Exchange Uncertainty and Export Performance in Egypt: New Insights from Wavelet Decomposition and Optimal GARCH Model

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Exchange Rate Uncertainty and Exports Performance in Egypt: New Insights from Wavelet Decomposition and Optimal GARCH Model

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Abstract: To effectively assess the link between exchange rate uncertainty and exports performance in Egypt, this article relies on an optimal GARCH model among decomposed series on a scale-by-scale basis via wavelet approach. The observed outcomes reveal that the focal connection depends substantially on the frequency-to-frequency variation and slightly on the leverage effect. Indeed, the effect of exchange rate volatility on trade appears stronger at higher frequencies (i.e., the short-run). When subtracting energy's share, the results change remarkably. Accurately, the studied relationship becomes more important at lower frequencies (i.e., the long-run). The first findings may be due to the fact that the energy market is mainly driven by a great speculation, coupled with the absence of efficient anti-cyclical fiscal policy and insufficient financial development. We attribute the second ones to the composition of trade partners, the choice of a reference basket's currencies, the specialization in products with low technological content, the lack of innovative capacity and the weakness of institutions.

Keywords: Exchange rate uncertainty; exports; wavelets; optimal GARCH model; Egypt.

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1. Introduction

The relationship between exchange rate uncertainty and exports performance has been assessed in several researches but no consistent results have been up to now found. The results have varied widely. Some studies have found a negative interaction between currency risk and exports (e.g. McKenzie (1998), Vergil (2002), Nabli and Varoudakis (2002), Bahmani-Oskooee (2002) and Rey (2006), etc…). Others have found that higher risk associated with ups and downs exchange rate can lead to great opportunity increasing exports performance (e.g. De Grauwe (1992) and Achy and Sekkat (2003), among others). More recently, Egert and Zumaquero (2007), Bouoiyour and Selmi (2013) argue that there is an ambiguous effect of real exchange rate variability on international trade.

These empirical studies suggest that the link between exchange rate uncertainty and trade performance varies potentially depending on risk-averse, the absence of hedging instruments, the specialization and the degree of competitiveness. To reconcile the mixed results of prior researches, using meta-regression analysis, Coric and Pugh (2010) provide evidence that the effect of exchange volatility on trade is likely to be adverse when measured in real rather than nominal term and when less developed rather than developing countries are considered.

Despite the many studies on this subject and the different estimation techniques used, gaps remain, especially methodological ones. To contribute to this literature stream and to highlight more convincing elements of explanations, we extend our examination beyond by re-visiting this link and evaluating it depending to frequency-to-frequency variation through "sophisticated model", i.e. wavelet decomposition.

Alternatively, various questions can be raised. For example, what does it reveal about exchange rate uncertainty and export performance connection in Egyptian case? Do exports react differently when moving from one frequency band to another? How to choose the optimal model to determine properly volatility? Does the use of parsimonious and new techniques may help us to obtain solid and clearer outcomes for a controversial topic?

Answering rigorously and appropriately these several questions will enhance our understanding on the relationship between exchange rate volatility and exports performance in Egyptian case and allow us to identify the potential sources behind heterogeneity in findings and conclusions related to the focal linkage.

The remainder of this article proceeds as follows: Section 2 offers a brief overview of exchange and trade policies in Egypt. In section 3, we present our methodology. In section 4, we estimate the linkage between real exchange rate volatility and real exports returns through wavelet decomposition and an optimal model chosen among several GARCH extensions. Additionally, we discuss our main results. Section 5 concludes and offers some implications.

2. A brief overview of exchange and trade policies in Egypt

Since the demise of the Bretton Woods system in 1973, particularly early 80's, Egypt had a fixed system of its currency in relation to U.S. dollar. In 1991, the monetary authorities have announced the adoption of managed float. From 1997, the Egyptian exchange rate has undergone many external shocks as the Asian crisis in mid-1997 which led to capital outflows, a slowdown in the capital market and investment losses for investors. In 2001, in an effort to restore the stability of market, the Central Bank of Egypt adopted a system of crawling peg that allows the nominal exchange rate to move in a band within upper and lower limits (e.g. Kamar, 2004). As a result, a real depreciation of Egyptian pound has been sharply observed (Figure 1).

Between 1995 and 2009, real exports exhibited great instability (see Figure 2). The World Trade Organization agreement signed with the European Union in 1995 allowed Egypt to develop its export competitiveness, improve its comparative advantages and provide a greater access to developing markets with growing concern for manufactured sector (e.g. Nabli and Varoudakis, 2002). This reform led it to consolidate its position in foreign trade during the period from 1996 to 2004 (e.g. Sekkat, 2012). However, the dismantling of the textile and clothing agreement and the accession of China into the World Trade Organization have degraded the position of this sector compared to previous years.

To mitigate possible detrimental effects of real exchange rate uncertainty on exports, especially after the announcement of the flotation of the pound on January 2003, Egypt should dispose more proactive reforms such as: (i) the implementation of policy reforms to accelerate products' diversification. Obviously, the diversification on non-oil sectors can limit real exchange rate appreciation (e.g. Espinoza and Prasad, 2012); (ii) an integration in international financial market. This may allow the concerned country to smooth the adjustments of primary commodity prices and reduce costs of volatile exchange rate on exports performance (e.g. Gourinchas and Rey, 2007) ;(iii) more credible monetary policy to absorb several shocks and then to avoid the possible harmful effects of a continued overvaluation of real exchange rate.

3. Wavelet decomposition and optimal GARCH model

Since the majority of researches on the link between exchange rate volatility and exports performance were always contradictory and inconclusive, this study seeks to clarify the remarkably inconsistent results. In so doing, we assess differently the short-run interaction dynamic between changes in real exchange rates and those of real exports through wavelet decomposition and optimal GARCH model[3], with special reference to Egyptian case.

3.1. Why wavelets approach?

Wavelets are "small waves" that grow and decay in a limited time period. Wavelet analysis involves the projection of the original series into several frequencies by separating each series into its constituent frequency components. This technique is a decomposition of time series into high frequency or noisy components (short-term) and low frequency or trend components (long-term). Wavelet method allows us to extract the various time scales driving any macroeconomic variable in the time domain by decomposing it into several frequencies.

This approach is based on the mother wavelet denoted $\psi(t)$, which must satisfy:

$$\int_{-\infty}^{+\infty} \psi(t)dt = 0, \int_{-\infty}^{+\infty} |\psi|^2 dt = 1 \quad (1)$$

To quantify the importance of the wavelet decomposition into various frequencies, the mother wavelet $\psi(t)$ gets deleted, so:

$$\psi_{u,s} = \frac{1}{\sqrt{s}} \psi\left(\frac{t-u}{s}\right) \quad (2)$$

where u and s are the time location and frequency ranges, respectively, and $\frac{1}{\sqrt{s}}$ indicates that the norm of $\psi_{u,s}(t)$ is equal to unity.

[3] All GARCH extensions used in this study are summarized in Table 1.

The wavelet decomposition, in turn, is a succession of low and high-pass filters of the focal time series. Unlike time domain analysis, wavelets can identify which frequencies are present in the data at any given point in time. Ultimately, we obtain the following wavelet representation of the function *X(t)*:

$$X(t) = \lfloor w_1(t), v_1(t),...., w_j(t), v_j(t) \rfloor \tag{3}$$

where $w_1(t)$ and $v_1(t)$ respectively wavelet high frequency and wavelet low frequency.

Considering several frequency bands, time series can be extracted for further analysis. Firstly, with wavelets analysis, we can differentiate between time periods for decision making. Secondly, since wavelet method enables to decompose a signal into multi-resolution components, it may allow us to assess both real exchange rate and real exports data over specific horizons. Thirdly, with this technique, we can approximate structural changes that can happen over time. Finally, the problem of temporal aggregation bias can be neglected because time series were decomposed into different time scales. Therefore, wavelets analysis provides a fresh look into the link between exchange rate uncertainty and exports performance, by helping us to see whether it seems of utmost importance to account for nonlinearity when investigating this nexus.

3.2. Why optimal GARCH model?

While modeling strategies have evolved over time to incorporate new developments in econometric analysis, no single measure of exchange volatility has dominated the literature (e.g. Haile and Pugh, 2011). This highlights a need to choose carefully the econometric technique able to depict appropriately the process of volatility of real exchange rate, to better conduct an analysis on the relationship in question.

The formulation of linear and symmetrical GARCH models imposes a sensitivity of the risk premium volatility. They do not include cyclical behavior or a sudden shock that is why they are rather restrictive. However, for nonlinear GARCH models, the conditional variance follows two different processes depending on the sign of the error terms or according to the dynamics of the conditional variance or the standard deviation of returns (e.g. Zakoin, 1994). Instead, asymmetrical extensions describe the behavior of the conditional variance depending on the sign of shocks and not only their power (e.g. Engle, 1990). These specifications are s reported in Table 1.

In this study, we use 13 GARCH extensions while trying to select the best model that can capture better how behave real exports after great changes in real exchange rate. With regard to these different specifications, it is substantial to see whether changes in real exchange rate have temporary, permanent, transitory, asymmetrical or nonlinear effect on exports performance. Therefore, we seek to examine if: (i) volatile supply leads to temporal changes in demand conditions and thereby to multiple commodity price regime that affect widely the focal link, leading to take into account the threshold effect; (ii) the possible intervention of monetary authorities in exchange market leads us to consider the possible impacts of good and bad news and not only the magnitude of shock; (iii) the exchange rate volatility's effect on exports can be transitory or permanent. Thus, it seems important to decompose the connection between changes in real exchange rate and those of real exports into a long-run time varying trend and short-run transitory deviations from trend.

This remains an untapped area of serious research, encouraging us in the following to check these impressions through proper and appropriate econometric analysis.

3.3. Data and methodological framework

A central goal for this study is to check if the connection between real exchange rate uncertainty and real exports varies over time (i.e. from higher frequencies (short-run) to lower ones (long-run))). We estimate various GARCH extensions and seek the optimal model that may depict accurately the behavior of the connection between key variables on the basis of an historical evaluation. Intuitively, we explore a bivarite GARCH model[4] that link real exchange rate returns with trade flows returns. For this purpose, we built an indicator that replaces the simple changes of real exports in accordance with those of real exchange rate. This indicator is constructed using the variance between the variables under consideration.

We use monthly data for the period from 1994 to 2009 collected from Econstats™ and International Monetary Fund (IMF). Thus, we consider the following variables:

$$r_{XPRt} = log\ (XPR_t/XPR_{t-1}) \qquad (5)$$

where $r_{XPR\ t}$ is the return of real exports determined using the ratio between nominal exports and the export unit value.

[4] This method has been largely used recently to evaluate the link between the variability of dollar vis-à-vis various currencies and oil price returns (e.g. Narayan et al. (2007), Mansor (2011) and Gosh (2011)).

$$r_{REERt} = log\ (REER_t/REER_{t-1}) \quad (6)$$

where $r_{REER\ t}$ is the return of real exchange rate. The real exchange rate is constructed by dividing the trade-weighted foreign price level index by the corresponding domestic price level index, after converting the values to a common scale using nominal exchange rate.

$$REER_t = NEER_t\ (P^*_t/P_t) \quad (7)$$

To assess this link between real exchange rate returns and those of real exports under different time scales, we begin by a linear model which is forward looking at time *t*.

$$r_{XPR_t} = \alpha + \beta r_{REER_t} + \varepsilon_t \quad (8)$$

where ε_t is the error term.

