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Option-Implied volatility as a predictor of realized volatility in derivative markets.

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A research project submitted to the Gordon Institute of Business Science, University of Pretoria, in partial fulfilment of the requirements of the degree of Master of Business Administration.

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Abstract

The following study aims to examine the success of using option-implied volatility to forecast realized volatility in derivative markets as the preferred market practice. The approach adopted by this study was to compare realized volatility against the monthly average forecast over the period 2005 to 2010. The data selection spanned across currency and commodities markets; short and long-term horizons; before and after the global financial crisis; as well as developed and developing (emerging) markets. To test the success of the forecasting technique, the study used the T-test to test the sample means for any statistical differences between the means of the forecast variable (option-implied volatility) and the realized variable. The data for the study was obtained from Bloomberg™.

The findings across all research question showed that this forecasting technique has performed poorly in general for various reasons. There are different arguments in literature as to which forecasting method works best and under what conditions, some practitioners prefer using historical data methods others prefer more technical methods such as the GARCH 1.1.

The use of financial derivatives to mitigate financial risk has become a common practice for organizations with a global presence; however market volatility poses a great risk to the financial stability of these organizations. Forecasting volatility continues to be a challenge for market practitioners.

Keywords

- ***Hedger***: defined as a market participant who reduces his market risk exposure in an underlying asset by taking an offsetting investment position.
- ***Speculator***: a market participant who anticipates market price changes and takes positions in the market without an underlying asset.
- ***Arbitrageurs***: a market participant who takes advantage of two or more similar markets by buying and selling similar assets at the same time.
- ***OTC Market***: Over-the-counter market.
- ***ATM Option***: At-the-money option
- ***ITM Option***: In-the-money Option
- ***OTM Option***: Out-the-money option
- ***Volatility***: A measure of risk associated with the returns of an asset.

Declaration

I declare that this research project is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration at the Gordon Institute of Business Science, University of Pretoria. It has not been submitted before for any degree or examination in any other University. I further declare that I have obtained the necessary authorisation and consent to carry out this research.

_____ _____

Thabiso Ramashala Date

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Chapter 1

1. Introduction

1.1. International trade and exchange rate exposure

One of the effects of globalisation has been an increase in the global economic activity across countries. The expansion in international trade and investment flows has resulted in most countries being more open, which has lead to an increase international competitive pressures (Hutson & Stevenson, 2010). This increase in economic activity has been directly linked to the global economic growth. In a quest to find alternative and competitive ways of doing business, companies began trading beyond their borders; as a result, this global economic activity has also lead to an increase in foreign exchange flows between countries.

The negative side of international trade was that companies became more exposed to external economic risks such as the exchange rate movements, the more open an economy is to foreign trade the more its firms are exposed to exchange rate movements (Hutson & Stevenson, 2010). The exchange rate exposure of companies can either be direct or indirect. Direct exposure relates to transactional business resulting in the fluctuation of future cash flow, indirect exposure is when the company manufactures and sells its products locally, as the domestic currency strengthens the company faces increasing competition from cheaper import products (Hutson & Stevenson, 2010). Foreign currency exposure also extends to the investment community whereby some portfolio managers hold indirect positions in foreign currency when they invest in foreign

assets such as bonds and equities without hedging the foreign currency exposure (CAMPBELL, SERFATY-DE MEDEIROS, & VICEIRA, 2010).

1.2 Development of financial derivative markets

The exposure to external economic risks has lead to the development of risk management tools and their relative markets. The Chicago Mercantile Exchange (CME) introduced currency futures, while the Philadelphia Stock Exchange (PHLX) introduced option trading on major currencies (Liu, 2007). The Chicago Board Options Exchange (CBOE) began trading option contracts by 1973 and created an orderly market with well defined option contracts (Hull, 2006). One of the main reasons for the development of financial derivatives market was to reduce the volatility associated with the movements in currency and commodities prices.

Companies have been using hedging techniques across markets to moderate the exposure to exchange rate movements and cash flow fluctuation (Hutson & Stevenson, 2010). While they have also recognised some benefits of hedging such as, a widespread access to a range of risk management tools (Hutson & Stevenson, 2010). Another key benefit to hedging is that it reduces the likelihood of financial distress and expected financial distress cost by moderating the volatility of expected future cash flows (Hutson & Stevenson, 2010). Financial derivative markets are classified into:

- Futures markets (including currency, equities, and commodities)
- Foreign currency derivatives
- Commodity derivatives

- Interest rate derivatives

The focus of this research will be limited to foreign currency and commodity derivative markets.

1.3. Research Problem

Asset volatility plays a critical role in the derivative market, particularly in the valuation and pricing of derivative instruments. The forecasting of market volatility across financial markets has been at the centre stage of academics and practitioners for many years (K. Wang, 2010). This has lead to the development of superior forecasting techniques; however, in an attempt to find out which of these techniques is superior, there is still no clear conclusion as to which of the forecasting methods best predicts financial market volatility (K. Wang, 2010).

While volatility has various definitions, it refers to the fluctuations observed in the returns of an underlying asset over time (Andersen, Bollerslev, Christoffersen, & Diebold, 2005). It is used to describe the variability of the random component of a time series; however, in more financial terms it is defined as the standard deviation of the random Wiener-driven component in a continuous-time diffusion model (Andersen et al., 2005).

The use of volatility forecasting techniques spans across corporate treasures, fund managers and financial market traders in risk management, portfolio hedging and option pricing. Volatility is generally recognized as an important determinant of risk asset values such as exchange rates, equities and bond prices (Busch, Christensen, & Nielsen, 2011). In evaluation procedures, it is the

forecasting of future volatility from variables in the current information set that is important for asset pricing, derivative pricing, hedging and risk management (Busch et al., 2011).

1.4. Research Objectives

The volatility forecasting techniques in literature are generally classified into two, namely:

- Forecasting based on modelling past observations,
- Forecasting based on implied volatility calculated from observed option prices (K. Wang, 2010).

Forecasting based on past observations include historical volatility models, moving average models, exponential weighted moving average models (EWMA), autoregressive conditional heteroskedasticity (GARCH) models and their variations (K. Wang, 2010).

Those based on implied volatility calculated from option prices differ in that they do not rely on market data observation, however, they are calculated on an assumption of an option price, and then worked backwards using an option pricing model such as, the Black and Scholes option pricing model (Ser-Huang Poon & Granger, 2005).

This volatility is referred to as the market traded volatility and forms the basis of option valuation (Ederington Louis H. & Guan Wei, 2006). Implied volatility has been generally accepted as more accurate in forecasting future volatility, this is supported by the findings of (Ederington Louis H. & Guan Wei, 2006), (K. Wang, 2010) and (Ser-Huang Poon & Granger, 2005).

This research has been shaped to in four dimensions, while the option-implied volatility forecast method has been accepted as superior to time-series based volatility forecasting methods; the research dimensions focused on the effectiveness of option-implied volatility in forecasting future volatility:

- In developed markets compared to developing markets,
- In commodities market compared to currency market,
- In the short term compared to long term structures, and
- Before and after the 2008/2009 global financial crisis.

1.5. Research Aim

The fundamental aim of this research was to compare the success of the option-implied volatility forecasting technique, as the market practise, to forecast realized volatility, which in turn reflects the accuracy of the assumptions made on option price levels. Much of the literature studies focused developed economies regarding volatility forecasting; this research explored the application of this forecasting technique in developing and emerging markets.

Furthermore; the research looked into the effectiveness of this technique in forecasting short term and long term volatility as well as before and after the global economic crisis.

Chapter 2

2. Literature Review

2.1. Derivative market overview

Derivative markets have contributed to the development of financial infrastructure of countries by making links between cash markets, hedgers and speculators (Lien & Zhang, 2008). The use of derivative products offer alternatives for efficient risk management, and facilitate capital flows into emerging economies (Lien & Zhang, 2008). Commodity futures markets have been known to provide risk reduction instruments and disseminators of price information. The expansion of futures markets has largely been in developed markets although the use of commodity futures in emerging markets has gained increasing ground as possible solutions to the price and revenue volatility problems faced by producers (Lien & Zhang, 2008).

The derivatives markets are classified into exchange traded markets and over-the-counter markets (OTC) (Hull, 2006). In exchange traded markets, the derivative contracts are standardized and defined by the exchange (Hull, 2006). Exchange traded instruments also reduce counterparty and operational risk through centralised clearing institutions, which are considered to be more transparent, liquid and accessible to a broader range of market participants (Hans J. Blommestein, Das Udaibir, Alison Harwood, Ceyla Pazarbasioglu, & Anderson Silva, 2008).

Over-the-counter derivative products are flexible to customisation and do not require an underlying cash market (Hans J. Blommestein et al., 2008). Market participants are free to negotiate any mutually attractive deal (Hull, 2006).

2.1.1. Market Participants

Hedgers

Hedgers use derivatives to reduce the risk of potential future movements in a market variable (Hull, 2006), e.g. hedging against the movement in the price of maize.

Speculators

They use derivatives to bet on the future direction of market variables (Hull, 2006), e.g. Selling maize futures without the underlying product for possible delivery.

Arbitrageurs

They use derivatives to lock in profits by taking offsetting positions in two or more instruments whereby there is a market mispricing that creates an arbitrage opportunity (Hull, 2006).

2.2. Theory of derivative products

There are four basic building blocks of derivative instruments, each of which have distinctive payoff profiles (Finnerty & Pathak, 2011), these are

- Forward change contracts
- Futures contracts
- Options and
- Swaps.

The following discussion focuses on each and the practical application in financial markets.

2.2.1. Forward Exchange contracts

By definition, it is an agreement between two counterparties to buy or sell an asset at a certain future date at a certain future price (Hull, 2006). This is an obligatory agreement in which the terms of the contract are fixed at the time the parties enter into the contract (Finnerty & Pathak, 2011). They are traded on an over the counter basis, thus customisation enables them to be tailored to better suit the needs of both counterparties (Finnerty & Pathak, 2011).

The payoff profiles of both a long and short forward contract position is illustrated in the figure 1 below

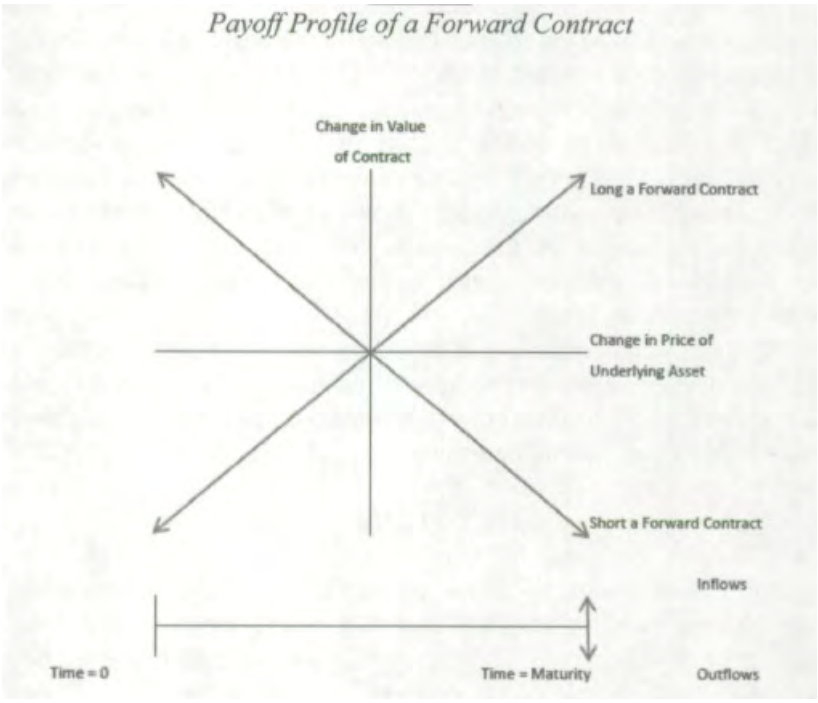


Figure 1: Source (Finnerty & Pathak, 2011)***.***

Forward contracts are useful in eliminating price uncertainty, largely used by hedgers who seek to secure their future cash flows (Finnerty & Pathak, 2011).

However, the price certainty does not guarantee that the forward contract will outperform the market.

2.2.2. Futures Contracts

A futures contract is like forward contract in that it is an agreement between two parties to buy or sell an asset at an agreed forward date and price (Al-Shboul & Alison, 2009), however, unlike forward contracts they are exchange traded (Finnerty & Pathak, 2011; Hull, 2006). Trades involving futures contracts are settled through a clearing house which guarantees the performance of the buyer and the seller (Finnerty & Pathak, 2011). The payoff profile for futures contracts is exactly the same as that of forward contracts; however the gains and losses under futures contracts are realized on a daily basis as the clearing house mark each position to the market daily (Finnerty & Pathak, 2011).

2.2.3. Swap Contracts

In a swap contract, two parties agree to exchange payment obligations tied to specified interest rates, exchange rates, asset prices or indexes (Finnerty & Pathak, 2011). An example of an interest rate swap involves two counterparties where by one agrees to pay a fixed interest rate and the other a floating interest rate based on a stated notional principal amount (Finnerty & Pathak, 2011).

2.2.4. Option Contracts

An option contract is an agreement between two parties which gives the holder of the contract the right, but not the obligation to buy or sell an underlying asset at an agreed price known as the strike price and at a pre-determined date

forward date known as the expiry date (Finnerty & Pathak, 2011). This research focuses on this area of derivatives, particularly on the pricing and the valuation of options. There are two fundamental types of options, call option which gives the holder the right but not the obligation to buy an asset and a put option which gives the holder the right but not the obligation to sell an asset (Finnerty & Pathak, 2011), and (Hull, 2006). Call options are used by investors who expect the price of an underlying asset to increase over the life of the option, while put options are used when the price is expected to fall (Finnerty & Pathak, 2011). The payoff profile for both put and call options are illustrated in figure 2 below:

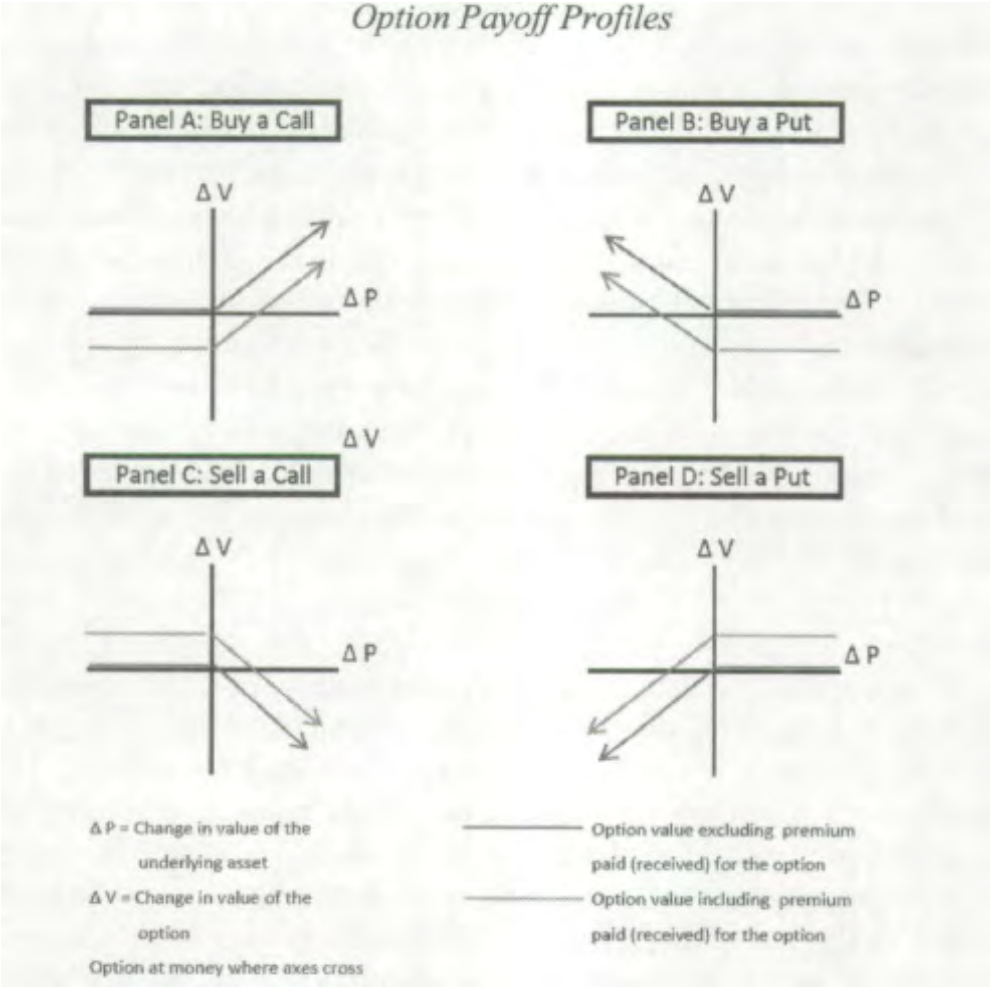


Figure 2: Source (Finnerty & Pathak, 2011)

Options function as insurance in that the buyer pays a premium for the right to buy or sell an asset; the seller of the option bears the risk that the option might be exercised by the buyer and for this risk, the buyer pays a premium for the option (Hull, 2006) and (Finnerty & Pathak, 2011).

2.3. Theoretical background of option trading

Generally, options are classified into two categories

- American option: this option type gives the holder the right but not the obligation to exercise the option at any time up to the expiry date (Amornwattana, Enke, & Dagli, 2007).
- European option: this type of option can only be exercised on the expiry date agreed upon (Amornwattana et al., 2007).

As a result of the additional flexibility, American options are priced higher than European options (Hull, 2006) and (Amornwattana et al., 2007). Options can also be in-the-money (ITM), out-of-the-money (OTM) or at-the-money (ATM):

- An in-the-money option (ITM): is an option which would give the ***holder*** a positive cash flow if it were exercised (Hull, 2006) and (Amornwattana et al., 2007).
- An out-of-the-money option (OTM): is an option which would give the ***seller*** a negative cash flow if it were exercised (Hull, 2006) and (Amornwattana et al., 2007).
- An at-the-money option (ATM): would have a zero cash flow implication if it were exercised (Hull, 2006) and (Amornwattana et al., 2007).

The price of an option as calculated using different pricing models consists of two parts, the intrinsic value and the time value (Amornwattana et al., 2007).

The intrinsic value is defined as the difference between the strike price and the current price of the underlying instrument max(S – X, 0) with a minimum of zero, where S is the strike price and X is the price of the underlying instrument (Hull, 2006). Thus an option can either have an intrinsic value equal to (S – X) for a call option and (X – S) for a put option or a zero intrinsic value. The time value component of the option price is derived from the possible movements (favourable or unfavourable) in the price of an underlying instrument during the life of the option (Amornwattana et al., 2007). This time value component has been the basis of option pricing and the bed rock of volatility estimation in the effort to accurately price options.

2.3.1 The Greeks

The two components of an option price are both subject to the changes in the underlying market price; the sensitivity to the market changes is described by the "the Greeks" (Enke & Amornwattana, 2008). There are five commonly measured Greeks namely, Delta, Gamma, Vega, Theta, and Rho; with each of these measuring a different aspect of the risk and sensitivity of the value of the option relative to the market movement of the underlying instrument (Enke & Amornwattana, 2008):

- ***Delta***: measures the sensitivity of an option price to a 1 point change in the price of the underlying asset, the delta of an option ranges between 0 and +1 for call options (-1 for put options) (Enke & Amornwattana, 2008) and (Hull, 2006).

- ***Gamma***: measures the sensitivity of the option delta to a 1 point change in the underlying assets price (Enke & Amornwattana, 2008) and (Hull, 2006).
- ***Vega***: measures the sensitivity in the option price to a 1 point change in the volatility of the underlying asset (Enke & Amornwattana, 2008) and (Hull, 2006).
- ***Theta***: measures the sensitivity of an option price relative to the passage of time, this tracks the changes in the option price as 1 day elapses in the remaining time before expiration (Enke & Amornwattana, 2008).
- ***Rho***: measures the sensitivity of the option price relative to a 1% change in the interest rates (Enke & Amornwattana, 2008) and (Hull, 2006).

2.3.2 Popular vanilla structures

- *Importer Collar*

This involves a simultaneous purchase of a call option at a certain strike level and a sale of a put option at a strike level that would fund the call option to make the structure a zero cost structure.

Example: An importer with a commitment to deliver US$10 million against Rand on the 29 July 2011 looking to hedge the currency exposure against possible Rand weakness. The importer purchases the following call option:

***Amount**: US$ 10 million*

***Exercise date**: 27 July 2011 (Delivery 29 July 2011)*

***Strike price**: 6.9544*

***Forward Exchange rate**: 6.8719*

***Option price**: R 763 000 (premium payable by the importer)*

To fund the call option, the importer sells the following put option:

***Amount**: US$ 10 million*

***Exercise date**: 27 July 2011 (Delivery 29 July 2011)*

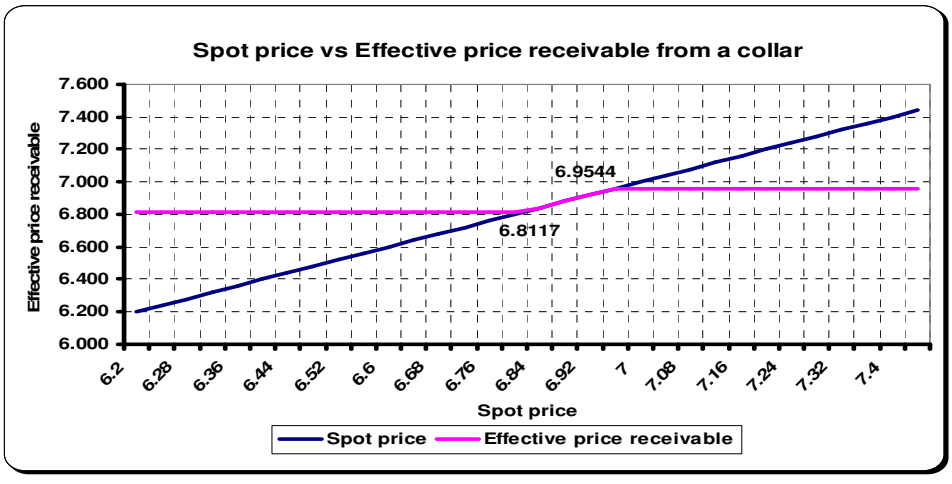
***Strike price**: 6.8117*

***Option price**: R 763 000 (due to the importer)*

The pay off profile of the structure is given in figure 3. It shows that at spot prices between 6.8117 and 6.9544, both options will expire worthless and thus the importer will purchase the US$10 million in the market. At prices below 6.8117 the importer will be obligated to purchase the currency at 6.8117 as the put is exercised, however this rate compared to the forward rate at the time of trade (6.8719) is far better.

At levels above 6.9544 the importer will exercise the call option and purchase currency at 6.9544 thus outperforming the spot price.

Figure 3: Importer Collar



- *Importer Geared Collar*

  This involves a simultaneous purchase of a call option at a certain strike level and a sale of *two* put options at the same strike level that would fund the call option to make the structure a zero cost structure.

  Example: An importer with a commitment to deliver US$10 million against Rand on the 29 July 2011 looking to hedge the currency exposure against possible Rand weakness. The importer purchases the following call option:

  Amount**: **US$ 10 million

  ***Exercise date**: 27 July 2011 (Delivery 29 July 2011)*

  ***Strike price**: 6.8750*

  ***Forward Exchange rate**: 6.8550*

  ***Option price**: R 828 000 (premium payable by the importer)*

  To fund the call option, the importer sells the following put option:

  Amount**: **US$ 20 million (2 put options at the same strike)

  ***Exercise date**: 27 July 2011 (Delivery 29 July 2011)*

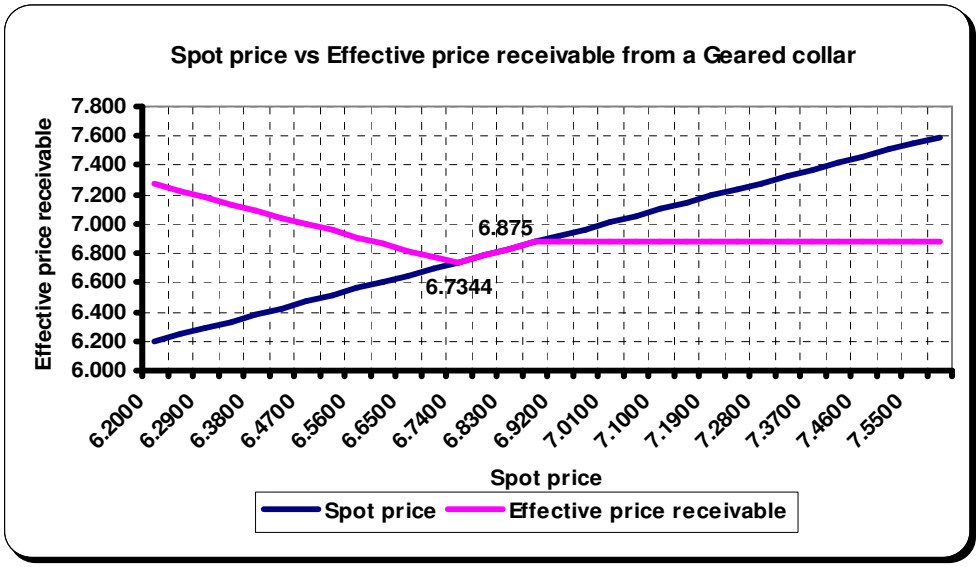
  ***Strike price**: 6.7344*

  ***Option(s) price**: R 828 000 (due to the importer)*

  The pay off profile of the structure is given in figure 4. It shows that at spot prices between 6.7344 and 6.8750, both options will expire worthless and thus the importer will purchase the US$10 million in the market. At prices below 6.7344, the importer will be obligated to buy 2 X US$ 10 million at 6.7344 as the 2 put options are exercised, this rate still outperforms the forward rate (6.8550) at the time of the trade. At spot

prices above 6.8750 the importer exercises the call option and purchases the currency at the strike rate (6.8750) thus outperforming the spot price.

