Modeling exchange volatility in Egypt using GARCH models

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Abstract: In this study, we consider the generalized autoregressive conditional heteroscedastic approach in modeling real effective exchange rate in Egypt using monthly data from 1994 to 2009. Various GARCH extensions are performed here. The main results show that real effective exchange rate volatility may have different behaviors based on measures enable to determine it. More importantly, when we take into account volatility clustering (i.e. Standard GARCH), we observe a quite persistence implying a mean reverting variance process. However, when we consider the leverage effect (i.e. Exponential GARCH), we notice a tendency to a long memory which can be itself a source of an explosive process.

Keywords: Exchange volatility, GARCH model, Egypt.

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1. Introduction

Modeling exchange rate volatility has gained a great importance since 1973 when several countries have chosen to move from fixed exchange regime towards floating exchange regime. In this vein, we thought to assess the volatile behavior of Egyptian real exchange rate by using various GARCH (the generalized autoregressive conditional heteroscedastic approach) extensions. In our knowledge, there is no works that compare the ability of different volatility or particularly different measures of risk.

Furthermore and based on the works of Mandelbrot (1963), Fama (1965) and Bouoiyour et al. (2012), there are six main stylized facts about exchange rate volatility: (i) Fat tails (i.e. when each financial time series (real exchange rate, for example) is compared with Gaussian distribution, fatter tails are observed; (ii) Persistence of volatility; (iii) Leverage effect; (iv) Long memory process; (v) Co-movements in volatility and (vi) Regular events.

To verify whether Egyptian real exchange rate is distinguished during the different features above mentioned, we apply thereafter various GARCH specifications (i.e. standard GARCH, optimal GARCH model) in terms of historical evaluation by using information criteria (i.e. Akaike, Schwartcz and Hannan-Quinn)[2].

Hence, the remainder of this paper is as follows: Section 2 is a brief overview of Egyptian exchange policy. Section 3 is a recall of the notion of volatility. In section 4, we proceed to estimate the linkage between real exchange rate at time t and its lagged value at time by using an optimal model among several GARCH extensions[3] chosen by various

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[2] These criteria evaluate models based on historical behavior of each variable. The model with the lowest values is most preferred. The discrimination function differs from one to another criterion. The Bayesian criterion is more parsimonious than that of Akaike since it introduces more parameters in the model. It should be noted that these criteria are sufficient to judge the quality of our estimates in historical terms.

[3] See Appendix A for detailed explanations of the different GARCH extensions used in this study.

information criteria to compare them thereafter to standard GARCH. Section 5 presents some economic implications. Section 6 concludes the paper.

2. Brief overview of Egyptian exchange policy

The early 70's, Egypt had a fixed system of its currency against the U.S. dollar. This period was marked by a succession of ups and downs of the Egyptian real exchange rate, which shows that the country is very illustrative of the impact of global shocks on its economy (e.g. Bouoiyour and Selmi, 2012). With the start of the economic reform program in 1991, the monetary authorities chose to adopt an unified exchange rate system and announced the adoption of managed float. In fact, the exchange rate was devalued only in 1991-1992 (e.g. Kamar, 2004). From 1997, the Egyptian exchange rate has undergone many external shocks, the Asian crisis in mid-1997 led to capital outflows, a slowdown in the capital market and investment losses for investors. In 1998, world oil prices fell in U.S. dollar which strengthened the deteriorating current account balance. Tensions in the peace process in the Middle East at the end of 90 years have all impacted negatively the exchange rate policy in Egypt. Thus, and following these tensions, the government decided in January 2001 to restore the stability of market by announcing a new exchange policy and to introduce therefore a system of crawling peg . A three-step of devaluation was made during the year and the Egyptian pound has lost 32 percent of its value (e.g. Kamar, 2004). It is the policy of depreciation that has helped stabilization of the currency market.

Unfortunately, this stabilization is only partial, since the negative effects already identified after the events of September 11, 2001 which were marred the image of Egypt as an attractive location for international investment. On January 28, 2003, Egyptian monetary authorities announced a managed float of the Egyptian pound. In October of that year, the exchange rate fell by 33 percent. Thereafter, Egypt tries to translate to more flexible exchange regime to promote its exports competitiveness.

3. Volatility

« The risk is highly correlated to instantaneous variability of asset returns, i.e. volatility » advance Bouoiyour et al. (2012). Hence, it is crucial to determine a good measure of volatility. This is especially important because this process is not observable, and its definition is based on the specification of an unknown model. It should, therefore, be very cautious in choosing the specification used to model volatility.

The traditional econometric models consider the distribution of asset returns as being stable, especially the moments of order two. This amounts to assign equal weight to each variation of the sample, which implies that economic agents formulate their expectations in the same way regardless of the period. This assertion is obviously far from reality. Indeed, during periods of agitation (crises, natural disasters, institutional changes, tensions in the markets, etc...). The variance-covariance of returns is volatile, and there is a problem well known to econometricians which is the heteroscedasticity.