Then, we applied GARCH model chosen the distinct frequencies involved. It is of course shown that GARCH-type modeling allows us to have several results (e.g. Anderson et al. 2009). The unobserved conditional variance has affected widely the development of various GARCH-type models (e.g. Engle, 1982). Several specifications have been advanced to capture different features that are thought to be important. For instance, some GARCH extensions allow the volatility to react asymmetrically to positive and negative shocks (e.g. Nelson, 1991), others consider only the magnitude of shocks (e.g. Bollerslev, 1986). This has created a need to understand clearly if the performance of GARCH models varies heavily or slightly over time. Accordingly, a large strand of literature on financial engineering has attempted to check whether GARCH models vary depending to time periods (e.g. Bollerslev et al. (1993), Bera and Higgins (1993), Campbell and Mackinlay (1997), among others).

The common conclusion is that across different time periods, there is a change in volatility's behavior, leading to a change in GARCH parameters. More precisely, the model is capable of accommodating systematic changes in the amplitude of the volatility clusters that cannot be explained by a constant-parameter GARCH model. Recently, Mazur and Pipien (2013) show that Financial markets data often exhibit volatility clustering and cyclical behavior, where time series show periods of high volatility and periods of low volatility.

Hence, in order to choose the best model, we use standard criteria such as the Akaike criterion, the Bayesian Information Criterion and Hannan and Quinn criterion. Table 2 summarizes their expressions. These criteria evaluate the models based on the historical volatility. The discrimination function differs from one test to another. Obviously, there is not really an optimal model but the optimality remains concerning the choice of the test. Given this, these criteria seem sufficient to judge the quality of the estimation (e.g. Bouoiyour et al. 2012).

4.1.Application Preliminary analysis

We report the descriptive statistics in Table 3. The sample means of real exchange rate returns and those of real exports are negative. Skewness and kurtosis measures indicate that distributions of the returns of both series are positive. Therefore, the returns of these series are skewed and leptokurtic relative to a normal distribution. The Jarque–Bera normality test indicates high levels, and thus we reject the normality for both variables.

Figure 3 depicts a positive impact of changes in real exchange rate on those of real exports in Egyptian case, but this effect appears minor. These preliminary results await confirmation using rigorous econometric assessment.

4.2.Main findings: Estimates with energy versus without energy

As we stated at the outset, we assess the linkage between real exchange rate returns and those of real exports using wavelet method. We consider seven frequency bands, as we report in Table 4. This wavelet decomposition relies on a symmlet basis[5].

Our estimates of the optimal model chosen among various GARCH extensions that link the two key variables under time domain and distinct frequencies are summarized in Table 5. We find a significant and positive effect of real exchange rate returns on those of real exports (with energy) among the distinct frequencies involved (, which is theoretically and empirically unexpected. Normally, we expect that an increase in real exchange rate volatility raises the transaction costs and then threatens trade performance. Nevertheless, some studies on this topic emphasize that export performance-exchange rate uncertainty connection may depend intensely to the volatile behavior of oil prices (e.g. Egert and Zumaquero, 2007). Based on this assumption, we thought to subtract the share of energy from real exports and differential price. By doing so, we show a negative and significant linkage between the two variables, either in time domain or across the different monthly frequencies under

[5] See Appendix A.

consideration. Let try in the following to explain more accurately these outcomes based on the frequency transformation.

4.2.1. Time domain

For the time domain, we show that an increase in the real exchange rate by 10% prompts a significant increase in real exports by 28.6% (Table 5). Contrary to expectations, we uncover a positive and significant correlation between our key variables for all returns from January 1994 to October 2009. This result changes considerably when subtracting the share of energy from total exports and differential price. Indeed, we find that an appreciation of real exchange rate by 10% leads to a decrease in the level of real exports by 1%. This implies that the energy's share in total exports, which presents 26% (see Sekkat, 2012), makes a difference in the considered relationship, and thus this connection appears sensitive to energy prices mainly driven by speculation.

4.2.2. Frequency bands

For all considered frequencies (i.e. D1, D2, D3, D4, D5, D6 and D7), we find from Table 5 that the effect of real exchange rate returns on those of real exports is positive and significant. We worthy observe that an increase in the real exchange rate by 10% yields an increase in real exports by 36.9%, 25.4%, 26.3%, 17.9%, 37.5%, 13.9% and 12.22%, respectively. Our first observation to these outcomes shows that the power of the relationship in question dissipates remarkably in the long-term, i.e., when moving from higher frequencies including particularly (D1: 2-4M and D2: 4-8M) to lower frequency bands, specifically (D6: 64-128M and D7: >128M). The subtraction of energy leads to different results, which do not change substantially in terms of the sign from one frequency to another, while they change in terms of magnitude, depending to frequency transformations. Thus, an increase in the real effective exchange rate by 10% produces a drop in real exports by 0.5%, 1.3%, 0.1%, 0.2%, 1.8%, 2.3% and 1.9%, respectively under D1, D2, D3, D4, D5, D6 and D7. When subtracting energy, the effect of exchange rate volatility on exports becomes more harmful at lower frequencies than medium and higher frequencies. It amounts for example 0.5% in the short-run, in particular at D1 (2-4M) and 0.2% at the medium-term (D4: 16-32M), while it reaches 2.3% at D6 and 1.9% at D7 (in the long-run).

Equally important, for time domain and across all the frequencies, we note much greater persistence of the link in question (with energy) and lesser persistence (without energy), initiating the tendency to long memory process in the first case and to short memory process in the second one (Table 6). Furthermore, without subtracting energy, the coefficient γ is positive, which implies that the effect of bad news is stronger than that of good news. In contrast, by subtracting energy, the coefficient γ becomes negative and statistically significant. This highlights the importance to account for asymmetry and therefore to the sign of shocks (bad and good news). As we depict in Figure 4, the conditional variance behaves better when subtracting energy's share from total exports and differential price.

The above results seem heavily expected because of the important proportion of energy in the total of exports of Egypt (i.e., 26%). In addition, the real exchange rate is defined as the differential price of a basket of traded and non-traded goods between the domestic and the foreign economy leading to a great sensitivity to the boom-bust commodity prices including those of energy. Consistently, previous studies highlight a complex relationship between energy price and real exchange rate uncertainties, especially in oil exporting countries; for example, Chen and Rogoff (2003), Engel and West (2005), Rogoff and Rossi (2010) and Bodenstein et al. (2011), among others.

4.3.Discussion of results

The varying results obtained within wavelet decomposition framework imply that the relationship between exchange rate uncertainty and exports is more complex than it may appear. Depending to frequency-to-frequency variation, it tends to be nonlinear and asymmetrical. As we depict in Table 4, the interaction dynamic between exchange rate volatility and exports (with energy) appears nonlinear at D, D2, D4 and D5 and asymmetrical under D1, D3, D6 and D7. Without energy, the link between both variables remains nonlinear in some frequencies and asymmetrical in other ones. At this stage, we can assert that the use of the best GARCH model among several GARCH extensions effectively differentiates all the possible effects[6]. This may, of course, help the Egyptian authorities to better understand the

[6] The best model chosen should explain properly the nature of the effect of exchange uncertainty on exports in that period. More precisely, when the GARCH extension chosen by information criteria is T-GARCH or GJR-GARCH or N-GARCH, this implies that the variance between exchange rate and exports depends heavily on switching regime (i.e., structural breaks). Additionally, if the model chosen is, for example the E-GARCH, this means that the conditional variance between variables depends on the sign of innovations.

evolution of the connection between the key variables and avoid possible future shocks, including those related to energy market.

In addition, for all studied cases (i.e. without and with energy and across different time scales), we note that the leverage effect impacts more the considered link than the switching regime. More precisely, we show that, with energy, the magnitude of exchange rate uncertainty's effect on exports is equal to 35.34% (as average) when we account the sign of innovations compared to 23.52% (as average) when we account structural breaks in the process of volatility. At the same way but less important, without energy, real exchange rate volatility's effect on real exports is equal to 1.83% (as average) and 1.26% (as average), respectively. Not surprisingly, in oil exporting economies that adopt managed exchange regime as Egypt, the adjustment in real exchange rate will come through changes in consumer prices (e.g. Bouoiyour and Selmi, 2013). This implies that the differential price uncertainty itself highly sensitive to oil price fluctuations can make Egypt unable to adjust its currency and lead to excessive swings in real exchange rates that may lead to damageable effects on exports performance. Besides, because energy market is deeply driven by speculative attacks and cyclicality of prices, sizable variability of oil price may outweigh a positive effect[7].

With energy, the exchange uncertainty's effect on real exports is greater at higher frequencies (i.e., the short-run), and it becomes much less important in the long-run. This may be highly attributed to speculative attacks that characterize obviously international energy market. More precisely, the energy market is a large market relative to other commodities and the assumption of financial speculation may be evident.[8] This leads to an increase of co-movement (business cycle) between the spot price of oil and futures prices. In related works, Alquist and Kilian (2010) and Fattouh et al. (2012) argue that the demand and supply shocks in the global oil market often entailed offsetting changes in oil inventories to reinforce then changes in oil prices, implying the presence of great speculation.

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[7] For details, we can refer to Sester (2007). This latter advance that "dollar pegs will not prevent the currencies of oil exporting economies from eventually appreciating in real terms."

[8] For more details about how speculators can be drivers of oil price uncertainty, we can refer to Buyuksakin and Harris (2011).

Without energy, real exports react more to real exchange rate volatility at lower frequency than higher frequency. This means that the link in question becomes more considerable in the long-run. This outcome may be due to various structural drawbacks and inappropriate policy choices associated essentially to the choice of the pegged exchange regime as exchange rate policy, for instance. Accurately, when the domestic country carries most of its trade with a single major country, pegging the local currency to that of its main partner may be beneficial. However, the effective exchange rate can capture the value's effects of the local currency vis-à-vis the currencies of its trading partners (see Ngouana, 2012). For our case of study, Egyptian exports may be largely affected by the euro's movements, especially because its main exports partner is Europe with share almost equal to 15.7% (see Appendix C). This implies also that the fluctuations of oil price denominated in dollar can coincide with a great volatility of euro (e.g. Arezki et al. 2011). The statistics reported in Appendix D reinforce the adequacy of the above assertion. We clearly note that exports to European Union are dominated by mineral and energy products, denominated on dollar. Importantly, for pegs, the choice of a reference basket of currencies involves decisions that are dependent on trade concentration, the degree of market openness and the size of the country (e.g. Magda and Dincer, 2008) that may outweigh unexpected real exchange rate volatility's effect on trade (i.e., we can observe a positive connection, for example, in a country mainly distinguished by its fiscal policy ineffectiveness and insufficient financial development).Moreover, slow labor market adjustments in Egypt can produce dramatic and unsustainable current account imbalances. Furthermore,

Our results suggest that information on respectively drivers and consequences of commodity prices 'evolution including those of energy could be well recognized. Such information also about the exchange rate movements, the domestic and imported inflation rate and a clearer understanding of the major channels through which oil price can affect real exchange rates and then real exports might be heavily needed.