Figure 4: Importer Geared Collar



2.4 Volatility

In both option pricing and valuation, the anticipated volatility over the life of the option is a crucial unknown, and thus the estimation of future volatility is a very critical step (Ederington Louis H. & Guan Wei, 2006) and (Ang, Gwoduan, & Tsong-Yue Lai, 2009). The implications of incorrectly estimating future volatility can be dramatic (Ederington Louis H. & Guan Wei, 2006). An example would be, when a gold mine has a gold hedge book consisting of gold option hedges and is in a process of negotiating a merger; the valuation of the hedge book would be subject to volatility estimation; thus an incorrect estimation of volatility could lead to incorrectly pricing the hedge book and influencing the merger decision either by over valuing or under-valuing the book.

As discussed, there are two main methods of forecasting volatility, those based on historical data and those based on option-implied volatility from assumed option prices (K. Wang, 2010). There are however conflicting arguments in literature as to which forecasting techniques are superior, with (K. Wang, 2010) concluding that option-implied volatility forecasts provide better results than historical data forecast methods; while (Brous, Ince, & Popova, 2010) argues that the forecasting accuracy of using option-implied volatility is generally inferior when compare to historical measures. Some studies have shown that option-implied volatility is upwardly biased as the option price assumed generally has margin built into it and thus yield higher forecast results (Brous et al., 2010), others argues that option-implied volatility contains resent information set such as the knowledge of future scheduled events that could move the market (Ederington Louis H. & Guan Wei, 2006) and (Ser-Huang Poon &

Granger, 2005). The following section looks at volatility forecasting techniques from a theoretical framework.

2.4.1 Option implied Volatility from Black and Scholes model

The Black and Scholes option pricing model was developed based on a few underlying assumptions including; the volatility of the returns in the underlying assets is set to be constant; the model is used for pricing on non-dividend paying assets; and that there are no riskless arbitrage opportunities (Hull, 2006).

This research shall not go into deriving the model; however we shall describe the terms and relevance of each in the calculation of option prices.

For call options: $c = S_0 N(d_1) - Ke^{-rT} N(d_2)$

For put options: $p = Ke^{-rT} N(-d_2) - S_0 N(-d_1)$

$$d_1 = [\ln (S_0/K) + (r + \sigma^2/2)T] / \sigma\sqrt{T}$$

$$d_2 = [\ln (S_0/K) + (r - \sigma^2/2)T] / \sigma\sqrt{T} = (d_1 - \sigma\sqrt{T})$$

Where:

c = price of the call option

p = price of the put option

S_0 = Spot price of the underlying asset

K = strike price

r = risk free rate

σ = option Implied volatility

T = Time to maturity of the option

N(x) = cumulative probability distribution function for a standardized normal distribution (Hull, 2006) and (Ang et al., 2009).

The option implied volatility is calculated using the above pricing model by assuming an option price then working backwards, this method of forecasting volatility has since become market practice. This option-implied volatility will be the focus of the research and its success in forecasting realized volatility.

The challenge with using this approach is that calculating implied volatility requires the option price; while calculating an option price requires an estimate of market volatility (Ederington Louis H. & Guan Wei, 2006).

2.4.2 Historical data forecasting techniques

2.4.2.1 Historical Volatility

Historical volatility is defined as the annualized volatility of daily returns during a specific period in the past (P. f. Wang, Li, & Zhou, 2010). This is calculated by using the formula below:

$$\sigma_{his} = \sqrt{\frac{1}{(n-1)} \sum_{i=1}^{n} (R_i - \mu)^2}$$

Where R_i is the log return of the underlying asset, and μ is the corresponding mean of the *n* daily log returns, this method assigns each return deviation (R - μ) an equal weighting of 1/(n – 1) (P. f. Wang et al., 2010). This method of forecasting volatility is largely preferred by most derivative text over some recent period (Ederington Louis H. & Guan Wei, 2006).

This also has a few challenges; because it considers only past returns, it ignores other possible information sets that may move markets; also, all past squared returns are weighted equally and all other observations

before the a selected period are ignored, volatility clustering and persistence indicates that more recent observations contain more relevant information regarding volatility (Ederington Louis H. & Guan Wei, 2006); lastly, historical standard deviation and variance are functions of squared return deviations, they are sensitive to outliers which could lead to an over or under-estimation of volatility (Ederington Louis H. & Guan Wei, 2006).

2.4.2.2 Moving average volatility

Often used in traditional time-series analysis by market analysts as a predictor of mean returns (K. Wang, 2010), this is given by the formula:

$$\sigma_t = \sqrt{\frac{1}{n}\sum_{j=1}^{n}\sigma^2_{t-j}}$$

Where, σ^2_{t-j} is the volatility estimates calculated as historical variance in the estimation period of the sample *n* (K. Wang, 2010).

2.4.2.3 Exponential weighted moving average (EWMA)

This puts more weight on the more recent observations, and thus takes some account of the dynamic ordering in the returns (K. Wang, 2010). The resulting volatility estimate from the EWMA reacts immediately following an unusually large return, as such, the effect of this return diminishes over time (K. Wang, 2010). This is given by the formula:

$$\sigma^2_{EWMA,t} = (1-\beta)\sum_{i=1}^{n}\beta^{i-1}(R_{t-i}-\mu)^2$$

2.4.2.4 ARCH/GARCH volatility

These techniques are also part of the historical data based forecasting models; referred to as (generalized) autoregressive conditional heteroskedasticity models, there are varying types of these models in literature used as forecasting techniques (K. Wang, 2010). They are given by the following formulae:

ARCH is given by:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t+1-i}^2$$

GARCH is given by:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t+1-i}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2$$

This research and thus the literature is not focused on the econometric modelling behind the models nor does it discuss the mathematics of each; however, the normal standard deviation forecasting techniques will be compared to the option-implied volatility forecasting technique.

2.5 Characteristics of Volatility

Constant market volatility models such as the Black and Scholes option pricing models have been widely accepted and applied in the market (Belaifa & Morimune, 2006). However the assumption of constant volatility has been proven to be incorrect (Hoi & Zhao, 2008) due to the following characteristics of market volatility:

- Volatility tends to persist and cluster over a period of time, this means that high-volatility periods tend to group together and the same applies to low-volatility periods (Ser-Huang Poon & Granger, 2005).
- The unconditional distribution of asset returns displays fat tails with a positive kurtosis (Cont, 2005).
- Linear autocorrelations of asset returns tend to be very insignificant except for small intraday time scales (Cont, 2005).
- Trading volume has been positively correlated to market volatility; trading volume and volatility are found exhibit the same type of long memory behaviour (Cont, 2005).
- High volatility has been associated with high interest rate levels and vice versa (Ser-Huang Poon & Granger, 2005).
- Volatility from option prices tends to show patterns of “smiles” for a given range of strike prices (Hoi & Zhao, 2008). The volatility smile of an option is a graphical representation of the relationship between the implied volatility and the strike price (Amornwattana et al., 2007).

The above characteristics of volatility are some of the reasons the argument of constant volatility as assumed by generally accepted pricing models has been rejected (Hoi & Zhao, 2008).

2.6 Challenges of using Financial Derivatives

In the advent derivatives and derivative trading, it has become harder for market participants to predict market movements thus making the market pricing more efficient (Liu, 2007). Shareholder value theories have also explained how hedging using financial derivatives can create value as a result of one or more market imperfections (Hutson & Stevenson, 2010). However, there are some challenges that are associated with the use of financial derivatives as we have recently seen in the 2008-2009 global financial crisis. The misuse of financial derivatives lays the foundation for financial crises and can accelerate large capital outflows for an economy (Lien & Zhang, 2008). As a result the volatility of international capital outflow increases thus exacerbating the crisis by the unpredictability of the crisis dynamics (Lien & Zhang, 2008).

Derivative products can disguise the nature of the risk exposures, leverage up exposure volume and reduce transparency of transaction reporting; these risks are all potentially destructive to companies and economies (Lien & Zhang, 2008). The development of the regulatory environment and improved reporting on the market value of these instruments was a direct result of the destructive nature of these products.

Chapter 3

3.1 Research questions and Hypothesis

The literature review points out that, there has been development in the improvement of volatility forecasting techniques over the years, with each having both advantages and disadvantages. However, there is no clear indication as to which of the techniques is superior in forecasting volatility. Current market practice favours the use of option-implied volatility over historical observation based methods. This is supported by some literature as a better alternative for forecasting volatility (Ederington Louis H. & Guan Wei, 2006).

This research seeks to address the following questions (RQ):

- Has option-implied volatility been an effective predictor of realized volatility in developed financial market currencies compared to emerging markets over the period 2005 to 2010? The question was to evaluate the technique of forecasting the volatility of, for example EURO/US Dollar (€/$) as a developed market currency pair, compared to US Dollar/Rand ($/R) as an emerging market currency pair.

  - ***Null Hypothesis 1 (H_0)^{RQ1}***

    Given the market practice of using the option implied volatility forecasting methods to predict realized volatility; the null hypothesis for research question 1 ***($(H_0)^{RQ1}$)*** was that, option-implied volatility was an efficient predictor of realized volatility across developed

and emerging market currencies over the period 2005 to 2010.

- Has option-implied volatility been equally effective in forecasting currency market volatility and commodity market volatility over the period 2005 to 2010? Most volatility studies in literature have focused on equities and equity indices; the question was to understand the effectiveness of the forecasting technique in currencies as well as in commodities market.

  - ***Null Hypothesis 2 $(H_0)^{RQ2}$***

    The null hypothesis for research question 2 **($(H_0)^{RQ2}$)** was that, option-implied volatility has been effective in predicting realized volatility across currency and commodities markets over the period 2005 to 2010.

- Has option-implied volatility been equally effective in forecasting short term volatility when compared to forecasting long term volatility over the period 2005 to 2010? The question was to understand the impact of longer forecasting horizons compared to the short end of the volatility curve.

  - ***Null Hypothesis 3 $(H_0)^{RQ3}$***

    The null hypothesis for research question 3 **($(H_0)^{RQ3}$)** was that, option-implied volatility has been an effective predictor of both short term and long term volatility over the period 2005 to 2010.

- Has the 2008/2009 global economic crisis had any effect on the ability to forecast realized volatility using option-implied volatility?

  - ***Null Hypothesis 4 (H_0)^{RQ4}***

    The null hypothesis for research question 4 (**(H_0)^{RQ4}**) was that, the effectiveness of option-implied volatility to forecast realized volatility was unaffected by the 2008/2009 global economic crisis.

Chapter 4

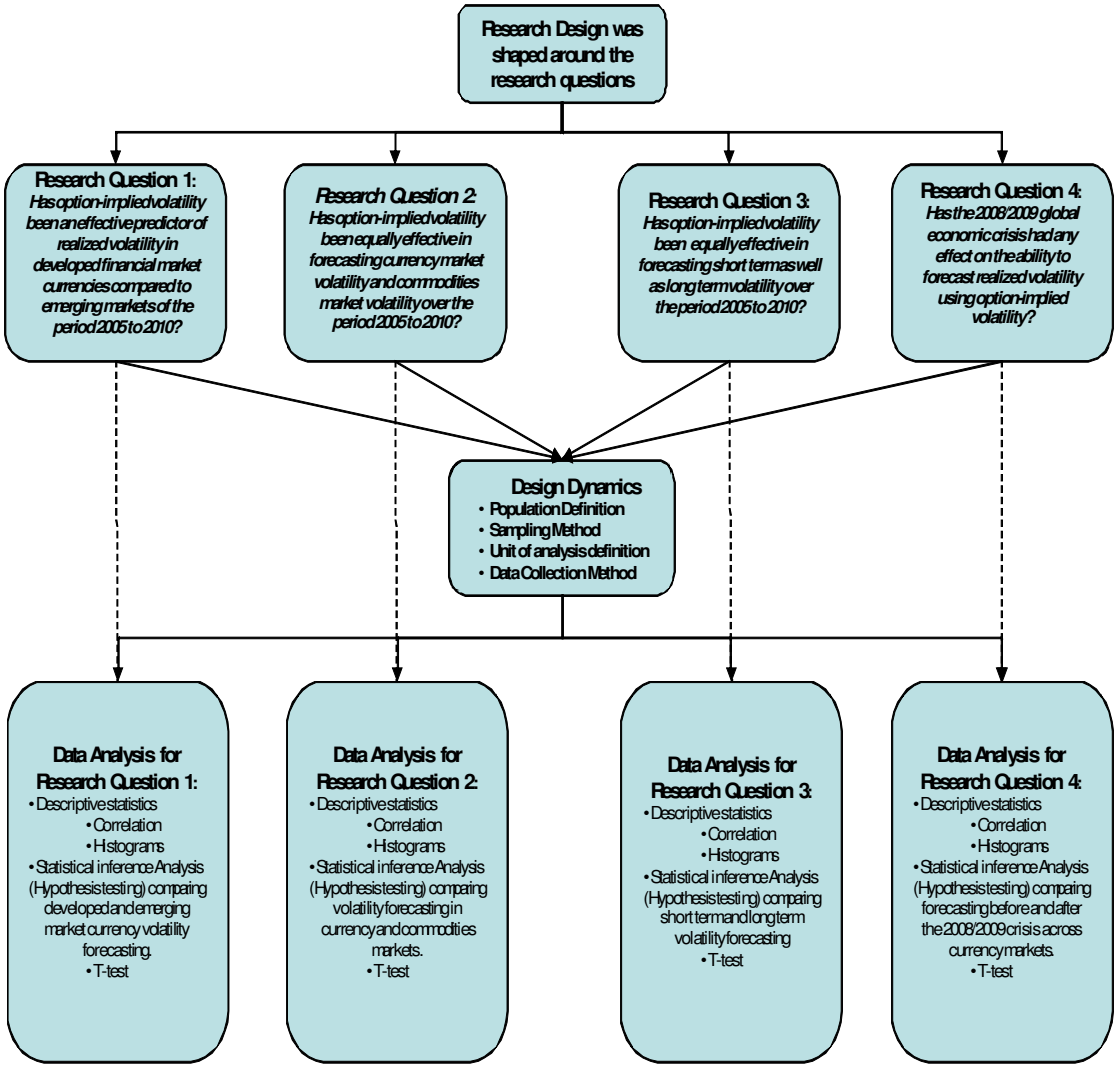
4.1 Research Methodology

The literature on volatility studies has largely employed quantitative research methods. Quantitative research methods assume the meaning of a phenomenon such as volatility in the case of this research, and refer to the measure of this phenomenon (Boris Blumberg, Donald R. Cooper, & Pamela S. Schindler, 2007). The objective of a quantitative research study in this case was to understand the relationships between the forecast variable (implied volatility) and the realized variable (Historical volatility). The underlying assumptions about volatility and its definition were assumed to be valid for the purposes of this study.

4.2 Research Design

Research design by definition is a plan and structure of the investigation to find the answers to the stated research questions (Boris Blumberg et al., 2007), it constitutes the collection, measurement, and analysis of data (Boris Blumberg et al., 2007). The research design undertaken was shaped by the research questions in chapter 3; the structure of the design is show in figure 5. The design began by categorising each question, applying the design dynamics across each question such as population definition, sampling method, unit of analysis definition and data collection. These components of the research design were generic across the research questions; however the data analysis section was customised to each question.

Figure 5: Research design structure



4.3 Population

By definition, a population includes all the observations a study is interested in (Albright, Winston, & Zappe, 2009). For the purposes of this research study, focus was on the data collected from the market by Bloomberg™ on option-implied volatility and realized volatility across currencies and commodities; this represented the population. However the sampling method for each research question has been described in the next session.

4.4 Sampling

By definition, a sample is a subset of a population which is often randomly chosen and representative of the population (Albright et al., 2009). The first step in the sampling method was to select a period from which data was collected, the period selected was from January 2005 to December 2010. From this period, the following currency and commodity pairs were selected for the research:

Developed market data (1, 3, and 12 months)

- British pound against US dollar (GBP\US$)
- Euro against US dollar (EUR\US$)
- Euro against British pound (EUR\US$)

Emerging market data (1, 3, and 12 months)

- US Dollar against Rand (US$\ZAR)
- US Dollar against Brazilian real (US$\BRL)
- US Dollar against Turkish lira (US$\TRY)

Commodities data (1, 3, and 12 months)

- US Dollar against Gold (US$XAU)
- US Dollar against Platinum (US$\XPT)
- US Dollar against Brent crude (US$\BRT)

Because Bloomberg™ collects option-implied and realized volatility data across all market dimensions such as, 1 month volatility through to 12 month volatility; this research has been limited to the time horizons in table 1 for both option-implied volatility and realized volatility.

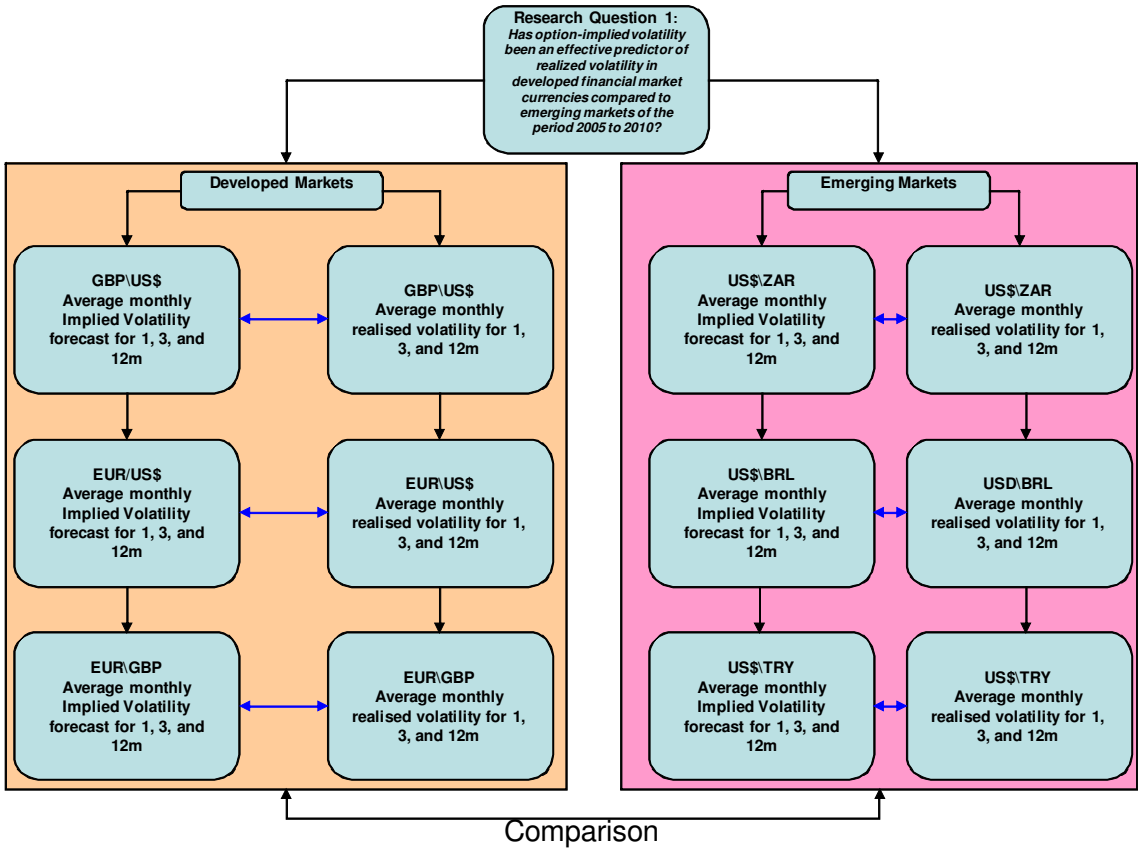
Table 1

		Sampling Method					
	Code	Option-implied Vol	Realized Vol	Option-implied Vol	Realized Vol	Option-implied Vol	Realized Vol
Developed Market Currencies	GBP\US$	1m	1m	3m	3m	12m	12m
	EUR\US$	1m	1m	3m	3m	12m	12m
	EUR\GBP	1m	1m	3m	3m	12m	12m
Emerging Market Currencies	US$\ZAR	1m	1m	3m	3m	12m	12m
	US$\BRL	1m	1m	3m	3m	12m	12m
	US$\TRY	1m	1m	3m	3m	12m	12m
Commodities	US$\XAU	1m	1m	3m	3m	12m	12m
	US$\XPT	1m	1m	3m	3m	12m	12m
	US$\BRT	1m	1m	3m	3m	12m	12m

4.4.1 Sampling for Research Question 1

To compare the effectiveness of volatility forecasting between developed and emerging markets, the research used the average monthly data for the currency pairs in table 1, as categorised, to analyse the data for 1m, 3m, and 12m volatility across both markets.

Figure 6: Sampling for Research question 1

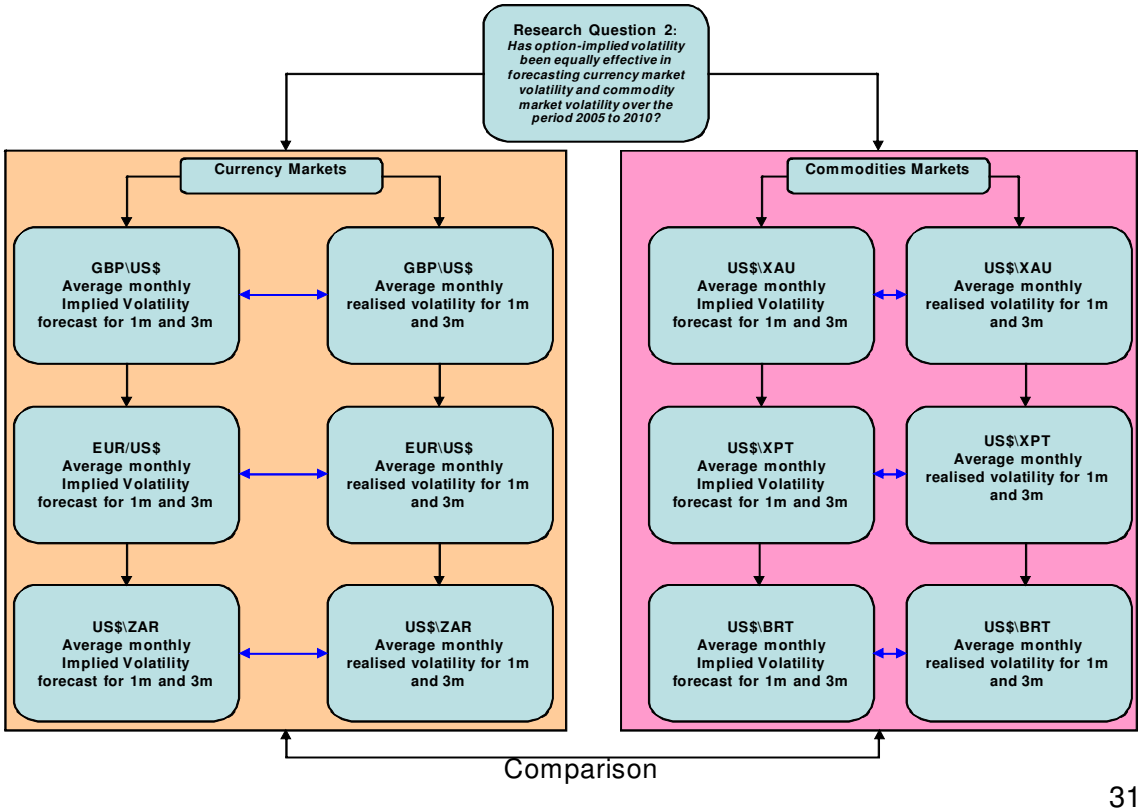


For example, as depicted in figure 6, the effectiveness of option-implied volatility in predicting realized volatility for 3 month GBP\US$ in developed markets was first analysed, then compared to that of the emerging market, such as 3 month USD\BRL. The comparison between the two markets was done across all the selected currency pairs and their respective periods.