The traditional modeling (ARMA, ARIMA) is therefore insufficient to account for these fluctuations for several reasons. It addresses at the same way the old and new variations of the sample, while the intuition that the first would be better able to explain the volatility than the latter. This is obviously detrimental of the calculation of risk and therefore return, leading thereafter to the emergence of new models which assume that the volatility is not constant. This tends to confirm that the volatility is not homoscedastic.

This heteroscedasticity leads intensely to the introduction of conditional variance model for dependent time, of autoregressive conditional heteroscedastic model (ARCH).

Engle (1982) devised a joint process. He kept the structure of the ARMA model whereas the white noise hasn't a constant volatility.

An interesting extension is relative on the asymmetry of the new information. Indeed, new information may have an asymmetric effect on volatility, i.e. leverage effect. New information may contain either good news or bad news. The asymmetry means that bad news can affect volatility more than good news, or vice versa.

Furthermore, GARCH extensions may be linear or nonlinear, symmetric or asymmetric, with switching regime or without switching regime, with power effect or with component effect. They are also able to identify the existence of a short or long memory of the volatility process.

Nonlinear models are those with function indicators which take the value 1 if the residue of the previous period is negative and 0 otherwise. The conditional variance follows two different processes depending on the sign of the error terms or according to the dynamics of the conditional standard deviation of returns (Threshold). It is piecewise linear functions depending on the sign of the shock (Zakoin, 1994).

Symmetric models were introduced by Engle (1982) and Bollerslev (1986). The formulation of these extensions GARCH imposes a sensitivity of the risk premium volatility. These models do not take into account cyclical behavior or sudden shocks series that is why they are rather restrictive. Instead, asymmetric models describe the behavior of the conditional variance using good or bad news. The asymmetry of the volatility can be explained, for example, by the intervention of the monetary authorities (Engle, 1990).

4. Application

4.1.Preliminary analysis

The descriptive statistics of real effective exchange rate returns are reported in Table 1. The sample means of real exchange rate returns are negative. The measures of skewness and kurtosis indicate that distributions of returns of real exchange rate are positive. This implies that the returns of series are skewed and leptokurtic relative to a normal distribution. The Jarque Bera normality test indicates a high level. This means a reject of normality of considered variable.

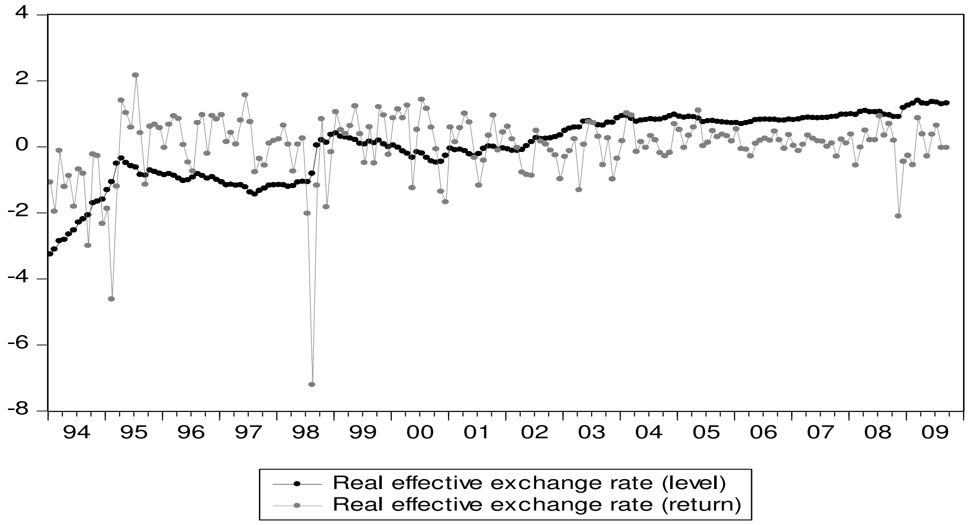
Table1. Descriptive statistics

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	J-Bera
r	-0.0022	-0.0005	0.020377	-0.07770	0.010460	2.85336	18.53189	2156.226

Note: r : Real exchange rate returns.

It is also observable from Figure 1 the excessive volatile behavior of real exchange rate level as well as its returns. The Figure indicates also three main peaks mainly due to an increase in the deficit of trade in 1994, Asian crisis in 1997 and current economic crisis beginning in 2008.

Figure 1. Real exchange rate movements



Source: Econstats and IMF (Normalized data).

With regard to our preliminary results presented above, it is time to examine carefully the real exchange rate volatility in Egyptian case.

4.2. Exchange rate volatility

The effective exchange rate[4] volatility is not directly observable. This latter depends potentially to leverage effect (i.e. innovations or good and bad news) switching regime (i.e. structural breaks) (e.g. Bouoiyour and Selmi, 2012).

Thereafter, the application of GARCH models allows us to determine various values depending to the structure of each extension. To choose the best model among several GARCH specifications[5], we used various information criteria (i.e. Akaike, Bayesian and Hannan-Quinn). These criteria evaluate models based on historical behavior of each variable. The model with the lowest values is most preferred. The discrimination function differs from one to another criterion. The Bayesian criterion is more parsimonious than that of Akaike since it introduces more parameters in the model. It should be noted that these criteria are sufficient to judge the quality of our estimates.