Summing up and given the above outcomes, Egypt should improve coordination between monetary policy and fiscal policy to react quickly and effectively to external shocks, speculative attacks and cyclicality that drive greatly energy market.

5. Conclusion

We have investigated the relationship between real exchange rate uncertainty and exports performance to check whether there is a significant nonlinear and asymmetrical short-run dynamic between them. For this purpose, we have selected an optimal GARCH model chosen among distinct frequencies via wavelet decomposition.

The results reveal that the use of "sophisticated models" effectively enhances our understanding on a complex relationship and a debate controversy. In this study, we show two main interesting results:

(i) With energy, real exports react more to real exchange rate volatility at higher frequencies (D1, D2 and D3) and medium ones (D4) than lower frequency bands (D5, D6 and D7). We attribute this to the great speculation and the sharp cyclicality that mainly characterize energy market, coupled with the inefficiency of financial system, the ineffectiveness of fiscal policy.

(ii) Without energy, the relationship between exchange volatility and exports performance behaves differently and therefore appears more intense at lower frequencies (i.e. trend component). This observed finding may be owing to the choice of exchange regime's drawbacks, the specialization in products with low technological content, the weaker diversification in terms of trade partners and the lack of innovative capacity and the weakness of institutions.

To conclude, this article provides a starting point for policy advisors and practitioners in exchange and trade policies in Egypt. Regulatory efforts would be a preferable way of dealing with the possible detrimental effects of volatile real exchange rate on export performance, mainly driven by ups and downs of energy prices, themselves driven by speculation. The implementation of policy reforms to accelerate investment diversification on competitive non-oil sectors can mitigate the vulnerability of this economy to oil price shocks.

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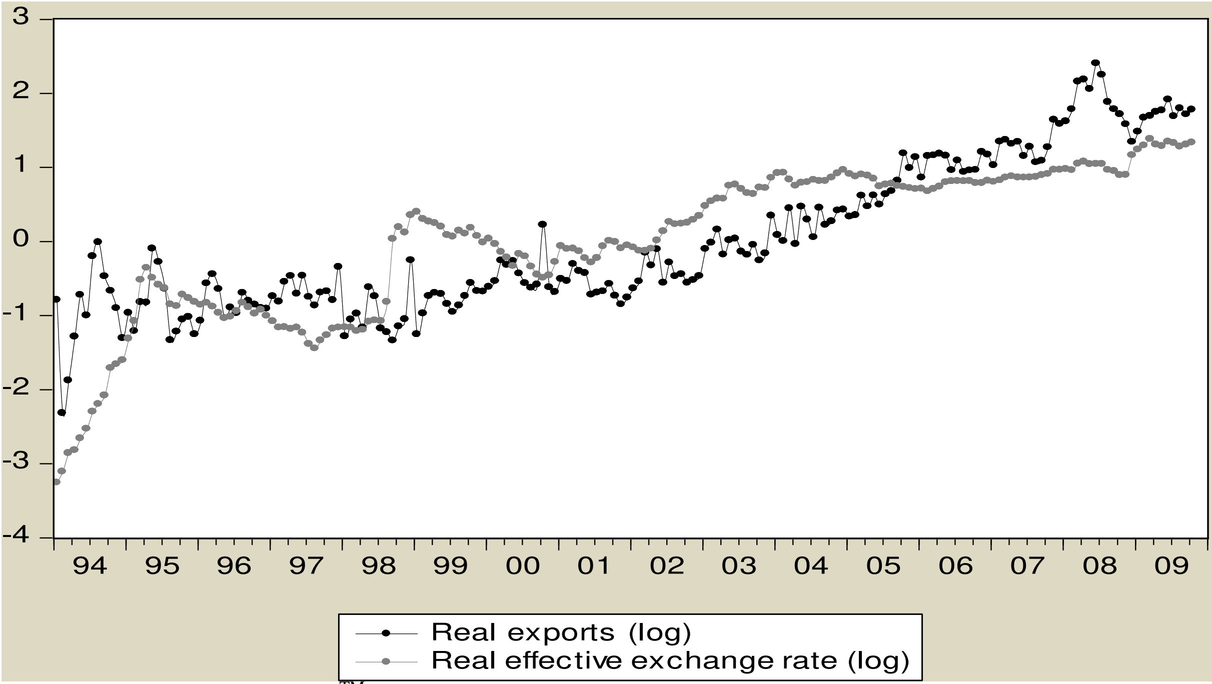
Table 1. GARCH extensions used in the study

	linear	nonlinear	symmetric	Asymmetric
1. GARCH (Bollerslev, 1986) $\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_j \sigma_{t-j}^2$	x		x	
2. GARCH-M (GARCH in mean, Bollerslev and Wooldridge, 1990) $r_t = \mu_t + \varepsilon_t + \lambda\sigma_t^2$	x		x	
3. C-GARCH (Component GARCH, Ding et al. 1993) $(\sigma_t^2 - \sigma^2) = \alpha(\varepsilon_{t-1}^2 - \sigma^2) + \beta(\sigma_{t-1}^2 - \sigma^2)$	x		x	
4. QGARCH (Quadratic GARCH, Engle and Ng, 1993) $\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i (\varepsilon_{t-i} - b_i)^2 + \sum_{i=1}^{p} \beta_j \sigma_{t-j}^2$		x	x	
5. IGARCH (Integrated GARCH, Engle and Bollerslev, 1986) $\sigma_t^2 = \omega + \varepsilon_{t-1}^2 + \sum_{i=1}^{q} \alpha_i (\varepsilon_{t-i}^2 - \varepsilon_{t-1}^2) + \sum_{i=1}^{p} \beta_j (\sigma_{t-j}^2 - \varepsilon_{t-1}^2)$	x		x	
6. AGARCH (Asymmetric GARCH, Engle, 1990) $\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i (\lvert\varepsilon_{t-i}\rvert + \gamma_i \varepsilon_{t-i})^2 + \sum_{i=1}^{p} \beta_j \sigma_{t-j}^2$	x			x
7. TGARCH (Threshold GARCH, Zakoian, 1994) $\sigma_t^2 = \omega + \sum_{i=1}^{q} (\alpha_i \lvert\varepsilon_{t-i}\rvert + \gamma_i \lvert\varepsilon_{t-i}^{+}\rvert) + \sum_{i=1}^{p} \beta_j \sigma_{t-j}$		x		x
8. GJR-GARCH (Glosten et al., 1993) $\sigma_t^2 = \omega + \sum_{i=1}^{q} (\alpha_i + \gamma_i I_{(\varepsilon_{t-i>0}})\varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_j \sigma_{t-j}^2$		x		x
9. GJR-PARCH (GJR power GARCH, Glosten et al. 1993) $\sigma_t^{\varphi} = \omega + \sum_{i=1}^{q} (\alpha_i + \gamma_i I_{(\varepsilon_{t-i>0}})\varepsilon_{t-i}^{\varphi} + \sum_{i=1}^{p} \beta_j \sigma_{t-j}^{\varphi}$		x		x
10. EGARCH (Exponential GARCH, Nelson, 1991) $\log(\sigma_t^2) = \omega + \sum_{i=1}^{q} (\alpha_i z_{t-i} + \gamma_i (\lvert z_{t-i}\rvert - \sqrt{2/\pi})) + \sum_{i=1}^{p} \beta_j \log(\sigma_{t-j}^2)$				x
11. PGARCH (Power GARCH, Higgins and Bera, 1992) $\sigma_t^{\varphi} = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^{\varphi} + \sum_{i=1}^{p} \beta_j \sigma_{t-j}^{\varphi}$	x		x	
12. A-PGARCH (Asymmetric power GARCH, Ding et al., 1993) $\sigma_t^{\varphi} = \omega + \sum_{i=1}^{q} \alpha_i (\lvert\varepsilon_{t-i}\rvert + \gamma_i \varepsilon_{t-i})^{\varphi} + \sum_{i=1}^{p} \beta_j \sigma_{t-j}^{\varphi}$				x
13. NGARCH (Nonlinear GARCH, Duan, 1995) $\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i (\varepsilon_{t-i} - \kappa_i)^2 + \sum_{i=1}^{p} \beta_j \sigma_{t-j}^2$		x	x	

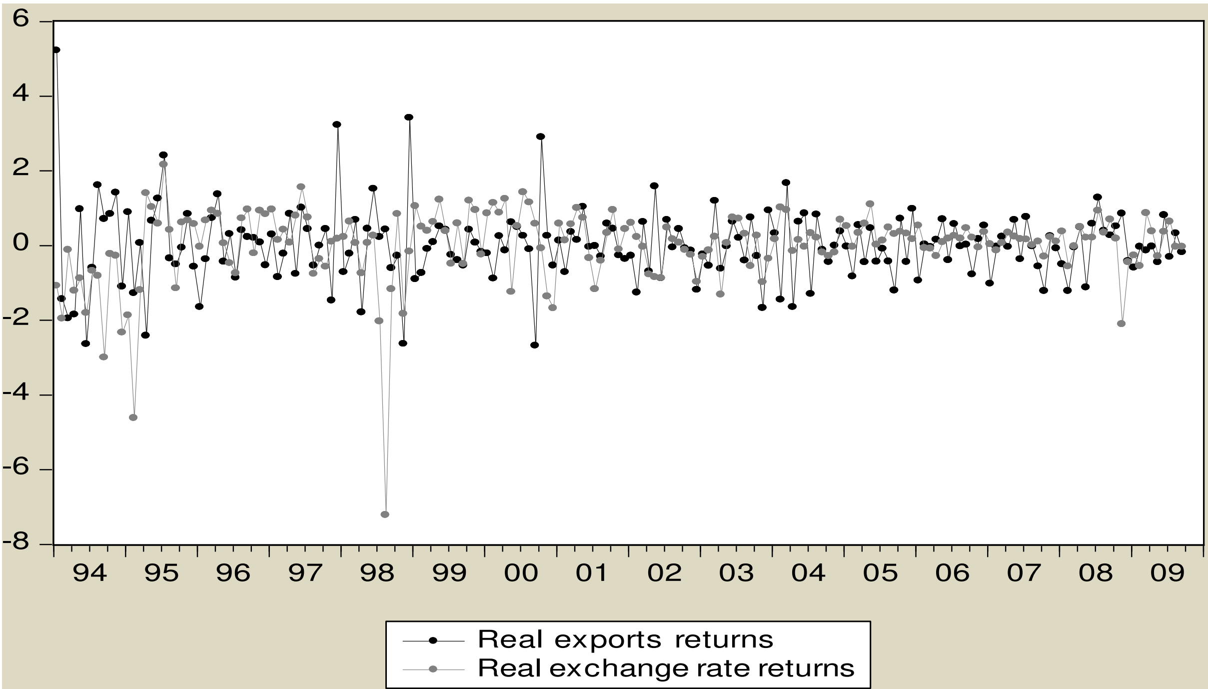
Notes: σ_t^2 : conditional variance, σ_t : conditional standard deviation, ω : reaction of shock, α_0 : reaction of shock, α_1 : ARCH term, β_1 : GARCH term, ε : error term; I_t: denotes the information set available at time t; I_{t-1}: denotes the information set available at time t-1; z_t: the standardized value of error term where $z_t = \varepsilon_{t-1}/\sigma_{t-1}$; μ : innovation, γ : leverage effect; $\sigma^2 = \omega/(1-\alpha-\beta)$: corresponds to the unconditional variance ; b : quadratic order, φ : power parameter.