4.4.2 Sampling for Research Question 2

Sampling for this question required the selection of actively traded commodities pegged against the US$. The commodities selected were Gold, Platinum and Brent crude oil. For the currency markets, the currency pairs selected spanned across both developed markets and emerging markets. These currencies were EUR\US$, GBP\US$, and US$\ZAR. The forecast period for the comparison was 1 month and 3 month average forecasts. The success of the forecast was analysed across these markets.

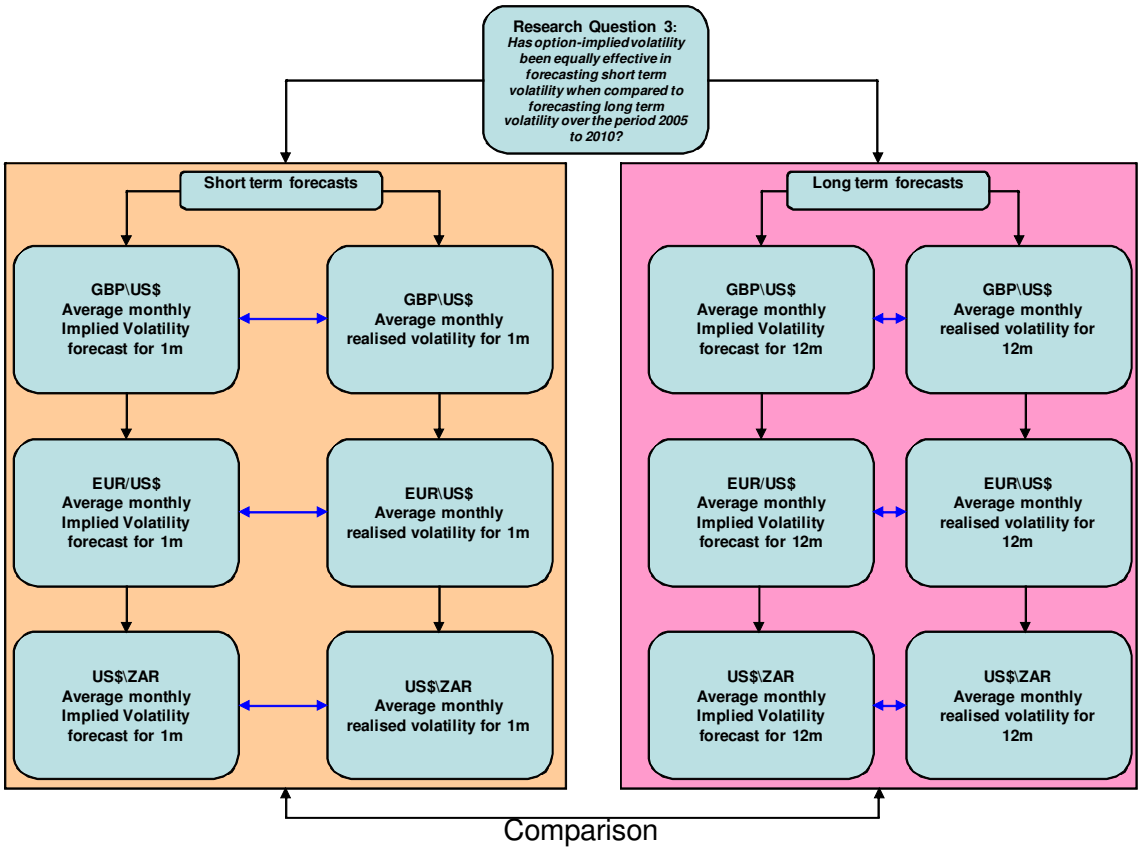
Figure 7: Sampling for Research question 2



4.4.3 Sampling for Research Question 3

The currency pairs for the sample data in response to this question were EUR\US$, GBP\US$, and US$\ZAR. To compare the success of forecasting over different time horizons, the research used the monthly average forecasts for 1 month volatility as the short term horizon and the monthly average forecast for 12 months volatility as the long term horizon across these currency pairs as shown in figure 8.

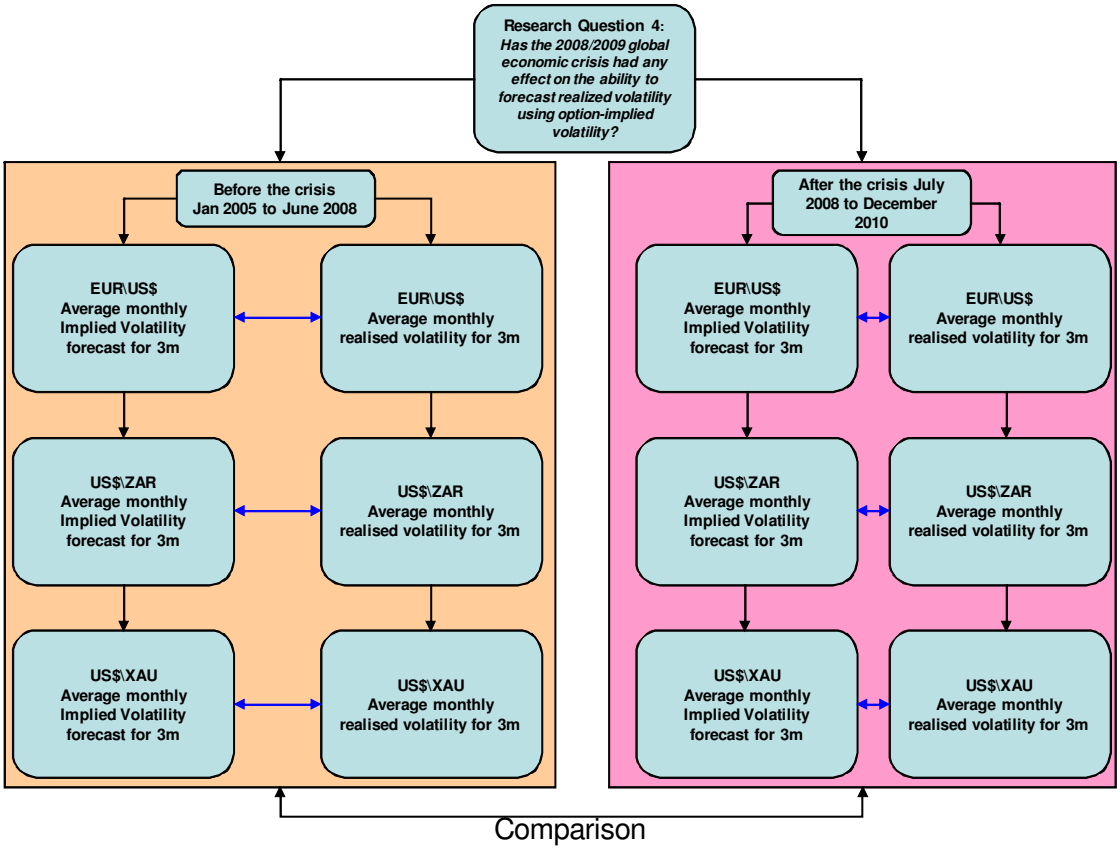
Figure 8: Sampling for Research question 3



4.4.4 Sampling for Research Question 4

For the purpose of this research, the period before the financial crisis was defined as January 2005 to June 2008; while the period after the financial crisis was defined as July 2008 to December 2010. The currency pairs selected for the analysis were EUR\US$, US$\ZAR and US$\XAU, and the analysis was done for the 3 month volatility forecasting horizon as it was considered to be the most liquid. Figure 9 shows the sampling method for research question 4.

Figure 9: Sampling for Research question 4



4.5 Unit of Analysis

The unit of analysis for the research was market volatility. The market convention to express the unit has always been as a percentage, and the research adopted the same convention.

4.6 Data Collection

The research data was sourced from the Bloomberg™ data base of market information. The collection of data only focused on the period between 2005 and 2010 as mentioned in the sampling section. The data collected by Bloomberg™ on volatility spans from daily to yearly averages, for example, implied volatility for 1m forecasts is collected as daily averages or even as a monthly average forecast. The research only focused on average monthly forecasts across 1m, 3m, and 12m as stipulated in table 1 on page 31.

4.7 Data Analysis

The first part of the data analysis was descriptive statistical study which was only concerned with understanding the relationship between realized volatility and option-implied volatility. The second part of the analysis was the analysis of the measures of variability between the forecasts variable and the realized variable. This research was in the form of an ex-post facto design in that it had no control over the variables or could they be manipulated (Boris Blumberg et al., 2007). The purpose of the research was to report on what transpired regarding forecasting market volatility.

4.7.1 Descriptive Statistics

The most common measures for descriptive stats are the measures of central location of any data set (Albright et al., 2009). In this analysis, the descriptive stats included, the mean of the sample data, which represents the average of all the data points in the sample (Albright et al., 2009); and the median, which represents the middle observation of the data set when arranged from smallest to largest (Albright et al., 2009). Other measures that fall in the area of descriptive statistics which were measured included:

- Maximum: the largest observed value in the data set (Albright et al., 2009).
- Minimum: the smallest observed value in the data set (Albright et al., 2009).
- Range: the difference between the minimum and the maximum (Albright et al., 2009).
- Standard deviation: the deviation from the mean.
- Skewness: measures the deviation of the distribution from symmetry (Hill & Lewicki, 2007).
- Kurtosis: the peakedness of the distribution (Hill & Lewicki, 2007).

Other measures that fall under descriptive statistics are measures of association (Albright et al., 2009). Because this research was concerned about the accuracy of forecasting volatility, it was

necessary to check the correlation between the forecast and the observed variable. This correlation was to measure the strength of the correlation if any, between the two variables.

4.7.2 Statistical test

While descriptive statistics painted a picture about the data set, a more important task of the research was to determine the successfulness of volatility forecasting across markets from a statistical significance point of view. The following statistical test was performed to test the hypotheses of the research questions in chapter 3:

- *t-Test for the difference between two paired sample means*

  The t-test is the most common statistical test used to evaluate the differences in the means between two samples or population groups (Hill & Lewicki, 2007). To test the success of forecasting of volatility, the research under took this test to assess the statistical difference between the sample means of both implied and realized volatility across the research questions

4.8 Research limitations

This research was confined within the following limitations

- The research only focused on the period between 2005 and 2010. This excluded any other data outside the time frame.
- The data used for the research was market closing data, this excluded all intraday market movements and the information contained therein.
- The assumptions made in the calculation of realized volatility by Bloomberg™ were not tested by this research.
- The assumptions made in the forecasting of volatility were also not tested in this research. The data was collected for analysis purposes only.
- Where there are many financial instruments that this research could have included as part of the data, it was limited to the selected currencies, and commodities.
- While Bloomberg™ collects daily data, this research only used monthly averages across the selected market instruments.

Chapter 5

5.1 Results

The data analysis approach was clustered around each research question and hypothesis, the first section was the descriptive statistics of each of the sample data, followed by the correlation analysis between the forecast variable and the realized variable, and lastly the statistical T-test for paired samples as described in chapter 4.

5.1.1 Research question 1

The first research question was looking to compare the volatility forecasting technique between developed market and emerging market currencies. The currency pairs selected to represent developed markets were; GBPUSD, EURUSD and EURGBP; while the currency pairs selected to represent the emerging markets were USDZAR, USDBRL and USDTRY. For each of these pairs, the data analysis was performed on the 1, 3 and 12 month data.

In the first section of the data analysis, the descriptive statistics for each of the currency pairs and for each period was executed using SPSS. These descriptive stats were run across both option-implied volatility and realized volatility. Table 2 below provides detail results of the descriptive statistics run; Table 3 provides the detail results on the correlation between each pair and finally Table 4 provides details of the T-test for the sample means to establish whether they are significantly different or not.

Table 2: Descriptive statistics for Research question 1

Descriptive Statistics										
	N	Range	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
GBPUSD 1m Option-implied	72	20.50	5.05	25.55	10.33	4.44	1.628	.283	2.394	.559
GBPUSD 1m Realized	72	23.39	4.75	28.14	10.00	4.50	2.019	.283	4.382	.559
GBPUSD 3m Option-implied	72	17.11	5.28	22.39	10.40	4.08	1.295	.283	1.172	.559
GBPUSD 3m Realized	72	19.02	5.18	24.20	10.15	4.34	1.845	.283	2.935	.559
GBPUSD 12m Option-implied	72	13.75	5.84	19.60	10.49	3.65	.882	.283	-.229	.559
GBPUSD 12m Realized	72	12.11	6.38	18.49	10.18	3.63	1.163	.283	.016	.559
EURUSD 1m Option-implied	72	18.07	4.89	22.96	10.39	3.97	1.489	.283	2.323	.559
EURUSD 1m Realized	72	17.52	4.30	21.82	9.50	3.59	1.711	.283	3.687	.559
EURUSD 3m Option-implied	72	16.55	5.14	21.69	10.54	3.70	1.156	.283	1.332	.559
EURUSD 3m Realized	72	16.79	4.64	21.43	9.57	3.47	1.638	.283	3.122	.559
EURUSD 12m Option-implied	72	12.77	5.79	18.56	10.70	3.23	.604	.283	-.302	.559
EURUSD 12m Realized	72	10.47	5.72	16.19	9.70	2.94	.934	.283	.059	.559
EURGBP 1m Option-implied	72	17.44	3.78	21.22	8.16	4.02	1.405	.283	1.975	.559
EURGBP 1m Realized	72	20.20	3.10	23.30	7.53	3.88	1.933	.283	4.598	.559
EURGBP 3m Option-implied	72	15.56	4.04	19.60	8.27	3.81	1.130	.283	1.052	.559
EURGBP 3m Realized	72	17.08	3.76	20.84	7.60	3.76	1.786	.283	3.520	.559
EURGBP 12m Option-implied	72	14.29	4.13	18.42	8.53	3.65	.794	.283	-.116	.559
EURGBP 12m Realized	72	10.18	4.29	14.47	7.66	3.33	.960	.283	-.367	.559
USDZAR 1m Option-implied	72	33.77	11.45	45.21	17.99	6.08	2.625	.283	8.844	.559
USDZAR 1m Realized	72	46.53	8.80	55.33	16.76	7.36	3.061	.283	12.700	.559
USDZAR 3m Option-implied	72	22.50	12.65	35.15	17.80	4.68	1.866	.283	3.885	.559
USDZAR 3m Realized	72	36.97	9.88	46.85	17.14	6.81	2.659	.283	8.477	.559
USDZAR 12m Option-implied	72	14.95	13.62	28.57	17.89	3.76	1.446	.283	1.714	.559
USDZAR 12m Realized	72	17.05	12.74	29.79	18.07	5.19	1.377	.283	.524	.559
USDBRL 1m Option-implied	72	41.92	7.21	49.13	15.99	7.46	2.812	.283	9.256	.559
USDBRL 1m Realized	72	63.44	3.90	67.34	14.75	9.46	3.432	.283	15.551	.559
USDBRL 3m Option-implied	72	29.07	8.64	37.71	15.69	5.68	2.350	.283	6.531	.559
USDBRL 3m Realized	72	49.19	5.55	54.74	15.53	8.91	2.721	.283	8.925	.559
USDBRL 12m Option-implied	72	20.59	10.09	30.68	16.24	4.15	1.386	.283	2.972	.559
USDBRL 12m Realized	72	24.07	8.06	32.13	16.67	6.59	1.440	.283	.817	.559
USDTRY 1m Option-implied	72	27.00	6.44	33.44	14.18	5.26	1.723	.283	3.767	.559
USDTRY 1m Realized	72	41.95	4.37	46.33	13.88	7.54	2.207	.283	6.082	.559
USDTRY 3m Option-implied	72	18.72	8.20	26.92	14.56	3.96	1.232	.283	1.751	.559
USDTRY 3m Realized	72	35.61	4.87	40.47	14.45	6.91	1.724	.283	3.544	.559
USDTRY 12m Option-implied	72	12.85	10.31	23.15	16.07	2.75	.407	.283	.495	.559
USDTRY 12m Realized	72	16.18	8.55	24.72	15.46	4.50	.881	.283	-.202	.559

Table 3: Correlation analysis for Research question 1

Paired Samples Correlations				
		N	Correlation	Sig.
Pair 1	GBPUSD 1m Option-implied & GBPUSD 1m Realized	72	.952	.000
Pair 2	GBPUSD 3m Option-implied & GBPUSD 3m Realized	72	.930	.000
Pair 3	GBPUSD 12m Option-implied & GBPUSD 12m Realized	72	.832	.000
Pair 4	EURUSD 1m Option-implied & EURUSD 1m Realized	72	.946	.000
Pair 5	EURUSD 3m Option-implied & EURUSD 3m Realized	72	.933	.000
Pair 6	EURUSD 12m Option-implied & EURUSD 12m Realized	72	.794	.000
Pair 7	EURGBP 1m Option-implied & EURGBP 1m Realized	72	.970	.000
Pair 8	EURGBP 3m Option-implied & EURGBP 3m Realized	72	.945	.000
Pair 9	EURGBP 12m Option-implied & EURGBP 12m Realized	72	.864	.000
Pair 10	USDZAR 1m Option-implied & USDZAR 1m Realized	72	.945	.000
Pair 11	USDZAR 3m Option-implied & USDZAR 3m Realized	72	.899	.000
Pair 12	USDZAR 12m Option-implied & USDZAR 12m Realized	72	.819	.000
Pair 13	USDBRL 1m Option-implied & USDBRL 1m Realized	72	.926	.000
Pair 14	USDBRL 3m Option-implied & USDBRL 3m Realized	72	.933	.000
Pair 15	USDBRL 12m Option-implied & USDBRL 12m Realized	72	.723	.000
Pair 16	USDTRY 1m Option-implied & USDTRY 1m Realized	72	.914	.000
Pair 17	USDTRY 3m Option-implied & USDTRY 3m Realized	72	.889	.000
Pair 18	USDTRY 12m Option-implied & USDTRY 12m Realized	72	.728	.000

Table 4: T-test results for Research question 1

Paired Samples Test										
		Paired Differences					t	df	Sig. (2-tailed)	Results
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper				
Pair 1	GBPUSD 1m Option-implied - GBPUSD 1m Realized	.3340	1.3850	.1632	.0085	.6594	2.046	71	.044	Reject the Null Hypothesis
Pair 2	GBPUSD 3m Option-implied - GBPUSD 3m Realized	.2415	1.5964	.1881	-.1336	.6166	1.284	71	.203	Accept the null Hypothesis
Pair 3	GBPUSD 12m Option-implied - GBPUSD 12m Realized	.3049	2.1120	.2489	-.1914	.8011	1.225	71	.225	Accept the null Hypothesis
Pair 4	EURUSD 1m Option-implied - EURUSD 1m Realized	.8875	1.2937	.1525	.5835	1.1915	5.821	71	.000	Reject the Null Hypothesis
Pair 5	EURUSD 3m Option-implied - EURUSD 3m Realized	.9679	1.3290	.1566	.6557	1.2802	6.180	71	.000	Reject the Null Hypothesis
Pair 6	EURUSD 12m Option-implied - EURUSD 12m Realized	.9985	1.9975	.2354	.5291	1.4679	4.242	71	.000	Reject the Null Hypothesis
Pair 7	EURGBP 1m Option-implied - EURGBP 1m Realized	.6304	.9852	.1161	.3988	.8619	5.429	71	.000	Reject the Null Hypothesis
Pair 8	EURGBP 3m Option-implied - EURGBP 3m Realized	.6777	1.2547	.1479	.3829	.9726	4.583	71	.000	Reject the Null Hypothesis
Pair 9	EURGBP 12m Option-implied - EURGBP 12m Realized	.8696	1.8478	.2178	.4354	1.3038	3.993	71	.000	Reject the Null Hypothesis
Pair 10	USDZAR 1m Option-implied - USDZAR 1m Realized	1.2332	2.5725	.3032	.6286	1.8377	4.067	71	.000	Reject the Null Hypothesis
Pair 11	USDZAR 3m Option-implied - USDZAR 3m Realized	.6577	3.3090	.3900	-.1199	1.4353	1.687	71	.096	Accept the null Hypothesis
Pair 12	USDZAR 12m Option-implied - USDZAR 12m Realized	-.1820	3.0149	.3553	-.8905	.5264	-.512	71	.610	Accept the null Hypothesis
Pair 13	USDBRL 1m Option-implied - USDBRL 1m Realized	1.2455	3.8042	.4483	.3515	2.1394	2.778	71	.007	Reject the Null Hypothesis
Pair 14	USDBRL 3m Option-implied - USDBRL 3m Realized	.1613	4.1520	.4893	-.8144	1.1370	.330	71	.743	Accept the null Hypothesis
Pair 15	USDBRL 12m Option-implied - USDBRL 12m Realized	-.4327	4.5956	.5416	-1.5126	.6472	-.799	71	.427	Accept the null Hypothesis
Pair 16	USDTRY 1m Option-implied - USDTRY 1m Realized	.2995	3.4697	.4089	-.5159	1.1148	.732	71	.466	Accept the null Hypothesis
Pair 17	USDTRY 3m Option-implied - USDTRY 3m Realized	.1076	3.8425	.4528	-.7953	1.0106	.238	71	.813	Accept the null Hypothesis
Pair 18	USDTRY 12m Option-implied - USDTRY 12m Realized	.6088	3.1291	.3688	-.1265	1.3441	1.651	71	.103	Accept the null Hypothesis

The Null hypothesis for research question 1 ($(H_0)^{RQ1}$ in chapter 3 stated that option-implied volatility was an efficient predictor of realized volatility across developed and emerging market currencies over the period 2005 to 2010, it hypothesized that the difference between the sample means was zero. To test this hypothesis, the t-test for the mean difference of paired samples was executed and the results in table 4 above where obtained. A more detailed discussion of the results is in chapter 6.

5.1.2 Research Question 2

Research question 2 was looking to compare the forecasting capability of option-implied volatility against realized volatility between currency markets and commodities markets. To represent the currency markets, the following currency pairs were selected, GBPUSD, EURUSD and USDZAR. To represent the commodities markets, the following pairs were selected, XAUUSD, XPTUSD and BRTUSD.

The first section of the results for this research question begins with the descriptive statistics, and then followed by the correlation analysis and lastly the T-test for paired sample means. Below are the results for this research question.

Table 5: Descriptive Statistics for research question 2

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
GBPUSD 1m Option-implied	72	20.503	5.046	25.549	10.332	.523	4.439	19.703	1.628	.283	2.394	.559
GBPUSD 1m Realized	72	23.393	4.748	28.141	9.998	.530	4.499	20.241	2.019	.283	4.382	.559
GBPUSD 3m Option-implied	72	17.108	5.284	22.391	10.396	.481	4.080	16.646	1.295	.283	1.172	.559
GBPUSD 3m Realized	72	19.023	5.180	24.203	10.154	.512	4.342	18.849	1.845	.283	2.935	.559
EURUSD 1m Option-implied	72	18.065	4.894	22.959	10.391	.468	3.971	15.770	1.489	.283	2.323	.559
EURUSD 1m Realized	72	17.524	4.298	21.821	9.504	.423	3.586	12.856	1.711	.283	3.687	.559
EURUSD 3m Option-implied	72	16.550	5.136	21.685	10.536	.436	3.700	13.688	1.156	.283	1.332	.559
EURUSD 3m Realized	72	16.788	4.638	21.426	9.568	.409	3.470	12.041	1.638	.283	3.122	.559
USDZAR 1m Option-implied	72	33.767	11.446	45.214	17.994	.716	6.077	36.929	2.625	.283	8.844	.559
USDZAR 1m Realized	72	46.527	8.801	55.327	16.760	.868	7.364	54.235	3.061	.283	12.700	.559
USDZAR 3m Option-implied	72	22.503	12.646	35.149	17.799	.552	4.682	21.918	1.866	.283	3.885	.559
USDZAR 3m Realized	72	36.970	9.876	46.846	17.141	.802	6.809	46.368	2.659	.283	8.477	.559
XAUUSD 1m Option-implied	72	39.150	11.222	50.372	20.852	.921	7.814	61.055	1.606	.283	3.158	.559
XAUUSD 1m Realized	72	36.111	8.766	44.877	19.201	.902	7.656	58.612	1.372	.283	1.873	.559
XAUUSD 3m Option-implied	72	31.707	11.405	43.112	21.677	.858	7.281	53.013	1.132	.283	1.275	.559
XAUUSD 3m Realized	72	32.178	10.277	42.455	19.481	.847	7.189	51.688	1.321	.283	1.449	.559
XPTUSD 1m Option-implied	60	.574	.176	.750	.323	.016	.126	.016	1.149	.309	1.092	.608
XPTUSD 1m Realized	60	.551	.078	.629	.255	.016	.126	.016	1.211	.309	1.040	.608
XPTUSD 3m Option-implied	60	.441	.189	.630	.346	.014	.105	.011	.723	.309	-.155	.608
XPTUSD 3m Realized	60	.471	.124	.595	.263	.015	.114	.013	1.112	.309	.800	.608
BRTUSD 1m Option-implied	72	.806	.269	1.075	.411	.020	.170	.029	2.301	.283	5.169	.559
BRTUSD 1m Realized	72	.910	.182	1.092	.364	.022	.185	.034	2.402	.283	5.449	.559
BRTUSD 3m Option-implied	72	.563	.260	.823	.372	.014	.121	.015	1.935	.283	3.663	.559
BRTUSD 3m Realized	72	.602	.206	.807	.330	.016	.136	.019	2.165	.283	4.175	.559

The second part of the results is the correlation analysis as tabled in table 6 below.