Hence, we thought to here to apply GARCH models while trying to choose the optimal models in both evaluations to compare thereafter them to standard GARCH model.

4.2.1. Exchange rate volatility: Standard GARCH

The GARCH-type modeling has been very useful and valuable after the pioneering study of Engle (1982). The latter was among the first to model the conditional variance of time series. Bollerslev (1986) has generalized the work of Engle assuming that the conditional

[4] The effective exchange rate is the exchange rate of a monetary area measured as a weighted sum of exchange rates with different trading partners. We measure the nominal effective exchange rate (*NEER*) with nominal parities, and the real effective exchange rate (*REER*) with the consideration for the differential price indices (between domestic price (*P*) and foreign price (*P**): $REER_t = NEER_t\ (P/P^*)_t$.

[5] We choose this model among 17 GARCH specifications reported in Appendix A.

variance follows an ARMA process. Other extensions followed Bollerslev (2008), for instance. Introduced by Bollerslev in 1986, the GARCH (General Autoregressive Conditional Heteroskedasticity) is an extension of the ARCH model developed by Engle (1982). The GARCH model allows a representation of the autoregressive conditional variance process.

The basic GARCH model is presented as follows:

$$r_t = \mu_t + \varepsilon_t \qquad (1)$$

Where $Var(\varepsilon_t | I_{t-1}) = \sigma_t^2$ r_t is the growth rate of each series (return of one action, for example), $\mu_t = E(r_t | I_{t-1})$ where I_t is the information available to date $t-1$. v_t is a sequence of random variables independently and identically distributed. It is possible to define, from the conditional variance σ_t^2, different models of volatilities or various GARCH extensions. We defined the standardized value ε_t as $z_t = \varepsilon_t / \sigma_t$. The standard GARCH itself can be written as follows:

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_j \sigma_{t-j}^2 \qquad (2)$$

where α_i, β_i and ω are parameters to estimate.

The standard GARCH is also able to test whether the conditional variance can affect the average of future returns. Thus, the coefficients ARCH and GARCH are different from zero but in opposite sign. The difference in terms of sign here is not very important, especially since it has not a leverage effect (see Table 2).

Table 2. Parameters of GARCH (1, 1)

Dependent Variable: r_t

Method: ML - ARCH (Marquardt) - Normal distribution

Sample (adjusted): 1994M01 2010M12

Included observations: 204 after adjustments

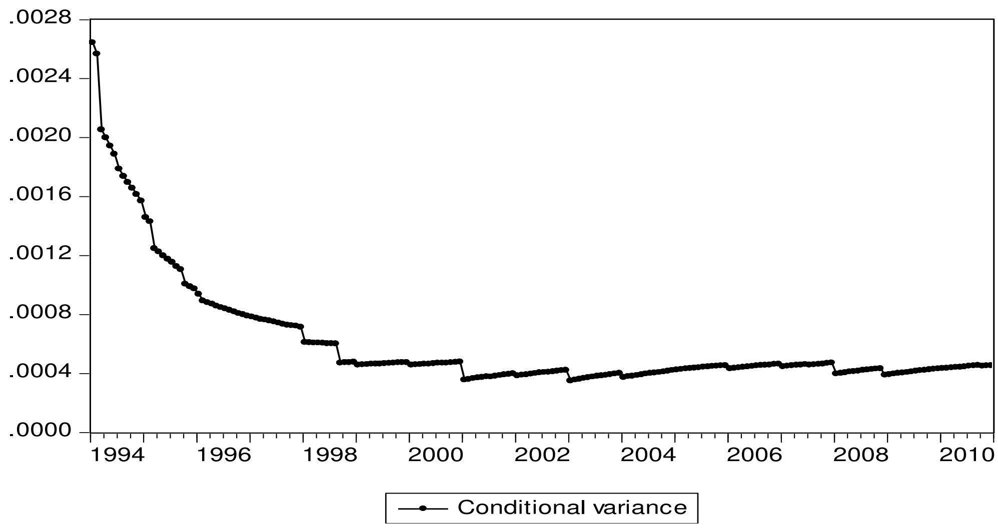
Convergence achieved after 48 iterations

Presample variance: backcast (parameter = 0.7)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
w	1.02E-05	2.46E-06	4.170145	0.0000
α	-0.006964	0.020634	-0.337517	0.7357
β	0.913877	0.020572	44.42260	0.0000
Log likelihood	612.3145			
Akaike info criterion	-5.954064			
Schwarz criterion	-5.872737			
Hannan-Quinn criter.	-5.921166			

It is difficult to compare models of the conditional variance of real exchange rate by using standard GARCH which is a linear and symmetrical model with other extensions GARCH (i.e. nonlinear and asymmetric). The variance here is quite persistent (i.e. the sum of ARCH and GARCH effects is equal to 0.91) implying a mean reverting variance process. Figure 2 thereafter reveals also that there is not inherently excessive volatility in conditional variance of Egyptian real effective exchange rate when the leverage effect and threshold order are not considered or when we take only into account volatility clustering.