Figure 1. Real exports and real effective exchange rate (Normalized data)



Source: IMF, IFS and Econstats™.

Figure 2. Real exports and real exchange rate returns (Normalized data)



Source: IMF, IFS and Econstats™ and authors' calculations.

Table 2. Criteria used on the choice of the optimal GARCH model

Akaike criterion :	*-2log(vraisemblance)+2k*
Bayesian criterion :	*-2log(vraisemblance)+log(N).k*
Hannan-Quinn criterion :	*-2log(vraisemblance)+2k.log(log(N))*

Note: *k* the degree of freedom and *N* the number of observations.

Table 3. Descriptive statistics

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	J-Bera
r_{XPR}	-0.0098	-0.0165	1.105350	-0.58324	0.213640	0.836873	7.647297	192.1405
r_{REER}	-0.0022	-0.0005	0.020377	-0.07770	0.010460	2.85336	18.53189	2156.226

Note: r_{XPR} : Real exports returns ; r_{REER} : Real exchange rate returns.

Figure 3. First correlation between real exports and real exchange rate

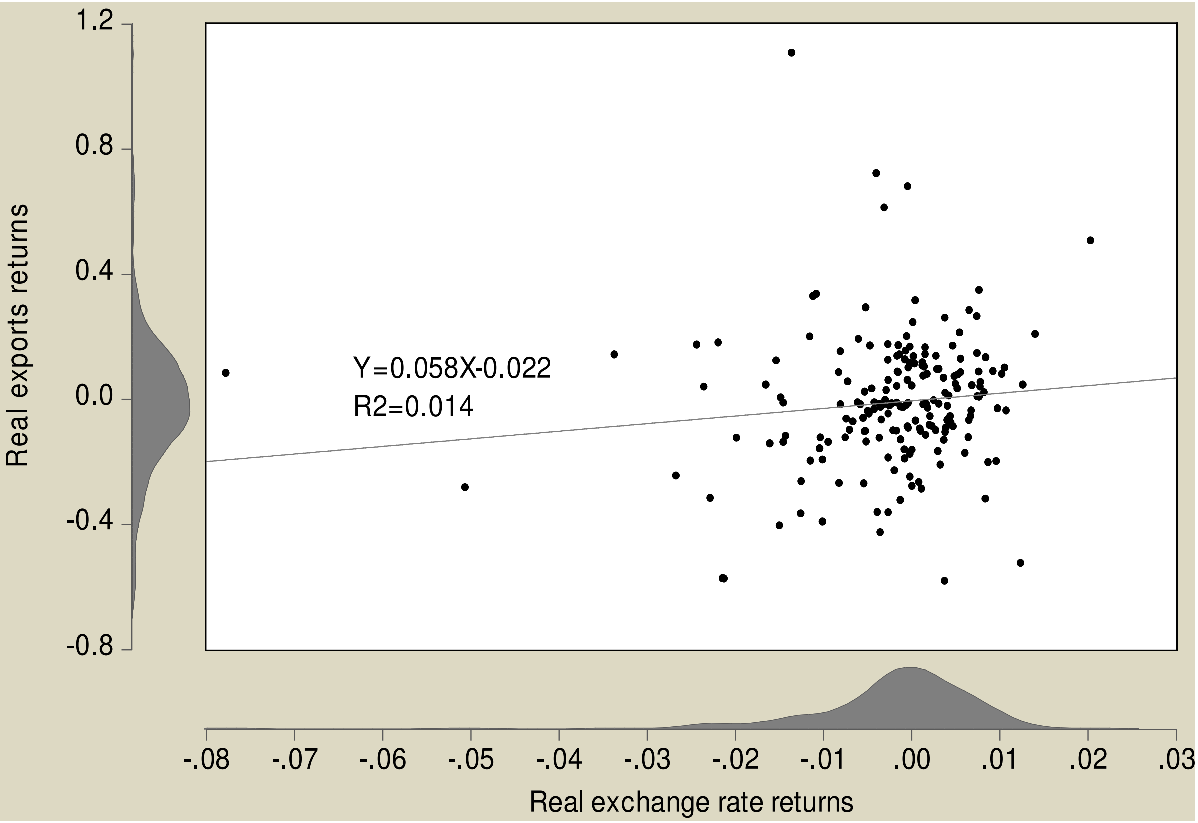


Table 4. Frequency bands

Decomposition of time series	Frequencies		Time scales
D1	Higher frequencies	2-4	Short-term
D2		4-8	
D3		8-16	
D4	Medium frequencies	16-32	Medium term
D5	Lower frequencies	32-64	Long-term
D6		64-128	
D7		$^{2}>128$	

Table 5. The link between changes in real exchange rate and those of real exports: Parameters of optimal GARCH model

Dependent variable: r_{XPR}								
				WITH ENERGY				
	Time domain	Frequency bands (months)						
	D	D1	D2	D3	D4	D5	D6	D7
	AP-GARCH	T-GARCH	GJR-GARCH	E-GARCH	N-GARCH	SA-GARCH	T-GARCH	E-GARCH
				Mean Equation				
Constant	-0.027*	-0.035**	-0.117*	-0.028*	-0.006	-0.008	-0.014**	-0.032*
	(-1.897)	(-2.408)	(-1.868)	(-1.964)	(-0.479)	(-0.767)	(-2.101)	(-1.876)
r_{REER}	0.286***	0.369*	0.254***	0.263***	0.179***	0.375***	0.139**	0.122***
	(3.393)	(1.842)	(3.728)	(3.251)	(3.717)	(3.717)	(2.355)	(3.111)
				Variance Equation				
α_0	0.046**	0.008**	0.009**	-1.019**	0.026***	0.031***	0.012**	-0.747**
	(2.550)	(2.947)	(2.620)	(-2.502)	(9.119)	(12.865)	(2.592)	(-2.195)
α_1	0.207**	-0.064	0.226**	0.292*	0.856***	0.884***	-0.066	0.311**
	(2.355)	(-1.103)	(2.934)	(1.873)	(25.444)	(45.323)	(-0.885)	(2.000)
β_1	0.603***	0.574**	0.501***	0.316**	-0.0005	-0.078**	0.506**	-0.303***
	(3.854)	(2.922)	(3.682)	(2.631)	(-0.156)	(-3.681)	(2.004)	(-3.145)

Y	1.000*	0.574***	0.222**	0.767***	0.181	0.147**	0.410***	0.660***
	(1.698)	(4.820)	(2.934)	(8.250)	(0.459)	(2.398)	(3.617)	(3.441)
WITHOUT ENERGY								
	Time domain	Frequency bands (months)						
	D	D1	D2	D3	D4	D5	D6	D7
	T-GARCH	E-GARCH	GJR-GARCH	E-GARCH	T-GARCH	N-GARCH	SA-GARCH	E-GARCH
Mean Equation								
Constant	-0.0003	-0.001***	-0.018*	-0.0005*	-0.0011	-0.007*	-0.0002	-0.016*
	(-0.579)	(-5.800)	(-1.641)	(-1.819)	(-0.459)	(-1.728)	(-0.891)	(-1.637)
r_{REER}	-0.010**	-0.005**	-0.013***	-0.001*	-0.002**	-0.018*	-0.023**	-0.019**
	(-2.913)	(-2.423)	(-4.259)	(-1.597)	(-2.315)	(-1.496)	(-2.119)	(-2.085)
Variance Equation								
α_0	-3.74***	8.9E-07**	-1.320**	-1.096**	-0.093	-1.101	0.0051*	-1.007
	(-4.833)	(2.720)	(-2.099)	(-2.105)	(-1.303)	(-0.766)	(1.699)	(-0.832)
α_1	0.768***	-0.098***	0.143*	0.228**	0.501*	0.223***	-0.10***	0.214*
	(5.372)	(-6.359)	(1.781)	(2.000)	(1.810)	(4.664)	(-3.254)	(1.653)
β_1	0.148*	0.755***	0.526***	0.174*	-0.101**	0.184**	0.513*	0.407**
	(1.615)	(4.622)	(9.703)	(1.918)	(-2.054)	(2.930)	(1.708)	(2.133)
Y	-0.675**	-0.658***	-0.514**	-0.603*	-0.495**	-0.609**	-0.502*	-0.619**
	(-2.926)	(-4.101)	(-2.832)	(-1.609)	(-2.223)	(-2.415)	(-1.688)	(-2.115)

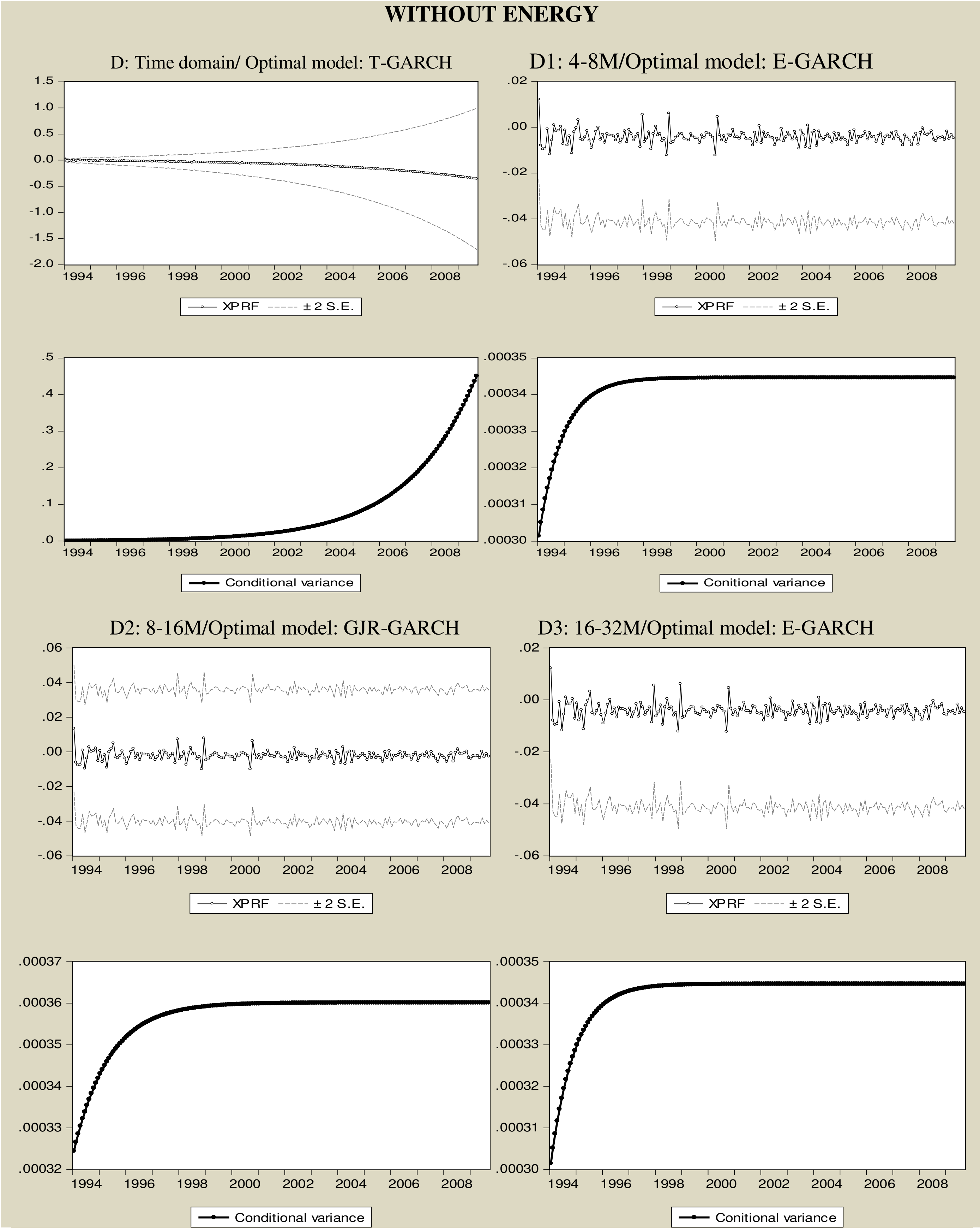
Note*:* standard deviations are in parentheses, *** significant at 1%, ** 5% * 10%. r_{XPR} *:* changes in oil prices; r_{REER}: changes in real effective exchange rate; *w :* The reaction of conditional variance; α : ARCH effect; β : ARCH effect; *Y* : Leverage effect.

