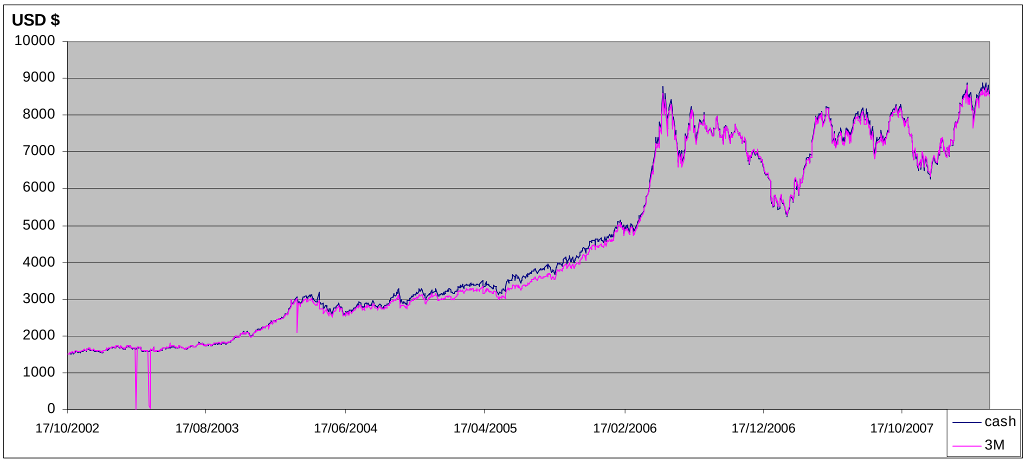
Source: ICSG (International Copper Study Group) – www.icsg.org.

Table-2: Copper Supply-Demand Balance, 2002-2008 ('000 tons)

	2002	2003	2004	2005	2006	2007	2008
WW mine production	**11.007**	**11.093**	**11.909**	**12.278**	**12.150**	**12.975**	**13.700**
% ch. y-o-y	1,6	0,8	7,4	3,1	-1,0	6,8	5,6
Net exports of concs to "Eastern" countries	347	448	857	1.400	1.400	1.500	1.600
Smelter losses	165	166	179	184	184	197	206
WW primary production	10.395	10.125	10.407	10.662	10.975	11.315	11.825
% ch. y-o-y	-4,4	-2,6	2,8	2,5	2,9	3,1	4,5
Secondary production	1.282	1.282	1.165	1.165	1.175	1.185	1.225
WW refined production	**11.677**	**11.407**	**11.534**	**11.790**	**12.150**	**12.500**	**13.050**
% ch. y-o-y	-3,3	-2,3	1,1	2,2	3,1	2,9	4,4
Net exports of metal to "Western" countries	109	-310	-250	-145	250	-200	-250
Chilean stockpile	0	-200	200	0	0	0	0
WW total supply	**11.786**	**10.897**	**11.484**	**11.645**	**12.400**	**12.300**	**12.800**
% ch. y-o-y	-3,9	-7,5	5,4	1,4	6,5	-0,8	4,1
WW consumption	**11.554**	**11.636**	**12.296**	**11.895**	**12.187**	**12.250**	**12.600**
% ch. y-o-y	-2,2	0,7	5,7	-3,3	2,5	0,5	2,9
Metal balance	**232**	**-739**	**-812**	**-250**	**213**	**50**	**200**
Reported stock change	51	-267	-861	-35	237		
Reported stocks							
Producers	497	751	615	584	701		
Consumers	209	170	135	104	127		
Merchants	15	19	11	6	6		
LME	856	431	49	92	196		
Comex	362	255	44	6	31		
SHFE	75	121	32	58	31		
Total Stocks	2.014	1.747	886	850	1.092	1.142	1.342
Total as No. weeks con	9,1	7,8	3,7	3,7	4,7	4,8	5,5
LME as No. weeks con	3,9	1,9	0,2	0,4	0,8		
LME cash ($/tonne)	**1.558**	**1.780**	**2.868**	**3.684**	**6.731**	**7.126**	**7.150**
% ch. y-o-y	-1,3	14,2	61,1	28,5	82,7	5,9	0,3