Figure 2. Real exchange volatility by using GARCH (1, 1)



4.2.2. Exchange rate volatility: Optimal GARCH model in Historical terms

Based on various information criteria (Akaike, Schwartcz and Hannan-Quinn), the Exponential GARCH is the optimal model among various GARCH extensions (see Table 3) enables to determine exchange rate volatility. It allows the inclusion of the asymmetry in the response of the conditional variance to innovation. In fact, this model introduces a form of asymmetry dependent not only on positive or negative sign of innovation, but also on the magnitude of this shock. Moreover, this specification has the advantage of not requiring the non-negativity of its parameters (to ensure the positivity of the conditional variance), unlike the standard GARCH.

$$\log(\sigma_t^2) = \omega + \sum_{i=1}^{q} (\alpha_i z_{t-i} + \gamma_i (|z_{t-i}| - E(|z_{t-i}|)) + \sum_{i=1}^{p} \beta_j \log(\sigma_{t-j}^2) \qquad (3)$$

Table 3. Models chosen by information criteria

3.1. models chosen by Akaike criterion		
N°	**Model**	**Distribution value**
1	E-GARCH	-5.980
2	GARCH	-5.976
3	T-GARCH	-5.876
4	N-GARCH	-5.805
5	GJR-GARCH	-5.784
3.2. Models chosen by Schwartcz criterion		
N°	**Model**	**Distribution value**
1	E-GARCH	-5.882
2	GARCH-M	-5.880
3	I-GARCH	-5.752
4	T-GARCH	-5.733
5	GJR-GARCH	-5.659
3.3. Models chosen by Hannan-Quinn criterion		
N°	**Model**	**Distribution value**
1	E-GARCH	-5.941
2	Q-GARCH	-5.927
3	C-GARCH	-5.918
4	T-GARCH	-5.876
5	GJR-GARCH	-5.841

It is worth observable from Table 4 that the GARCH term β is intensely higher comparable to the ARCH term α indicating a negative value leading therefore to a long lasting persistence of conditional variance. The duration of persistence ($\alpha+\beta+0{,}5\gamma$) is almost equal to 1 (i.e. it is equal to 0.94) indicating then that the volatility of Egyptian real exchange rate is very close to a long memory process. The coefficient γ is positive and significant implying the presence of leverage effect. Furthermore, Egyptian real exchange rate reacts more to bad news than good news. This result is confirmed by the fact that the effect of a positive shock $\alpha+\gamma$ is equal to 0.04 while that of a negative shock $-\alpha+\gamma$ is equal to 0.12.

Table 4. Parameters of Exponential-GARCH (1, 1)

Dependent Variable: r_t

Method: ML - ARCH (Marquardt) - Normal distribution

Sample (adjusted): 1994M01 2010M12

Included observations: 204 after adjustments

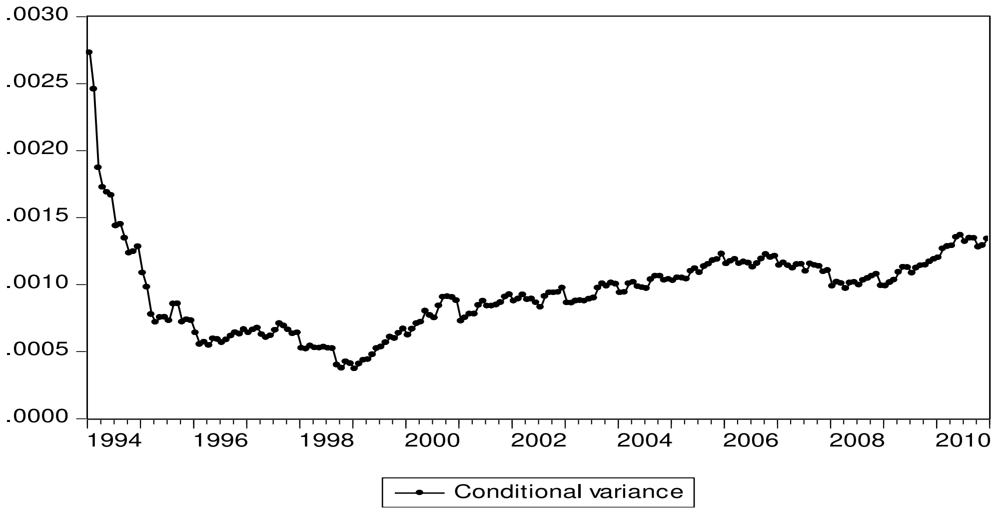
Convergence achieved after 15 iterations

Presample variance: backcast (parameter = 0.7)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
w	-0.152795	0.003369	-45.34764	0.0000
α	-0.046652	0.004595	-10.15258	0.0000
β	0.949143	0.011847	4.148286	0.0000
γ	0.080430	0.000171	57.40571	0.0000
Log likelihood	616.0114			
Akaike info criterion	-5.980504			
Schwarz criterion	-5.882913			
Hannan-Quinn criter.	-5.941027			

Figure 3 confirms the volatile behavior of real exchange rate when we use Exponential GARCH extension or more precisely when we take into account the leverage effect (i.e. the sign of innovations or either good or bad news).

