Exchange volatility and trade performance in Morocco and Tunisia: what have we learned so far?

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Abstract: This paper attempts to assess two interesting issues for two small open economies (Morocco and Tunisia). First, it analyses the historical behaviour of nominal exchange rate, differential price and real exchange rate uncertainties. Second, it investigates the stability of the interaction between exchange volatility and exports in nominal and real terms. Our main results reveal that the effect of differential price volatility on exports exceeds that of nominal exchange rate by a large margin in terms of duration of persistence, ARCH and GARCH effects and intensity of shock. The relationship appears complex. In Morocco, it is negative and significant in 75.82% (as average) of cases in nominal terms and in 77.22% in real terms. This link is stronger in Tunisia with averages, respectively, equal to 85.88% and 89.99%. We associate the apparently mixed results to the differential price uncertainty itself sensitive to ups and down oil price movements, switching regime and leverage effects.

Keywords: exchange volatility; total exports; sectoral exports; GARCH.

JEL classification: F31; F1; C32.

1. Introduction

The effect of exchange rate uncertainty on trade performance has been and continues to be a keen interest to economists, especially, because in the short run, it is still difficult to identify the reasons behind excessive exchange volatility. Throughout the historical literature, excessive ups and down exchange rate movements have played a critical role on exports (e.g. Bailey et al. (1986) and Koray and Lastrapes (1989)). Given the attention to this linkage, a considerable literature has been devoted to study it (e.g. Brooks and McKenzie (1997), Dell'Ariccia (1999) and McKenzie (1999), etc…).

Some studies have found a negative interaction between currency risk and exports (e.g. Baum et al (2001), Vergil (2001), etc…). Others have found positive effects (e.g. De Grauwe (1992) and Achy and Sekkat (2003), among others). Despite this large strand of literature on the considered issue, the theory upon this relationship varies and there is no clear-cut linkage to be found. Up to now, very few studies advance convincing arguments on the controversial effect of exchange rate uncertainty on trade.

Earlier, to reconcile the mixed results of prior researches, using meta-regression analysis, Coric and Pugh (2008) provide evidence that the effect of exchange volatility on trade is likely to be adverse when measured in real rather than nominal term, when low frequency rather than high frequency variations are considered and when less developed rather than developing countries are considered. Bouoiyour and Selmi (2013) add using the same technique (i.e. meta-analysis) that the effect of exchange volatility on exports performance differs depending to modeling strategies.

Following this viewpoint, we thought to revisit the exchange rate volatility effects on exports performance by carrying out different GARCH specifications to determine the volatility (i.e. symmetrical versus asymmetrical, linear versus nonlinear, with threshold order versus with level shift and with power effect versus component effect, etc…). By doing so, we try to highlight additional explanations of conflicting results widely expected either theoretically or empirically.

Importantly, this paper provides support for the view that in countries which adopt managed float regime, real exchange rate is more affected by the volatile behavior of differential commodity price rather than that of nominal exchange rate[1].

Hence, the remainder of the paper is structured as follows: Section 2 presents an overview of exchange and trade policies in Morocco and Tunisia. Section 3 presents a recall of the notion of volatility followed by the different measures used in this work. Section 4 derives and develops our strategy to evaluate the link between exchange rate uncertainty and total and sectoral exports in both nominal and real terms.Section 5 is devoted to robustness check k. Section 6 concludes our paper.

2. Exchange and trade policies in Morocco and Tunisia

Following the demise of the Bretton Woods system in 1973, Morocco and Tunisia have chosen very similar development paths. Indeed, they opted for liberalism since their independence. They also implemented adjustment programs almost at the same time (i.e. mid-80s). Then, they signed at the same time a significant association agreement with the European Union in order to create a free trade zone. Regarding our subject, we also note that the two countries have a close exchange policies. Until the early 1980s, these two small open economies maintained the nominal effective exchange rate within a stable band. In 1996, these countries chose to adopt managed float regime to preserve external competitiveness. Hence, the nominal exchange rate movements were limited in this period (see Figure 1). However, we depict in Figure 2, a great variability of differential price. This can be explained by the concentration of partners' destination[2] (see Figure 3) and the specialization in more volatile products (see Figure 4), which can ultimately affect the price of commodities a major source of real exchange volatility.

Thereafter, particularly in the period from 1999 to 2003, the exports in percentage of GDP of both considered countries have not fluctuated largely. However, from 2004 to 2009, these slight movements have evolved to continuous increase. It appears clearly from Figure 5

[1] 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 vulnerability to the volatility of commodity prices. In

[2] The concentration of foreign trade and the distribution of Moroccan and Tunisian exports are almost similar (Baccouche et al. 2008).

that the total exports contributed to the production of GDP with a marked superiority of Tunisia. In that context, it should be added that manufactured products accounted the largest share representing almost 50 percent of overall exports (see Figure 6). Dependents strongly to manufacturing and mining exports, Morocco and Tunisia may be potentially influenced by the commodity prices uncertainty.

Despite this similarity worthy observable in terms of exchange and trade policies[3], the results associated to price competitiveness and economic growth can differ. This creates a need to assess whether exchange policy plays crucial role in providing increase in exporting incentives in Morocco and Tunisia.

3. The notion of exchange volatility

3.1. Definition

A large strand of literature define exchange volatility as the absolute percentage of changes in exchange rates or the moving average standard deviation of the exchange growth rate; For example, Bailey et al. (1986), Chowdhury (1993) and Dell'Ariccia (1999), among others. Theoretically, these models may ignore the information on stochastic processes through which exchange rates are generated.

Statistically, financial markets data often exhibit volatility clustering, where time series show periods of high volatility and periods of low volatility. In fact, time-varying volatility is more common than constant volatility. In that context, GARCH extensions are considered more appropriate to define volatility (e.g. Bollerslev et al. 1993). These models are very useful for describing the volatility of the conditional variance by taking into account the characteristics of series using the past errors in estimates.

While a variety of exchange rate volatility measures have been used in the empirical literature (e.g. McKenzie (1998), Nabli and Varoudakis (2002), Sandikov et al. (2004), etc…), there is still no consensus on which measure is the most appropriate.

In this study, we perform robustness check using 2880 GARCH extensions[4] in order to choose the best model able to determine the volatility of nominal exchange rate, that of

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[3] For details about exchange rate regimes and trade reforms , see Appendix A.

[4] The measures of volatility are reported in Appendix B. We used 17 extensions GARCH. For each specification, we apply 04 combinations ((1,1) ; (1,2) ; (2,1) ; (2,2)), following 03 distributions (Gaussian, Student and GED). For each extension, we apply a few options. Thus, each specification can be zero Mean ($u_t=0$), constant mean ($u_t= u_0$) ou in mean ($u_t= u_0+ u_1\sigma_{t-1}^2$)

differential price and that real effective exchange rate. Hence, it is useful to recall that GARCH modeling initiated by Engle (1982) and generalized by Bollerslev (1986) assume that the conditional variance follows an ARMA process. Subsequently, it has undergone a remarkable evolution of GARCH extensions (e.g. Tong (1990), Nelson (1990), Ding et al. (1993) and Zakoin (1994), etc…). The standard GARCH can be written as follows:

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

Where α_i, β_i, ε, σ et ω are parameters to be estimated and are successively ARCH effect, GARCH effect, errors estimates, conditional variance and reaction to the shock.

GARCH models may be linear or nonlinear[5], symmetrical or asymmetrical[6]. These specifications are summarized in appendix B[7]. Since the quality of the results depends not only on the relevance of the model, but also the efficiency of the algorithm, we consider different options (i.e. models with zero mean, constant mean and in mean, with moving average process and without moving average process and following Maquardt and Berndt-Hall-Hall-Hausman algorithmic optimizations) based on the study of Koksal (2009) and Bouoiyour et al. (2012).

3.2. Estimates

3.2.1. Descriptive statistics

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and perhaps also with MA term (with moving average process) or without MA term (without moving average process). These models are applied to algorithmic optimizations Maquardt and Berndt-Hall-Hall-Hausman (For more details, see appendices C and D).

[5] Nonlinear models are those with function indicator that 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).

[6] 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).

[7] For detailed analysis of GARCH specifications, see Bouoiyour et al. (2012).

To measure the volatility of nominal exchange rate, differential price and real exchange rate, it seems important to choose the optimal models able to determine the historical behaviors of their uncertainties.

To start, the $REER_t$ is constructed by dividing the trade-weighted foreign price level index (P_t*) by the corresponding domestic price level index (P_t), after prior conversion to a common numeraire using nominal effective exchange rate ($NEER_t$).

$$REER_t = NEER_t (P_t^* / P_t) \quad (2)$$

Figure 7 allows us to highlight changes in exchange rate in both nominal and real terms that will interest us throughout this study. We clearly observe a large and permanent variability for these variables.

In addition, the results reported in Table 1 reveal that the coefficient of kurtosis is greater than 3 for the exchange rate and the differential price of considered countries, except for the Moroccan *REER*. This indicates that the distribution is less flattened than the normal in the first cases and inversely in the last one. The skewenss is positive in the case of Morocco across all time series. This shows that the asymmetrical distribution is more plausible in Moroccan case, unlike Tunisia where the skewness is negative, suggesting the effectiveness of symmetrical distribution. Then, the Jarque Bera test reveals a low value for the *NEER*, *(P/P*)* and *REER*, leading to accept the normality hypothesis for these variables.

Then, to confirm the existence of asymmetrical effects on the conditional variance of exchange rates and differential price, we follow Zivot (2008) by determining the correlation between returns and lagged squared returns (see Table 2). We note that the correlations between returns and lagged squared returns have a negative values for the *NEER*, *(P/P*)* and *REER* for Moroccan case and positive values for Tunisian case. This indicates the presence of leverage effect in Morocco and its absence in Tunisia.

These results seem unexpected, because Morocco and Tunisia are very close in terms of exchange and trade policies (e.g. Baccouche et al. (2008) and Emmonot and Rey (2008)). Remains to check whether these preliminary results are solid and do not change substantively when we move to historical evaluation.

3.2.2. Historical evaluation

The application of GARCH models allows us to determine the exchange rate volatility in nominal and real terms. To choose the best model among many extensions GARCH, we used various information criteria (i.e. Akaike, Schwartcz and Hannan-Quinn). These criteria evaluate models based on historical behavior of each variable. The model with the lowest values is most preferred[8]. The discrimination function differs from one criterion to other. It should be noted that these criteria are sufficient to judge the quality of our estimates (see Bouoiyour et al. 2012).