Table 6: Correlation Analysis for research question 2

Paired Samples Correlations				
		N	Correlation	Sig.
Pair 1	GBPUSD 1m Option-implied & GBPUSD 1m Realized	72	.952	.000
Pair 2	GBPUSD 3m Option-implied & GBPUSD 3m Realized	72	.930	.000
Pair 3	EURUSD 1m Option-implied & EURUSD 1m Realized	72	.946	.000
Pair 4	EURUSD 3m Option-implied & EURUSD 3m Realized	72	.933	.000
Pair 5	USDZAR 1m Option-implied & USDZAR 1m Realized	72	.945	.000
Pair 6	USDZAR 3m Option-implied & USDZAR 3m Realized	72	.899	.000
Pair 7	XAUUSD 1m Option-implied & XAUUSD 1m Realized	72	.939	.000
Pair 8	XAUUSD 3m Option-implied & XAUUSD 3m Realized	72	.917	.000
Pair 9	XPTUSD 1m Option-implied & XPTUSD 1m Realized	60	.546	.000
Pair 10	XPTUSD 3m Option-implied & XPTUSD 3m Realized	60	.610	.000
Pair 11	BRTUSD 1m Option-implied & BRTUSD 1m Realized	72	.963	.000
Pair 12	BRTUSD 3m Option-implied & BRTUSD 3m Realized	72	.938	.000

The correlation analysis above was to examine the strength of the relationship between the forecast variable and the realized variable. The next section of the analysis was the T-test as tabled in table 7.

Table 7: T-test results for research question 2

Paired Samples Test										
		Paired Differences					t	df	Sig. (2-tailed)	Results
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Lower	95% Confidence Upper				
Pair 1	GBPUSD 1m Option-implied - GBPUSD 1m Realized	.3340	1.3850	.1632	.0085	.6594	2.046	71	.044	Reject the Null Hypothesis
Pair 2	GBPUSD 3m Option-implied - GBPUSD 3m Realized	.2415	1.5964	.1881	-.1336	.6166	1.284	71	.203	Accept the null Hypothesis
Pair 3	EURUSD 1m Option-implied - EURUSD 1m Realized	.8875	1.2937	.1525	.5835	1.1915	5.821	71	.000	Reject the Null Hypothesis
Pair 4	EURUSD 3m Option-implied - EURUSD 3m Realized	.9679	1.3290	.1566	.6557	1.2802	6.180	71	.000	Reject the Null Hypothesis
Pair 5	USDZAR 1m Option-implied - USDZAR 1m Realized	1.2332	2.5725	.3032	.6286	1.8377	4.067	71	.000	Reject the Null Hypothesis
Pair 6	USDZAR 3m Option-implied - USDZAR 3m Realized	.6577	3.3090	.3900	-.1199	1.4353	1.687	71	.096	Accept the null Hypothesis
Pair 7	XAUUSD 1m Option-implied - XAUUSD 1m Realized	1.6504	2.7159	.3201	1.0122	2.2886	5.156	71	.000	Reject the Null Hypothesis
Pair 8	XAUUSD 3m Option-implied - XAUUSD 3m Realized	2.1965	2.9480	.3474	1.5037	2.8892	6.322	71	.000	Reject the Null Hypothesis
Pair 9	XPTUSD 1m Option-implied - XPTUSD 1m Realized	.0681	.1199	.0155	.0371	.0990	4.397	59	.000	Reject the Null Hypothesis
Pair 10	XPTUSD 3m Option-implied - XPTUSD 3m Realized	.0830	.0971	.0125	.0579	.1081	6.625	59	.000	Reject the Null Hypothesis
Pair 11	BRTUSD 1m Option-implied - BRTUSD 1m Realized	.0471	.0504	.0059	.0353	.0590	7.941	71	.000	Reject the Null Hypothesis
Pair 12	BRTUSD 3m Option-implied - BRTUSD 3m Realized	.0412	.0478	.0056	.0300	.0524	7.317	71	.000	Reject the Null Hypothesis

The null hypothesis for research question 2 $(H_0)^{RQ2}$ stated that, option-implied volatility has been effective in predicting realized volatility across currency and commodities markets over the period 2005 to 2010. The T-test results above are further discussed in chapter 6 in response to this research question.

5.1.3 Research Question 3

Research question 3 was concerned with comparing the forecasting technique between two time horizons, the short end – represented by the 1 month volatility forecast, and the long end – represented by the 12 month volatility forecast. The currency pairs selected were GBPUSD, EURUSD, and USDZAR. The first section of results was descriptive statistics; followed by the correlation analysis, and then the T-test hypothesis testing. The results are tabled below.

Table 8: Descriptive statistics for research question 3

Descriptive Statistics												
	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
GBPUSD 1m Option-implied	72	20.5033	5.0457	25.5490	10.3318	.5231	4.4389	19.703	1.628	.283	2.394	.559
GBPUSD 1m Realized	72	23.3933	4.7480	28.1413	9.9978	.5302	4.4990	20.241	2.019	.283	4.382	.559
EURUSD 1m Option-implied	72	18.0650	4.8941	22.9591	10.3914	.4680	3.9712	15.770	1.489	.283	2.323	.559
EURUSD 1m Realized	72	17.5237	4.2978	21.8215	9.5039	.4226	3.5855	12.856	1.711	.283	3.687	.559
USDZAR 1m Option-implied	72	33.7673	11.4464	45.2138	17.9936	.7162	6.0770	36.929	2.625	.283	8.844	.559
USDZAR 1m Realized	72	46.5269	8.8006	55.3275	16.7604	.8679	7.3644	54.235	3.061	.283	12.700	.559
GBPUSD 12m Option-implied	72	13.7532	5.8446	19.5978	10.4856	.4299	3.6476	13.305	.882	.283	-.229	.559
GBPUSD 12m Realized	72	12.1060	6.3830	18.4890	10.1808	.4281	3.6327	13.197	1.163	.283	.016	.559
EURUSD 12m Option-implied	72	12.7653	5.7946	18.5599	10.6998	.3803	3.2270	10.413	.604	.283	-.302	.559
EURUSD 12m Realized	72	10.4736	5.7200	16.1935	9.7013	.3461	2.9364	8.622	.934	.283	.059	.559
USDZAR 12m Option-implied	72	14.9490	13.6193	28.5683	17.8917	.4430	3.7589	14.129	1.446	.283	1.714	.559
USDZAR 12m Realized	72	17.0510	12.7370	29.7880	18.0737	.6112	5.1866	26.901	1.377	.283	.524	.559

Table 9: Correlation Analysis for research question 3

Paired Samples Correlations				
		N	Correlation	Sig.
Pair 1	GBPUSD 1m Option-implied & GBPUSD 1m Realized	72	.952	.000
Pair 2	EURUSD 1m Option-implied & EURUSD 1m Realized	72	.946	.000
Pair 3	USDZAR 1m Option-implied & USDZAR 1m Realized	72	.945	.000
Pair 4	GBPUSD 12m Option-implied & GBPUSD 12m Realized	72	.832	.000
Pair 5	EURUSD 12m Option-implied & EURUSD 12m Realized	72	.794	.000
Pair 6	USDZAR 12m Option-implied & USDZAR 12m Realized	72	.819	.000

The null hypothesis for research question 3 ($(H_0)^{RQ3}$) in Chapter 3 stated that, option-implied volatility has been an effective predictor of both short term and long term volatility over the period 2005 to 2010. Using the paired sample T-test on the selected data the following on table 10 results were obtained.

Table 10: T-test results for research question 3

Paired Samples Test										
		Paired Differences					t	df	Sig. (2-tailed)	Results
					Confidence					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper				
Pair 1	GBPUSD 1m Option-implied - GBPUSD 1m Realized	.3340	1.3850	.1632	.0085	.6594	2.046	71	.044	Reject the Null Hypothesis
Pair 2	EURUSD 1m Option-implied - EURUSD 1m Realized	.8875	1.2937	.1525	.5835	1.1915	5.821	71	.000	Reject the Null Hypothesis
Pair 3	USDZAR 1m Option-implied - USDZAR 1m Realized	1.2332	2.5725	.3032	.6286	1.8377	4.067	71	.000	Reject the Null Hypothesis
Pair 4	GBPUSD 12m Option-implied - GBPUSD 12m Realized	.3049	2.1120	.2489	-.1914	.8011	1.225	71	.225	Accept the null Hypothesis
Pair 5	EURUSD 12m Option-implied - EURUSD 12m Realized	.9985	1.9975	.2354	.5291	1.4679	4.242	71	.000	Reject the Null Hypothesis
Pair 6	USDZAR 12m Option-implied - USDZAR 12m Realized	-.1820	3.0149	.3553	-.8905	.5264	-.512	71	.610	Accept the null Hypothesis

5.1.4 Research Question 4

Research question 4 was concerned with assessing the impact of the global economic crisis of 2008/2009 on the forecasting ability of volatility in financial markets. As described in the chapter 4 of the research methodology, the period before the crisis was defined as January 2005 to June 2008 and the period after was defines as July 2008 to December 2010.

As with the other research questions; the results were categorised into descriptive statistics, correlation analysis and T-test analysis. The results are tabled in the following section respectively.

Table 11: Descriptive statistics for research question 4

Descriptive Statistics													
Period		N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
		Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Before the Crisis	EURUSD 3m Option-implied	42	5.523	5.136	10.658	8.130	.222	1.442	2.079	-.502	.365	-.717	.717
	EURUSD 3m Realized	42	5.547	4.638	10.185	7.781	.244	1.583	2.505	-.503	.365	-.966	.717
	USDZAR 3m Option-implied	42	8.607	12.646	21.254	15.904	.346	2.240	5.017	.350	.365	-.691	.717
	USDZAR 3m Realized	42	10.725	10.615	21.340	15.093	.444	2.881	8.297	.081	.365	-1.006	.717
	XAUUSD 3m Option-implied	42	18.379	11.405	29.784	18.702	.786	5.092	25.930	.399	.365	-.750	.717
	XAUUSD 3m Realized	42	19.742	10.277	30.019	17.689	.781	5.064	25.642	.599	.365	-.323	.717
After the crisis	EURUSD 3m Option-implied	30	11.887	9.798	21.685	13.903	.591	3.235	10.464	1.188	.427	.570	.833
	EURUSD 3m Realized	30	13.257	8.169	21.426	12.069	.703	3.852	14.840	1.223	.427	.405	.833
	USDZAR 3m Option-implied	30	21.055	14.094	35.149	20.452	1.066	5.839	34.088	1.131	.427	.530	.833
	USDZAR 3m Realized	30	36.970	9.876	46.846	20.009	1.705	9.338	87.205	1.718	.427	2.536	.833
	XAUUSD 3m Option-implied	30	25.809	17.303	43.112	25.842	1.442	7.898	62.371	1.045	.427	-.240	.833
	XAUUSD 3m Realized	30	30.605	11.850	42.455	21.989	1.624	8.896	79.132	.997	.427	-.267	.833

Table 12: Correlation analysis for research question 4

Paired Samples Correlations				
		N	Correlation	Sig.
Pair 1	EURUSD 3m Option-implied & EURUSD 3m Realized	42	.926	.000
Pair 2	USDZAR 3m Option-implied & USDZAR 3m Realized	42	.874	.000
Pair 3	XAUUSD 3m Option-implied & XAUUSD 3m Realized	42	.901	.000
Pair 4	EURUSD 3m Option-implied & EURUSD 3m Realized	30	.915	.000
Pair 5	USDZAR 3m Option-implied & USDZAR 3m Realized	30	.894	.000
Pair 6	XAUUSD 3m Option-implied & XAUUSD 3m Realized	30	.942	.000

The null hypothesis for research question 4 ($(H_0)^{RQ4}$) in chapter 3 stated that, the effectiveness of option-implied volatility to forecast realized volatility was unaffected by the 2008/2009 global economic crisis. The results from the T-test assessing the hypotheses are tabled below and further discussed in chapter 6.

Table 13: T-test results for research question 4

Paired Samples Test										
		Paired Differences					t	df	Sig. (2-tailed)	Results
		Mean	Std. Deviation	Std. Error Mean	Confidence Interval of the Lower	Upper				
Pair 1	EURUSD 3m Option-implied - EURUSD 3m Realized	.3495	.5982	.0923	.1631	.5359	3.786	41	.000	Reject the Null Hypothesis
Pair 2	USDZAR 3m Option-implied - USDZAR 3m Realized	.8113	1.4268	.2202	.3667	1.2559	3.685	41	.001	Reject the Null Hypothesis
Pair 3	XAUUSD 3m Option-implied - XAUUSD 3m Realized	1.0136	2.2567	.3482	.3103	1.7168	2.911	41	.006	Reject the Null Hypothesis
Pair 4	EURUSD 3m Option-implied - EURUSD 3m Realized	1.8338	1.5775	.2880	1.2447	2.4228	6.367	29	.000	Reject the Null Hypothesis
Pair 5	USDZAR 3m Option-implied - USDZAR 3m Realized	.4427	4.8834	.8916	-1.3808	2.2662	.496	29	.623	Accept the null Hypothesis
Pair 6	XAUUSD 3m Option-implied - XAUUSD 3m Realized	3.8525	3.0354	.5542	2.7191	4.9860	6.952	29	.000	Reject the Null Hypothesis

Chapter 6

Discussion of results

Chapter 6 discusses the research results reported in chapter 5 in more detail, the structure of the discussion was such that the first section was more generic across the research question and dealt with descriptive statistics inline with some of the characteristics of market volatility described in section 2.5. Then the T-test analysis section was structured and discussed around each research question.

6.1 Discussion of descriptive statistics

One of the characteristics of asset returns (volatility) is that they tend to display fat tails and positive kurtosis (Cont, 2005). The research finding in this regards confirms that this is true for most of the sample data as shown in table 14, however with some exceptions such as EURGBP in the 3 months and EURUSD in the 12m. However, in general, the data reflects the positive kurtosis confirming the characteristic.

Another characteristic that appears to be predominant across the sample data is the skew, which is by and large positive for all but one variable; the XPTUSD in the 12 month. This is further evidenced by the histogram comparisons in appendix 1 indicating a positive skew followed by flat tails (Cont, 2005).

Option-implied volatility and realized volatility has been found to be positively correlated as seen in table 15. The strength of the correlation varies from pair to pair and generally significant with the exception of XPTUSD in the 12 month period, the relationship between the forecast variable and realized viable only shows a 3.1% positive correlation while the other pairs show correlation levels above 50%. This is further evidenced by the indexed graphs of the two variables in appendix 2.

Table 14: General Descriptive Statistics across research questions

Descriptive Statistics

	N	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
GBPUSD 1m Option-implied	72	10.332	.523	4.439	19.703	1.628	.283	2.394	.559
GBPUSD 1m Realized	72	9.998	.530	4.499	20.241	2.019	.283	4.382	.559
GBPUSD 3m Option-implied	72	10.396	.481	4.080	16.646	1.295	.283	1.172	.559
GBPUSD 3m Realized	72	10.154	.512	4.342	18.849	1.845	.283	2.935	.559
GBPUSD 12m Option-implied	72	10.486	.430	3.648	13.305	.882	.283	-.229	.559
GBPUSD 12m Realized	72	10.181	.428	3.633	13.197	1.163	.283	.016	.559
EURUSD 1m Option-implied	72	10.391	.468	3.971	15.770	1.489	.283	2.323	.559
EURUSD 1m Realized	72	9.504	.423	3.586	12.856	1.711	.283	3.687	.559
EURUSD 3m Option-implied	72	10.536	.436	3.700	13.688	1.156	.283	1.332	.559
EURUSD 3m Realized	72	9.568	.409	3.470	12.041	1.638	.283	3.122	.559
EURUSD 12m Option-implied	72	10.700	.380	3.227	10.413	.604	.283	-.302	.559
EURUSD 12m Realized	72	9.701	.346	2.936	8.622	.934	.283	.059	.559
EURGBP 1m Option-implied	72	8.156	.474	4.021	16.165	1.405	.283	1.975	.559
EURGBP 1m Realized	72	7.526	.457	3.876	15.024	1.933	.283	4.598	.559
EURGBP 3m Option-implied	72	8.273	.449	3.808	14.501	1.130	.283	1.052	.559
EURGBP 3m Realized	72	7.596	.443	3.762	14.150	1.786	.283	3.520	.559
EURGBP 12m Option-implied	72	8.534	.430	3.649	13.313	.794	.283	-.116	.559
EURGBP 12m Realized	72	7.664	.393	3.335	11.121	.960	.283	-.367	.559
USDZAR 1m Option-implied	72	17.994	.716	6.077	36.929	2.625	.283	8.844	.559
USDZAR 1m Realized	72	16.760	.868	7.364	54.235	3.061	.283	12.700	.559
USDZAR 3m Option-implied	72	17.799	.552	4.682	21.918	1.866	.283	3.885	.559
USDZAR 3m Realized	72	17.141	.802	6.809	46.368	2.659	.283	8.477	.559
USDZAR 12m Option-implied	72	17.892	.443	3.759	14.129	1.446	.283	1.714	.559
USDZAR 12m Realized	72	18.074	.611	5.187	26.901	1.377	.283	.524	.559
USDBRL 1m Option-implied	72	15.991	.880	7.463	55.697	2.812	.283	9.256	.559
USDBRL 1m Realized	72	14.746	1.115	9.465	89.584	3.432	.283	15.551	.559
USDBRL 3m Option-implied	72	15.690	.669	5.676	32.214	2.350	.283	6.531	.559
USDBRL 3m Realized	72	15.528	1.050	8.907	79.333	2.721	.283	8.925	.559
USDBRL 12m Option-implied	72	16.239	.489	4.149	17.215	1.386	.283	2.972	.559
USDBRL 12m Realized	72	16.672	.776	6.588	43.404	1.440	.283	.817	.559
USDTRY 1m Option-implied	72	14.182	.620	5.260	27.672	1.723	.283	3.767	.559
USDTRY 1m Realized	72	13.883	.888	7.539	56.833	2.207	.283	6.082	.559
USDTRY 3m Option-implied	72	14.560	.467	3.961	15.689	1.232	.283	1.751	.559
USDTRY 3m Realized	72	14.452	.814	6.911	47.755	1.724	.283	3.544	.559
USDTRY 12m Option-implied	72	16.073	.324	2.751	7.569	.407	.283	.495	.559
USDTRY 12m Realized	72	15.464	.530	4.497	20.225	.881	.283	-.202	.559
XAUUSD 1m Option-implied	72	20.852	.921	7.814	61.055	1.606	.283	3.158	.559
XAUUSD 1m Realized	72	19.201	.902	7.656	58.612	1.372	.283	1.873	.559
XAUUSD 3m Option-implied	72	21.677	.858	7.281	53.013	1.132	.283	1.275	.559
XAUUSD 3m Realized	72	19.481	.847	7.189	51.688	1.321	.283	1.449	.559
XAUUSD 12m Option-implied	72	23.123	.848	7.199	51.825	.552	.283	.050	.559
XAUUSD 12m Realized	72	19.966	.682	5.787	33.491	.817	.283	-.322	.559
XPTUSD 1m Option-implied	60	.323	.016	.126	.016	1.149	.309	1.092	.608
XPTUSD 1m Realized	60	.255	.016	.126	.016	1.211	.309	1.040	.608
XPTUSD 3m Option-implied	60	.346	.014	.105	.011	.723	.309	-.155	.608
XPTUSD 3m Realized	60	.263	.015	.114	.013	1.112	.309	.800	.608
XPTUSD 12m Option-implied	60	.392	.008	.065	.004	-.124	.309	-.449	.608
XPTUSD 12m Realized	60	.271	.012	.092	.008	.608	.309	-.443	.608
BRTUSD 1m Option-implied	72	.411	.020	.170	.029	2.301	.283	5.169	.559
BRTUSD 1m Realized	72	.364	.022	.185	.034	2.402	.283	5.449	.559
BRTUSD 3m Option-implied	72	.372	.014	.121	.015	1.935	.283	3.663	.559
EURGBP 3m Realized	72	.330	.016	.136	.019	2.165	.283	4.175	.559
BRTUSD 12m Option-implied	72	.316	.008	.071	.005	1.087	.283	1.085	.559
BRTUSD 12m Realized	72	.286	.011	.091	.008	1.383	.283	.526	.559

Table 15: Correlation matrix between the forecast and realized variable

Paired Samples Correlations				
		N	Correlation	Sig.
Pair 1	GBPUSD 1m Option-implied & GBPUSD 1m Realized	72	.952	.000
Pair 2	GBPUSD 3m Option-implied & GBPUSD 3m Realized	72	.930	.000
Pair 3	GBPUSD 12m Option-implied & GBPUSD 12m Realized	72	.832	.000
Pair 4	EURUSD 1m Option-implied & EURUSD 1m Realized	72	.946	.000
Pair 5	EURUSD 3m Option-implied & EURUSD 3m Realized	72	.933	.000
Pair 6	EURUSD 12m Option-implied & EURUSD 12m Realized	72	.794	.000
Pair 7	EURGBP 1m Option-implied & EURGBP 1m Realized	72	.970	.000
Pair 8	EURGBP 3m Option-implied & EURGBP 3m Realized	72	.945	.000
Pair 9	EURGBP 12m Option-implied & EURGBP 12m Realized	72	.864	.000
Pair 10	USDZAR 1m Option-implied & USDZAR 1m Realized	72	.945	.000
Pair 11	USDZAR 3m Option-implied & USDZAR 3m Realized	72	.899	.000
Pair 12	USDZAR 12m Option-implied & USDZAR 12m Realized	72	.819	.000
Pair 13	USDBRL 1m Option-implied & USDBRL 1m Realized	72	.926	.000
Pair 14	USDBRL 3m Option-implied & USDBRL 3m Realized	72	.933	.000
Pair 15	USDBRL 12m Option-implied & USDBRL 12m Realized	72	.723	.000
Pair 16	USDTRY 1m Option-implied & USDTRY 1m Realized	72	.914	.000
Pair 17	USDTRY 3m Option-implied & USDTRY 3m Realized	72	.889	.000
Pair 18	USDTRY 12m Option-implied & USDTRY 12m Realized	72	.728	.000
Pair 19	XAUUSD 1m Option-implied & XAUUSD 1m Realized	72	.939	.000
Pair 20	XAUUSD 3m Option-implied & XAUUSD 3m Realized	72	.917	.000
Pair 21	XAUUSD 12m Option-implied & XAUUSD 12m Realized	72	.768	.000
Pair 22	XPTUSD 1m Option-implied & XPTUSD 1m Realized	60	.546	.000
Pair 23	XPTUSD 3m Option-implied & XPTUSD 3m Realized	60	.610	.000
Pair 24	XPTUSD 12m Option-implied & XPTUSD 12m Realized	60	.031	.813
Pair 25	BRTUSD 1m Option-implied & BRTUSD 1m Realized	72	.963	.000
Pair 26	BRTUSD 3m Option-implied & EURGBP 3m Realized	72	.938	.000
Pair 27	BRTUSD 12m Option-implied & BRTUSD 12m Realized	72	.830	.000

6.2 T-test results for each research question

The research approach adopted to assess the success of forecasting volatility across markets made use of the T-test for paired samples, in this test, the sample means of both the forecast and realized variable were compared and the difference between then was tested for statistical significance. The following section discusses the findings of the tests and the assumptions made to reach the conclusion for each research question.