Figure 3. Real exchange volatility by using Exponential-GARCH (1, 1)



5. Economic implications

The results of our studies reveal that assessing real exchange volatility can be a signal for practitioners in exchange policy in developing countries, generally and in Egyptian case, particularly.

It is widely conceivable that flexible exchange regimes intensely increase countries' vulnerability to shocks leading considerably to "fear of floating" which is prominent among developing countries (Bouoiyour and Selmi, 2013).

In addition, when the domestic country carries most of its trade with a single major country, pegging the local currency to that of foreign country's currency can mitigate exchange rate uncertainty. Nonetheless, the effective exchange rate can capture the value's effects of the local currency vis-à-vis the currencies the trading partners of its main partner. Intuitively, Egyptian commodities exports may be affected by the euro's movements, especially because its main exports partner is Europe with share almost equal to 15.7% on the overall of exports (see Appendix B) even when international prices are quoted in dollar.

It is also important to add that Europe is also considered one of main imports partners of Egypt followed by USA and China. This implies that the volatility of real exchange rate in Egyptian case pegged to dollar may be intensely sensitive to (euro/dollar) uncertainty. Nevertheless, it is notable from Appendix C that either imports from Europe or exports to European Union, both are dominated by mining and energy sector which are denominated on US $ (i.e. 66.5% of exports and 41.8% of imports as average). This implies that this composition (both that of trade partners and that of products to import or export) can be detriment of exchange rate risk.

This shows also that Egyptian monetary authorities succeed on their choice of exchange regime which is pegged or crawling peg regime, especially, because large part of its trade (i.e. both imports and exports) is denominated in US dollar (54.1% as average). This can be a start point of future research by suggesting that policymakers should pay a much attention to trade patterns 'weights.

In addition, in oil exporting economies that adopt managed exchange regime such as Egypt, the adjustment in real exchange rate will come through changes in consumer prices. This implies that both rise and fall of crude of oil put inflationary pressures when the considered economies are pegged in the dollar. In this context, Sester (2007) argues that "dollar pegs will not prevent the currencies of oil exporting economies from eventually appreciating in real terms." Hence, in oil exporting countries with basket currencies dominated by US dollar, the inflation and oil price uncertainty make them unable to adjust their currencies and lead to excessive swings in real exchange rates. However, for our case, the lack of competitiveness on energy sector (i.e. see Appendix C) with its peg to dollar can improve the tendency to a long memory process in conditional variance.

It appears of course interesting from our results that Egypt to remedy an explosive process of real exchange rate should dispose more proactive reforms and act by: (i) threatening its dependency to oil prices or to energy sector; (ii) diversifying their exported products; (iii) diversifying the currencies of their basket; (iv) taking attention to imported goods which can have a great effect on inflation outcomes (by the imported inflation pass-through canal) driver of real exchange volatility in countries that adopt pegged exchange regime.

6. Conclusion

The main objective of this study is to evaluate the real exchange rate uncertainty in Egyptian case by using various GARCH extensions (i.e. the first one that capture volatility clustering or standard GARCH, the second one (i.e. optimal model in terms of historical behavior) enables to detect the leverage effect. Interestingly, when we take into account volatility clustering (case of Standard GARCH), we observe a quite persistence implying a mean reverting variance process. However, when we consider leverage effect or the sign of innovations (case of Exponential GARCH), we notice a tendency to a long memory process.

Furthermore, by using Exponential GARCH, we note that the negative shock lead to great periods of volatility than positive shock. Our results appear interesting indicating clearly that real exchange rate may be adequacy and differently assessed by using class GARCH.

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Appendix A. A brief overview on GARCH extensions

The GARCH-type modeling has been very useful and valuable after the pioneering study of Engle (1982). The latter was among the first to model the conditional variance of time series. Bollerslev (1986) has generalized the work of Engle assuming that the conditional variance follows an ARMA process. Other extensions followed, Bollerslev (2008) and Anderson et al. (2009), among others.

The main objective of this paper is to use different specifications of u_t, ε_t and σ_t^2. Hence and according to Koksal (2009) and Bouoiyour et al. (2012), we can decompose the family of GARCH models in two subsets: linear GARCH models and nonlinear GARCH models. The first ones are based on a quadratic specification of the conditional variance of the errors. These are the ARCH (q), GARCH (p, q) and IGARCH (p, q) ... The second ones are characterized by asymmetric specification errors. These include, among others, EGARCH (p, q), GJR-GARCH (q) and TGARCH (p, q) models ... We can list the following specifications that seek to describe at best the behavior of the series.

a. ARCH

It is expressed as follows :

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \varepsilon_{t-i}^2 \qquad (1)$$

b. GARCH (Standard GARCH)