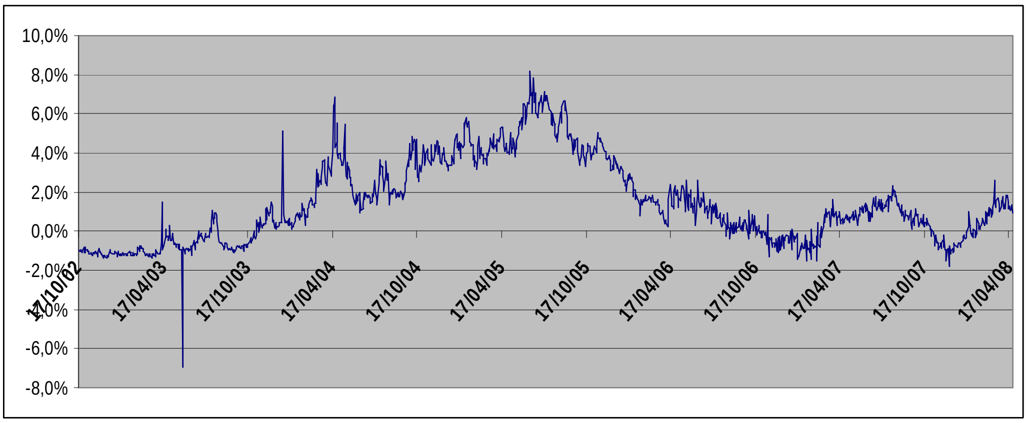
Source: ICSG (International Copper Study Group) – www.icsg.org.

Figure-6: Basis Risk: Cash Settlement Prices vs. 3-Month Settlement Prices of LME



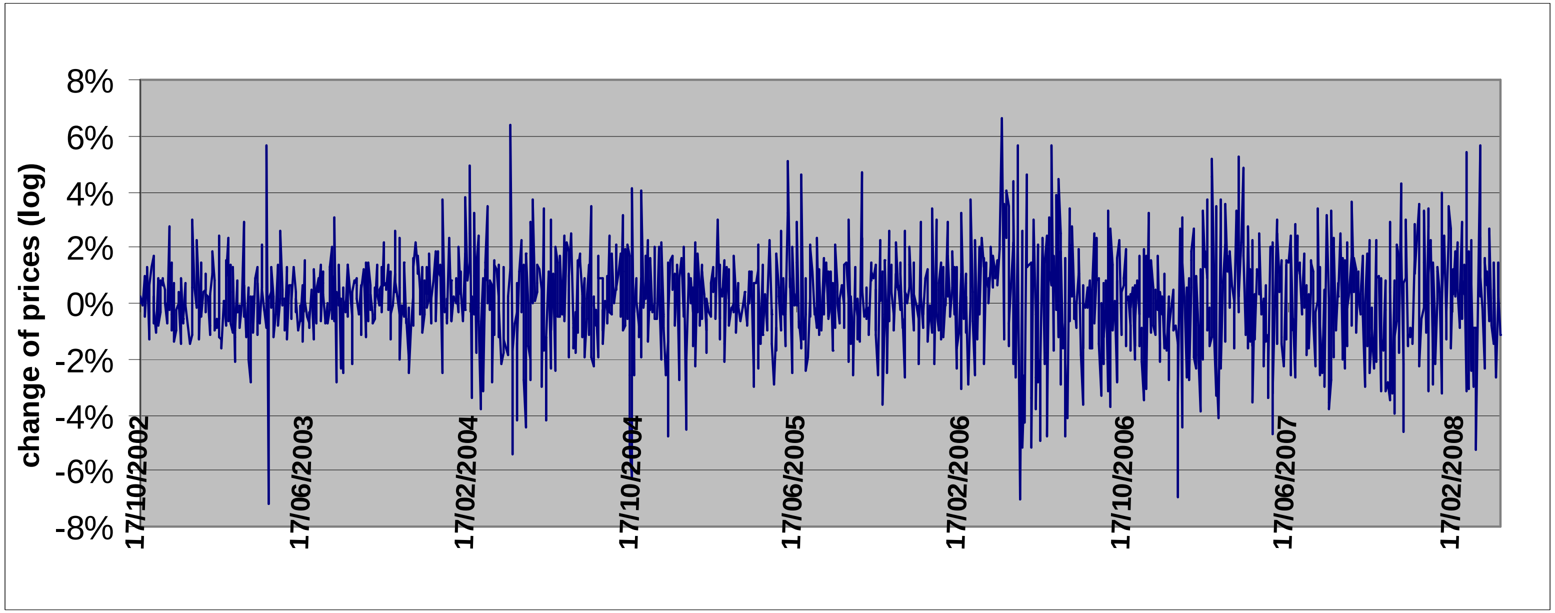
Source: LME (London Metal Exchange), http://www.lme.co.uk/copper