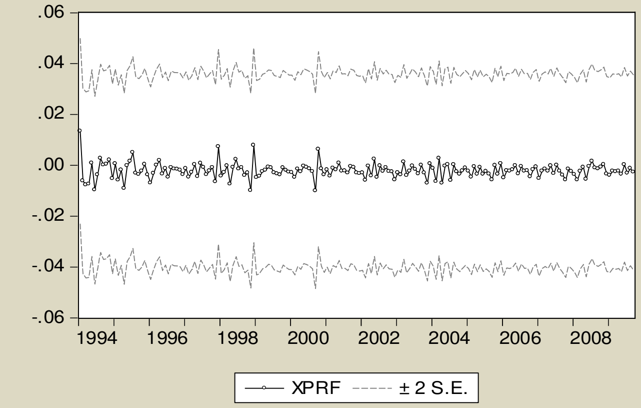
Table 6. Persistence of conditional variance

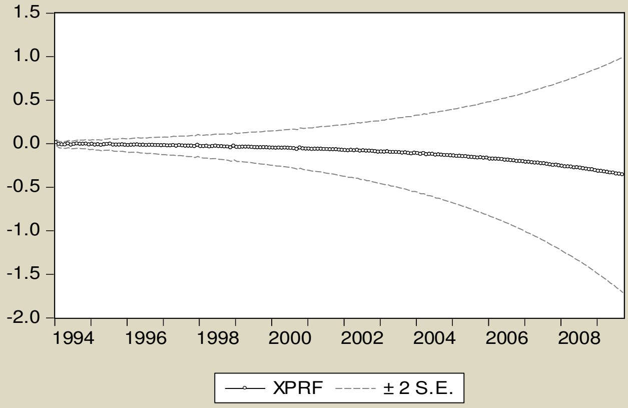
	D	D1	D2	D3	D4	D5	D6	D7
WITH ENERGY								
$\psi = \sum_{i=1}^{q}\alpha_i + \sum_{j=1}^{p}\beta_j + 0.5\gamma$	1.300	0.797	0.838	0.991	0.996	0.879	0.777	0.410
$\omega = \sum_{i=1}^{q}\alpha_i + \sum_{j=1}^{p}\beta_j$	0.810	0.510	0.727	0.608	0.856	0.806	0.572	0.080
$\theta = -\sum_{i=1}^{a}\alpha_i + \gamma$	0.793	0.638	-0.004	0.608	-0.675	-0.737	0.476	0.349
$\theta' = \sum_{i=1}^{a}\alpha_i + \gamma$	1.207	0.510	0.448	-0.024	1.037	1.031	0.344	0.971
α_0	0.046	0.008	0.009	-1.019	0.026	0.031	0.012	-0.747
γ	1.000	0.574	0.222	0.767	0.181	0.147	0.410	0.660
WITHOUT ENERGY								
$\psi = \sum_{i=1}^{q}\alpha_i + \sum_{j=1}^{p}\beta_j + 0.5\gamma$	0.579	0.328	0.437	0.101	0.153	0.103	0.252	0.311
$\omega = \sum_{i=1}^{q}\alpha_i + \sum_{j=1}^{p}\beta_j$	0.916	0.675	0.669	0.402	0.400	0.407	0.503	0.621
$\theta = -\sum_{i=1}^{a}\alpha_i + \gamma$	-0.093	-0.578	-0.675	-0.831	-0.996	-0.832	-0.402	-0.833
$\theta' = \sum_{i=1}^{a}\alpha_i + \gamma$	0.093	-0.783	-0.371	-0.375	0.006	-0.386	-0.602	-0.405
α_0	-3.74	8.9E-07	-1.320	-1.096	-0.093	-1.101	0.0051	-1.007
γ	-0.675	-0.658	-0.514	-0.603	-0.495	-0.609	-0.502	-0.619

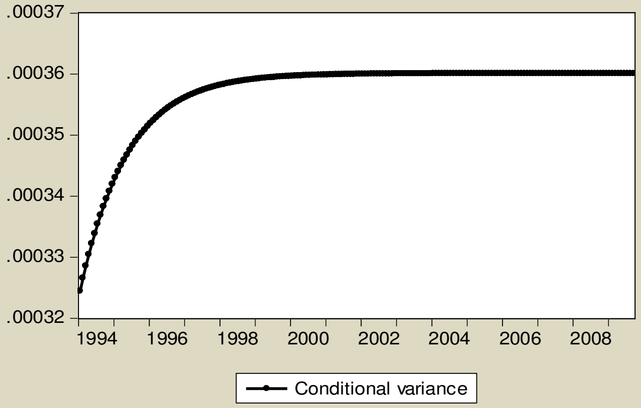
Note: ψ: the duration of persistence; ω: the sum of ARCH and GARCH effects; θ: intensity of negative shock; θ': intensity of positive shock; α_0: the reaction after shock; γ: the leverage effect.

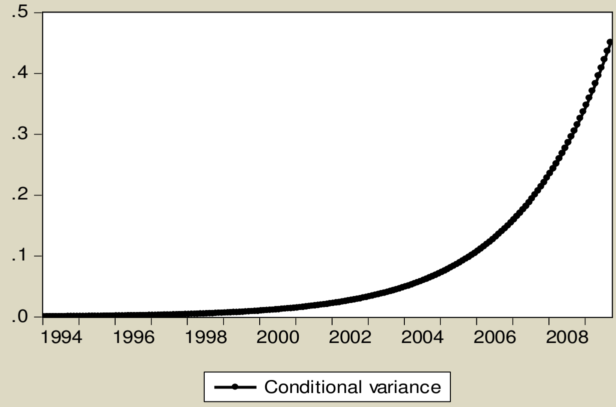
Figure 4. Conditional variance under Time domain and frequency bands by using optimal GARCH model