6.2.1 T-test findings for research question 1

The research showed that when comparing the forecasting technique between developed and emerging market currencies, it was more successful in forecasting volatility in emerging market than developed markets. The difference between sample means in developed markets proved to be statistically significant than in the emerging markets as shown in table 4 of chapter 5. Of the nine currency pairs representing developed markets, only two pairs showed that there was no significant difference in the sample means; namely 3 month GBPUSD and the 12 month GBPUSD pairs. This represents a 22.2% forecasting success rate in developed markets. While the forecasting success rate in emerging markets was found to be at 77.7%, with only two areas where the mean difference was found to be statistically different, namely the 1 month USDZAR and the 1 month USDBRL periods.

Conclusion

Even though the correlation between the variables was found to be positive and statistically significant across both developed and emerging markets, and given the research limitations, the market is only successful in forecasting volatility in emerging markets using the implied volatility technique. One of the potential reasons is that the volatility in the developed markets is driven by market sentiments and the global political landscape, while the volatility in emerging markets is driven by what actually transpires in the developed markets. This somehow sets the direction of the emerging markets, as such making it more successful to forecast the market volatility.

6.2.2 Findings for research question 2

The mean difference between the forecast variable and the realized variable in commodities market was found to be statistically significant for all selected pairs, which meant that the forecasting technique was found to be poor in commodities markets. However, the results in currency markets were mixed, in that they showed a 33.3% success rate in forecasting volatility. Only the 3 month GBPUSD and the 3 month USDZAR pairs proved to be successful in forecasting.

Conclusion

The result from the correlation also showed positive and significant relationships between the forecast and realized variables as shown in table 6, however from the T-test, the forecasting technique has been found to be less successful in commodities markets compared to currency markets. Commodities have been regarded as an investment safe haven in tough economic times, thus as the market seeks this investment safe haven, the volatility spikes as the trading volume increases; which is one of the characteristics described in chapter 2 (Cont, 2005). Forecasting in commodities markets is largely affected by this market behaviour in that, the option-implied volatility forecasting models cannot fully price-in the possible market spikes that impact the volatility.

6.2.3 Findings for research question 3

The third research question sort to establish the success of option-implied volatility in forecasting realized volatility in both short-term and long term as defined in chapter 4. The findings in table 10 of chapter 5 show that the mean differences in the sample pairs representing the short-term are statistically significant. Which means the null hypotheses of equal means between the forecast and realized variable, are rejected.

The findings for long-term forecasting had a 66.7% success rate in forecasting market volatility, only the 12 month EURUSD pair showed

statistically significant differences in the means and thus the hypothesis was rejected for this forecast horizon.

Conclusion

From the results and in the context of this research' limitations, the model of option-implied volatility forecasting has a better success rate in forecasting long-term market volatility when compared to the short-term. Short-term volatility is influenced by many factors, one which is the option gamma trading in the short end, when options are at the money and very close to maturity, traders often trade their underlying market position more frequently to reduce their market risk exposure, this results in increased market volatility (Hull, 2006). This increase in volatility directly impacts the final realized volatility average over the same horizon.

6.2.4 Findings for research question 4

From correlation matrix, the relationships between the variables were positive and very significant before the economic crisis and after. And the T-test results showed that the mean differences between the variables are statistically significant for the period before and after the crisis, apart from one; the 3 month USDZAR forecast which showed an improvement in forecasting the volatility for this currency pair.

Conclusion

The analysis for this research question was confined within the boundaries of the currency pairs selected, thus the conclusion was also confined as such. From the analysis, volatility forecasting was still an illusive exercise for market practitioners before and after the crisis because the results only show a slight improvement in one area. However from a statistical point of view, the difference in sample means between option-implied volatility and realized volatility was significant, leading to the conclusion that the forecasting method has not been effective before and after the global financial crisis.

6.3 General Conclusion

From the analysis across all research questions, there was strong correlation evidence between option-implied volatility and realized volatility; this was further evidenced by the indexed graphs on appendix 2. The T-test results however showed mixed results with a large portion rejecting the null hypothesis of statistically insignificant mean differences. However, this research was based on the assumption that the success of this forecasting technique was dependent on the mean difference between the variables and the conclusions drawn from it were confined to this assumption.

Chapter 7

7.1 Introduction

This concluding chapter highlights some of the research findings in-light of the literature review and also clusters each discussion around the research questions. The first section is a general discussion pooling together the research findings and some of the literature review in chapter 2.

7.2 Volatility in derivative markets

The development of derivative markets was as a result of financial risk mitigation efforts by market practitioners. In the advent of globalization and an increase in international trade, organisations began trading beyond their borders looking for opportunities in other countries (Hutson & Stevenson, 2010).

Derivative instruments span across all financial markets, from currencies to commodities (Hull, 2006). These instruments, just like any other financial market instrument require pricing, particularly options. However, pricing models such as the Black and Scholes require input variables one of which is volatility (or asset return). There are a few challenges of using volatility in pricing derivative instruments; some models assume that volatility remains constant over the pricing horizon. However, the biggest huddle in pricing is the fact that volatility is a forecast variable, and a host of forecasting techniques exist in literature with different arguments around the success of each. This research was particularly interested in the success of the market practise of using option-implied volatility to forecast realized volatility.

In pricing options across different financial derivative products, the market practitioners use option-implied volatility, which assumes an option price by taking into account recent market information; and works back to get the option price using models such as the Black and Scholes option pricing model. However, there are other volatility forecasting techniques such as the GARCH 1.1 and methods based on historical data observation, the success of which varies according to literature; some literature advocates for historical data methods while others advocate for techniques that take into account recent market information such as the option-implied volatility forecasting method. Literature argues that market volatility depends on a vast number of inputs and that there is no unifying theory defining a single measure of volatility used in pricing options (Lewis, Eschenbach, & Hartman, 2008).

Recent market volatility and the 2008/9 financial crisis have had great impact on the financial performance of many organizations, particularly those exposed to foreign currencies and foreign investments. As the market volatility increases, market uncertainty increases and investors pull their funds from “riskier” assets which results in a further increase in market volatility. The concept of volatility smiles came from this market behaviour in that, in turmoil times, volatility spikes. Forecasting volatility for pricing financial instruments has since become important to traders and treasury managers in attempt to reduce their market risks. However, the findings in this research have shown that even though forecasting methods have been developed over the years, market volatility continues to be very difficult to forecast, partly because it is subject to market sentiment, recent information and is influenced by the political environment.

7.3 Concluding remarks and recommendations

The following section will briefly give remarks for each research question and some recommendations for managers as well as market practitioners.

7.3.1 Volatility forecasting in developed and emerging markets

The findings for this research question showed that the forecasting technique was generally poor for developed markets when compared to emerging markets. This could be indicating that the market information flowing from developed markets, to some extent set direction to their emerging market counterparts thus making option prices assumed in working back the implied volatility more market related. The correlation between the variables was also confirmed to be positive and significant for most pairs.

However, the student T-test showed that there was statistically significant difference between the variables' sample means, which lead to the conclusion that the market practice of using option-implied volatility forecasting has not been an effective method across both developed and emerging markets.

7.3.2 Volatility forecasting currency and commodity markets

Forecasting market volatility using the option implied volatility method in the commodities markets was found to be very poor across all sample means. The findings however showed a 33% success rate in forecasting currency market volatility.

As stated in chapter 6, the volatility underlying commodity prices has been largely driven by, among other factors, demand and supply, as well as the sentiments in the investment community. Gold for example has been regarded as an investment safe haven in tough economic times. Other facts include the global political environment regarding natural resources. Oil prices on the other hand are also subject to demand and supply, decisions made by OPEG countries regarding supply and the investment community. Thus, option prices assumed in forecasting volatility cannot possibly contain all relevant information that could influence the price, rendering the method ineffective in forecasting volatility.

7.3.3 Volatility forecasting of short and long-term horizons

The findings for the third research question showed that the forecasting technique performed poorly in the short-term, but had a 67% success rate in forecasting volatility in the long-term horizon. The part of the reason why short-term volatility forecasting has been unsuccessful has been attributed to the fact that short-term option prices are subject to high delta and gamma trading; when options are closer to maturity and at-the money, traders often trade their underlying position resulting from

the sensitivity of the option prices to the spot market. This increased trading activity increases short-term volatility. Long-term option prices are less sensitive to the underlying spot prices and are relatively stable over the horizon.

7.3.4 Volatility forecasting before and after the crisis

Findings for this research question showed that the forecasting technique performed poorly before and after the global economic crisis. Even though the correlation between the forecast and realized variables was strong for both time horizons; however the mean difference between the samples was statistically significant according to the T-tests.

7.4 Recommendations

The general research finding across all research questions showed that the method of using option-implied volatility to forecast realized volatility has not been effective, though some results showed some level of success for some of the sample means. Volatility has been characterised by literature as following Brownian motion of random variables (Hull, 2006) and (Andersen et al., 2005). Forecasting this variable has proven difficult over time, many different techniques have been developed and much research still needs to be done particularly in comparing these techniques against realized volatility. However, the market continues to prefer using the option-implied volatility as it is thought to contain most of the market information relevant in the assumed option price and thus captures a picture which is closer to market conditions (Cont, 2005).

When using derivative products, managers and other market participants should consider the following:

- The use of derivative instruments requires careful monitoring and valuation of all hedge positions to ensure that cash flows are within the organisations limits and policies.
- The development of hedging policies has to be inline with the general strategy of shareholders.
- Reporting of all hedging activity has to be governed by the prevailing corporate governance rules and regulations.
- Managers have to be aware that volatility is subject to market variations and any other information that could influence the underlying prices of assets; adjustments to the hedge books need to be made to compensate for market movements that could impact the organisations financial health; running and reporting on daily mark-to-market positions should form part of corporate governance.

7.5 Research limitations

Research limitations outlined below set the boundaries for the findings contained in this research report and the conclusions thereof. These limitations also provide other areas of possible further research around the topic of volatility forecasting.

- There are many financial instruments in the market which make use of volatility forecasting, the data set used in this research report only represents the data selected and does not necessarily represent all the market dynamics.
- This research was only concerned with comparing the current market practise of using option-implied volatility to forecast realized volatility, it does not go further to discuss assumptions made by market practitioners in arriving at an option price nor does it discuss the information contained in the price.
- The research only ran the T-test to check the statistical significance of the difference between the sample means and assumed that the results thereof were sufficient to conclude upon. Furthermore, the report did not go further to discuss any other statistical approach that could have been applied to test the success of the forecasting technique.

7.6 Further research

Given the research limitations, other possible areas of further research include:

- Comparing various volatility forecasting techniques against each other.
- Using different statistical approaches to test the hypothesis on the mean difference between the forecast and realized variables.
- The data set used in this report was monthly averages; a different approach could be to use daily data.
- A qualitative study on the information contained in the assumed option prices when forecasting volatility.
- A quantitative-causal study of the relationship between the forecast variable and the realized variable.

7.7 Concluding Remarks

The use of financial derivative instruments plays a pivotal role in the development of risk mitigation techniques; however market practitioners must continue to exercise caution when using these instruments as the have devastating effects when used inappropriately. There have been a number of cases whereby organizations lost everything due to hedging with options. Volatility remains a critical unknown in the derivatives market and more forecasting techniques will continue to emerge in the effort to perfect its forecasting.

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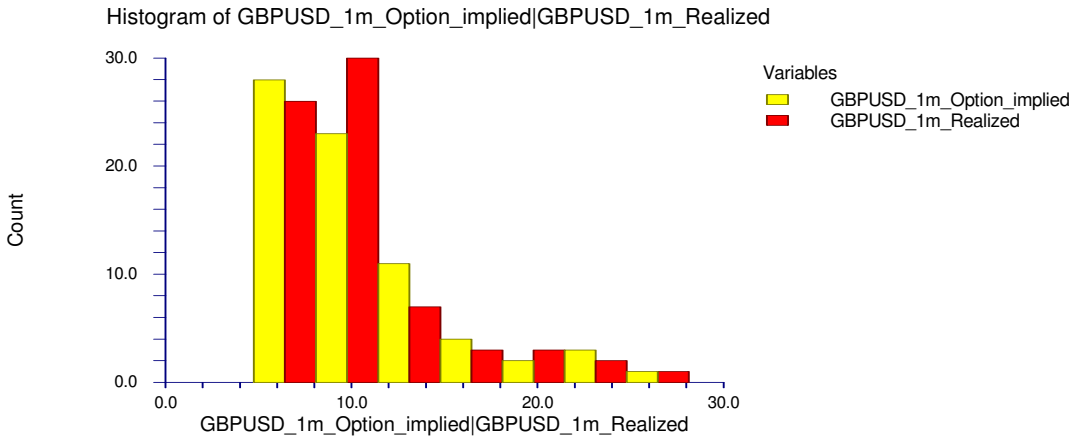
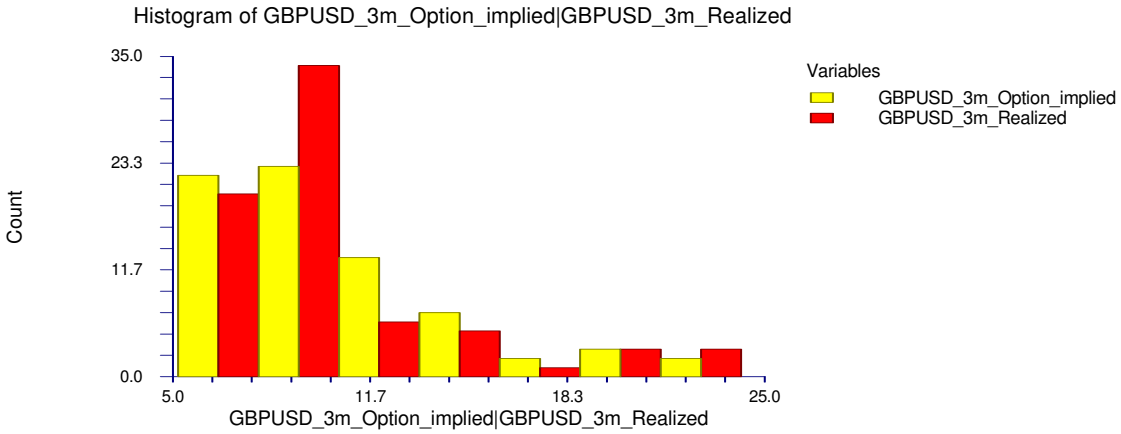
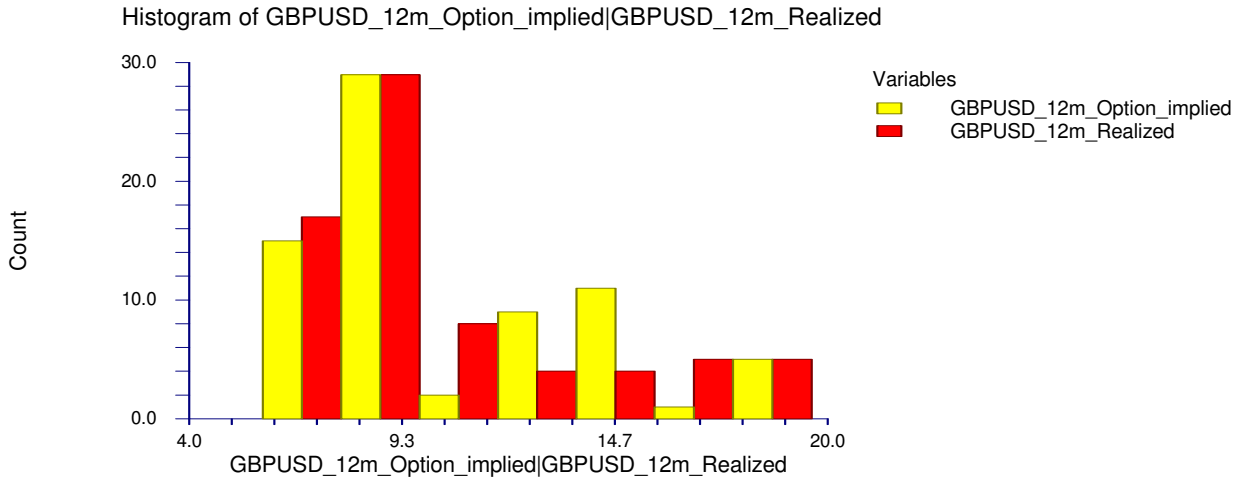
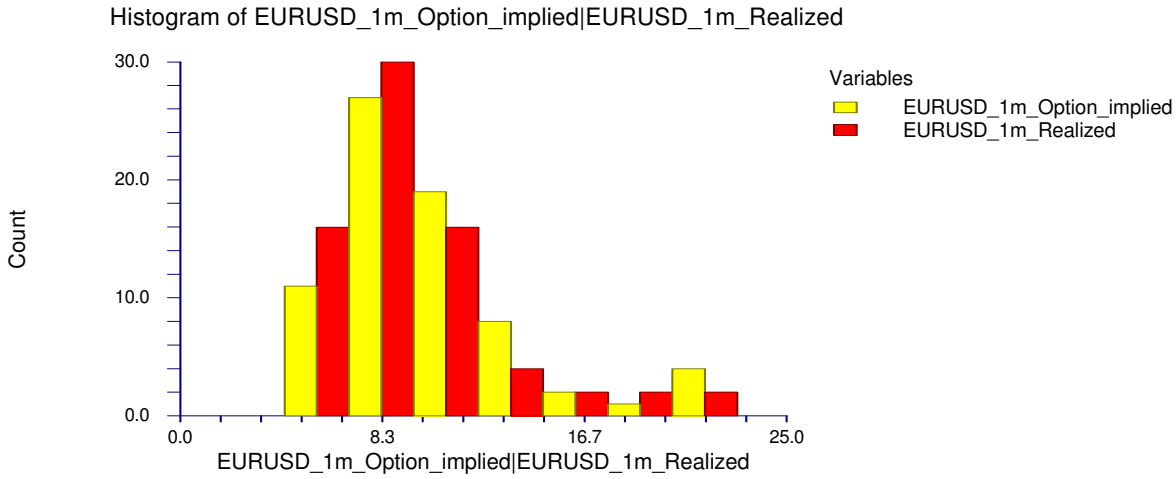
Appendix 1: Histogram comparison of the sample data





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0.0
8.3
16.7
25.0
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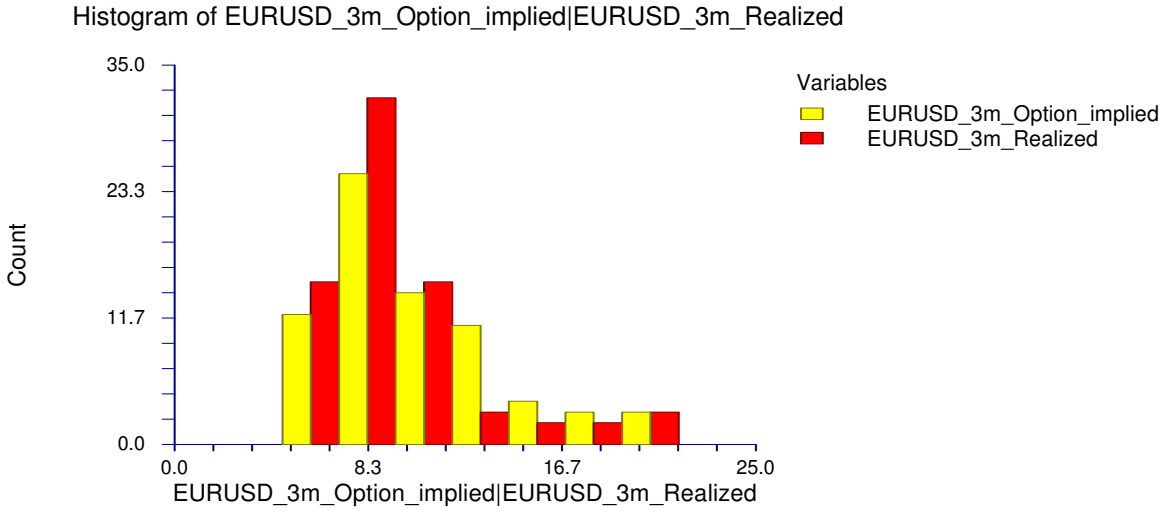
EURUSD_1m_Option_implied
EURUSD_1m_Realized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8.3
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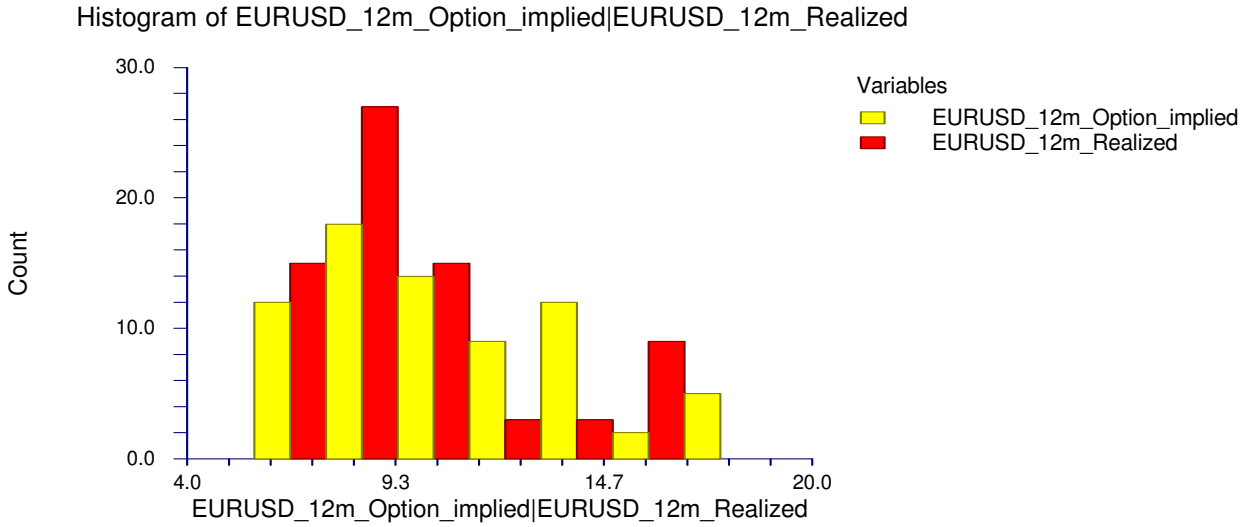
EURUSD_3m_Realized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9.3
14.7
20.0
EURUSD_12m_Option_implied|EURUSD_12m_Realized
Variables
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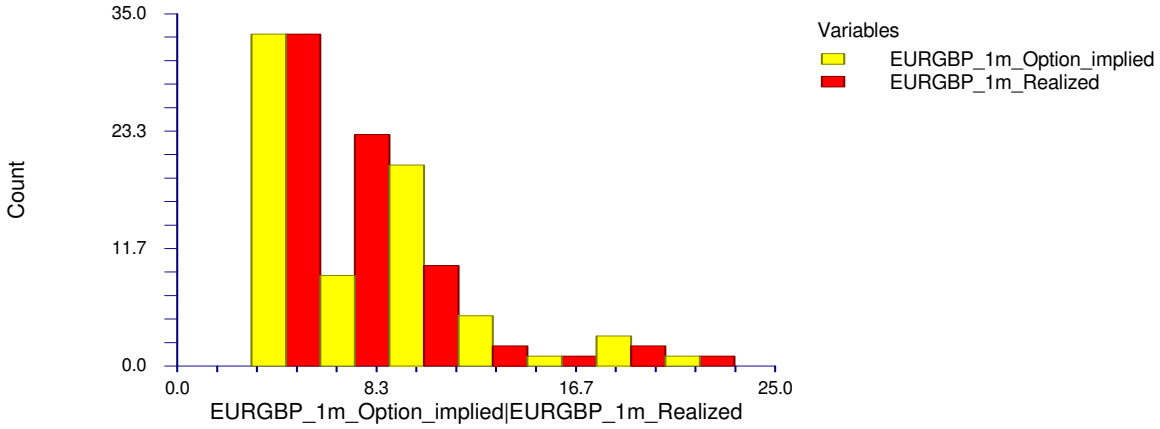
EURUSD_12m_Realized