For nominal exchange rate volatility, the best model chosen is the N-GARCH (1, 2) for Morocco and the GARCH (1, 1) for Tunisia. The specifications chosen to determine the relative commodity prices uncertainty are respectively, P-GARCH (1, 2) for Morocco and T-GARCH (2, 1) for Tunisia. The best models chosen in real terms in Morocco and Tunisia are respectively the E-GARCH (2, 1) and GARCH-M (1, 2)[9]. In Appendix C, we match the Kernel density of selected models. The x-axis shows a positive value of information criteria, larger values mean better options associated with chosen model. This method favors the Gaussian distribution for Morocco and Tunisia, with leverage effect for the first case and its absence for the second case.

Importantly, Table 3 shows that for both economies in question, the duration of persistence, the intensity of shock, the leverage effect and ARCH and GARCH effects of nominal exchange volatility and price differential are less important than real exchange volatility. More precisely, for Morocco, the leverage effect is positive for both nominal and real terms, indicating that bad news have greater impact than good news, but this effect is much more important for the real exchange rate. The effect of a positive shock for the *NEER* is less important than the *REER*, and similarly for the negative shock. It is observed that the bad and good news have the same impact on the conditional variance. The persistence of the conditional volatility is important for both cases with less importance for the *NEER*. The sum of ARCH and GARCH is more important for the *REER* than the *NEER*. The *REER* volatility is more sensitive to the *(P/P*)* uncertainty than that of *NEER* in terms of persistence, intensity of shock and ARCH and GARCH effects.

For Tunisia, the duration of persistence and the ARCH and GARCH effects of *NEER, (P/P*)* and *REER* are more important than Morocco. This result can not be confirmed with the

[8] The criterion of Schwartcz is more parsimonious than that of Akaike since it introduces more parameters in the model.

[9] For detailed explanations of each specification, see Anderson et al. (2009).

absence of asymmetrical effect in the model chosen to measure the Tunisian exchange uncertainty. But testing the same models for both countries, we show the same result, i.e. Tunisian volatility is more persistent. Thus, the conditional variance of nominal exchange rate behaves better than that of the real exchange rate. Figure 8 confirms the more volatile behavior of the real exchange rate than the nominal exchange rate and in Tunisia than in Morocco.

Therefore, the historical evaluation of exchange rate volatility in nominal and real terms confirms our preliminary analysis. Remains hereafter to be seen whether the linkage between exchange volatility and exports in Morocco and Tunisia vary depending to the duration of persistence, intensity of the shock, leverage effect and ARCH and GARCH effects associated to exchange uncertainty. To do so, we explore a vast array of regressors.

4. Estimates of the linkage between exchange volatility, relative commodity price uncertainty and exports

Most of the studies on the effect of exchange volatility and trade performance assume that the correlation between these two variables is consistently ambiguous but with magnitude less than 10% (e.g. McKenzie (1999), Vergil (2002), Achy and Sekkat (2003), Sadikov et al. (2004), Rey (2006) and Egert and Zumaquero (2007)…). Assuming away this question, our purpose here is to regress the total and sectoral exports on exchange volatility in nominal and real terms and other control variables. We use then the following model.

$$XPR_t= \alpha_0+\alpha_1 \, LnREER_t +\alpha_2 \, Ln \; VOLR_{t-1}+ \alpha_3 \, Ln \; (X_t)^{R} +\xi_t \qquad (3)$$

$$XPN_t= \alpha_0+\alpha_1 \, LnNEER_t +\alpha_2 \, Ln \; VOLN_{t-1}+ \alpha_3 \, Ln \; (P/P^*)_t + \alpha_4 \, Ln \; VOL \; (P/P^*)_{t-1} +\alpha_5 \, Ln(X_t)^{N} +\xi'_t \qquad (4)$$

Where ξ_t and ξ'_t are the error terms.

-The logarithm of nominal and real effective exchange rates, respectively, noted *NEER* and *REER*. There is no a priori reason that a variability of *REER* matches exactly that of the *NEER*, especially because the *REER* depends on both nominal exchange rate and relative commodity prices[10]. Following our export function specification, the domestic and foreign commodity price indices are producer prices[11].

-The logarithm of the volatility in nominal and real terms, approximated respectively by the volatility of nominal exchange rate (*VOLN*) and that of real effective exchange rate (*VOLR*). Exchange volatility is determined using optimal GARCH model chosen by information criteria. According to Nabli et al. (2004) and Egert and Zumaquero (2007), exchange volatility increase the degree of uncertainty in terms of export competitiveness and can have an ambiguous effect depending to the sector of exports.

-The volatility of differential price (*Ln (P/P*))* is determined using the optimal GARCH specification selected by information criteria and Kernel density. The differential price uncertainty dampens trade performance and can almost disrupt the trajectory of exports in primary producing countries (e.g. Blattman et al. (2007) and Arezki et al. (2011)).

-The logarithm of (*X*) presents control variables. We chose as explanatory variables the national *GDP* and the *GDP* of trade partners which have a pulling role in exports (e.g. Nabli and Varoudakis, 2002). For the *GDP* of importing countries, we used the weighted average of the main partners of Morocco and Tunisia, where the European zone corresponds to the share of exports to the euro area, the weight for the American zone represents the share of exports to the American countries...

Quarterly data from the International Monetary Fund and Econstats, covering the period from 1996 to the last quarter of 2009 were used to assess the extent to which exchange volatility may affect the total and sectoral exports in Morocco and Tunisia, and to check if differential price uncertainty really plays an important role in generating the results. All these variables are taken at time t unless the volatility is taken at time t-1[12].

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[10] It presents the differential between national commodity prices and foreign commodity prices.

[11] Some studies use consumer prices, but according to Egert and Zumaquero (2007), this index contains administered prices, indirect taxes and imported products, which can not reflect exactly the effect of relative commodity price on exports.

[12] It is obvious that exporters need a delay to adjust their prices.

4.1. Total of exports

Our results summarized in Table 4 reveal that the impact of exchange rate volatility on the total of exports is ambiguous. For Morocco, the relationship between these two variables appears negative and statistically significant. This result is valuable in both nominal and real terms. This may be attributable to the lack of developed hedging facilities in Morocco that can protect exporters against exchange rate uncertainty (e.g. Achy and Sekkat, 2003). However, the same relationship appears positive and significant for Tunisian case. If we link this result to the risk aversion (e.g. Ozturk and Acaravci, 2006), this can be far from true for the simple reason that we has no a clear indicator for the degree of risk aversion. Although, the real exchange rate is theoretically determined by many factors (e.g. Rogoff, 1996), studies on its fundamentals in developing countries emphasize the important role of terms of trade which are closely linked to oil prices (e.g. Egert and Zumaquero, 2007). Hence, the real exchange can be influenced by the movements of crude of oil. We try then to check this viewpoint by subtracting the share of energy from total exports.

Our results show that overall exports is more affected by exchange volatility in Tunisia than in Morocco, i.e. an increase by 10% in exchange rate volatility reduces Moroccan exports by 1.47% and increase of Tunisian exports by 5.70%. By subtracting the energy exports from the total of exports, we show a negative interaction between the considered series, implying that the relationship between exchange volatility and Tunisian exports is sensitive to the changes in oil prices, which is not the case for Morocco. Not surprisingly, the lack of sensitivity towards the subtraction of the energy sector from the Moroccan total exports is intensely due to the low proportion of these products in the global exports of this country (see Figure 4).

In addition, we observe clearly that an increase by 10% of nominal exchange volatility prompts a drop in nominal exports by 1.78% in Morocco and 4.43% in Tunisia. We notice also that the effect of differential price on exports is always stronger than that of nominal exchange rate, i.e. an increase in 10% of differential price uncertainty yields to a decrease in nominal exports by 3.20% in Morocco and by 5.85% in Tunisian case.

Besides, the effect of foreign exchange and differential price uncertainties on the total of exports has increased with the introduction of structural breakpoints[13]. We find also that the Moroccan and Tunisian *GDP* explain the competitiveness of exports more than the *GDP* of their importing countries, which means that the domestic production of these countries is less important than the foreign addressed demand. This result is heavily expected because the problem in these countries is their inability to meet external demand. More precisely, in Morocco and Tunisia, the domestic demand plays an important role as determinants of exports. Conversely, the foreign demand has a minor role in determining exports performance. We attribute this intensely to the weakness of production capacity (e.g. Baccouche et al. 2008).

4.2. Manufacturing sector

Despite the competitiveness of manufacturing sector on the total of exports in both Morocco and Tunisia (e.g. Sekkat, 2012), we find a negative and significant effect of volatility on manufactured exports for Moroccan case, which implies that the companies specialized in manufactured products would not be able to modify its inputs optimally to adapt excessive exchange volatility. However, this relationship is positive and significant for Tunisia. As total exports, we thought to subtract energy's share. This causes a change in signs (See Table5). That is to say, an increase by 10% in real exchange volatility leads to a decrease of the level of manufacturing exports by 3.14% in Morocco and an increase by 4.72% in Tunisia. For this last country, a subtraction of the energy share implies a decrease in manufacturing exports by 3.3%. Interestingly, the effect of differential price volatility on nominal exports still more important than that of nominal exchange rate and for Tunisia than Morocco. Introducing the dummy variable of economic crisis, the linkage between exchange volatility and exports becomes stronger.

[13] The structural break corresponds to a dummy variable, noted DV, representing the economic crisis which takes the value 0 before the economic crisis, i.e. before the second quarter of 2008 and 1 for the period with higher volatility assumed after the economic crisis.

4.3. Agricultural sector

Many empirical studies have been conducted on the effect of commodity price and exhange rate volatilities on sectoral trade, in particular, agriculture (e.g. Maskus (1986), Latrapes and Koray (1990), Kumar and Dhawan (1991), etc…). Accordingly, Kwanashie et al. (1994) argue that a depreciation of the effective exchange rate leads to an increase of agricultural prices of exports and boost of domestic production. Our results don't support this finding revealing a positive and insignificant interaction between the two variables (see Table 6). This result is expected because it seems normal that agriculture's exporters have a neutral attitude to exchange uncertainty since there are perishable products.

4.4. Mining sector

Our results indicate that mining sector is negatively affected by the volatility of exchange rate in both nominal and in real terms, i.e. an appreciation by 10% in exchange rate volatility affects the flows of mining trade leading to a drop of exports by 7.30% in Morocco and by 4.73% in Tunisia (see Table 7). This can be explained by the fact that the relationship between exchange volatility and mining sector is highly correlated with the international prices of mining and phosphates (e.g. Varangis et al. 2004). We note also that the impact of differential price volatility on exports still more intense than that of nominal exchange rate. Additionally, all the coefficients associated to exchange rate uncertainty either in nominal or in real terms appear small and quite comparable to those associated to other sectors. This is mainly due, based on the works of Bouoiyour and Rey (2005) and Bouoiyour and Selmi (2013) to the high degree of competitiveness associated to this sector in both countries.