Figure-7: Basis Risk in %: Cash Settlement Prices vs. 3-Month Settlement Prices of LME



Source: LME (London Metal Exchange), http://www.lme.co.uk/copper

Figure-8: Volatility of Copper Cash Settlement LME Prices for the period 2002-2008



Source: LME (London Metal Exchange), http://www.lme.co.uk/copper

Table-3: Mean Equation Model

Dependent Variable: DLP
Method: Least Squares
Date: 05/22/08 Time: 19:28
Included observations: 3315 after adjustments
Convergence achieved after 11 iterations
Backcast: 2/03/1995 2/06/1995

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.011670	0.011463	1.018030	0.3087
DLP(-1)	-0.093941	0.017369	-5.408472	0.0000
DLP(-2)	0.617418	0.150573	4.100450	0.0000
DLP(-3)	0.046890	0.024440	1.918533	0.0551
DLP(-4)	0.044962	0.017639	2.548968	0.0108
DLP(-5)	0.042893	0.017634	2.432471	0.0150
MA(2)	-0.637016	0.150353	-4.236818	0.0000

R-squared	0.012453	Mean dependent var	0.034095
Adjusted R-squared	0.010662	S.D. dependent var	1.618999
S.E. of regression	1.610345	Akaike info criterion	3.792883
Sum squared resid	8578.339	Schwarz criterion	3.805777
Log likelihood	-6279.704	F-statistic	6.952605
Durbin-Watson stat	2.000530	Prob(F-statistic)	0.000000

Inverted MA Roots	.80	-.80

Table-4: Stationary Test: GARCH (2, 1)

Dependent Variable: DLP
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 05/22/08 Time: 22:45
Sample (adjusted): 2/07/1995 10/22/2007
Included observations: 3315 after adjustments
Convergence achieved after 18 iterations
MA backcast: 2/03/1995 2/06/1995, Variance backcast: ON
GARCH = C(8) + C(9)*RESID(-1)^2 + C(10)*RESID(-2)^2 + C(11)
*GARCH(-1)

	Coefficient	Std. Error	z-Statistic	Prob.
C	0.013808	0.010723	1.287679	0.1979
DLP(-1)	-0.077140	0.019648	-3.926069	0.0001
DLP(-2)	0.629066	0.145840	4.313411	0.0000
DLP(-3)	0.046885	0.023761	1.973183	0.0485
DLP(-4)	0.032810	0.018174	1.805337	0.0710
DLP(-5)	0.021519	0.017161	1.253909	0.2099
MA(2)	-0.643733	0.145160	-4.434654	0.0000
		Variance Equation		
C	0.036077	0.007194	5.014865	0.0000
RESID(-1)^2	0.155998	0.016243	9.604126	0.0000
RESID(-2)^2	-0.104266	0.017736	-5.878902	0.0000
GARCH(-1)	0.934106	0.007890	118.3969	0.0000

R-squared	0.011626	Mean dependent var	0.034095
Adjusted R-squared	0.008635	S.D. dependent var	1.618999
S.E. of regression	1.611994	Akaike info criterion	3.611510
Sum squared resid	8585.526	Schwarz criterion	3.631772
Log likelihood	-5975.078	F-statistic	3.886459
Durbin-Watson stat	2.032898	Prob(F-statistic)	0.000029
Inverted MA Roots	.80	-.80	