Histogram of EURGBP_1m_Option_implied|EURGBP_1m_Realized



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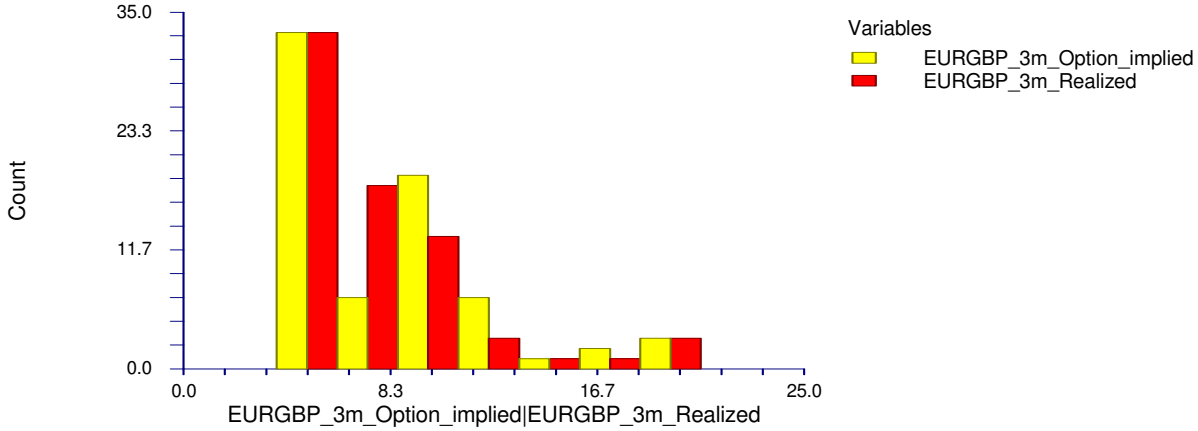

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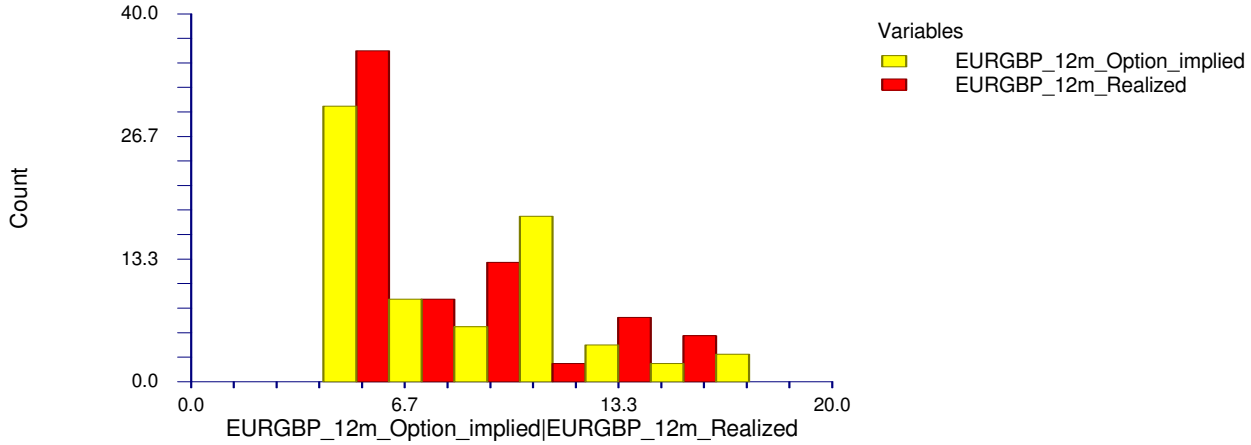

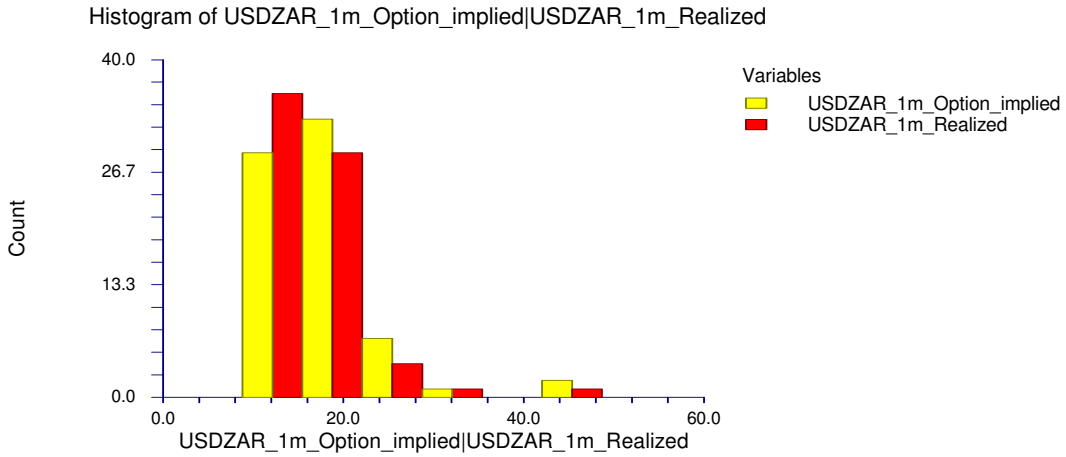
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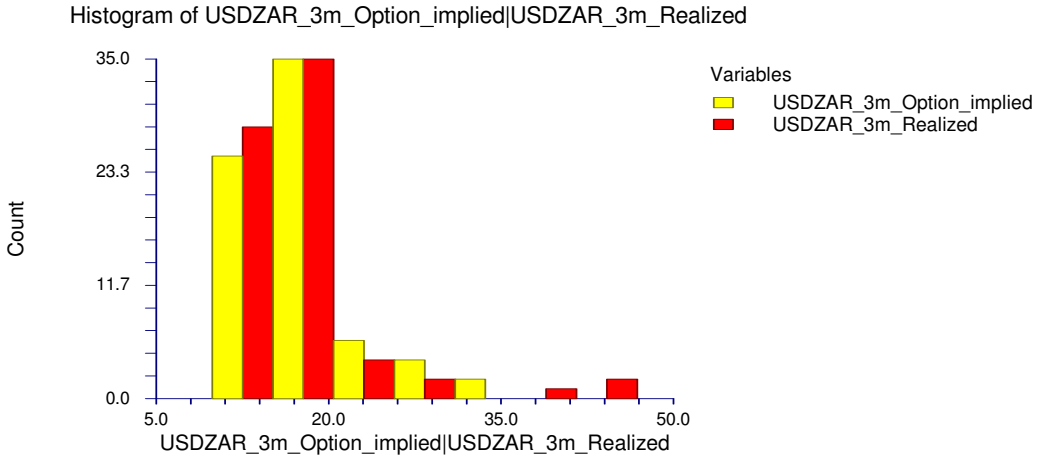
USDZAR_1m_Realized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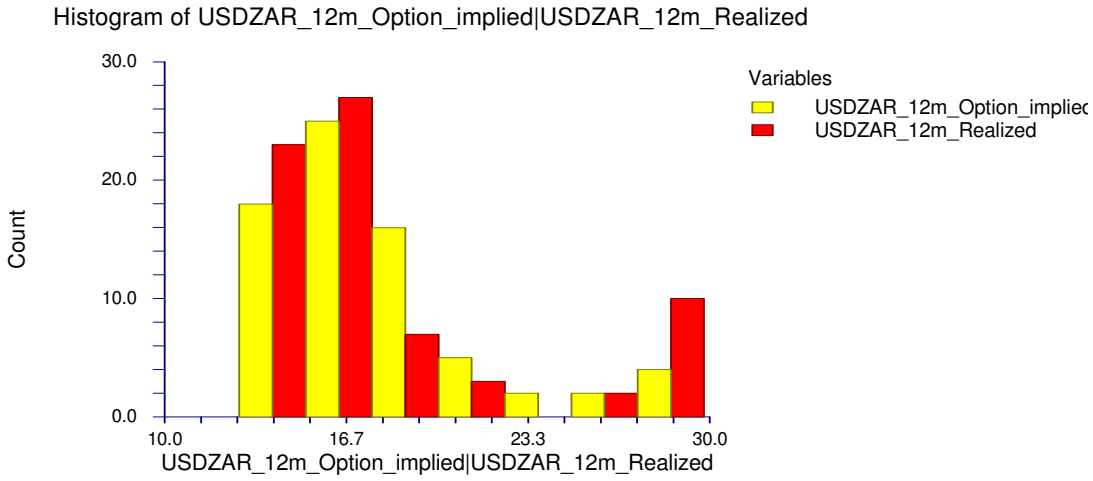
USDZAR_3m_Realized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Variables
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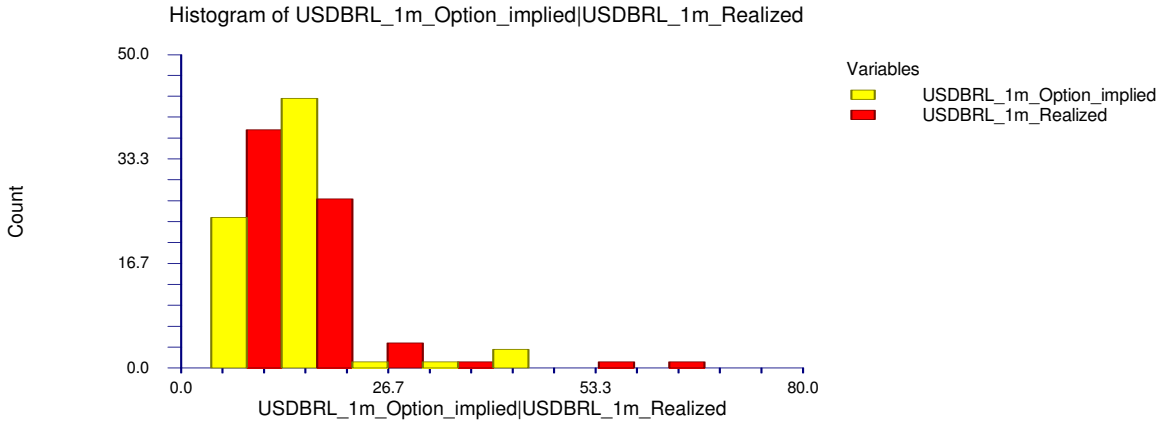
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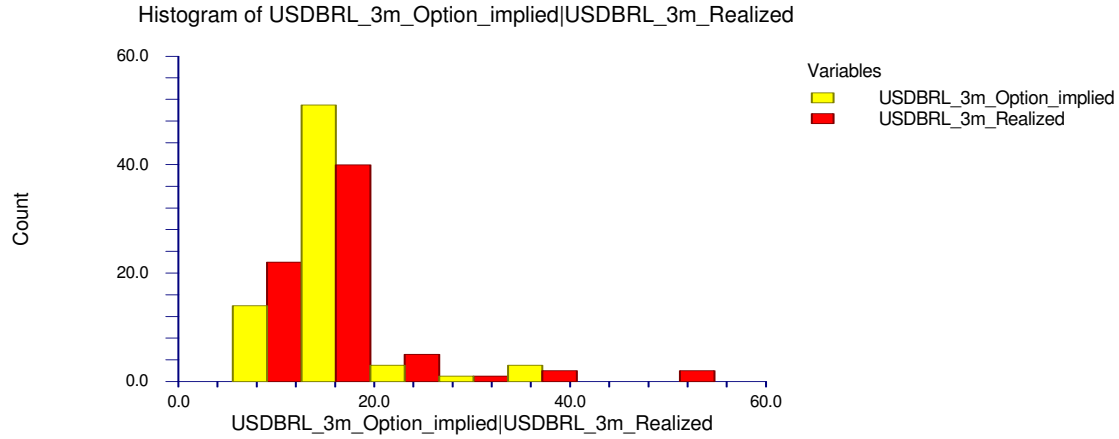
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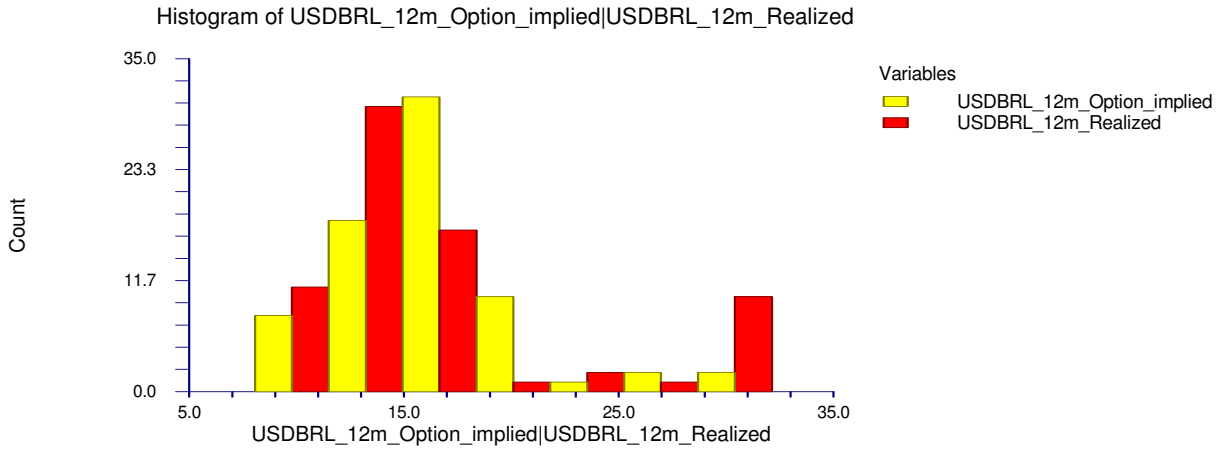
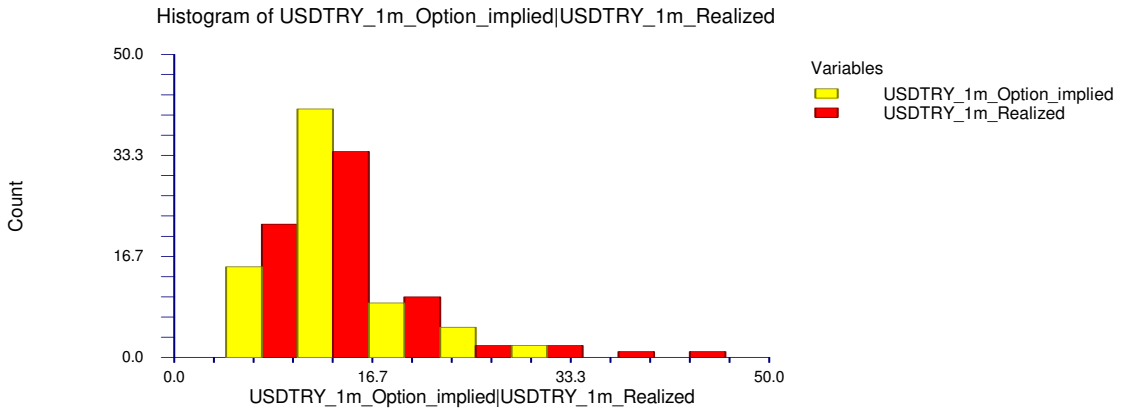
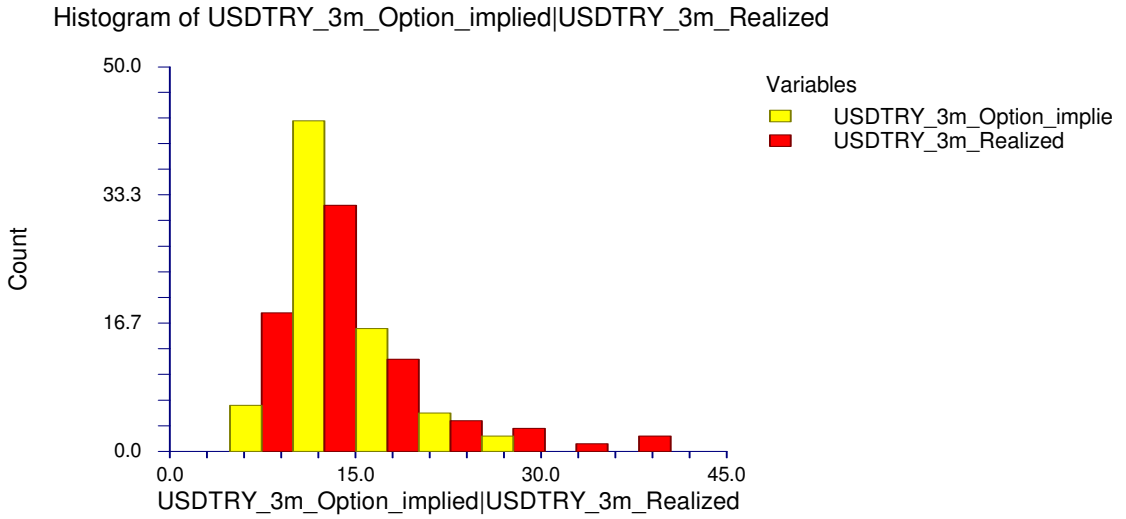
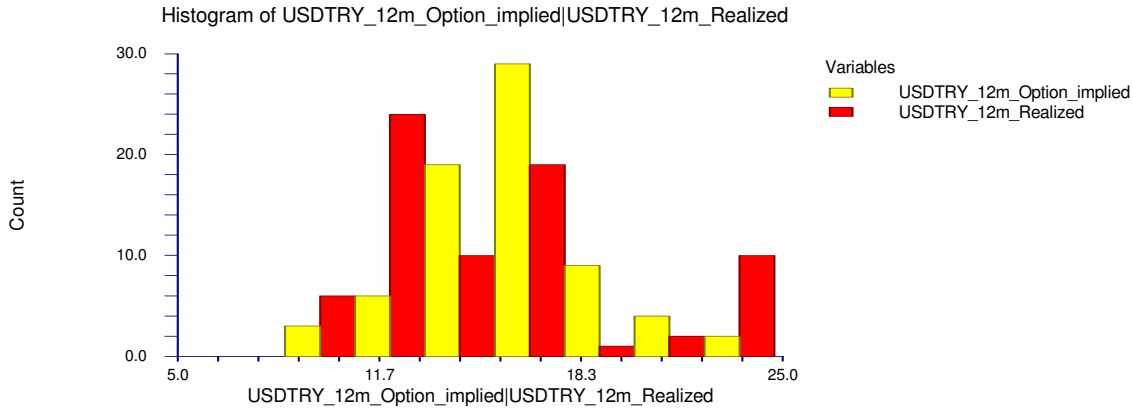
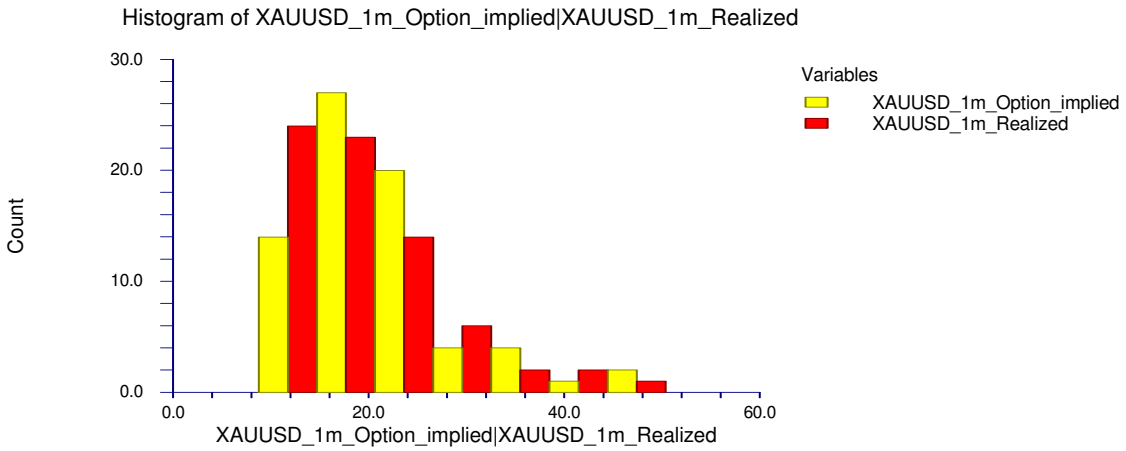
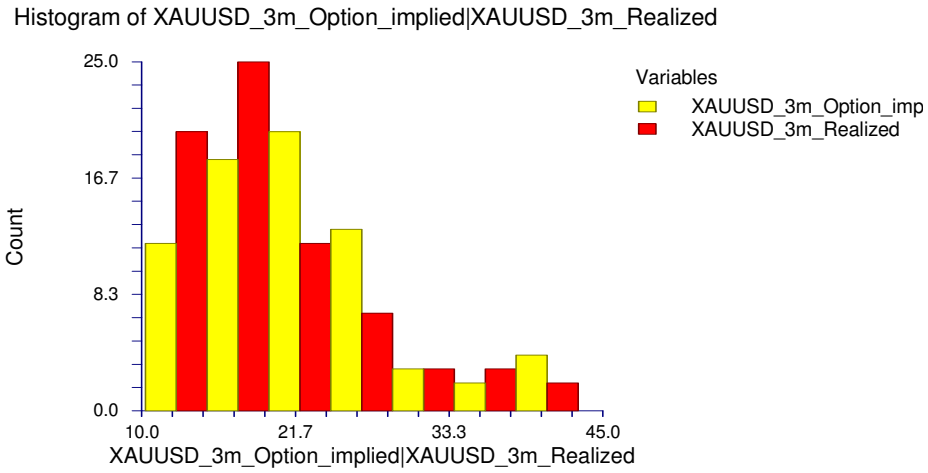

Histogram of USDBRL_12m_Option_implied|USDBRL_12m_Realized
Count
35.0
23.3
11.7
0.0
5.0
15.0
25.0
35.0
USDBRL_12m_Option_implied|USDBRL_12m_Realized
Variables
USDBRL_12m_Option_implied
USDBRL_12m_Realized

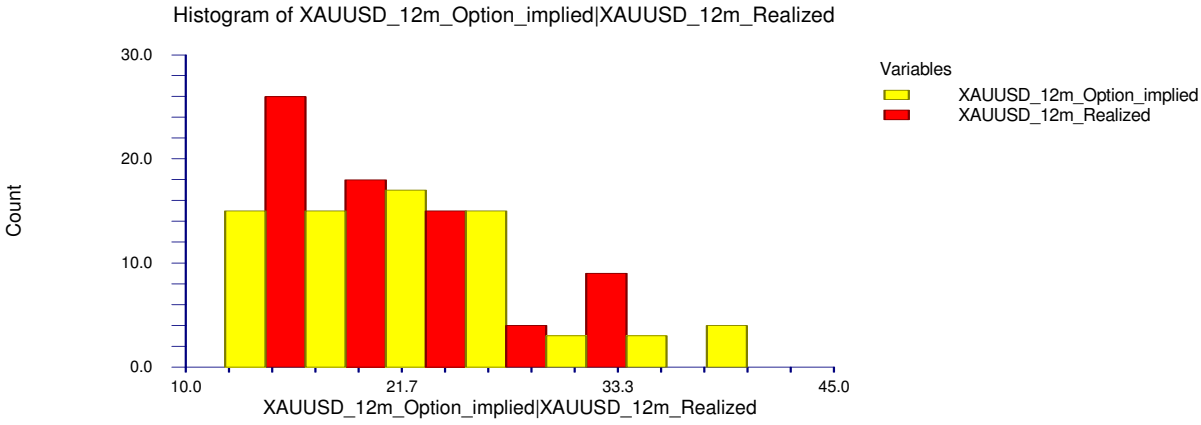

Histogram of USDTRY_1m_Option_implied|USDTRY_1m_Realized
Count
50.0
33.3
16.7
0.0
0.0
16.7
33.3
50.0
USDTRY_1m_Option_implied|USDTRY_1m_Realized
Variables
USDTRY_1m_Option_implied
USDTRY_1m_Realized

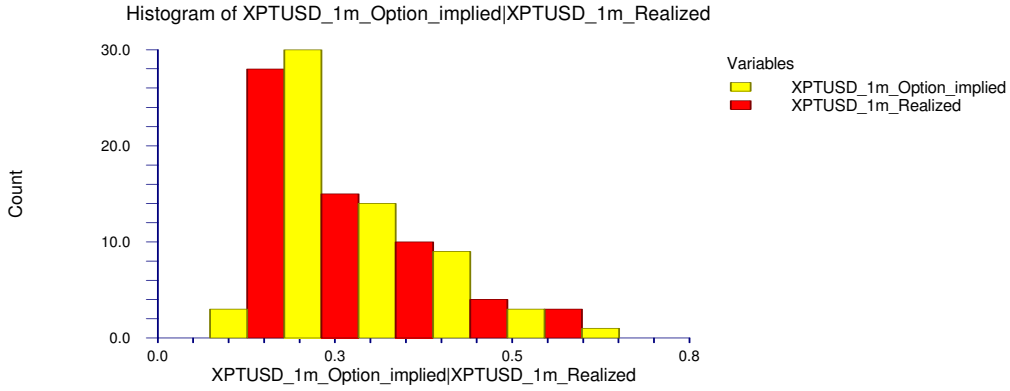

Histogram of USDTRY_3m_Option_implied|USDTRY_3m_Realized
Count
50.0
33.3
16.7
0.0
0.0
15.0
30.0
45.0
USDTRY_3m_Option_implied|USDTRY_3m_Realized
Variables
USDTRY_3m_Option_implie
USDTRY_3m_Realized