4.5. Energy sector

Highly fluctuations of the crude of oil and its impact on exchange rate have rekindled various questions regarding the dynamic behavior of exchange rate after changes in oil price (e.g. Bénassy et al. (2005) and Coudert et al. (2008)). In our paper, we evaluate only the relationship between exchange rate volatility and energy sector in Tunisian case, as the share associated of Moroccan energy exports is very low (see Figure 3). We find that this linkage is positive and statistically significant. More precisely, an increase by 10% in real exchange rate volatility leads to an increase by 4.73% in energy exports (see Table 8). The effect of nominal exchange uncertainty is negative and minor comparable to that of differential price. This finding may be intensely attributable the lack of a rough guidance about how exchange policy should cope with oil price uncertainty.

5. Robustness check

In this study, we performed 2880 estimates based on different GARCH extensions (linear versus nonlinear, symmetrical versus asymmetrical). These specifications follow various distributions (Gauss, Student, GED), can be zero mean, constant mean or in mean, with moving average term or without it and based on Maquardt or Berndt-Hall-Hall-Hausman algorithmic optimizations. Our results were given for only the best models.

To avoid overloading of our presentation, we thought that it is not crucial to present the results of mining, agricultural and energy sectors and to concentrate only on those of total exports and manufacturing sector. The results summarized in Table 9 reveal that:

(i) For Morocco, in 77.77% of cases, the volatility of nominal exchange rate has a negative and significant effect on total of exports[14], in 73.88% of cases for the differential commodity price uncertainty[15] and in 77.22% for the real exchange volatility[16]. Almost similarly for manufacturing sector.

(ii) For Tunisia (after subtracting energy's share), in 83.33% of cases, the nominal exchange risk has a negative and significant impact on overall exports[17]. In 88.44% of cases for the relative price uncertainty and in 89.99% for the real exchange volatility. As Morocco, the manufacturing sector in Tunisia is characterized by average effects of *VOLN, VOL (P/P*)* and *VOLR* almost equal to those of total exports. Not surprisingly, this finding may be due to the large share of this sector in the total of exports.

[14] Positive and significant in only 1.66% of cases, positive and insignificant in 6.10% of cases and negative and insignficant in 14.99% of estimates.

[15] Positive and significant in 4.44% of cases, positive and insignificant in 6.66% of estimates and negative and insignficant in 14.99% of estimates.

[16] Positive and significant in only 2.77% of cases, positive and insignificant in 16.66% of cases and negative insignficant in 9.16% of cases.

[17] Positive and significant in only 2.77% of estimates, positive and insignificant in 9.44% of cases and negative insignficant in 3.88% of estimates.

6. Conclusion

The objective of this study is twofold: First, to choose the best model able to determine the volatility of nominal exchange rate, differential price and real exchange rate of Morocco and Tunisia. Second, to regress total and sectoral exports on exchange volatility in both nominal and real terms and other variables expected to influence trade performance.

It appears from our results interesting insights:

(i) The nominal exchange rate is less volatile than that of differential commodity price and real exchange rate with regard to the duration of persistence, the intensity of shock, the leverage effect (i.e. sign of innovations) and ARCH and GARCH effects and their effects then on total and sectoral exports are minor.

(ii) The share of energy in total and manufacturing exports can occur an inverse effect of exchange volatility.

(iii) The effect of exchange volatility on exports depends to structural breaks. This result does not change depending to sector-to-sector variation.

These findings are robust according to the different specifications used. Interestingly, if we estimate exchange volatility-exports relationship using the naïve models (i.e. average absolute deviation and moving average absolute deviation), the association (not reported here) still robust and stable. In a nutshell, our results make an intuitive contribution. We show that the study-to-study variation on the focal relationship is mainly attributable to sectors' specialization, asymmetries and structural breaks in volatility process. Thus and to the extent that exchange rate and commodity price uncertainties are costly, a harder implication here is whether Moroccan and Tunisian policymakers should attempt to mitigate their effects on trade performance.

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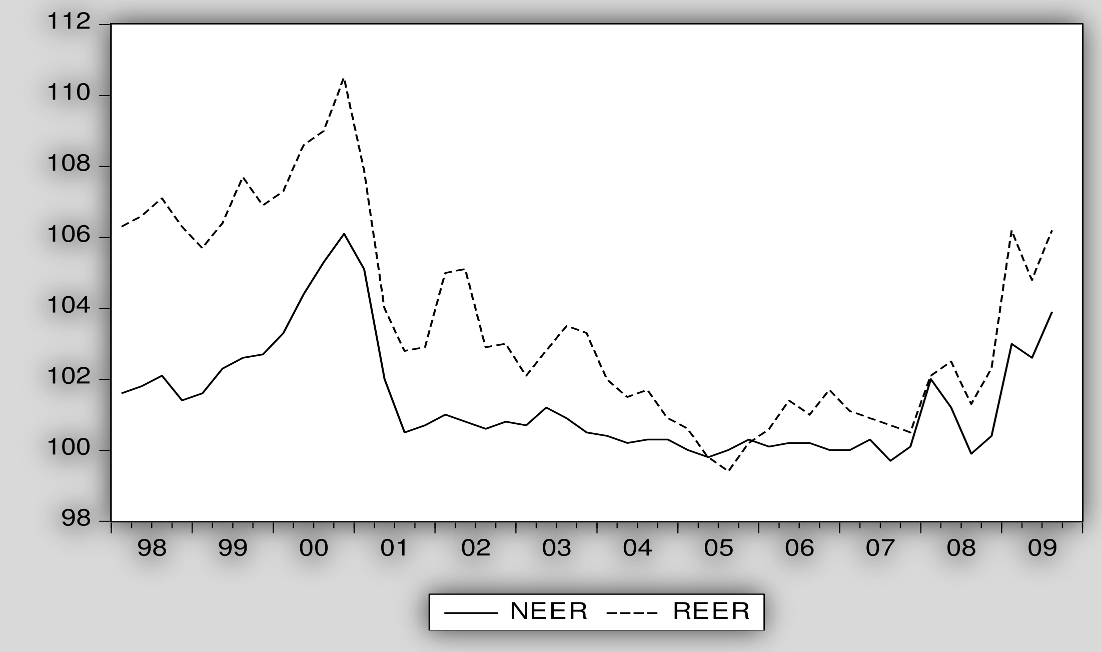
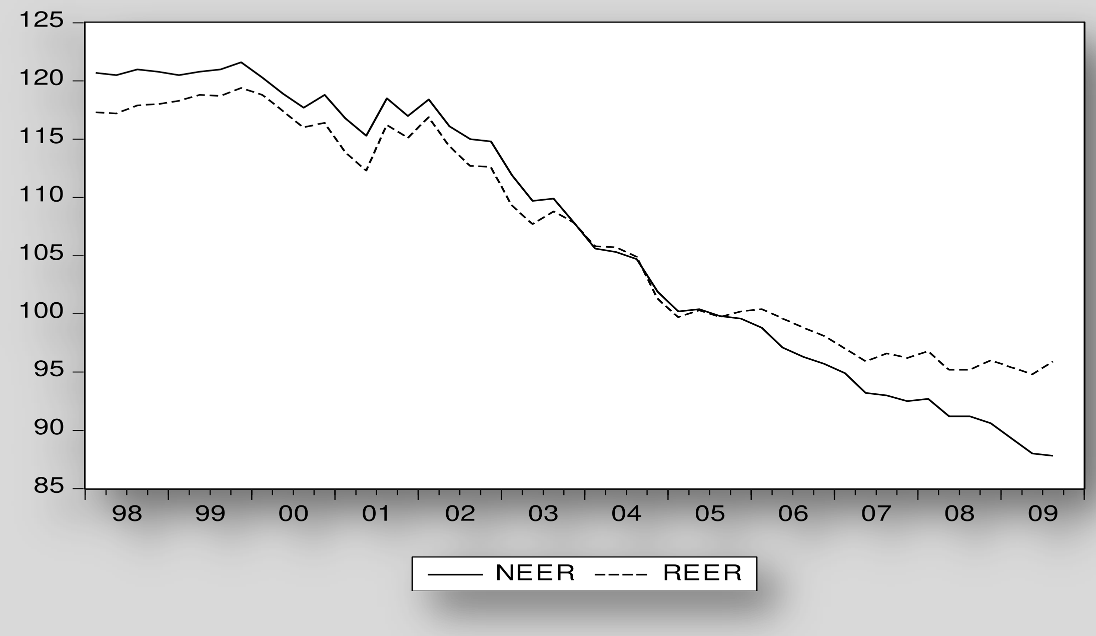
Figure 1. Exchange rate in nominal and real terms

Morocco



Tunisia

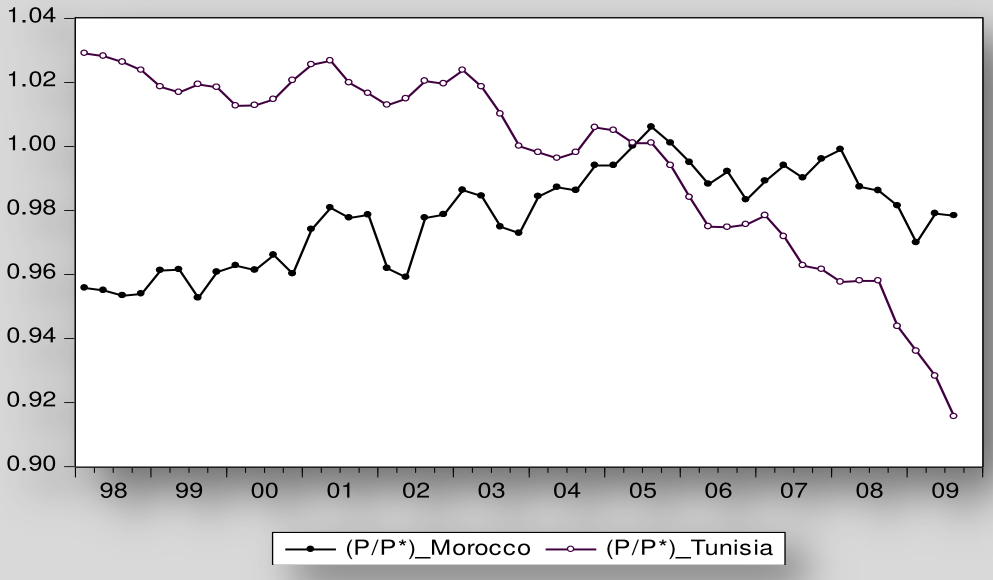


Source : Econstats™.