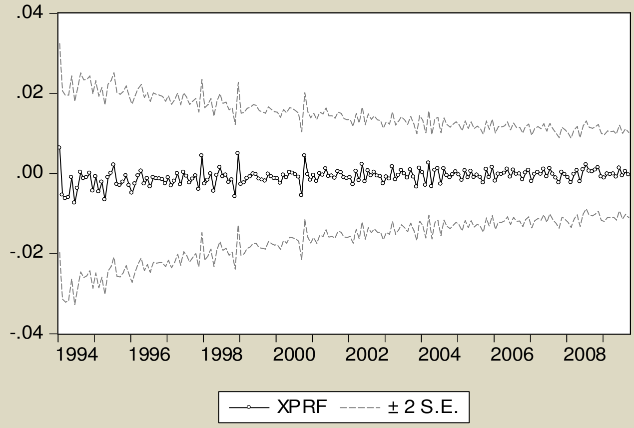


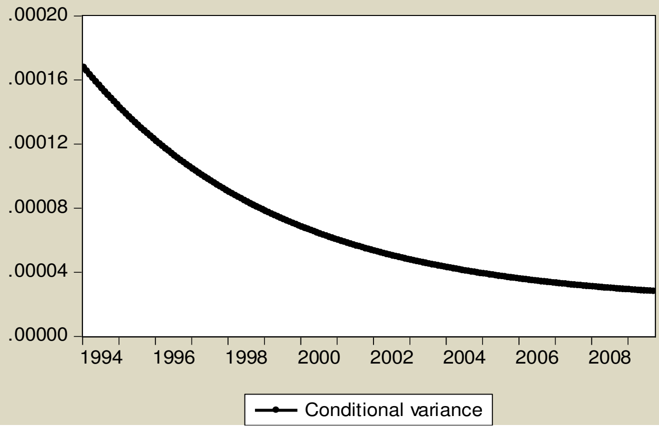




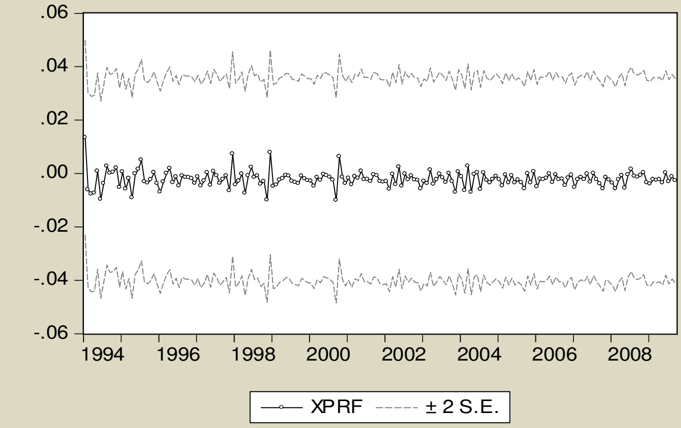


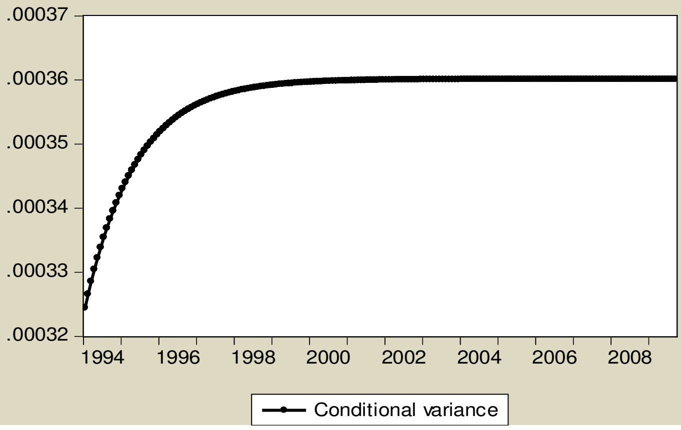
D4: 32-64M/Optimal model: T-GARCH



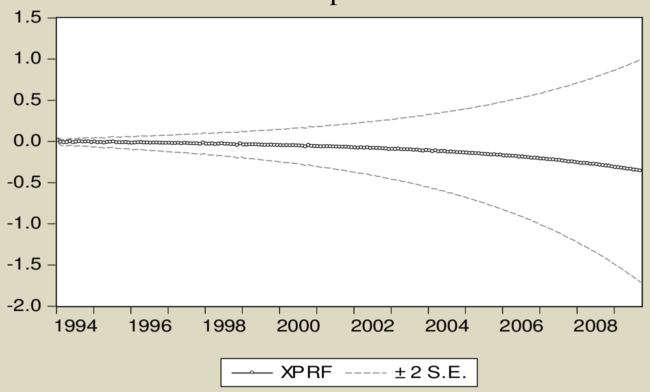


D5: 64-128M/ Optimal model: N-GARCH

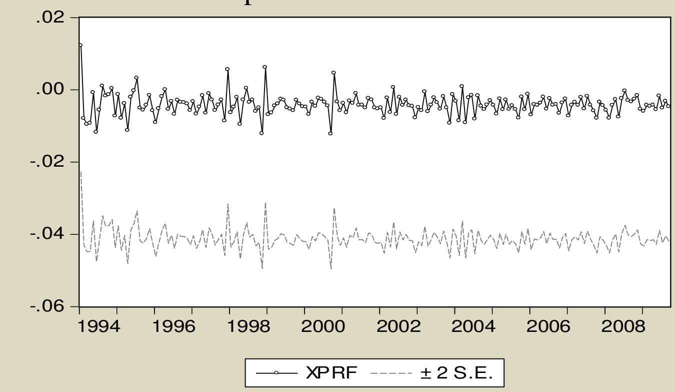


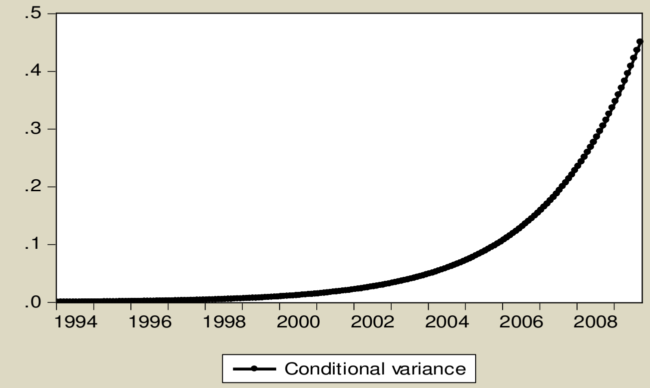


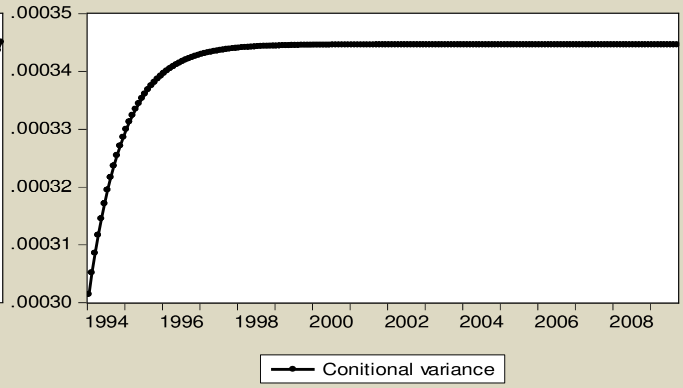
D6: 64-128M/ Optimal model: SA-GARCH



D7: >128M/ Optimal model: E-GARCH

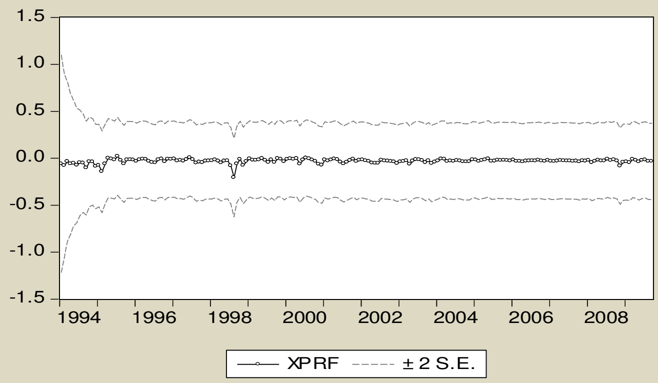




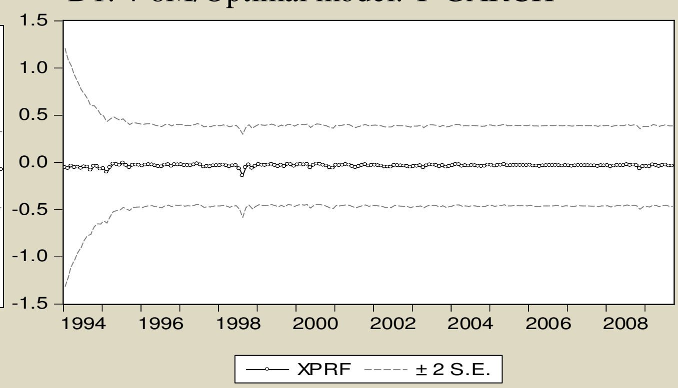