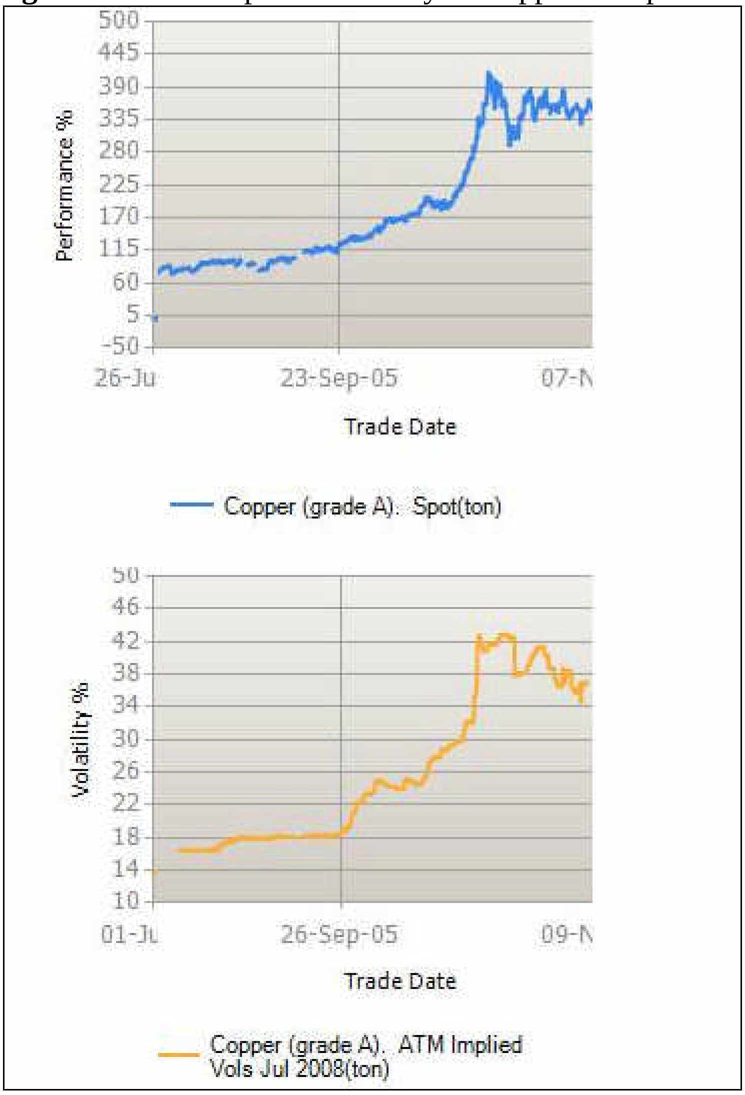
Table-5: Volatility Asymmetry Test: EGARCH

Dependent Variable: DLP
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 05/22/08 Time: 22:48
Sample (adjusted): 2/07/1995 10/22/2007
Included observations: 3315 after adjustments
Convergence achieved after 30 iterations
MA backcast: 2/03/1995 2/06/1995, Variance backcast: ON
LOG(GARCH) = C(8) + C(9)*ABS(RESID(-1)/@SQRT(GARCH(-1))) +
C(10)*RESID(-1)/@SQRT(GARCH(-1)) + C(11)*LOG(GARCH(-1))

	Coefficient	Std. Error	z-Statistic	Prob.
C	0.014400	0.010453	1.377597	0.1683
DLP(-1)	-0.074628	0.017355	-4.300059	0.0000
DLP(-2)	0.626195	0.143785	4.355082	0.0000
DLP(-3)	0.051074	0.022658	2.254172	0.0242
DLP(-4)	0.041470	0.018144	2.285589	0.0223
DLP(-5)	0.016231	0.017231	0.942006	0.3462
MA(2)	-0.650097	0.143335	-4.535510	0.0000
		Variance Equation		
C(8)	-0.131951	0.009581	-13.77196	0.0000
C(9)	0.208652	0.013617	15.32303	0.0000
C(10)	-0.019136	0.007101	-2.694704	0.0070
C(11)	0.963835	0.006199	155.4767	0.0000