Introduced by Bollerslev in 1986, the GARCH (General Autoregressive Conditional Heteroskedasticity) is an extension of the ARCH model developed by Engle (1982). The GARCH model is a representation of the autoregressive conditional variance process. This latter is written as follows:

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_j \sigma_{t-j}^2 \qquad (2)$$

Where α_i, β_i and ω are parameters to estimate.

c. I-GARCH (Integrated GARCH)

Introduced by Engle and Bollerslev (1986) and developed then by Nelson (1991). The Integrated Autoregressive Conditional Heteroskedasticity General model (I-GARCH) assumes the existence of a unit root in the process of conditional variance. This may be mainly due to changes in regimes that affect the level of variance. This model is able to capture a long memory process in conditional variance, i.e there are autocorrelations of long process which are very persistent. For this extension, volatility tends to zero much slower for a long memory than a short memory process.

$$\sigma_t^2 = \omega + \varepsilon_{t-1}^2 + \sum_{i=1}^{q} \alpha_i (\varepsilon_{t-i}^2 - \varepsilon_{t-1}^2) + \sum_{i=1}^{p} \beta_j (\sigma_{t-j}^2 - \varepsilon_{t-1}^2) \qquad (3)$$

We should add here that this process has a long-run persistence when the autocorrelation function is infinite, that is to say:

$$\lim_{n \to \infty} \sum_{j=-n}^{n} |\rho_j|$$

d. GARCH-M (GARCH in mean)

Another presentation of the GARCH model is the GARCH in mean (GARCH-M). It is a GARCH with moving average term. We test here if the variance can impact the average of future returns r_t. A GARCH in mean is presented as follows:

$$r_t = \mu_t + \varepsilon_t + \lambda \sigma_t^2 \qquad (4)$$

Sometimes volatility affects the performance rather than the variance. If $\lambda \neq 0$, this implies the presence of serial correlation of returns, since the variance is serially correlated and closely dependent to the variance. Most studies on this issue have found inconclusive results regarding the nullity of λ. When $\lambda \neq 0$, there is not consensus on its sign.

e. SA-GARCH (Simple Asymetric GARCH)

The Simple Asymmetric General Autoregressive Conditional Heteroskedasticity (i.e. SA-GARCH model) was developed by Bollerslev et al. (1993). This model belongs to the family of Fractional GARCH (F-GARCH specifications). A negative value of the leverage effect (γ_i) implies that the positive shocks lead to smaller increases in volatility comparable to negative shocks. It indicates that the conditional variance is represented like this:

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} (\alpha_i \varepsilon_{t-i}^2 + \gamma_i \varepsilon_{t-i}) + \sum_{i=1}^{p} \beta_j \sigma_{t-j}^2 \qquad (5)$$

f. E-GARCH (Exponential GARCH)

Introduced by Nelson in 1991, the Exponential General Autoregressive Conditional Heteroscedasticity (E-GARCH model) is a nonlinear GARCH model. It allows the inclusion of the asymmetry in the response of the conditional variance to innovation. In fact, this model introduces a form of asymmetry dependent not only on positive or negative sign of innovation, but also on the magnitude of this shock. Moreover, the EGARCH model has the advantage of not requiring the non-negativity of its parameters (to ensure the positivity of the conditional variance), unlike the standard GARCH.

$$\log(\sigma_t^2) = \omega + \sum_{i=1}^{q} (\alpha_i z_{t-i} + \gamma_i (|z_{t-i}| - E(|z_{t-i}|)) + \sum_{i=1}^{p} \beta_j \log(\sigma_{t-j}^2) \qquad (6)$$

Where $E|z_{t-i}|$ is the expectation of the absolute value of standardized shocks on *t-1.*

It should be added that the left side is the logarithm of the conditional variance. This implies that the leverage effect is exponential, rather than quadratic, and then this guarantee that the forecasts of conditional variance have a positive values. The presence of leverage effect can be tested by the hypothesis $\lambda_i < 0$. If $\lambda_i \neq 0$, then when we sheck it, we can say that there is an asymmetrical effect.

g. P-GARCH (Power-GARCH)

The Power General Autoregressive Conditional Heteroscedasticity (P-GARCH) is a linear model proposed by Higgins and Bera (1992), which is characterized by parameters associated with high conditional standard deviations over φ. When $\varphi = 2$, P-GARCH model provides the same values of the conditional variance of simple GARCH (p, q). By using the P-GARCH extension, we can analyze a broader class of transformations of the linkage between the two series.

$$\sigma_t^{\varphi} = \omega + \sum_{i=1}^{q} \alpha_i \left|\varepsilon_{t-i}\right|^{\varphi} + \sum_{i=1}^{p} \beta_j \sigma_{t-j}^{\varphi} \tag{7}$$

h. AP-GARCH (Asymmetric Power GARCH)