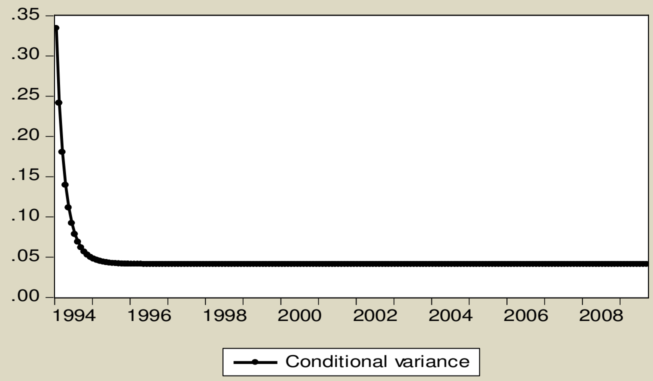
WITHOUT ENERGY

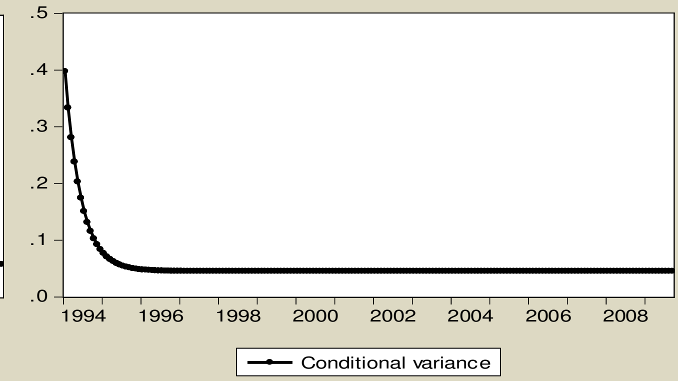
D: Time domain/ Optimal model: AP-GARCH

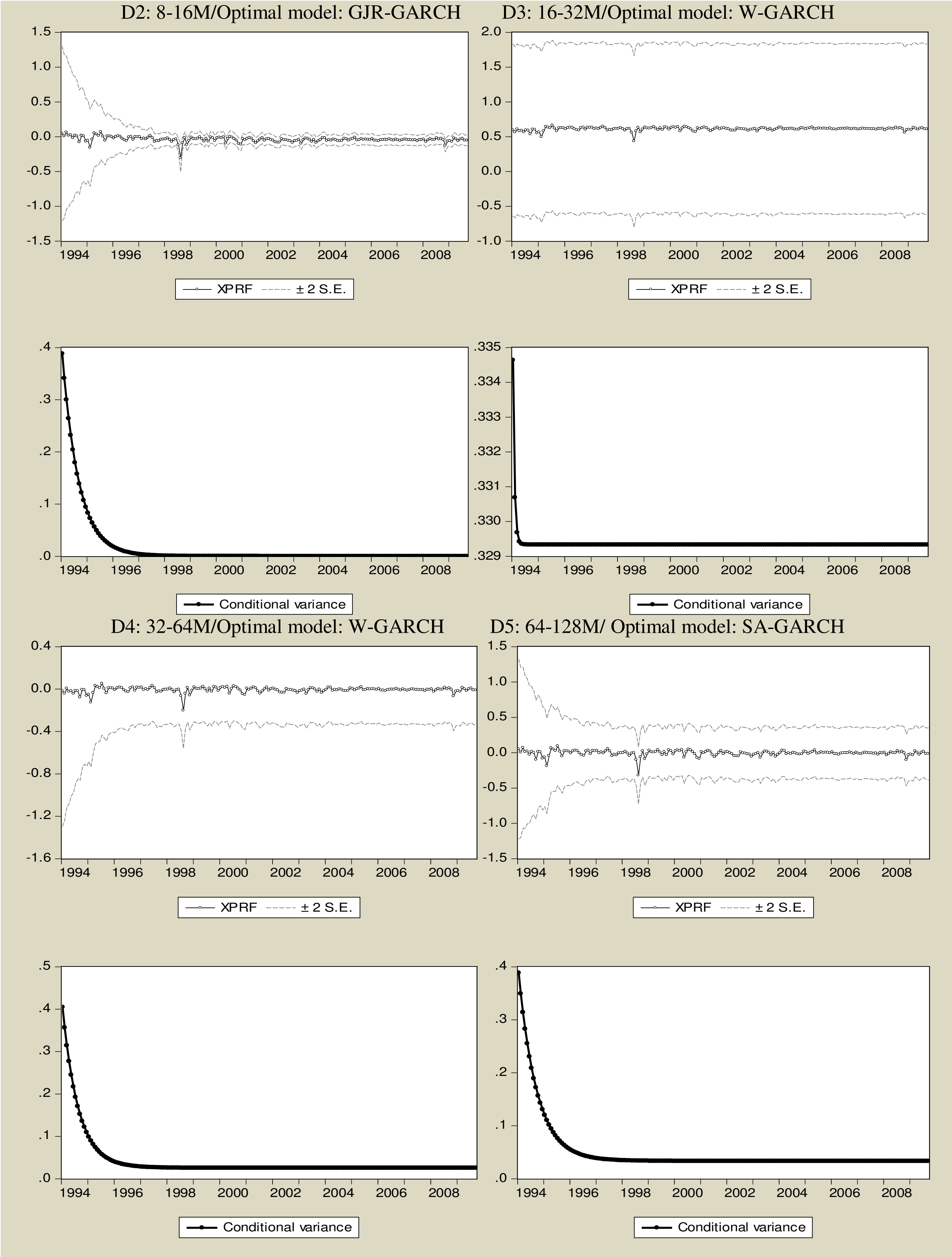


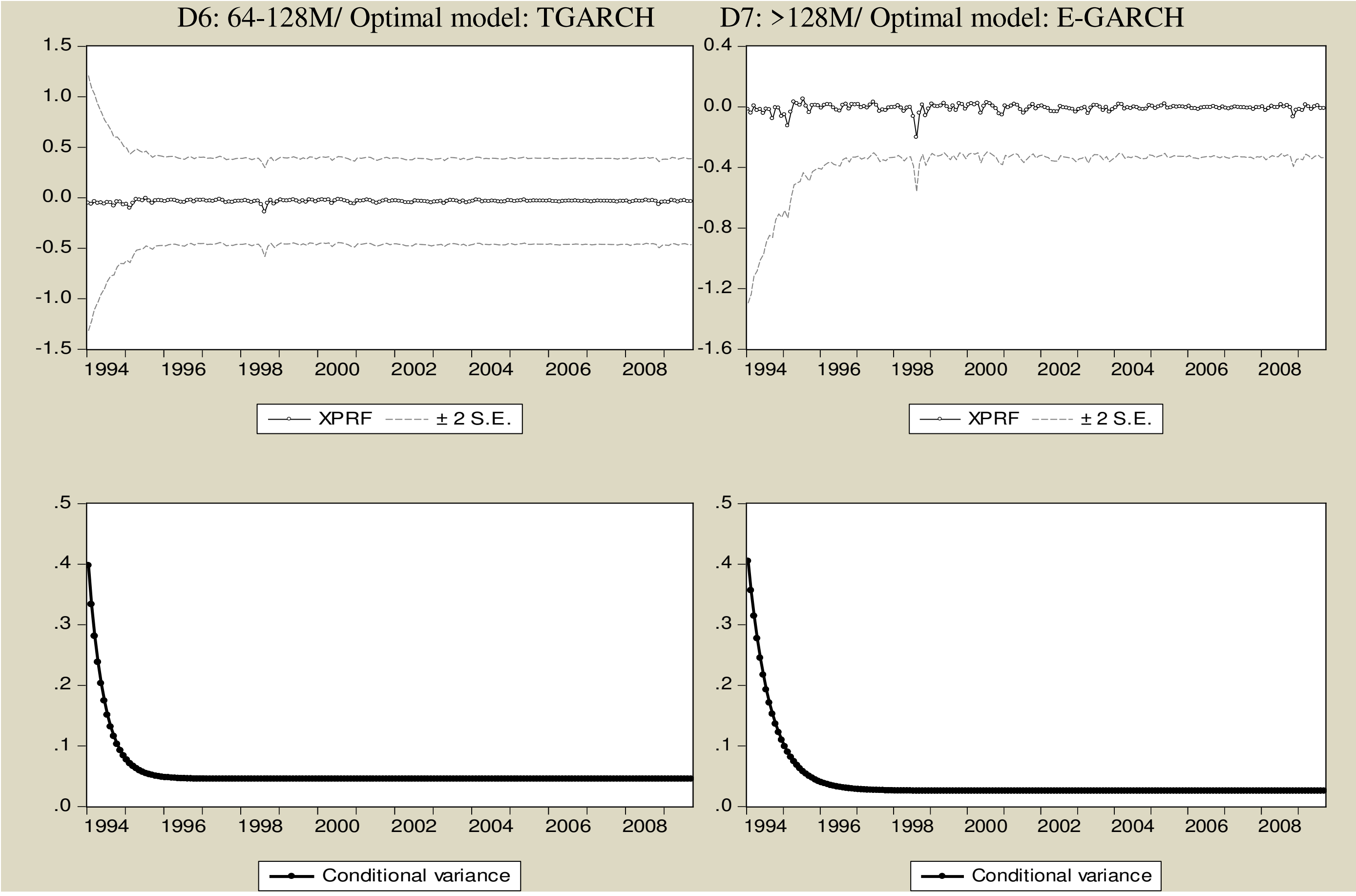
D1: 4-8M/Optimal model: T-GARCH







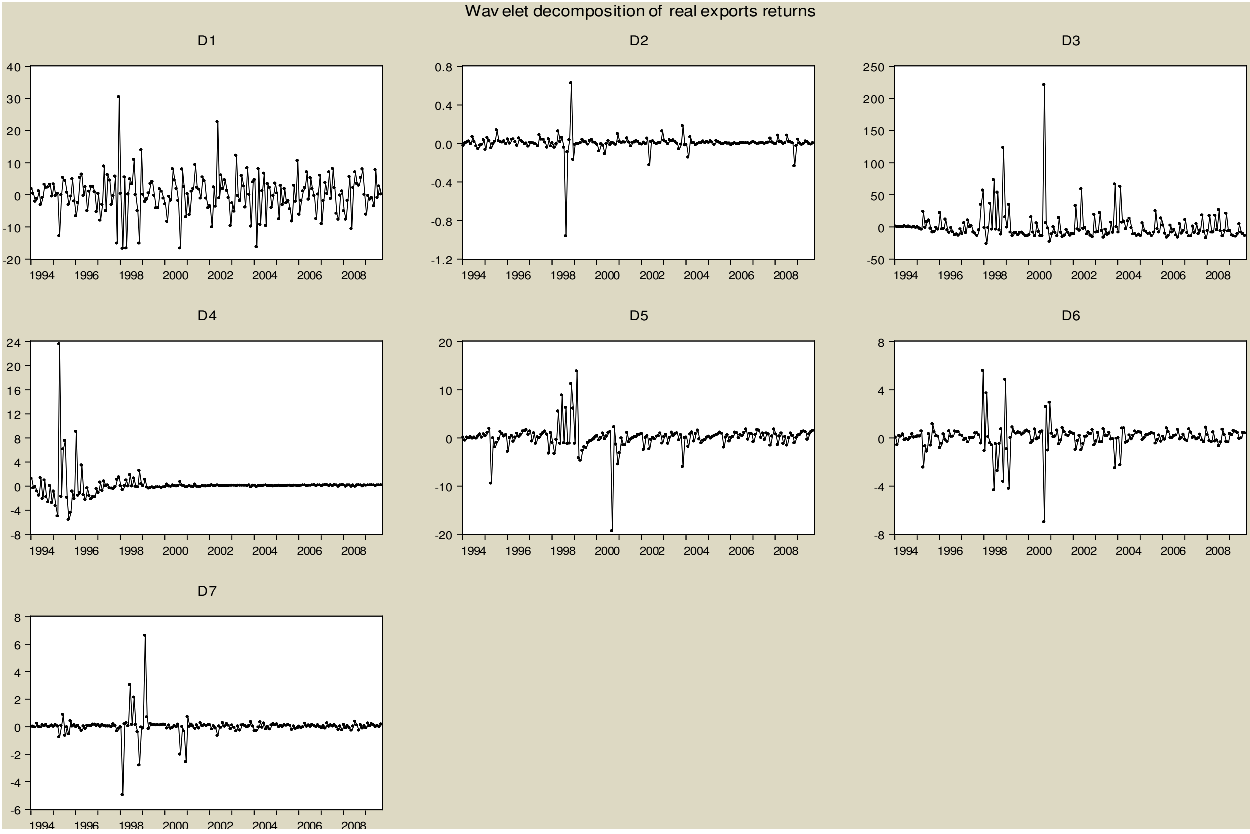

D2: 8-16M/Optimal model: GJR-GARCH
D3: 16-32M/Optimal model: W-GARCH
XPRF
± 2 S.E.
Conditional variance
D4: 32-64M/Optimal model: W-GARCH
D5: 64-128M/ Optimal model: SA-GARCH
1994
1996
1998
2000
2002
2004
2006
2008

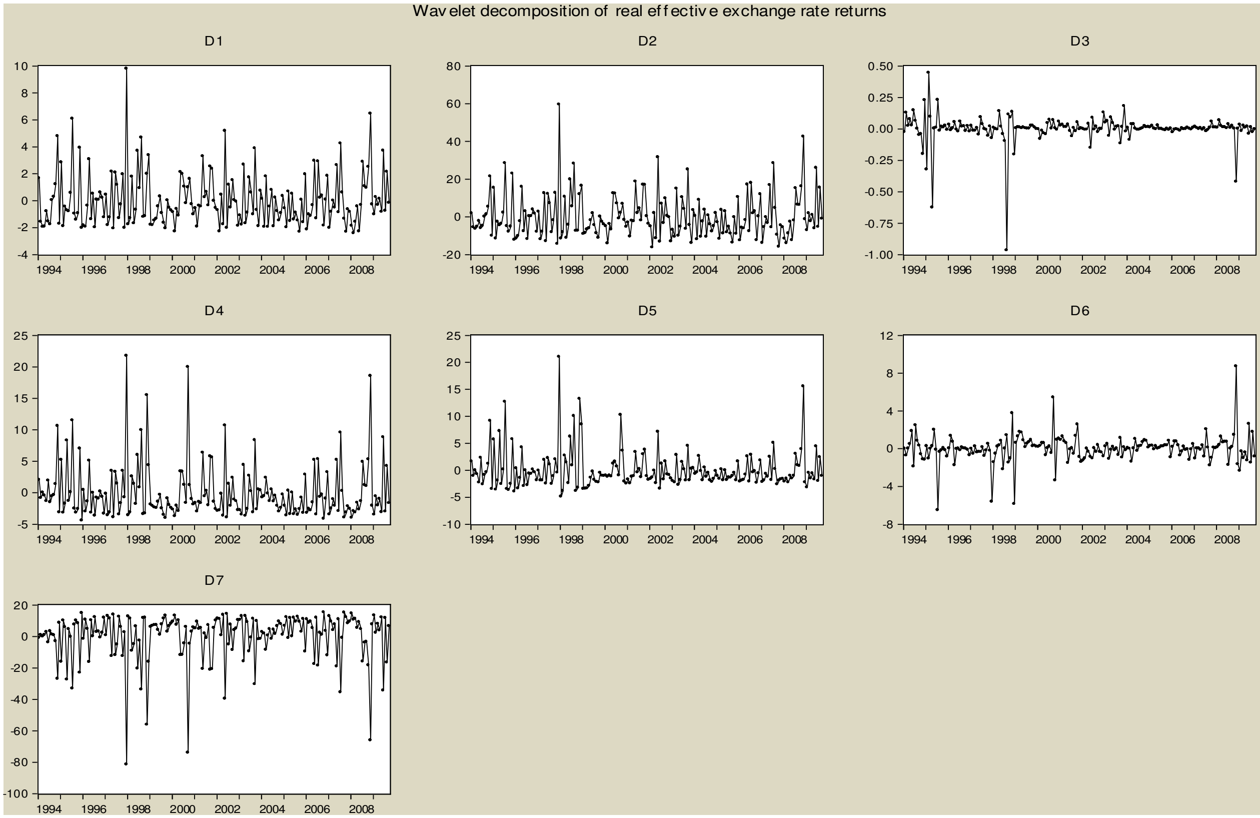


Note: Own calculation.