The data of Morocco are disponible on : http://www.econstats.com/ifs/NorGSc_Mor1_M.htm

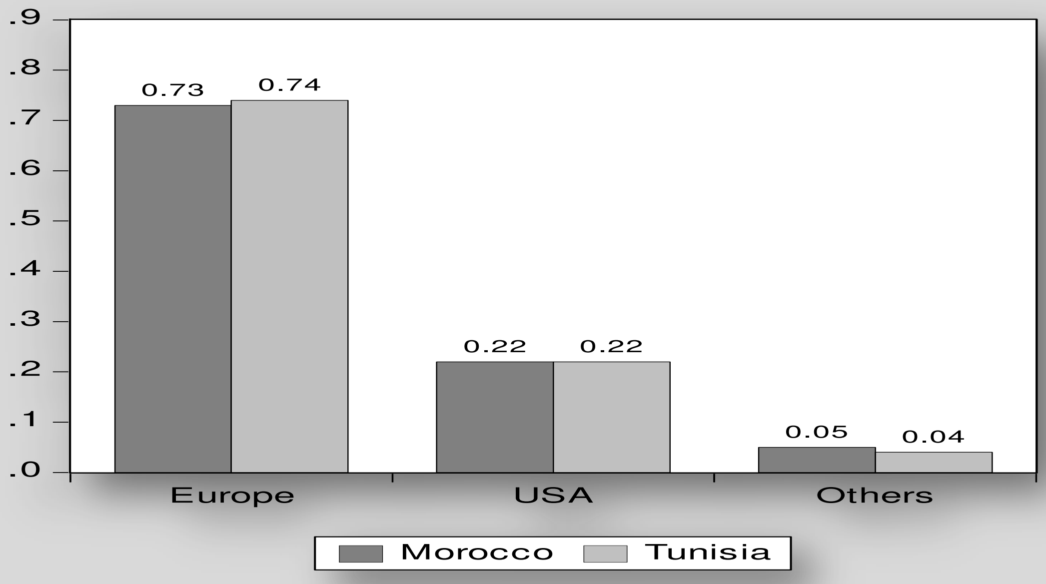
The data of Tunisia are disponible on : http://www.econstats.com/ifs/NorGSc_Tun1_M.htm

Figure 2. Evolution of differential price index



Source : Econstats™.

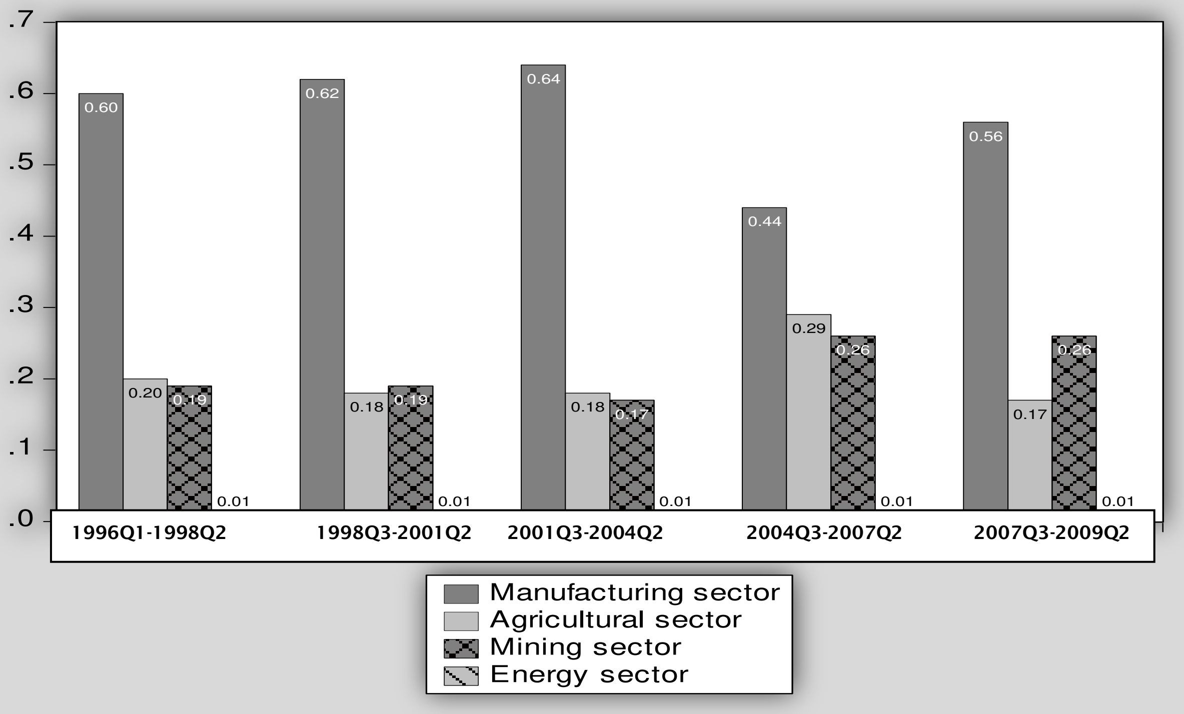
Figure 3. Share of the principal partners'destination in the total of partners



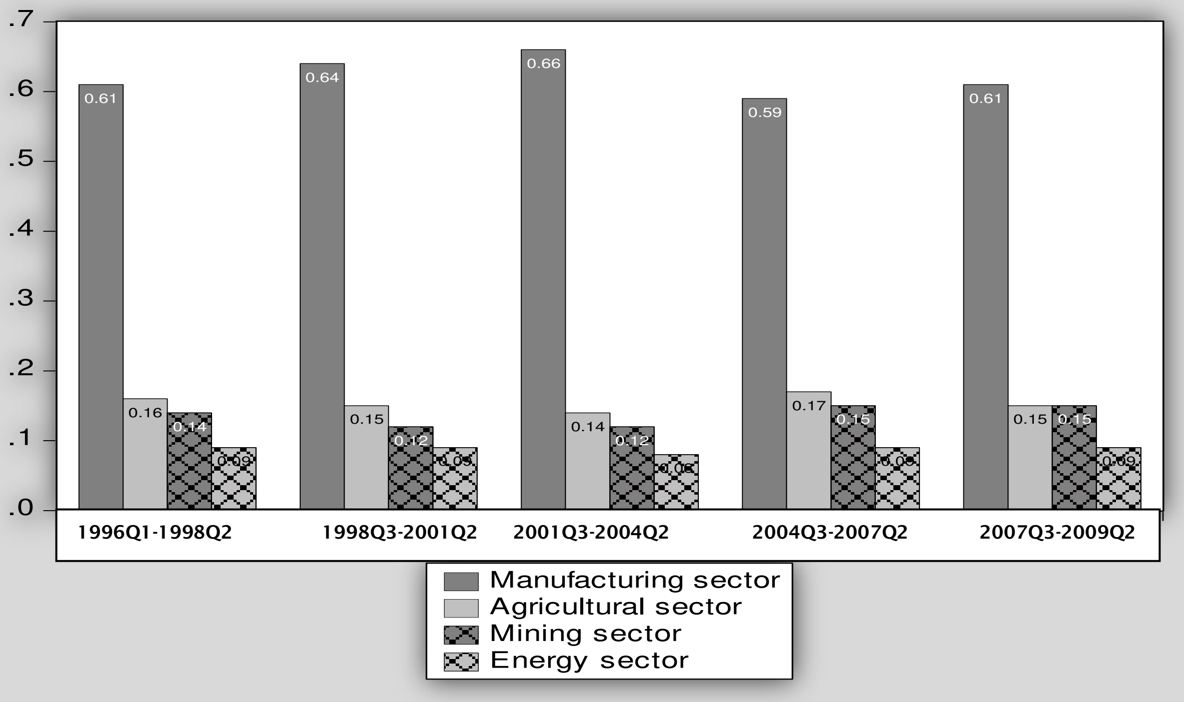
Source: CIA, World Factbook (2009). https://www.cia.gov/library/publications/the-world-factbook/

Figure 4. Share of each sector in the total of exports

Morocco

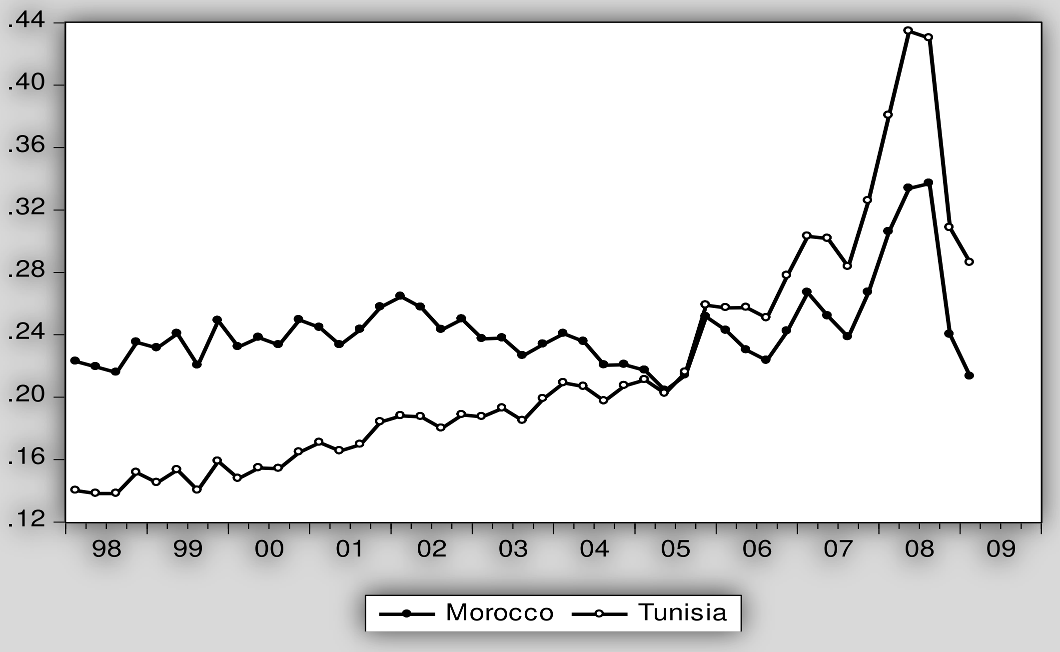


Tunisia



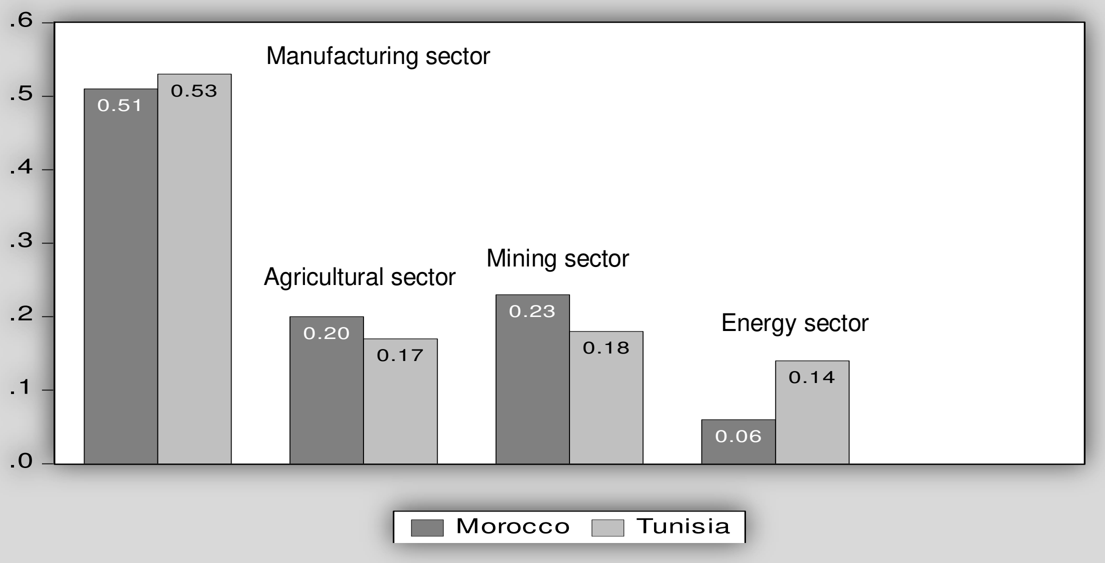
Source : UN Comtrade http://comtrade.un.org/db/