The Asymmetric Power General Autoregressive Conditional Heteroscedasticity (AP-GARCH) was introduced by Ding and al. (1993). As the Simple asymmetric GARCH, this process also occurs in the family Fractional GARCH. For this model, there are no restrictions in the process of conditional variance like as Power GARCH. It is an asymmetric function of delayed disturbances, expressed as follows:

$$\sigma_t^{\varphi} = \omega + \sum_{i=1}^{q} \alpha_i (\left|\varepsilon_{t-i}\right| + \gamma_i \varepsilon_{t-i})^{\varphi} + \sum_{i=1}^{p} \beta_j \sigma_{t-j}^{\varphi} \tag{8}$$

i. GJR-GARCH

The GJR-GARCH model was introduced by Glosten, Jagannathan and Runkle (1993). It is a specification that captures the leverage and thresholds effects. In other words, the impact of disturbance is asymmetric, and therefore the dynamic of conditional variance depends on the sign of shock and not just on its magnitude. It is a nonlinear model that accounts the asymmetry in the response of the conditional variance after innovation either good or bad news.

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} (\alpha_i + \gamma_i I_{(\varepsilon_{t-i>0})}) \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_j \sigma_{t-j}^2 \tag{9}$$

j. GJR power GARCH

It is an asymmetrical model (i.e. we notice the existence of leverage effect). It is a nonlinear model that describes the behavior of the conditional variance based on both good and bad news. The asymmetry of the volatility can be explained by the intervention of monetary authorities.

$$\sigma_t^{\varphi} = \omega + \sum_{i=1}^{q} (\alpha_i + \gamma_i I_{(\varepsilon_{t-i>0})}) \varepsilon_{t-i}^{\varphi} + \sum_{i=1}^{p} \beta_j \sigma_{t-j}^{\varphi} \quad (10)$$

Where φ is a paramater to estimate. If $\varphi = 2$, we found a GJR-GARCH model.

k. T-GARCH (Threshold GARCH)

Introduced by Tong (1990) and developed by Zakoin (1994), the autoregressive model with threshold order is a nonlinear model. We can say that there is a Threashold effect in each linkage when we have a level shift at which one series reacts differently to the second variable in question.This specification allows us to capture different regimes uder them we can see different effects of the series in question. Hence, theThreshold General Autoregressive Conditional Heteroskedasticity (T-GARCH model) can be expressed as follows:

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} (\alpha_i |\varepsilon_{t-i}| + \gamma_i |\varepsilon_{t\_i}^{+}|) + \sum_{i=1}^{p} \beta_j \sigma_{t-j} \quad (11)$$

l. Q-GARCH (Quadratic GARCH)

The process of Quadratic General Autoregressive Conditional Heteroskedasticity (Q-GARCH model) was developed by Sentani (1995). It assumes the asymmetries in the response of conditional volatility to innovations. It can be written like this:

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i (\varepsilon_{t-i} - b_i)^2 + \sum_{i=1}^{p} \beta_j \sigma_{t-j}^2 \quad (12)$$

m. N-GARCH (Nonlinear GARCH)

The Nonlinear General Autoregressive Conditional Heteroscedasticity (i.e. NGARCH model) was introduced by Duan (1995). As its name suggests, it is a nonlinear model that analyzes the threashlod effect or a switch between one regime and others.

$$\sigma_t = \omega + \sum_{i=1}^{q} \alpha_i (\varepsilon_{t-i} - \kappa_i)^2 + \sum_{i=1}^{p} \beta_j \sigma_{t-j}^2 \quad (13)$$

n. NP-GARCH (Nonlinear Power GARCH)

The Nonlinear Power General Autoregressive Conditional Heteroscedasticity (N-PARCH model) was initiated by Duan (1995) as an extension of the N-GARCH model. As its name suggests, it is a nonlinear model that takes into account the effect of the threshold order and not the leverage effect on the conditional variance, i.e. it does not analyze the signs of shock after both good and bad news. It is written as follows :

$$\sigma_t^{\varphi} = \omega + \sum_{i=1}^{q} \alpha_i (\varepsilon_{t-i} - \kappa_i)^2 + \sum_{i=1}^{p} \beta_j \sigma_{t-j}^{\varphi} \tag{14}$$

o. AT-GARCH (Asymmetric Threshold GARCH)

As the Threashold GARCH, it is a specification that takes into account both the nonlinearity (i.e. threshold effect) and asymmetry (i.e. leverage effect). This model combines the characteristics of Threashold GARCH and Simple asymmetric GARCH presented above. It is written as follows:

$$\sigma_t = \omega + \sum_{i=1}^{q} \alpha_i |\varepsilon_{t-i}| I |\varepsilon_{t\_i} \geq \gamma_i|) + \delta \sum_{i=1}^{q} |\varepsilon_{t-i}| I(\varepsilon_{t-i} \prec \gamma_i) + \beta_j \sigma_{t-i} \tag{15}$$

p. C-GARCH (Component GARCH)

It is a linear and symmetric model which captures a long dependency between the volatility of the conditional variance and the unconditional variance. There is a great diffrence between Component GARCH (C-GARCH) and other GARCH extensions in terms of structure. More precisely, we decompose here the conditional volatility into a long-run time-varying trend component and a short-run transitory component (deviations from that trend). This specification is written as follows:

$$(\sigma_t^2 - \sigma^2) = \alpha(\varepsilon_{t-1}^2 - \sigma^2) + \beta(\sigma_{t-1}^2 - \sigma^2) \tag{16}$$