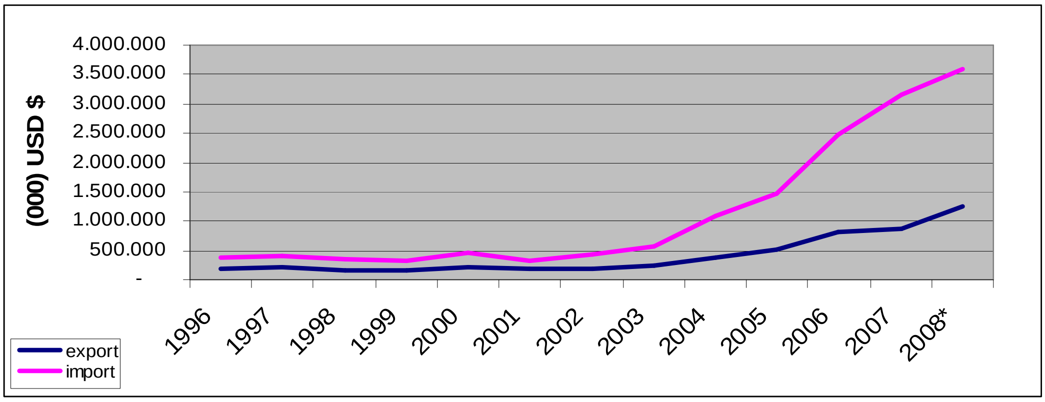
R-squared	0.011310	Mean dependent var	0.034095
Adjusted R-squared	0.008318	S.D. dependent var	1.618999
S.E. of regression	1.612252	Akaike info criterion	3.619138
Sum squared resid	8588.270	Schwarz criterion	3.639400
Log likelihood	-5987.722	F-statistic	3.779660
Durbin-Watson stat	2.038546	Prob(F-statistic)	0.000044
Inverted MA Roots	.81	-.81	

Figure-9: ATM Implied Volatility of Copper vs. Spot of Copper



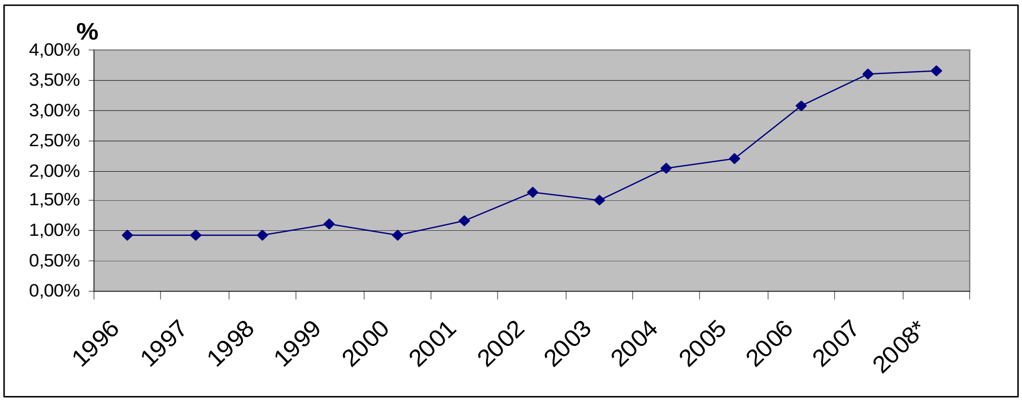
Source: www.superderivatives.com / supplied by Ran Agassi