Figure 5. Evolution of total exports as a % of GDP



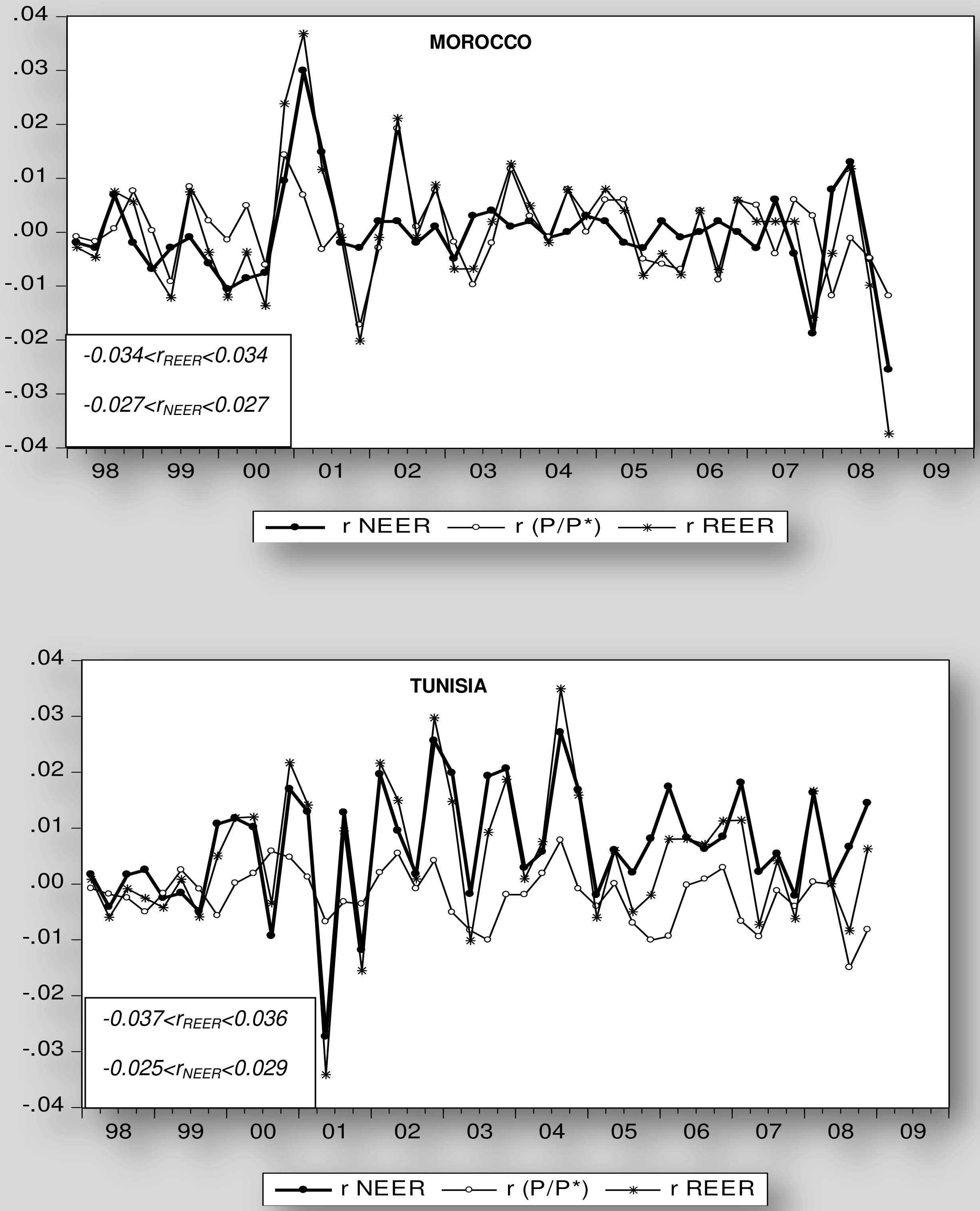
Source: Usherbrooke data and authors' calculations. http://perspective.usherbrooke.ca/bilan/statistiques/7

Figure 6. Average share of quarterly sectoral exports in the total of trade from 1996 to 2007



Source : UN Comtrade. http://comtrade.un.org/db/

Figure 7. Nominal exchange rate, differential price and real exchange rate returns



Note: r_{NEER}: Nominal effective exchange rate return; $r_{(P/P^*)}$: relative commodity prices returns; r_{REER} : Real effective exchange rate return; Source : Econstats™ and authors'calculations.

Table 1. Descriptive statistics						
	Morocco			Tunisia		
	r_{REER}	$r_{(P/P*)}$	r_{NEER}	r_{REER}	$r_{(P/P*)}$	r_{NEER}
Mean	4.616479	0.018253	4.634732	4.665740	-0.001095	4.671452
Median	4.610158	0.015811	4.625953	4.659658	-0.005003	4.679350
Maximum	4.664382	0.041774	4.705016	4.778283	0.039221	4.777441
Minimum	4.602166	-0.006018	4.599152	4.527209	-0.026364	4.563306
Std. Dev.	0.017022	0.013060	0.027611	0.086993	0.019542	0.070050
Skewness	1.760239	0.278449	1.099025	-0.115771	0.628116	-0.028419
Kurtosis	4.724646	2.239972	3.268616	1.544400	2.200746	1.509754
Jarque-Bera	19.85056	1.146712	6.333789	2.805994	2.863530	2.872747

Note : r_{NEER}: Nominal effective exchange rate return; $r_{(P/P*)}$: relative commodity prices returns; r_{REER} : Real effective exchange rate return; Source : Econstats™ .

Table 2. Test of leverage effect in the conditional volatility						
	Morocco			Tunisia		
	REER	*(P/P*)*	*NEER*	*REER*	*(P/P*)*	*NEER*
$\rho(r^2, r_{t-1})$	-0.211473	-0.210571	-0.384944	0.185777	0.157621	0.181537

Note : NEER : Nominal effective exchange rate; REER : Real effective exchange rate; (P/P*) : differential of prices; Source : Econstats™

Table 3. Historical evaluation: Parameters of variance equation

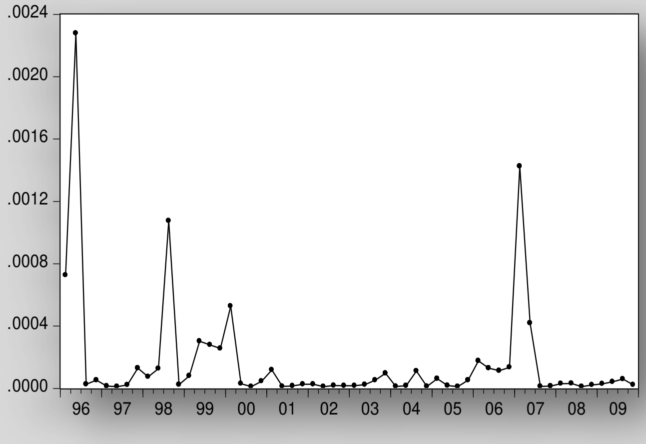
	Morocco			Tunisia		
	VOLR	*VOL (P/P*)*	*VOLN*	*VOLR*	*VOL (P/P*)*	*VOLN*
w	3.05E-06* (1.44)	3.82E-05* (1.492)	-1.2893** (-2.6625)	1.19E-05 (0.7248)	1.64E-05 (0.012)	0.0003 (0.2206)
α_1	-0.20** (-2.37)	-0.148* (-1.284)	0.0129 (0.0582)	0.2489* (1.2165)	0.133 (0.136)	0.4056** (2.3570)
α_2	0.011 (0.116)	-	-0.3426* (-1.4146)	-	0.044 (0.057)	-
β_1	0.98*** (20.31)	0.839*** (5.990)	0.7185* (1.4225)	0.6784*** (4.0016)	0.711 (0.375)	1.2388*** (16.5219)
β_2	-	-0.156 (-0.560)	-	-	-	-0.9276*** (-10.1759)
γ	0.171** (2.94)	-0.100*** (-3.637)	0.0831*** (6.7807)	-	-	-
Duration of persistence						
$Symmetric: \sum_{i=1}^{q} \alpha_i + \sum_{j=1}^{p} \beta_j$				0.91	0.84	0.71
$Asymmetric: \sum_{i=1}^{q} \alpha_i + \sum_{j=1}^{p} \beta_j + \gamma$	0.87	0.54	0.38			
Intensity of shock						
$Symmetric: \sum_{i=1}^{q} \alpha_i$				0.24	0.17	0.40
$Negativeshock: -\sum_{i=1}^{q} \alpha_i + \gamma$	0.36	0.48	0.65			
$Positiveshock: \sum_{i=1}^{q} \alpha_i + \gamma$	0.36	-0.24	0.41			
Leverage effect γ	0.17	-0.10	0.083			
ARCH and GARCH effects $\sum_{i=1}^{q} \alpha_i + \sum_{j=1}^{p} \beta_j$	0.79	0.54	0.37	0.91	0.84	0.71

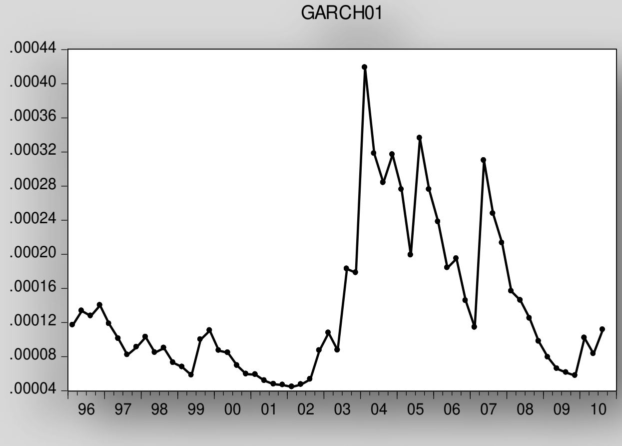
Note : *VOLN* : Volatility of nominal effective exchange rate ; *VOL (P/P*)* : Volatility of differential prices of commodities ; *VOLR :* Volatility of real effective exchange rate ; *w :* The reaction of conditional variance; α : ARCH effect; β : ARCH effect; Y : Leverage effect.