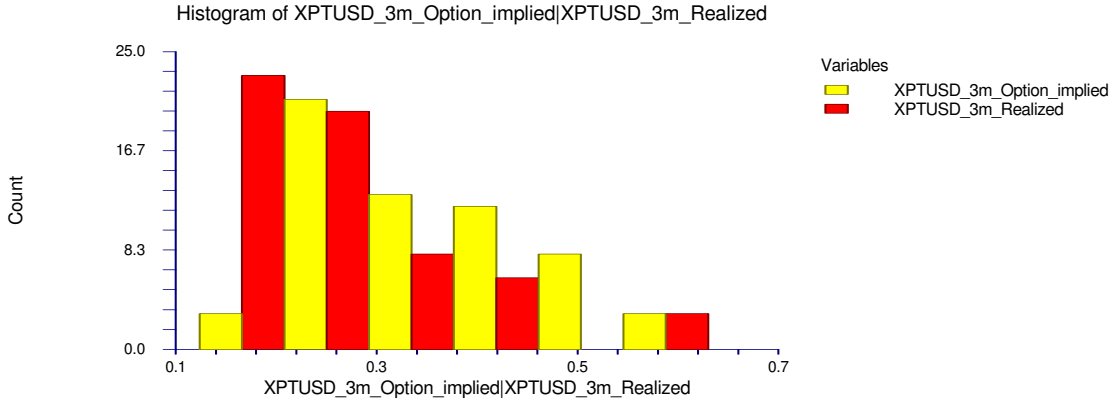

Histogram of USDTRY_12m_Option_implied|USDTRY_12m_Realized
Count
30.0
20.0
10.0
0.0
5.0
11.7
18.3
25.0
USDTRY_12m_Option_implied|USDTRY_12m_Realized
Variables
USDTRY_12m_Option_implied
USDTRY_12m_Realized

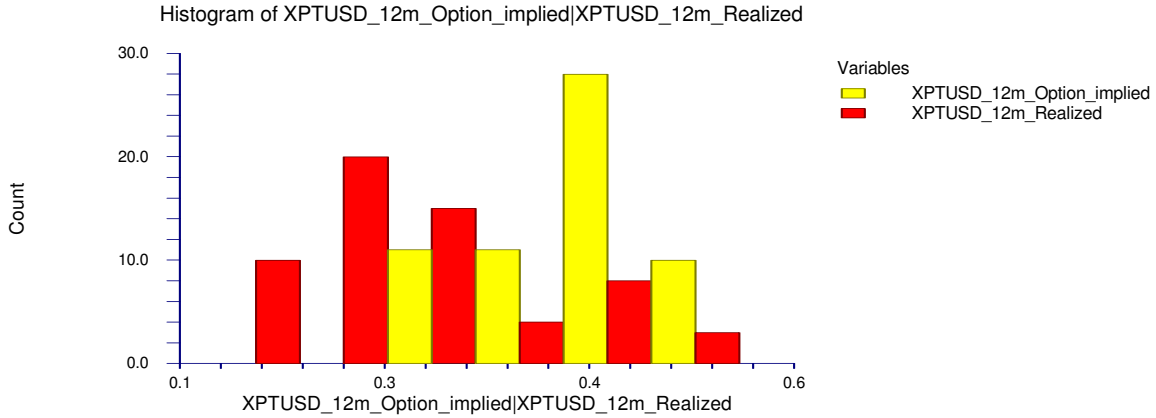

Histogram of XAUUSD_1m_Option_implied|XAUUSD_1m_Realized
Count
30.0
20.0
10.0
0.0
0.0
20.0
40.0
60.0
XAUUSD_1m_Option_implied|XAUUSD_1m_Realized
Variables
XAUUSD_1m_Option_implied
XAUUSD_1m_Realized

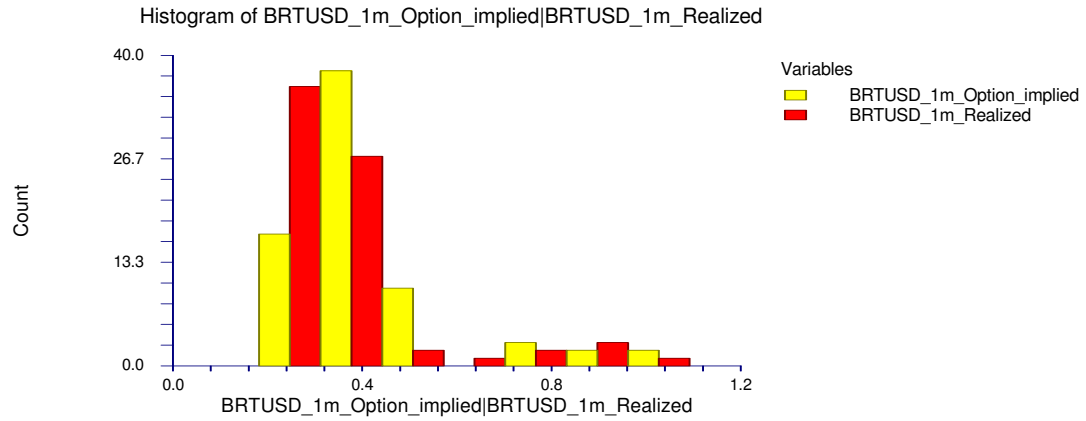

Histogram of XAUUSD_3m_Option_implied|XAUUSD_3m_Realized
Count
25.0
16.7
8.3
0.0
10.0
21.7
33.3
45.0
XAUUSD_3m_Option_implied|XAUUSD_3m_Realized
Variables
XAUUSD_3m_Option_imp
XAUUSD_3m_Realized

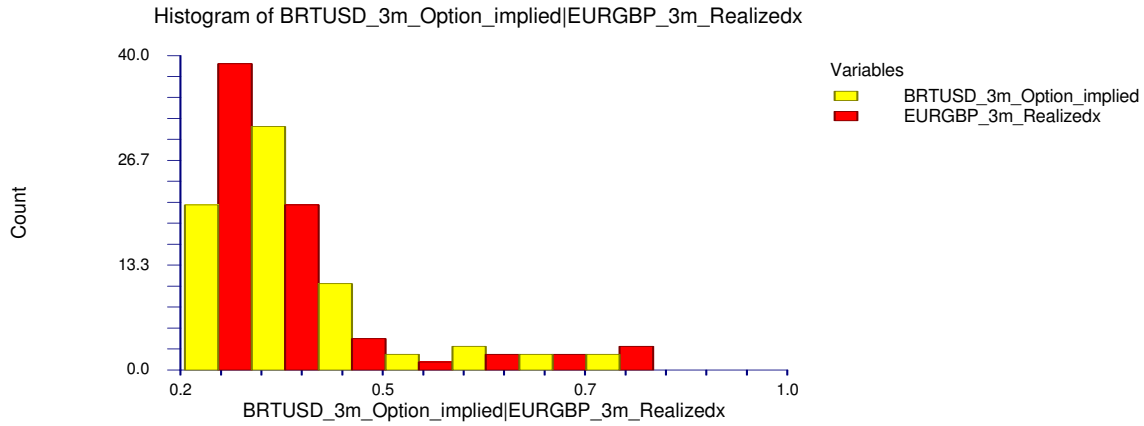

Histogram of XAUUSD_12m_Option_implied|XAUUSD_12m_Realized
Count
30.0
20.0
10.0
0.0
10.0
21.7
33.3
45.0
XAUUSD_12m_Option_implied|XAUUSD_12m_Realized
Variables
XAUUSD_12m_Option_implied
XAUUSD_12m_Realized

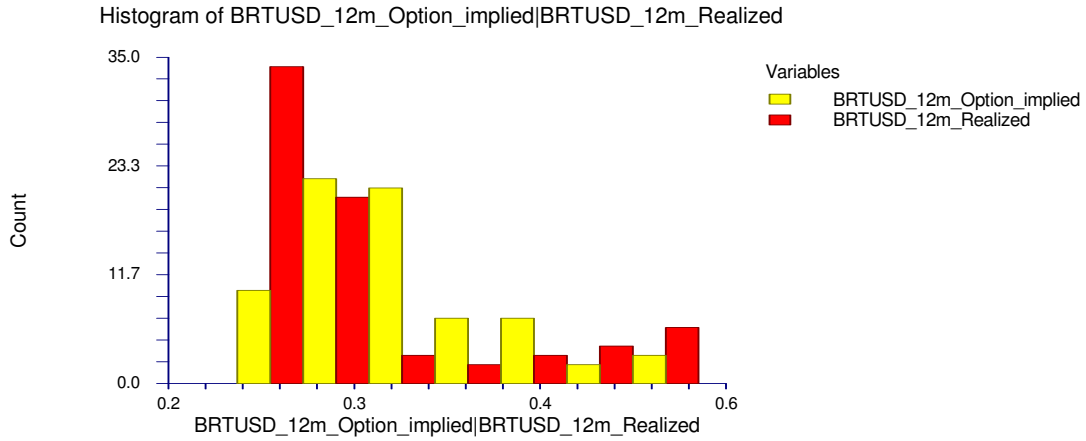

Histogram of XPTUSD_1m_Option_implied|XPTUSD_1m_Realized
Count
30.0
20.0
10.0
0.0
0.0
0.3
0.5
0.8
XPTUSD_1m_Option_implied|XPTUSD_1m_Realized
Variables
XPTUSD_1m_Option_implied
XPTUSD_1m_Realized


Histogram of XPTUSD_3m_Option_implied|XPTUSD_3m_Realized
Count
25.0
16.7
8.3
0.0
0.1
0.3
0.5
0.7
XPTUSD_3m_Option_implied|XPTUSD_3m_Realized
Variables
XPTUSD_3m_Option_implied
XPTUSD_3m_Realized

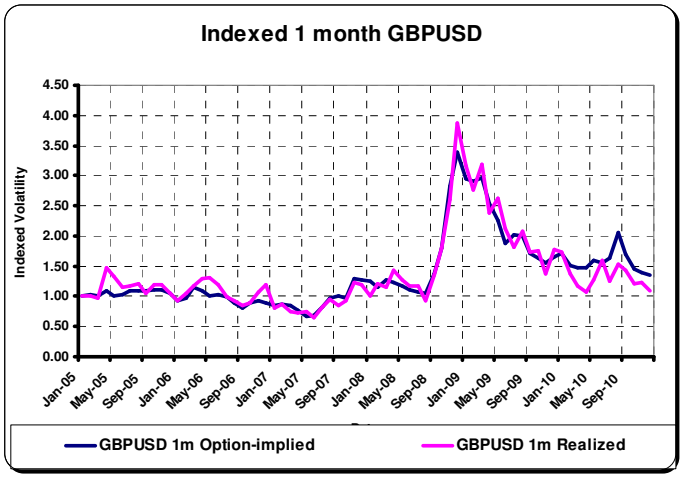

Histogram of XPTUSD_12m_Option_implied|XPTUSD_12m_Realized
Count
30.0
20.0
10.0
0.0
0.1
0.3
0.4
0.6
XPTUSD_12m_Option_implied|XPTUSD_12m_Realized
Variables
XPTUSD_12m_Option_implied
XPTUSD_12m_Realized

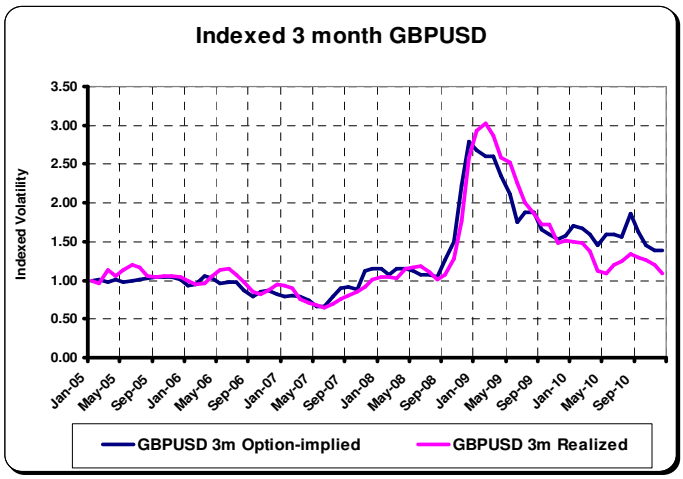

Histogram of BRTUSD_1m_Option_implied|BRTUSD_1m_Realized
Count
40.0
26.7
13.3
0.0
0.0
0.4
0.8
1.2
BRTUSD_1m_Option_implied|BRTUSD_1m_Realized
Variables
BRTUSD_1m_Option_implied
BRTUSD_1m_Realized

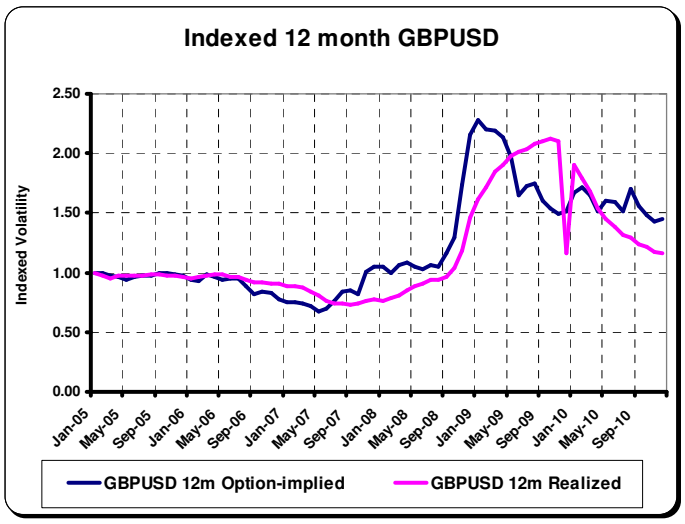

Histogram of BRTUSD_3m_Option_implied|EURGBP_3m_Realizedx
Count
40.0
26.7
13.3
0.0
0.2
0.5
0.7
1.0
BRTUSD_3m_Option_implied|EURGBP_3m_Realizedx
Variables
BRTUSD_3m_Option_implied
EURGBP_3m_Realizedx

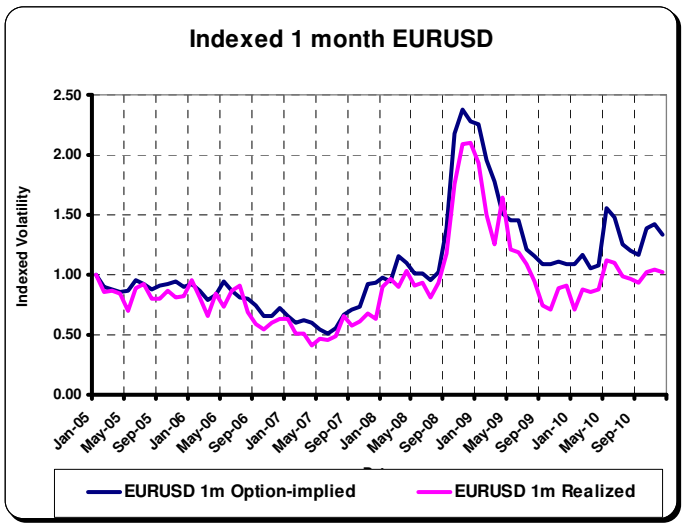

Histogram of BRTUSD_12m_Option_implied|BRTUSD_12m_Realized
Count
35.0
23.3
11.7
0.0
0.2
0.3
0.4
0.6
BRTUSD_12m_Option_implied|BRTUSD_12m_Realized
Variables
BRTUSD_12m_Option_implied
BRTUSD_12m_Realized

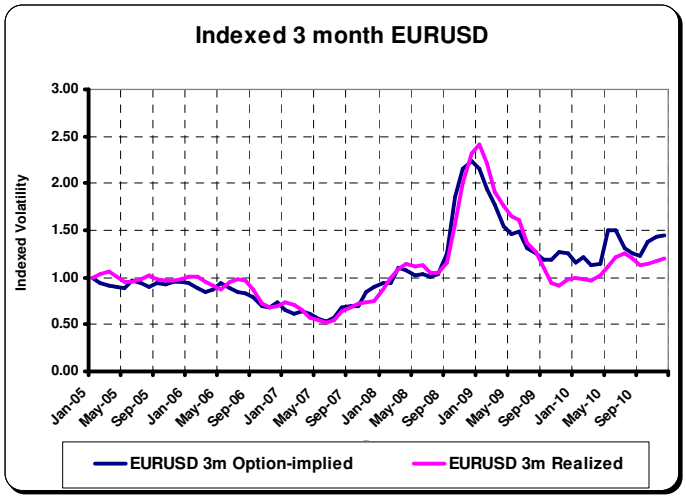
Appendix 2: Indexed Plots of Option-implied Volatility against Realized Volatility.

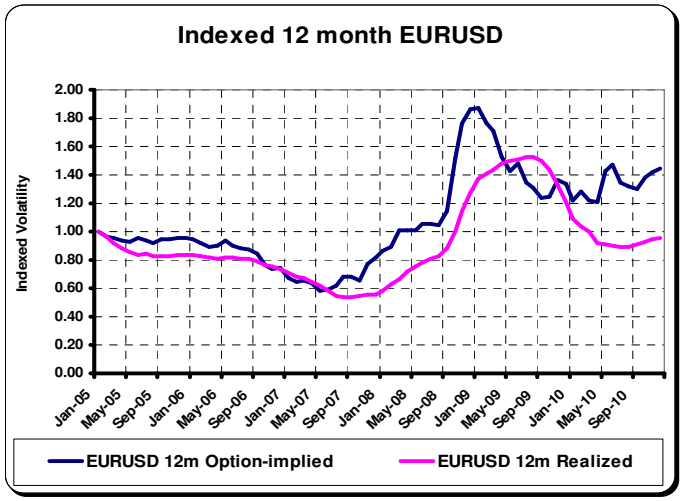


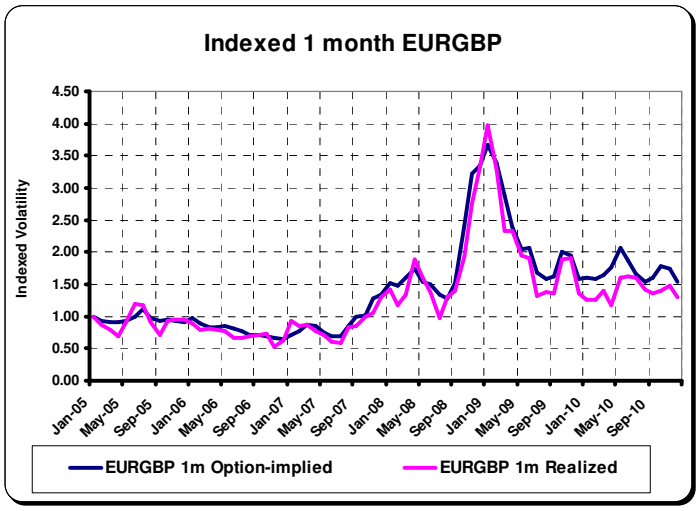


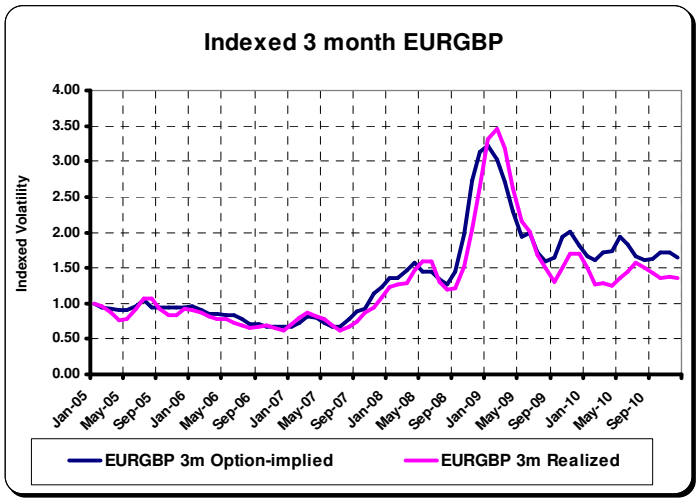


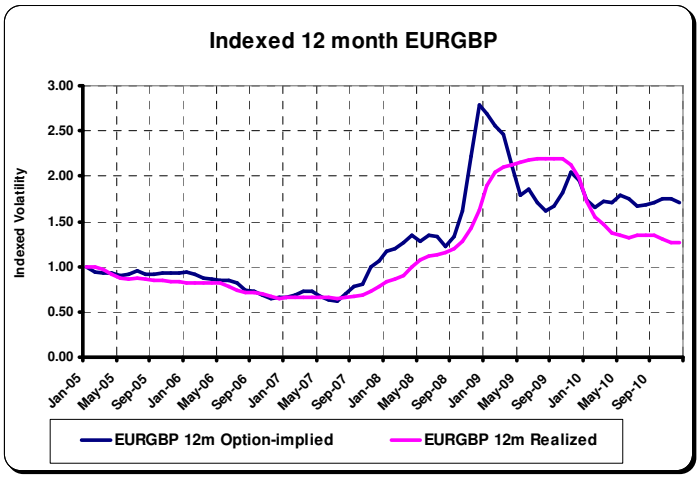


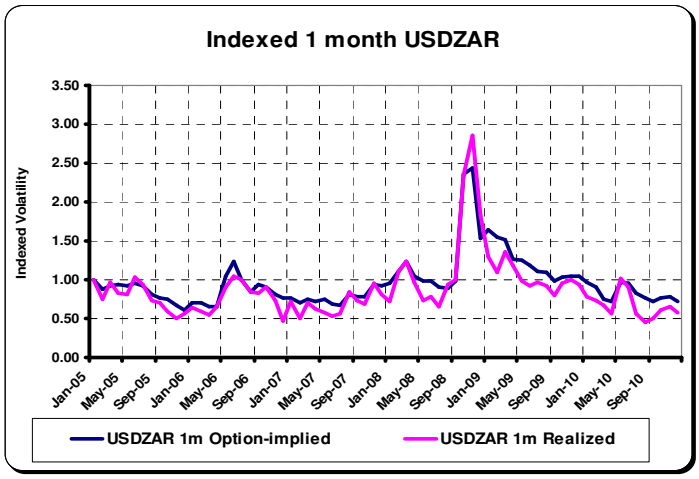


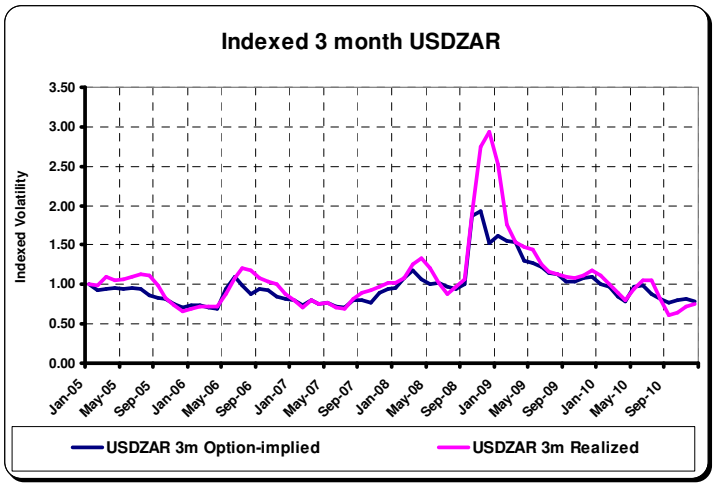


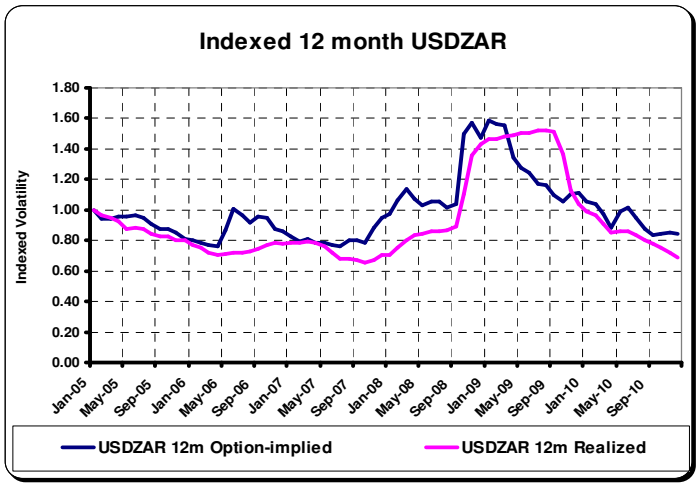

Indexed 1 month EURGBP
Indexed Volatility
EURGBP 1m Option-implied
EURGBP 1m Realized