Figure-10: Export-Import Balance of Copper in Turkey



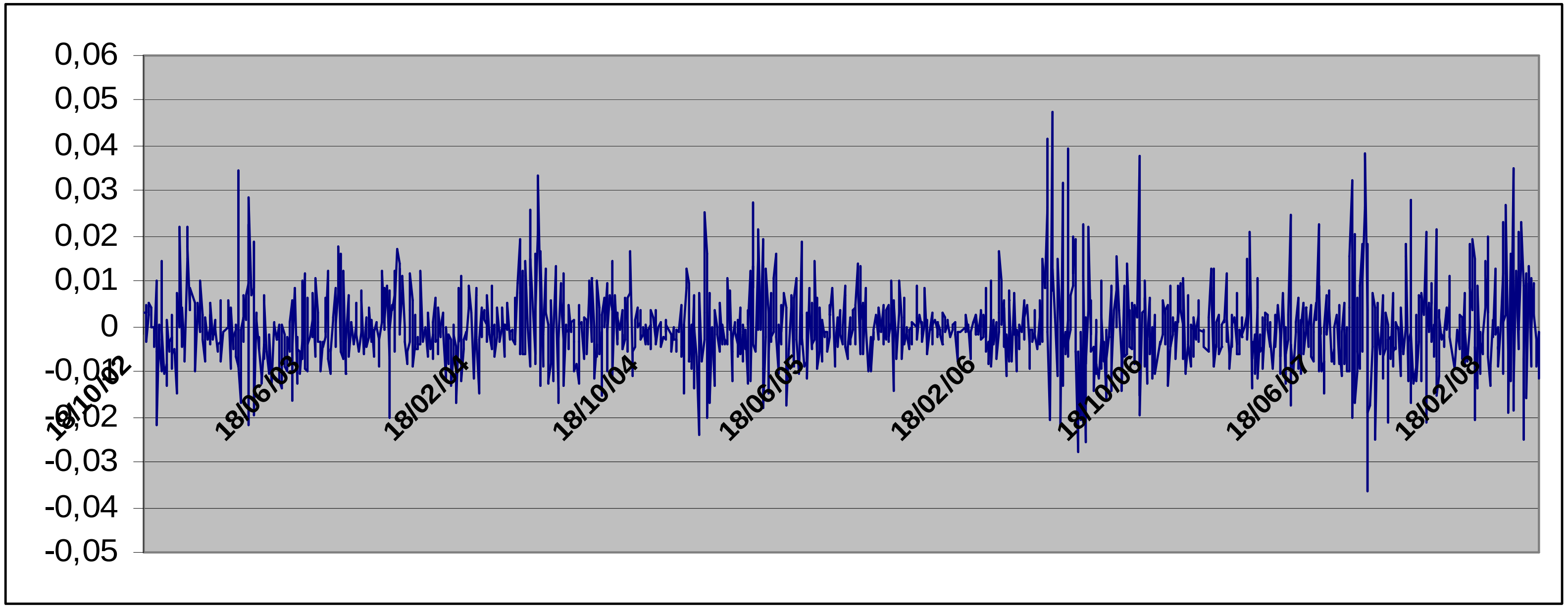
Source: Turkish Statistical Institute, www.tuik.gov.tr *2008 values are estimated.