Figure 8. Historical evaluation : Exchange and differential price volatilities

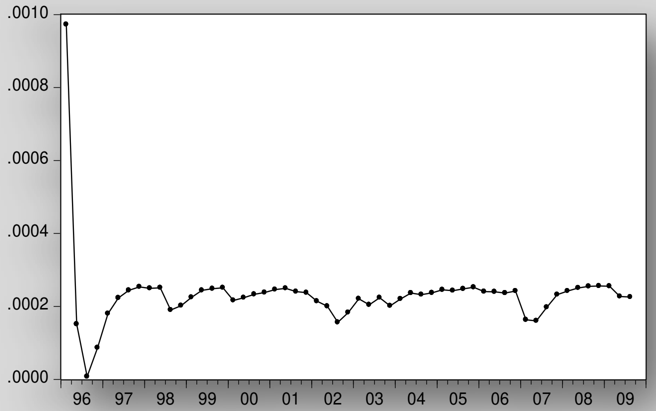
Morocco | **Tunisia**

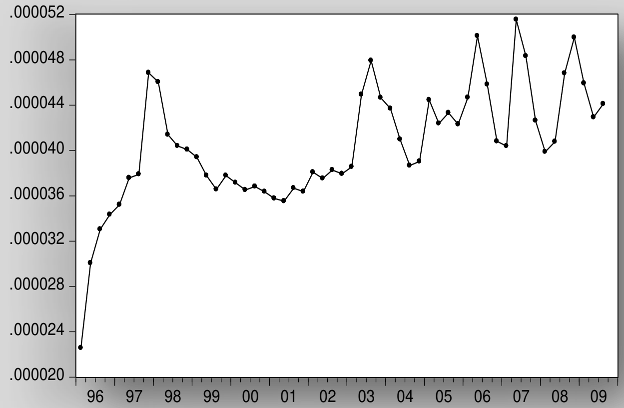
VOLN



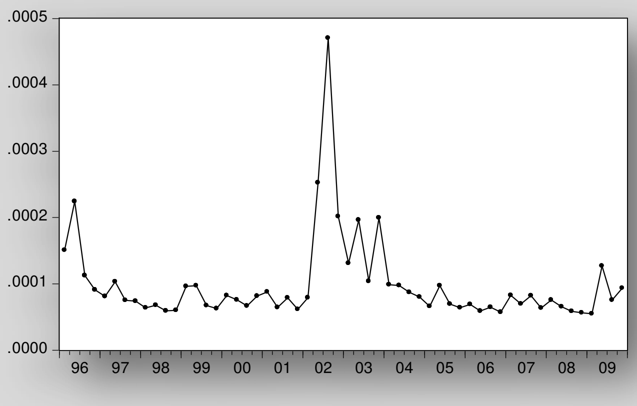


VOL(P/P)*





VOLR



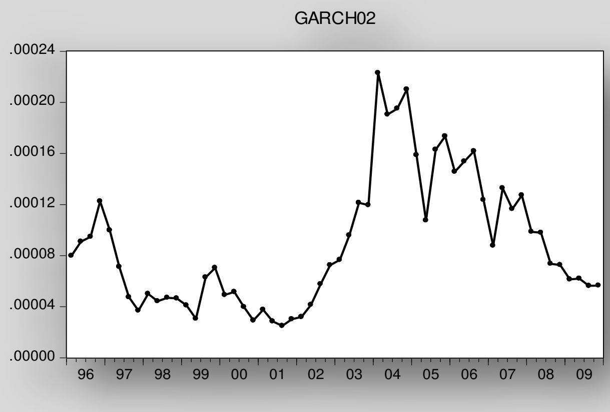


Table 4. Estimation of the relationship between exchange volatility, relative commodity prices uncertainty and total exports

	Morocco		Tunisia			
	(1)	(2)	(3)	(4)	(5)	(6)
In real terms						
C	0.5779 (0.085)	-2.31*** (-3.318)	5.980 (0.96)	-5.503** (-2.02)	1.077 (0.164)	-2.90* (-1.04)
REER	-1.784* (-1.03)	-1.514* (-1.37)	-0.703* (-1.764)	-0.305 (-0.704)	-0.179 (-0.409)	-0.422 (-0.927)
VOLR	-0.147* (-1.068)	-0.338* (-1.568)	0.570** (2.009)	-0.318* (-1.919)	-0.93*** (-5.091)	-0.193** (-2.111)
GDP	0.608* (1.910)	0.816*** (6.425)	1.109* (1.232)	2.681*** (14.709)	1.534* (1.567)	2.682*** (14.033)
*GDP**	0.029** (2.084)	0.113* (1.748)	0.023* (1.331)	0.041* (1.507)	0.041* (1.533)	0.043* (1.510)
DV	-	-0.200* (-1.155)	-	-	-0.08*** (-3.059)	-0.043** (-2.474)
R^2	0.81	0.86	0.71	0.83	0.76	0.88
In nominal terms						
C	1.234** (2.137)	1.762** (2.118)	6.237 (1.000)	-5.831** (-2.121)	1.123 (0.177)	-3.022* (-1.044)
NEER	-1.931* (-1.000)	-2.004* (-1.223)	-0.861** (-2.172)	-0.375 (-0.866)	-0.220 (-0.504)	-0.519 (-1.145)
(P/P)*	-1.311* (-1.334)	-1.290* (-1.003)	-1.336 (-1.166)	-1.31* (-1.162)	-1.330* (-1.208)	-1.135* (-1.099)
VOLN	-0.178** (-2.146)	-0.189* (-1.512)	-0.443* (-1.664)	-0.517** (-2.000)	-0.544* (-1.091)	-0.567* (-1.224)
VOL (P/P)*	-0.320* (-2.141)	-0.480* (-1.995)	0.585** (2.063)	-0.326* (-1.027)	0.95*** (5.228)	-0.19** (-2.167)
GDP	0.712*	0.904*	0.724*	1.75***	1.001*	1.751**

	(1.527)	(1.820))	(0.804)	(3.074)	(1.023)	(2.16)
*GDP**	0.053* (1.468)	0.094* (1.634)	0.030* (1.784)	0.054** (2.020)	0.054** (2.055)	0.057** (2.024)
DV	-	-0.243* (-1.350)	-	-	-0.032* (-1.414)	-0.413* (-1.200)
R^2	0.77	0.89	0.70	0.79	0.70	0.82

Note : DV : dummy variable equal to 1 until 2008 :Q2 to 2010 :Q4 (economic crisis) and equal to 0 otherwise; ***, **, * : significant respectively at 1%, 5% et 10% ; (1) : Moroccan exports without dummy variable ; (2): Moroccan exports with dummy variable; (3): Tunisian exports with energy share and without dummy variable ; (4) : Tunisian exports without energy share and without dummy variable ; (5) : Tunisian exports without energy share and with dummy variable ; (6) : Tunisian exports with energy share and with dummy variable.

Table 5. Estimation of the relationship between exchange volatility, relative commodity prices uncertainty and manufacturing sector						
	Morocco (51%, 48%)		**Tunisia (53%, 50%)**			
	(1)	(2)	(3)	(4)	(5)	(6)
In real terms						
C	-0.278 (-0.620)	-1.097* (-1.543)	-0.646 (-0.100)	-7.140* (-1.091)	5.425* (1.033)	2.054 (0.677)
REER	-0.920*** (-2.111)	-1.680** (-2.390)	-0.540* (-1.317)	-1.042** (-2.391)	-2.149** (-2.595)	-0.453* (-1.312)
VOLR	-0.314* (-1.180)	-0.813* (-1.756)	0.472* (1.835)	-0.34*** (-5.401)	-0.332* (-1.051)	-0.280** (-2.782)
GDP	0.890* (1.652)	1.287*** (3.902)	1.370* (1.481)	1.951** (2.009)	1.391*** (4.003)	1.442*** (3.006)
*GDP**	0.358* (1.467)	0.316* (1.130)	0.020* (1.288)	0.050* (1.664)	0.011* (1.071)	0.076* (1.229)
DV	**-**	-0.240* (-1.511)	-	-	-0.45*** (-3.420)	-0.380** (-2.903)
R^2	0.90	0.93	0.81	0.87	0.80	0.93
In nominal terms						
C	0.577 (0.085)	-2.31*** (-3.318)	5.980 (0.96)	-5.503** (-2.02)	1.077 (0.164)	-2.90* (-1.04)
NEER	-1.784* (-1.03)	-1.514* (-1.37)	-0.703* (-1.764)	-0.305 (-0.704)	-0.179 (-0.409)	-0.422 (-0.927)
(P/P)*	-1.202** (-2.342)	-0.765* (-1.309)	-1.000 (-0.765)	-0.631* (-1.184)	-0.773** (-2.255)	-0.591*** (-4.263)
VOLN	-0.077* (-1.222)	-0.092** (-2.043)	-0.103* (-1.007)	-0.168* (-1.115)	-0.871* (-1.432)	-0.682* (-1.621)
VOL (P/P)*	-0.147* (-1.068)	-0.338* (-1.568)	0.570** (2.009)	-0.318* (-1.919)	-0.93*** (-5.091)	-0.193** (-2.111)
GDP	0.608*	0.816***	1.109*	2.681***	1.534*	2.682***

	(1.910)	(6.425)	(1.232)	(14.709)	(1.567)	(14.033)
*GDP**	0.029** (2.084)	0.113* (1.748)	0.023* (1.331)	0.041* (1.507)	0.041* (1.533)	0.043* (1.510)
DV	-	-0.200* (-1.155)	-	-	-0.08*** (-3.059)	-0.043** (-2.474)
R^2	0.81	0.86	0.71	0.83	0.76	0.88

Note : DV : dummy variable equal to 1 until 2008 :Q2 to 2010 :Q4 (economic crisis) and equal to 0 otherwise; ***, **, * : significant respectively at 1%, 5% et 10% ; (1) : Moroccan manufactured exports without dummy variable ; (2): Moroccan manufactured exports with dummy variable ; (3): Tunisian manufactured exports with energy and without dummy variable ; (4) : Tunisian manufactured exports with energy and dummy variable ; (5) : Tunisian manufactured exports without energy and dummy variable; (6) : Tunisian manufactured exports without energy and with dummy variable . The first percentage is the average of the market share of each sector in total exports for total of period; the second is the percentage market share of each sector for the past year.