Where the formula mentioned below presents the unconditional variance:

$$\sigma^2 = \omega / (1 - \alpha - \beta)$$

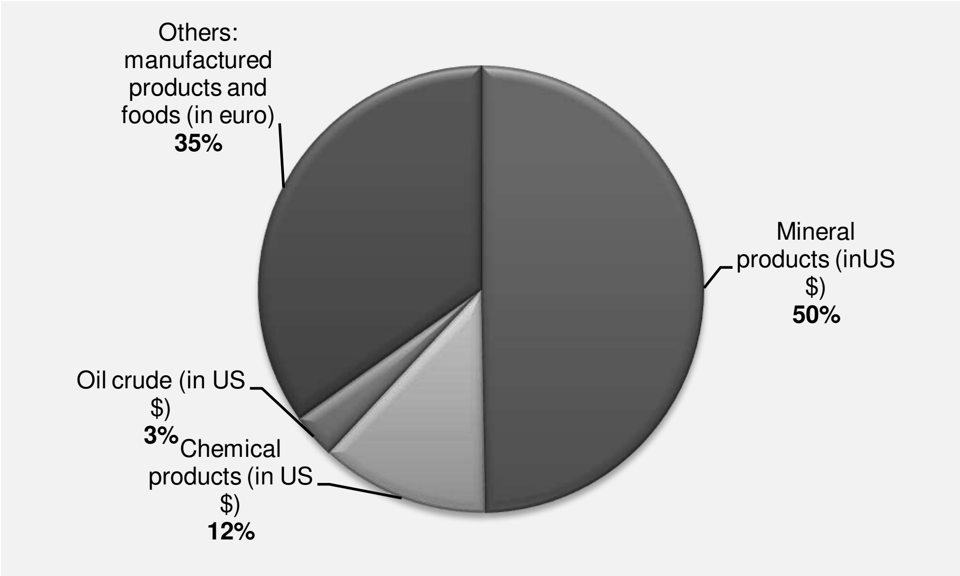
Appendix B. Ranking of Egyptian main trade partners

n°	Imports partners	Exports partners
1	EU 27 (14.8%)	EU 27 (15.7%)
2	USA (5.4%)	India (3.7%)
3	China (4.6%)	Saudi Arabia (3.1%)
4	Kuwait (2.4%)	USA (2.6%)
5	Turkey (2.2%)	Turkey (2.5%)
6	Saudi Arabia (2.1%)	South Africa (1.6%)
7	Russia (1.9%)	Lebanon (1.5%)
8	Brazil (1.8%)	Jordan (1.3%)
9	Ukraine (1.5%)	Emirates (1.3%)
10	South Korea (1.4%)	Syria (1.0%)

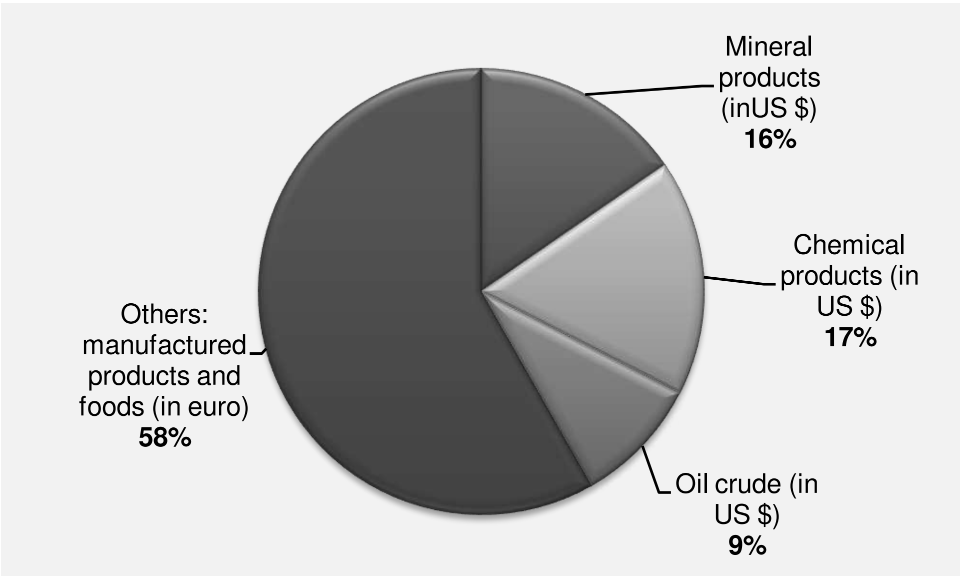
Note: For more details, we can see this link:
http://trade.ec.europa.eu/doclib/docs/2006/september/tradoc_113375.pdf

Appendix C. Egyptian trade composition (from and to Europe)

C.1. Imports composition



C.2. Exports composition



Note: For more details, we can see this link:

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