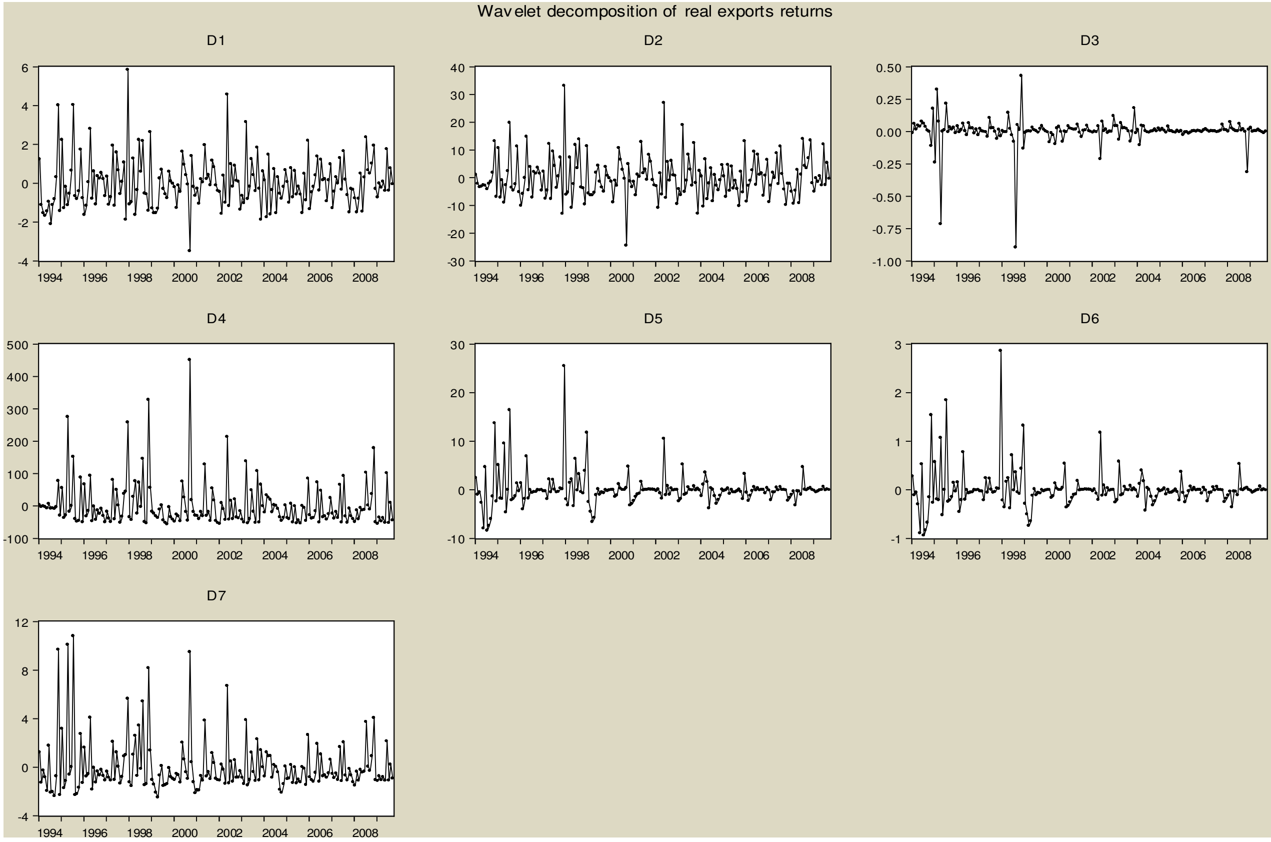
Appendices

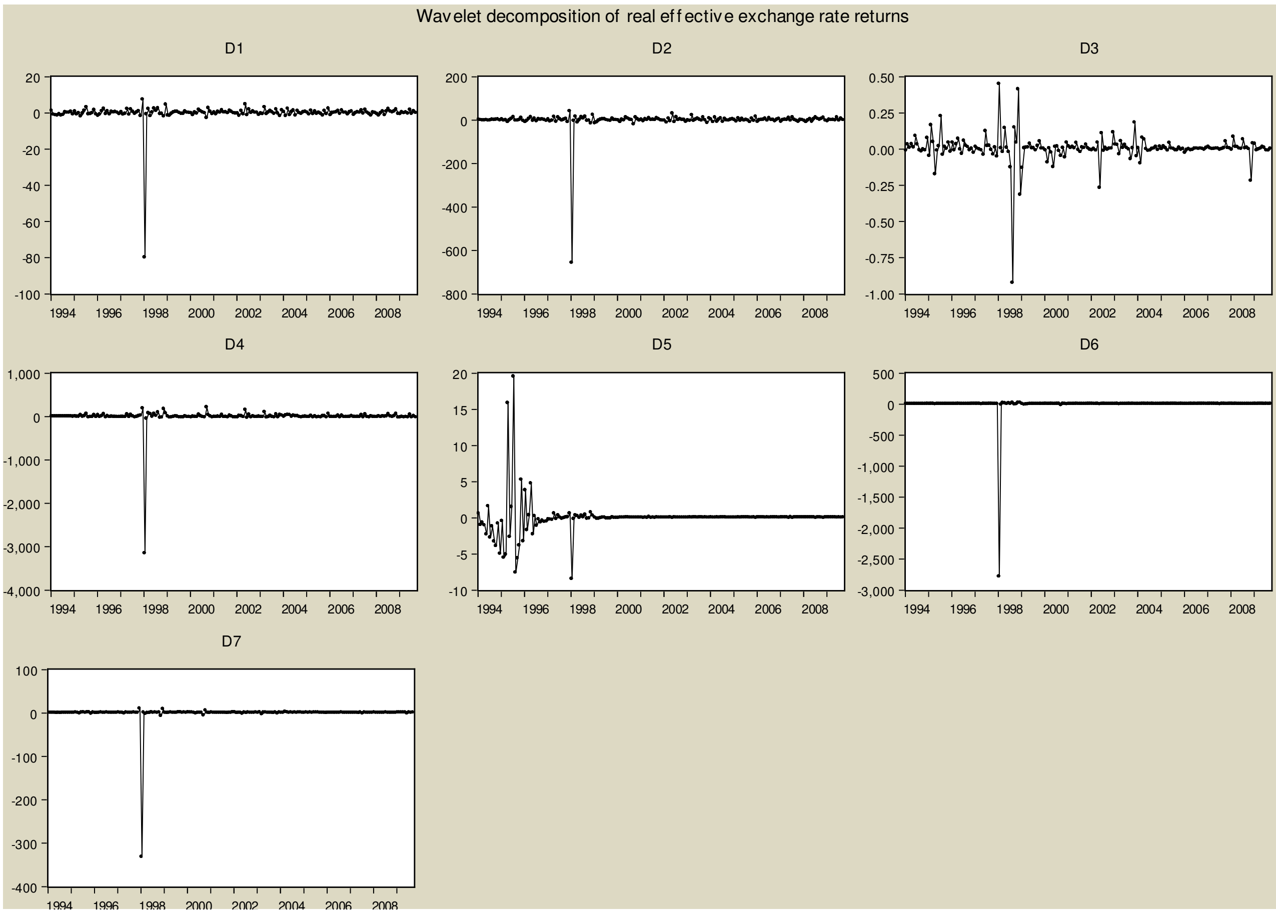
Appendix A. Wavelets of real exports and real exchange rate returns (WITH ENERGY)



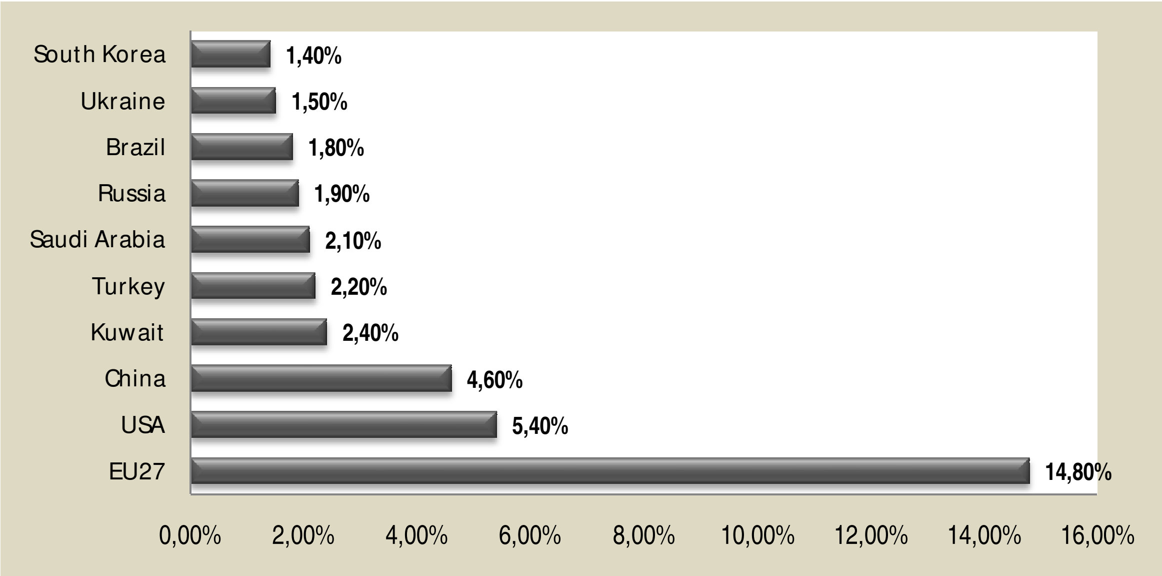


Appendix B. Wavelets of real exports and real exchange rate returns (WITHOUT ENERGY)



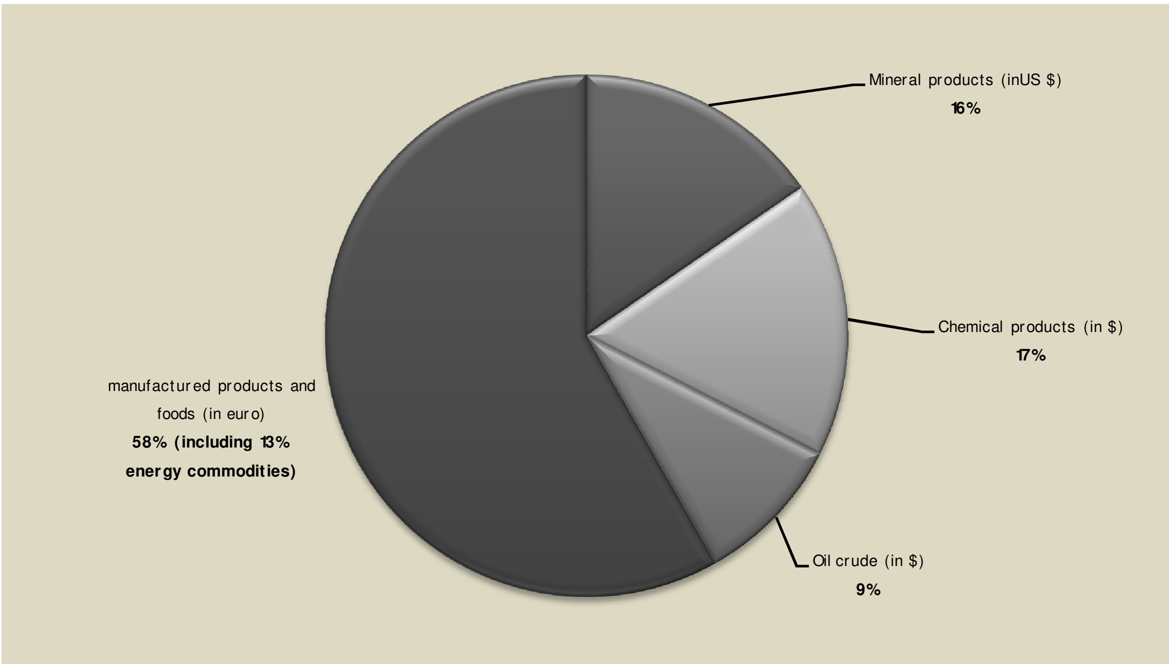


Appendix C. Egyptian main trade partners



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

Appendix D. Egyptian exports composition (to Europe)



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