Table 6. Estimation of the relationship between exchange volatility, relative commodity prices uncertainty and agricultural sector

	Morocco (20%, 21%)		Tunisia (17%, 19%)	
	(1)	(2)	(3)	(4)
In real terms				
C	0.064** (2.533)	-1.262** (-2.300)	2.352 (0.340)	1.654 (0.093)
REER	-0.811*** (-3.552)	-0.891* (-1.792)	-2.526** (-2.339)	-1.132 (-1.025)
VOLR	0.123 (0.940)	0.152 (0.696)	0.036 (1.089)	0.311 (0.578)
GDP	0.875* (1.436)	0.991*** (6.544)	2.959*** (6.528)	2.080* (1.843)
*GDP**	0.100* (1.804)	0.257* (1.951)	0.063 (0.314)	0.037* (1.195)
DV	-	-0.162** (-2.104)	-	-0.162** (-2.208)
R^2	0.78	0.86	0.83	0.88
In nominal terms				
C	0.927** (2.118)	1.225* (1.782)	0.969 (0.792)	-1.622* (-1.603)
NEER	-0.662*** (-3.491)	-0.823*** (-3.320)	-0.584* (-1.465)	-1.253 (-0.582)
(P/P)*	-1.204* (-1.055)	-1.306* (-1.211)	-1.002* (-1.153)	-0.911* (-1.212)
VOLN	0.231 (0.176)	0.314 (0.891)	0.219 (0.763)	0.156 (0.562)
VOL (P/P)*	0.610 (0.893)	0.652 (0.862)	0.473 (0.669)	0.264 (0.831)
GDP	0.875*	0.927**	0.921*	0.720***

	(1.436)	(2.613)	(1.023)	(3.913)
*GDP**	0.100* (1.804)	0.079* (1.228)	0.019* (1.122)	0.037* (1.225)
DV	-	-0.234*** (-3.091)	-	-0.122 (-0.451)
R^2	0.70	0.79	0.83	0.91

Note : DV : dummy variable equal to 1 until 2008 :Q2 to 2010 :Q4 (economic crisis) and equal to 0 otherwise; ***, **, * : significant respectively at 1%, 5% et 10% ; (1) Moroccan agricultural sector without dummy variable; (2) : Moroccan agricultural sector with dummy variable ; (3): Tunisian agricultural sector without dummy variable; (4) : Tunisian agricultural sector with dummy variable. The first percentage is the average of the market share of each sector in total exports for total of period; the second is the percentage market share of each sector for the past year.

Table 7. Estimation of the relationship between exchange volatility, relative commodity prices uncertainty and mining sector				
	Morocco (23%, 23%)		Tunisia (18%, 17%)	
	(1)	(2)	(3)	(4)
In real terms				
C	-1.227** (2.311)	-1.537* (-1.331)	0.969 (0.792)	-1.622* (-1.603)
REER	-0.662*** (-3.491)	-1.352** (-2.420)	-0.584* (-1.465)	-1.253 (-0.582)
VOLR	-0.730** (-2.280)	-0.775* (-1.149)	-0.473* (-1.669)	-0.664* (-1.083)
GDP	0.908* (1.903)	0.873** (2.081)	0.921* (1.023)	0.821*** (3.913)
*GDP**	0.100* (1.804)	0.079* (1.228)	0.019* (1.106)	0.034* (2.225)
DV	-	-0.234*** (-3.091)	-	-0.100 (-2.514)
R^2	0.69	0.81	0.85	0.92
In nominal terms				
C	0.980* (1.960)	-0.550** (-2.023)	1.077 (0.166)	-2.109* (-1.447)
NEER	-0.703* (-1.764)	-0.805** (-1.704)	-0.791* (-1.409)	-0.422 (-0.927)
(P/P)*	-1.093** (-2.099)	-1.162* (-1.003)	-1.039* (-1.153)	-0.921* (-1.107)
VOLN	-1.109* (-1.323)	-0.305** (-2.641)	-0.393*** (-5.091)	-0.393* (-2.111)
VOL (P/P)*	-0.570** (-2.009)	-0.818* (-1.919)	-0.634* (-1.576)	-0.357 (-1.602)
GDP	1.109*	1.621***	0.423*	1.044*

	(1.632)	(4.709)	(1.419)	(1.710)
*GDP**	0.323* (1.331)	0.441* (1.607)	0.293* (1.533)	0.052*** (4.033)
DV	-	-0.187** (-2.000)	-	-0.043** (-2.474)
R^2	0.71	0.83	0.76	0.88

Note : DV : dummy variable equal to 1 until 2008 :Q2 to 2010 :Q4 (economic crisis) and equal to 0 otherwise; ***, **, * : significant respectively at 1%, 5% et 10% ; (1) Moroccan mining sector without dummy variable; (2) : Moroccan mining sector with dummy variable ; (3): Tunisian mining sector without dummy variable; (4) : Tunisian mining sector with dummy variable. The first percentage is the average of the market share of each sector in total exports for total of period; the second is the percentage market share of each sector for the past year.

Table 8. Estimation of the relationship between exchange volatility, relative commodity prices uncertainty and energy sector

	Tunisia (12%, 11%)	
	(1)	(2)
In real terms		
C	-1.522* (-1.076)	-2.914*** (-7.733)
REER	-0.148* (-1.398)	-0.591*** (-10.052)
VOLR	0.473* (1.669)	0.137 (5.886)
GDP	0.921* (1.023)	0.686*** (27.563)
*GDP**	0.019* (1.106)	0.007* (1.352)
DV	-	-0.020** (-2.172)
R^2	0.66	0.66
In nominal terms		
C	0.894 (0.133)	-2.407 (-0.831)
NEER	-0.148* (-1.398)	-0.350* (-1.774)
(P/P)*	-1.107** (-2.342)	-0.822* (-1.141)
VOLN	-0.122* (-1.141)	-0.163* (-1.278)
VOL (P/P)*	0.172* 4.230)	0.200* (1.754)
GDP	0.774*	0.820***

	(1.302)	(11.660)
*GDP**	0.034* (1.273)	0.035* (1.254)
DV	-	-0.045** (-2.038)
R^2	0.70	0.73

Note : DV : dummy variable equal to 1 until 2008 :Q2 to 2010 :Q4 (economic crisis) and equal to 0 otherwise; ***, **, * : significant respectively at 1%, 5% et 10% ; (1): Tunisian energysector without dummy variable; (2) : Tunisian energy sector with dummy variable. The first percentage is the average of the market share of each sector in total exports for total of period; the second is the percentage market share of each sector for the past year.

Table 9. Robustness check: Significance of parameters associated to exchange rate and differential price uncertainties

Total of exports								
	Morocco (77.77% ; 73.88% ; 77.22%)				**Tunisia (83.33% ; 88.44% ; 89.99%)**			
	Positive+ significant	Negative+ Significant	Positive+ insignificant	Negative+ insignificant	Positive+ significant	Negative+ significant	Positive+ insignificant	Negative+ insignificant
Gauss :								
VOLN	1.66%	80.00%	6.66%	11.66%	3.33%	86.66%	6.66%	1.66%
VOL (P/P)*	3.33%	78.33%	5.00%	13.33%	0.00%	91.66%	8.33%	0.00%
VOLR	0.00%	86.66%	1.66%	11.66%	1.66%	91.66%	5.00%	3.33%
Student:								
VOLN	0.00%	80.00%	5%	15.00%	0.00%	90.00%	6.66%	3.33%
VOL (P/P)*	5.00%	76.66%	1.66%	16.66%	0.00%	93.33%	6.66%	0.00%
VOLR	3.33%	75.00%	8.33%	13.33%	0.00%	93.33%	5.00%	1.66%
GED:								
VOLN	1.66%	73.33%	6.66%	18.33%	5.00%	73.33%	15.00%	6.66%
VOL (P/P)*	5.00%	66.66%	13.33%	15.00%	6.66%	80.00%	10.00%	3.33%
VOLR	5.00%	70.00%	8.33%	16.66%	5.00%	85.00%	10.00%	0.00%
Manufacturing sector								
	Morocco (69.44% ; 74.99% ; 78.88%)				**Tunisia (75.55% ; 79.44% ; 82.22%)**			
Gauss :								
VOLN	1.66%	68.33%	8.33%	21.66%	3.33%	83.33%	1.66%	11.66%
VOL (P/P)*	3.33%	78.33%	6.66%	11.66%	5.00%	86.66%	0.00%	6.66%
VOLR	1.66%	80.00%	5.00%	13.33%	3.33%	90.00%	1.66%	5.00%
Student:								
VOLN	0.00%	76.66%	3.33%	20.00%	1.66%	76.66%	8.33%	13.33%
VOL (P/P)*	3.33%	81.66%	5.00%	10.00%	3.33%	80.00%	3.33%	13.33%
VOLR	1.66%	85.00%	5.00%	8.33%	3.33%	81.66%	0.00%	15.00%
GED:								
VOLN	1.66%	63.33%	11.66%	25.00%	1.66%	66.66%	5.00%	26.66%

VOL (P/P)*	1.66%	65.00%	13.33%	18.33%	5.00%	71.66%	3.33%	20.00%
VOLR	3.33%	71.66%	5.00%	20.00%	1.66%	75.00%	5.00%	18.33%

Note: Gauss is Gaussian distribution; studentt is a standardized Student distribution; GED is a generelized error distribution; the first percentage is the average of significance associated to the volatility of nominal exchange rate; the second percentage is the average of significance associated to the volatility of differential commodity price; the third percentage is the average of significance associated to the volatility of real exchange rate.

Appendix A. Exchange and trade policies by country

Exchange reforms		
Period	Morocco	Tunisia
1975-1980	Modification of the weights of dirham's basket.	Peg of the dinar to a basket expanded the dollar.
1981-1986	Depreciation of the dirham by 12% (e.g. Emmonot and Rey, 2008).	Recovery period of real overvaluation and structural adjustment program.
1987-1992	Adoption of a depreciation policy.	Liberalization of the current account.
1993-1998	Convertibility of the current account.	Creation of spot market.
1999-2004	Changes of weights of dirham's basket making a favor to euro.	Devaluation of the dinar by 5% to promote exports (e.g. Bouoiyour and Selmi, 2013).
2005-2010	Undervaluation of the dirham by 9% (e.g. Baccouche et al. 2008).	A period of stability of the dinar conditioned by the deliberate policy of the central bank.
Trade reforms		
1975-1980	Structural adjustment highlighting mechanisms to promote exports.	Financial support for investors by setting up an export promotion fund.
1981-1986	Accession of Morocco to the General Agreement on Tariffs and Trade.	A new strategy focusing on the development of economy.
1987-1992	Novel trade law compatible with the measures taken by the General Agreement with World Trade Organization.	General Agreement with World Trade Organization.
1993-1998	Grants by 30% for investors in agriculture to overcome the vagaries of the weather.	Partnership and co-development with Europe and textiles and clothing agreement.
1999-2004	Association agreement Europe-Morocco leading to a significant tariff reductions on the various products and Agadir agreement with main objective to reduce tariffs and make the country more attractive to foreign investors.	Progressive dismantling of tariffs and Agadir Agreement made to liberalize progressively trade.
2005-2010	Dismantling of the multi fiber agreement and the accession of China to the world trade organization.	The dismantling of the multi fiber agreement and the establishment of a fund access for exports to help companies to diversify their markets.