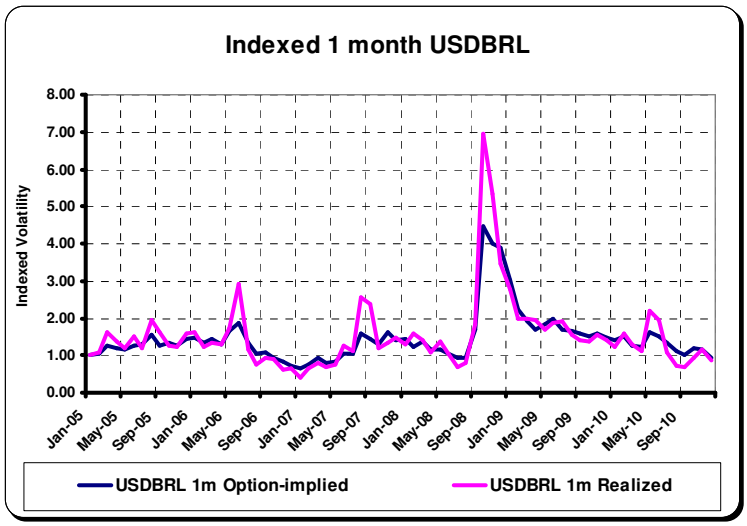

Indexed 3 month EURGBP
Indexed Volatility
EURGBP 3m Option-implied
EURGBP 3m Realized

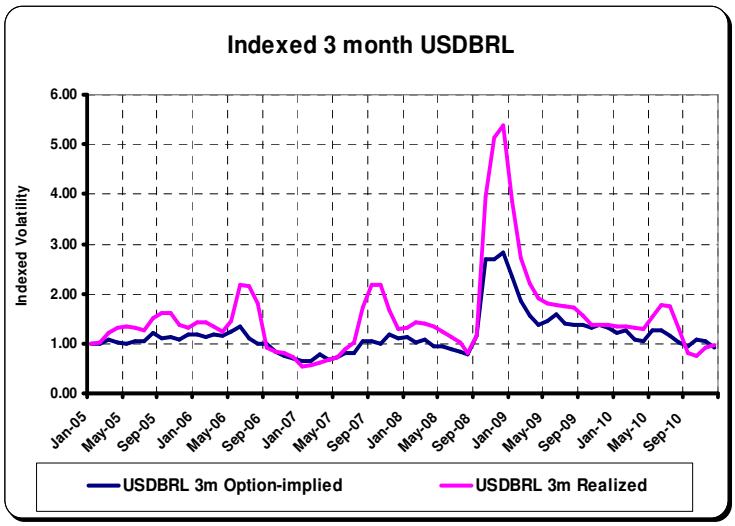

Indexed 12 month EURGBP
Indexed Volatility
EURGBP 12m Option-implied
EURGBP 12m Realized

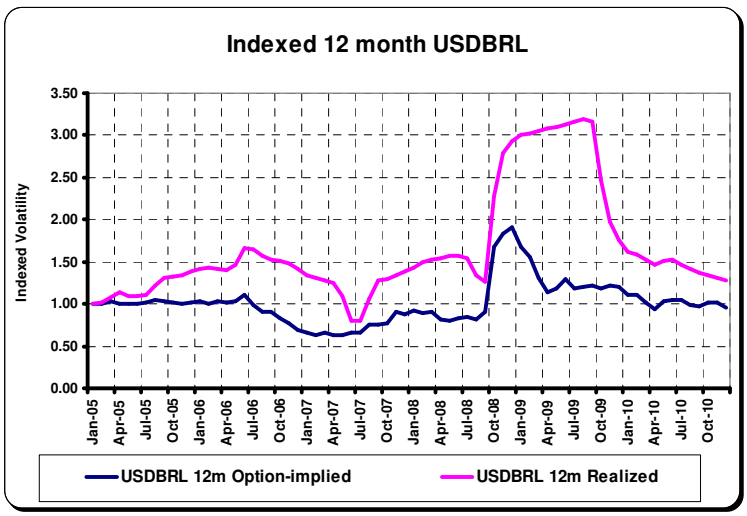

Indexed 1 month USDZAR
Indexed Volatility
USDZAR 1m Option-implied
USDZAR 1m Realized

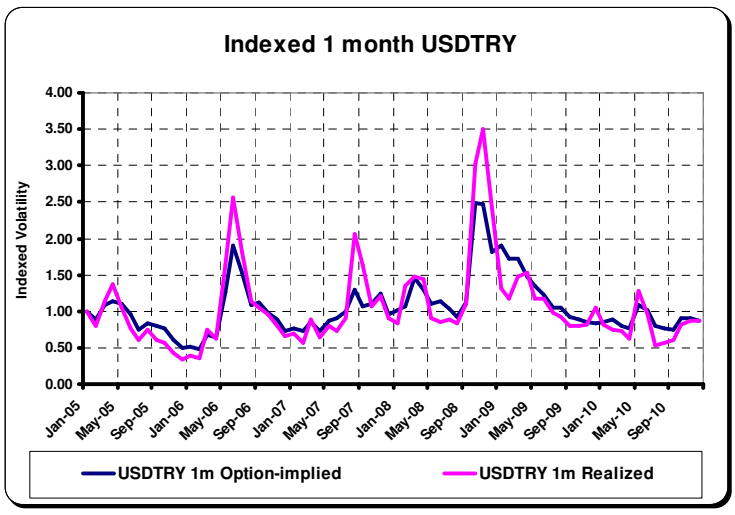

Indexed 3 month USDZAR
Indexed Volatility
USDZAR 3m Option-implied
USDZAR 3m Realized

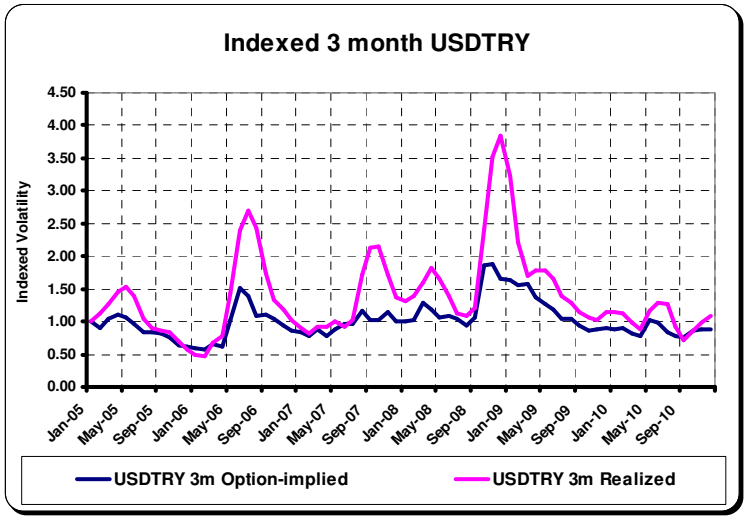

Indexed 12 month USDZAR
Indexed Volatility
USDZAR 12m Option-implied
USDZAR 12m Realized

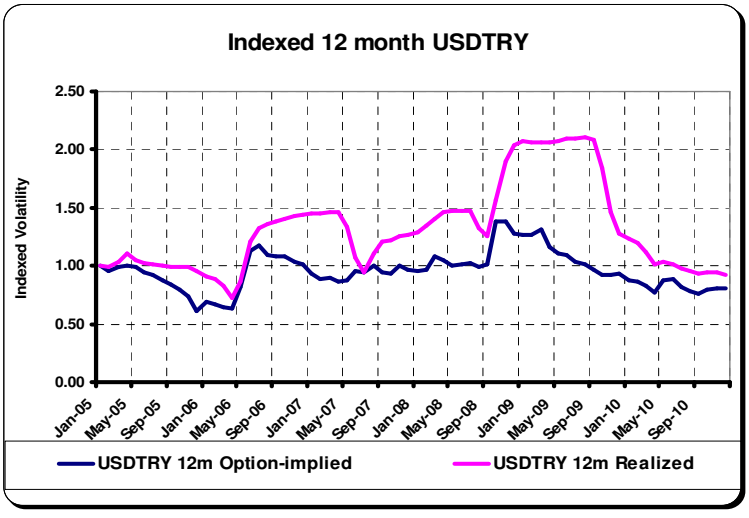

Indexed 1 month USDBRL
Indexed Volatility
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jan-05 May-05 Sep-05 Jan-06 May-06 Sep-06 Jan-07 May-07 Sep-07 Jan-08 May-08 Sep-08 Jan-09 May-09 Sep-09 Jan-10 May-10 Sep-10
USDBRL 1m Option-implied
USDBRL 1m Realized

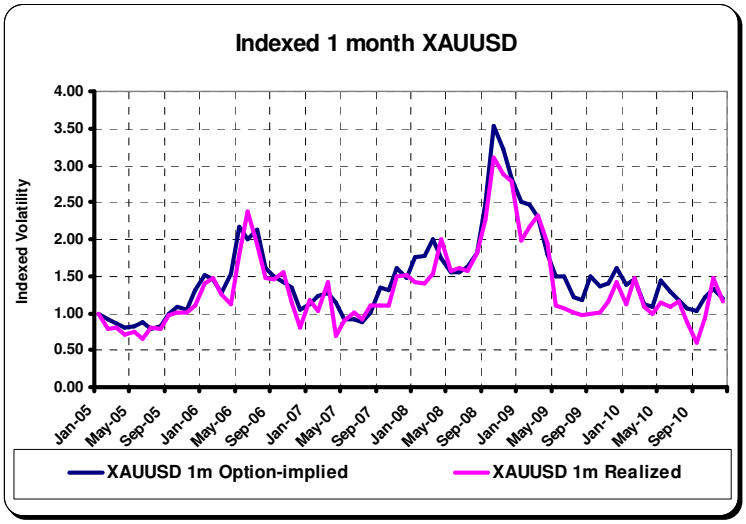

Indexed 3 month USDBRL
Indexed Volatility
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jan-05 May-05 Sep-05 Jan-06 May-06 Sep-06 Jan-07 May-07 Sep-07 Jan-08 May-08 Sep-08 Jan-09 May-09 Sep-09 Jan-10 May-10 Sep-10
USDBRL 3m Option-implied
USDBRL 3m Realized

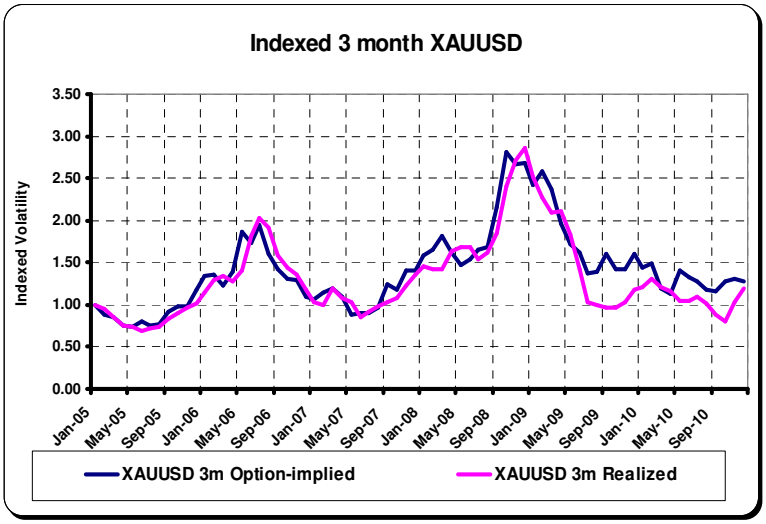

Indexed 12 month USDBRL
Indexed Volatility
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Jan-05 Apr-05 Jul-05 Oct-05 Jan-06 Apr-06 Jul-06 Oct-06 Jan-07 Apr-07 Jul-07 Oct-07 Jan-08 Apr-08 Jul-08 Oct-08 Jan-09 Apr-09 Jul-09 Oct-09 Jan-10 Apr-10 Jul-10 Oct-10
USDBRL 12m Option-implied
USDBRL 12m Realized

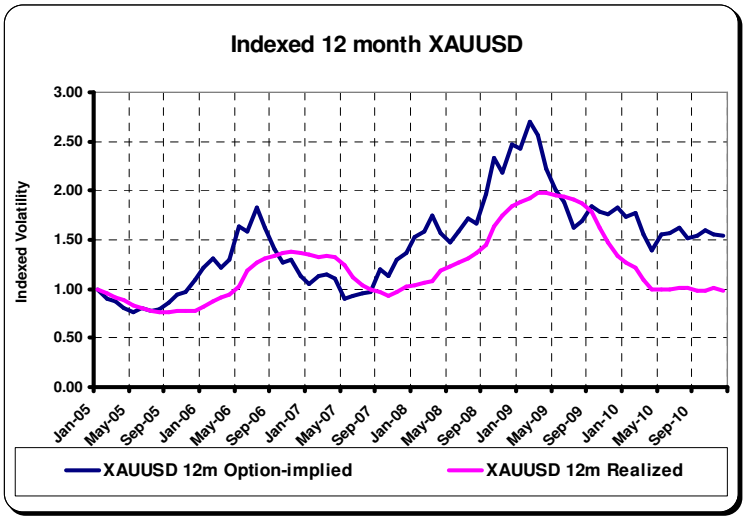

Indexed 1 month USDTRY
Indexed Volatility
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Jan-05 May-05 Sep-05 Jan-06 May-06 Sep-06 Jan-07 May-07 Sep-07 Jan-08 May-08 Sep-08 Jan-09 May-09 Sep-09 Jan-10 May-10 Sep-10
USDTRY 1m Option-implied
USDTRY 1m Realized

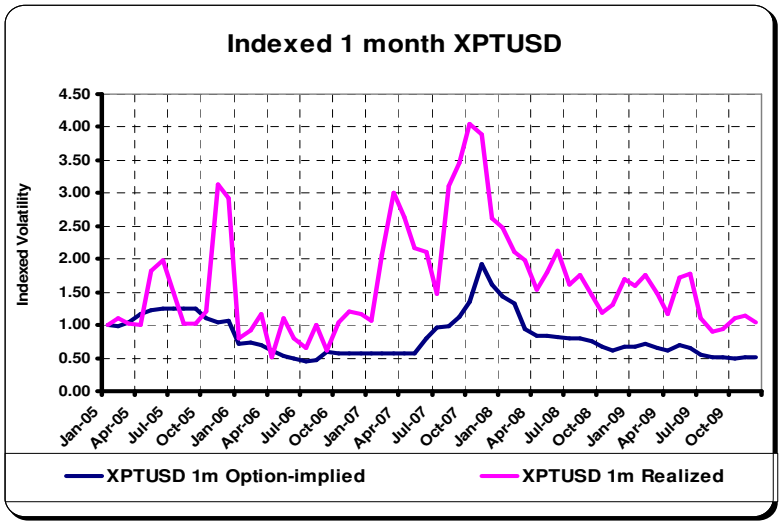

Indexed 3 month USDTRY
Indexed Volatility
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Jan-05 May-05 Sep-05 Jan-06 May-06 Sep-06 Jan-07 May-07 Sep-07 Jan-08 May-08 Sep-08 Jan-09 May-09 Sep-09 Jan-10 May-10 Sep-10
USDTRY 3m Option-implied
USDTRY 3m Realized

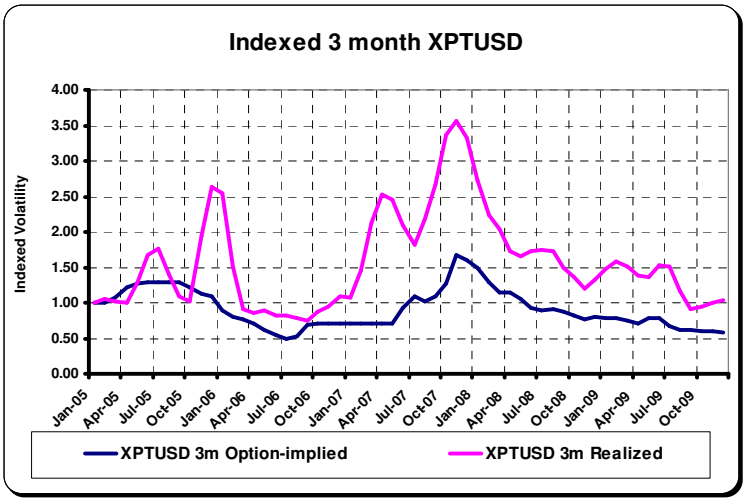

Indexed 12 month USDTRY
Indexed Volatility
2.50
2.00
1.50
1.00
0.50
0.00
Jan-05 May-05 Sep-05 Jan-06 May-06 Sep-06 Jan-07 May-07 Sep-07 Jan-08 May-08 Sep-08 Jan-09 May-09 Sep-09 Jan-10 May-10 Sep-10
USDTRY 12m Option-implied
USDTRY 12m Realized

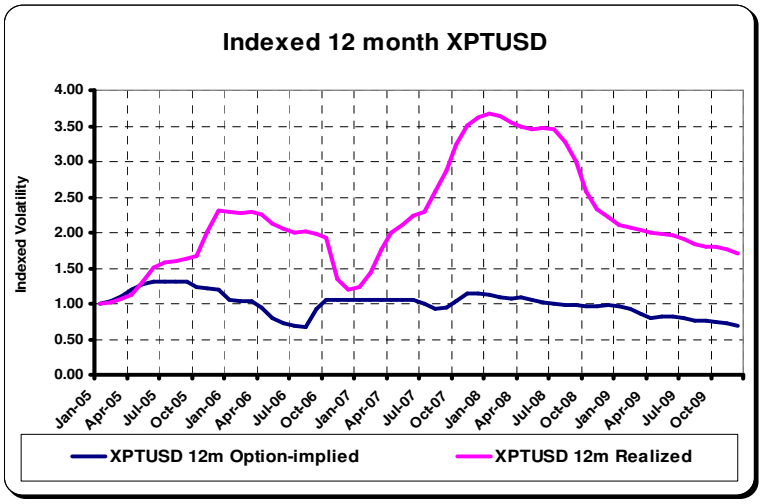

Indexed 1 month XAUUSD
Indexed Volatility
XAUUSD 1m Option-implied
XAUUSD 1m Realized

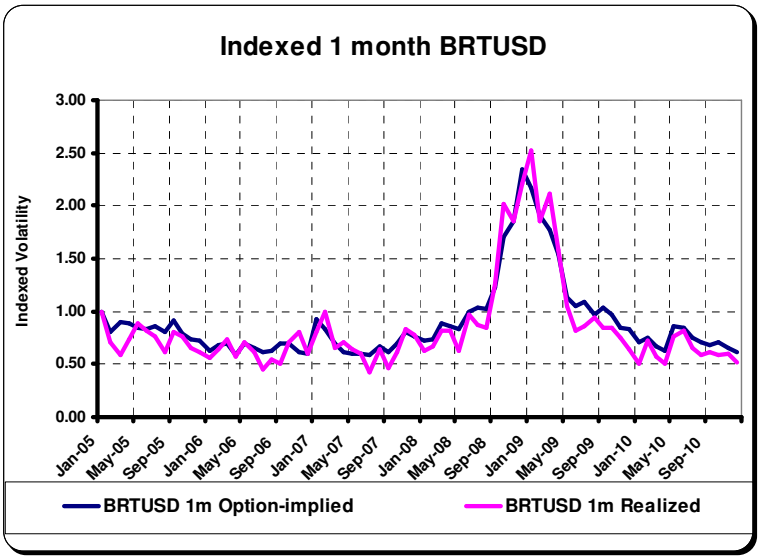

Indexed 3 month XAUUSD
Indexed Volatility
XAUUSD 3m Option-implied
XAUUSD 3m Realized

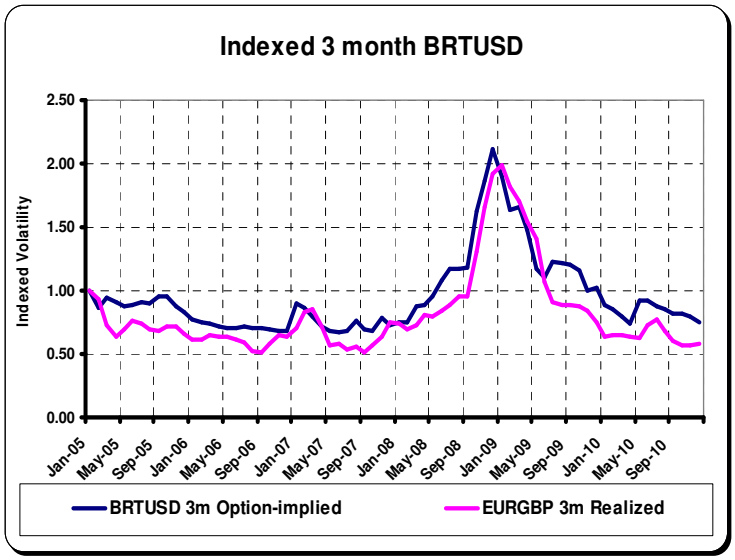

Indexed 12 month XAUUSD
Indexed Volatility
XAUUSD 12m Option-implied
XAUUSD 12m Realized

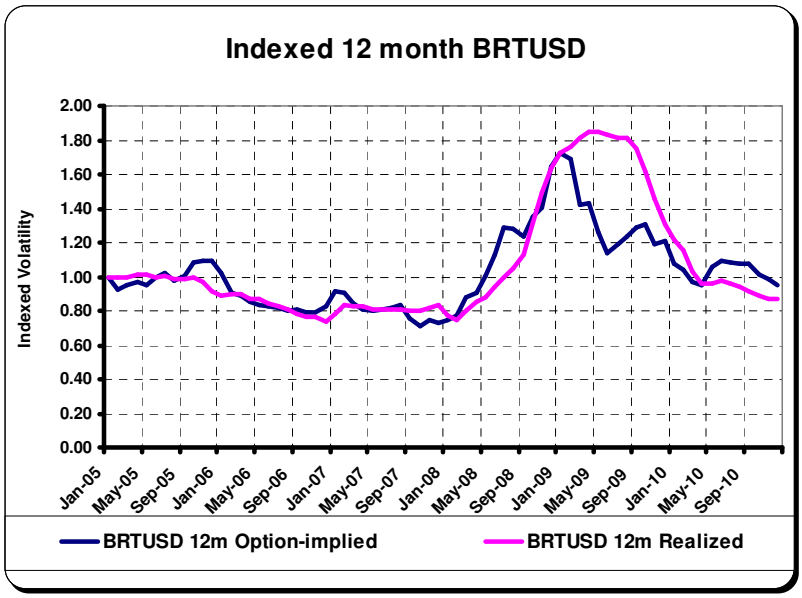

Indexed 1 month XPTUSD
Indexed Volatility
XPTUSD 1m Option-implied
XPTUSD 1m Realized


Indexed 3 month XPTUSD
Indexed Volatility
XPTUSD 3m Option-implied
XPTUSD 3m Realized


Indexed 12 month XPTUSD
Indexed Volatility
XPTUSD 12m Option-implied
XPTUSD 12m Realized


Indexed 1 month BRTUSD
Indexed Volatility
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Jan-05
May-05
Sep-05
Jan-06
May-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
May-09
Sep-09
Jan-10
May-10
Sep-10
BRTUSD 1m Option-implied
BRTUSD 1m Realized


Indexed 3 month BRTUSD
Indexed Volatility
2.50
2.00
1.50
1.00
0.50
0.00
Jan-05
May-05
Sep-05
Jan-06
May-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
May-09
Sep-09
Jan-10
May-10
Sep-10
BRTUSD 3m Option-implied
EURGBP 3m Realized


Indexed 12 month BRTUSD
Indexed Volatility
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Jan-05
May-05
Sep-05
Jan-06
May-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
May-09
Sep-09
Jan-10
May-10
Sep-10
BRTUSD 12m Option-implied
BRTUSD 12m Realized

Appendix 3: Consistency Matrix

Consistency Matrix			
Research Questions	**Literature Review**	**Data Collection**	**Analysis**
Is Option implied Volatility as an effective predictor of realized volatility in Developed vs. Developing Markets?	Donald and Mei (2008) Madsen (2009) Hull (2006)	Data to be obtained from Bloomberg Collection will be in categories of developed and emerging market currencies.	Correlation analysis T-test for paired samples
Is option-implied volatility equally effective at forecasting currency market volatility and commodities market volatility?	Wang, Li, Zhou (2010) Wang (2010) Hull (2006)	Data to be obtained from Bloomberg Collection will be in categories of commodities and currency volatility data	Correlation analysis T-test for paired samples
Is option-implied volatility equally effective at forecasting short term volatility when compared to forecasting long term volatility?	Blommestein, Udaibir, Harwood, Pazarbasioglu and Silva (2008)	Data to be obtained from Bloomberg data will be categorized as short term and long term	Correlation analysis T-test for paired samples
Has the 2008/2009 global economic crisis had any effect on the ability to forecast realised volatility using option-implied volatility?	Finnerty, Pathak (2011)	Data to be obtained from Bloomberg Data will be divided into pre-global financial crisis (2005 to 2008) and after the global financial crisis (2009 to 2010)	Correlation analysis T-test for paired samples