Figure-11: Copper Trade Deficit as Percentage of Total Trade Deficit of Turkey



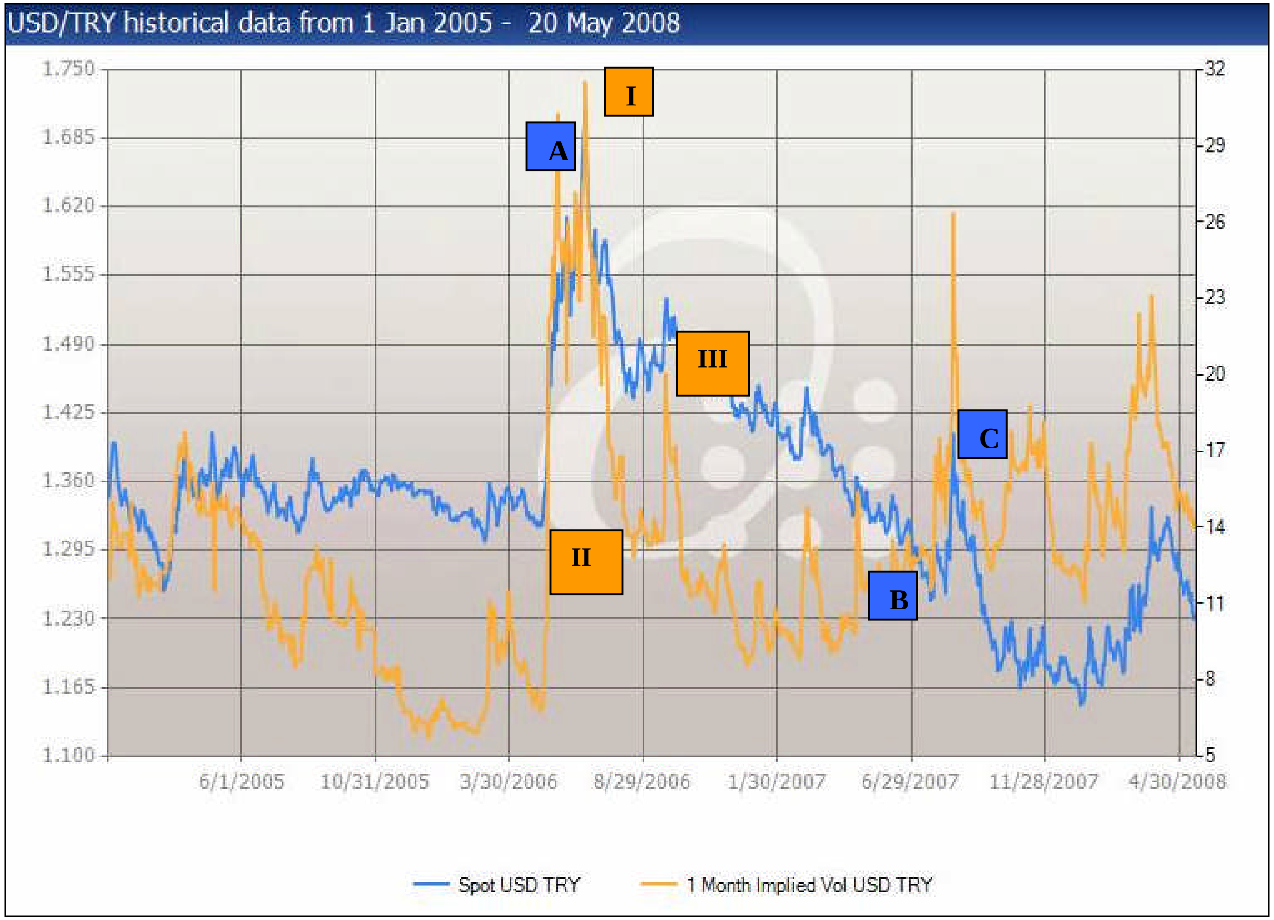
Source: Turkish Statistical Institute, www.tuik.gov.tr *2008 values are estimated.

Figure-12: Volatility of the $/TRY Exchange Rate for the Period 2002-2008.



Source: Central Bank of the Republic of Turkey, selling FX data. www.tcmb.gov.tr

Figure-13: One Month Implied Volatility USD/TRY vs. Spot USD/TRY



Source: www.superderivatives.com / supplied by Ran Agassi

Table-6: Hedging Approach for Value Maximizing Firms in Turkey

Hedging Approach for Value Maximizing Firms in Turkey under the Assumption 'Implied Volatility Orientates the Market'			
		Buyer	**Seller**
Implied volatility of copper & Implied volatility of $/TRY	↑ ↑	long position hedge	no need to hedge
Implied volatility of copper & Implied volatility of $/TRY	↓ ↓	no need to hedge	short position hedge
Implied volatility of copper & Implied volatility of $/TRY	↑ D* ↓	long position hedge by residual risk	no need to hedge
Implied volatility of copper & Implied volatility of $/TRY	↑ ↓ D*	no need to hedge	short position hedge by residual risk

*D refers dominant implied volatility