Appendix B. Measures of volatility

Naïve models				
1. Average absolute deviation $VOL = \left[(1/n)\sum_{i=1}^{n}(e_i - \overline{e_i})\right]^{1/2}$				
2. Moving average absolute deviation $VOL = \left[(1/m)\sum_{i=1}^{m}(e_{t+i-1} - e_{t+i-2})^2\right]^{1/2}$				
GARCH models				
	Linear	Nonlinear	Symmetric	Asymmetric
3. 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	
4. GARCH-M (GARCH in mean, Bollerslev et al. 1993) $r_t = \mu_t + \varepsilon_t + \lambda \sigma_t^2$	x		x	
5. 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	
6. QGARCH (Quadratic GARCH, Sentana, 1995) $\sigma_t^2 = \omega + \sum_{i=1}^{q}\alpha_i (\varepsilon_{t-i} - b_i)^2 + \sum_{i=1}^{p}\beta_j \sigma_{t-j}^2$		x	x	
7. IGARCH (Engle and Bollerslev, 1986 and Nelson, 1991) $\sigma_t^2 = \omega + \varepsilon_{t-1}^2 + \sum_{i=1}^{q}\alpha_i (\varepsilon_{t-i}^2 - \varepsilon_{t-1}^2) + \sum_{i=1}^{p}\beta_j (\sigma_{t-j}^2 - \varepsilon_{t-1}^2)$	x		x	
8. AGARCH (Asymmetric GARCH, Engle et al. 1987) $\sigma_t^2 = \omega + \sum_{i=1}^{q}\alpha_i (\lvert\varepsilon_{t-i}\rvert + \gamma_i \varepsilon_{t-i})^2 + \sum_{i=1}^{p}\beta_j \sigma_{t-j}^2$	x			x
9. 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

10. 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
11. 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
12. 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
13. 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	
14. 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
15. NGARCH (Nonlinear GARCH, Bollerslev et al.1993) $\sigma_t^2 = \omega + \sum_{i=1}^{q}\alpha_i(\varepsilon_{t-i} - \kappa_i)^2 + \sum_{i=1}^{p}\beta_j \sigma_{t-j}^2$		x	x	
16. NGARCHK (Nonlinear GARCH with one shift, special case of NGARCH) $\sigma_t^2 = \omega + \sum_{i=1}^{q}\alpha_i(\varepsilon_{t-i} - \kappa)^2 + \sum_{i=1}^{p}\beta_j \sigma_{t-j}^2$		x	x	
17. NPGARCHK (Nonlinear Power GARCH with shift, Bollerslev et al., 1993) $\sigma_t^{\varphi} = \omega + \sum_{i=1}^{q}\alpha_i(\varepsilon_{t-i} - \kappa)^{\varphi} + \sum_{i=1}^{p}\beta_j \sigma_{t-j}^{\varphi}$		x	x	

Note: e : The logarithm of exchange rate and that of relative commodity price, m : moving average order (m=8, similar to the value used in the majority of studies on this subject, like Latrape and Koray (1985). $\sigma_t^{\,2}$: 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, κ : level shift. For more details, see Anderson et al. (2009) and Bouoiyour et al. (2012).

Appendix C. Historical evaluation: Choice of the best model

Morocco

VOLN : Models chosen using Akaike criterion

Nº	Model	q	p	Distribution	MA term	Mean	Leverage	Optimization	Distribution
1	NGARCH	1	2	Gauss	No	Zero	Yes	Maquardlt	4.038
2	A-PARCH	1	2	Gauss	Yes	In	Yes	BHHH	4.053
3	NGARCH	1	1	t	Yes	Constant	Yes	Maquardlt	4.055
4	NGARCH	2	2	GED	No	Constant	Yes	Maquardlt	4.125
5	E-GARCH	2	1	t	Yes	Constant	Yes	BHHH	4.135

VOL (P/P)* : Models chosen using Akaike criterion

Nº	Model	q	p	Distribution	MA term	Mean	Leverage	Optimization	Distribution
1	P-GARCH	1	2	Gauss	Yes	In	No	Maquardlt	5.145
2	GARCH-M	1	2	t	Yes	In	No	Maquardlt	5.160
3	C-GARCH	1	1	t	No	Constant	No	Maquardlt	5.177
4	I-GARCH	1	1	Gauss	No	Constant	No	Maquardlt	5.230
5	GARCH-M	1	1	Gauss	Yes	Constant	No	Maquardlt	5.242

VOLR : Models chosen using Akaike criterion

Nº	Model	q	p	Distribution	MA term	Mean	Leverage	Optimization	Distribution
1	E-GARCH	2	1	Gauss	Yes	Zero	Yes	Maquardlt	5.336
2	I-GARCH	1	1	t	No	Zero	No	BHHH	5.339
3	GARCH-M	1	2	t	No	In	No	BHHH	5.351
4	I-GARCH	2	1	Gauss	No	Constant	No	Maquardlt	5.369
5	C-GARCH	1	1	Gauss	Yes	Zero	No	BHHH	5.396

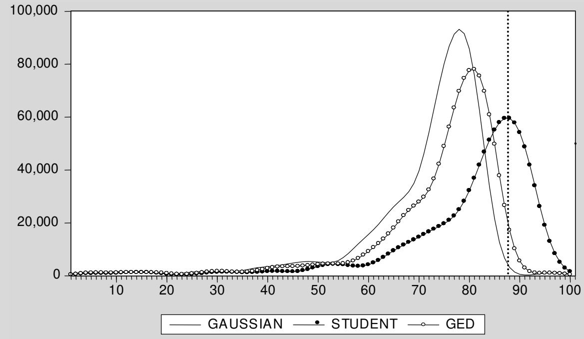
Tunisia									
VOLN: Models chosen using Akaike criterion									
N°	**Model**	**q**	**p**	**Distribution**	**MA**	**Mean**	**Leverage**	**Optimization**	**Distribution**
1	GARCH	1	1	Gauss	Yes	Zero	No	Maquardlt	4.083
2	GARCH	2	2	Gauss	Yes	Zero	No	BHHH	4.176
3	P-GARCH	1	2	Gauss	Yes	Zero	No	Maquardlt	4.181
4	C-GARCH	1	1	Gauss	Yes	Zero	No	Maquardlt	4.210
5	GARCH	2	1	t	Yes	Constant	No	Maquardlt	4.225
VOL (P/P)* : Models chosen using Akaike criterion									
N°	**Model**	**q**	**p**	**Distribution**	**MA**	**Mean**	**Leverage**	**Optimization**	**Distribution**
1	T-GARCH	2	1	Gauss	No	Constant	Yes	Maquardlt	4.438
2	T-GARCH	1	1	GED	Yes	In	Yes	BHHH	4.456
3	GJRGARCH	1	1	Gauss	Yes	In	Yes	BHHH	4 .490
4	GJRGARCH	2	1	Gauss	No	Constant	Yes	Maquardlt	4.497
5	T-GARCH	2	2	Gauss	Yes	Zero	Yes	Maquardlt	4.511
VOLR : Models chosen using Akaike criterion									
N°	**Model**	**q**	**p**	**Distribution**	**MA**	**Mean**	**Leverage**	**Optimization**	**Distribution**
1	GARCH-M	1	2	Gauss	No	In	No	Maquardlt	4.426
2	E-GARCH	1	1	t	No	Zero	Yes	Maquardlt	4.442
3	N-GARCH	1	2	GED	No	Zero	Yes	Maquardlt	4.446
4	I-GARCH	2	1	GED	Yes	Zero	No	Maquardlt	4.453
5	I-GARCH	2	2	Gauss	No	Zero	No	BHHH	4.457

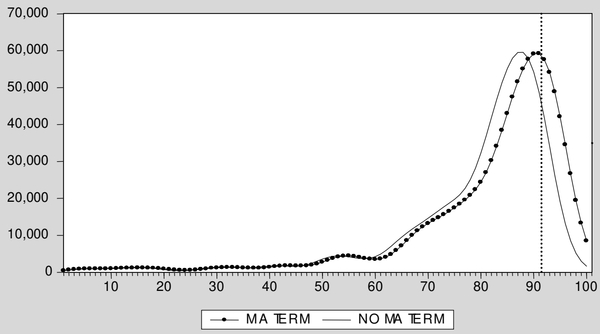
Note : Gauss is a Gaussian distribution ; t is a standardized Student distribution; GED is a generelized error distribution; MA: moving average term.

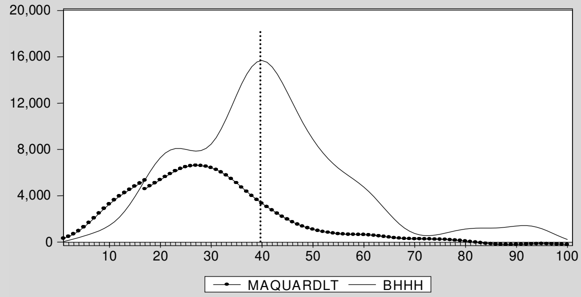
Appendix D. Choice of the best model by kernel density

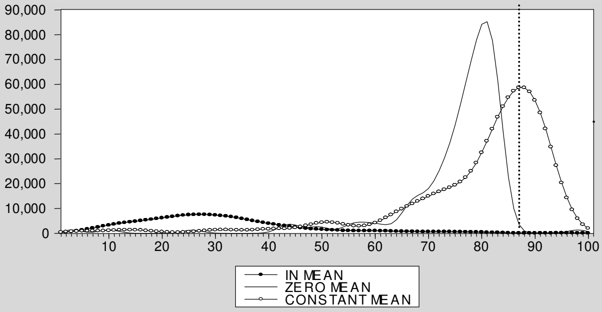
Morocco

VOLR

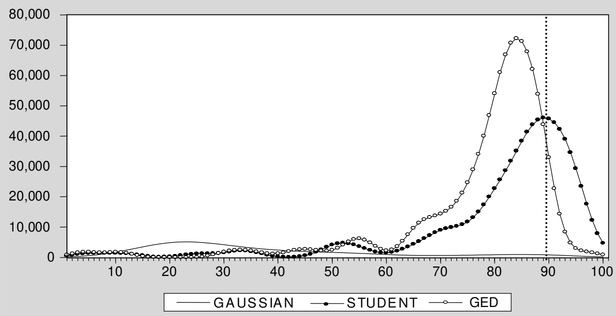


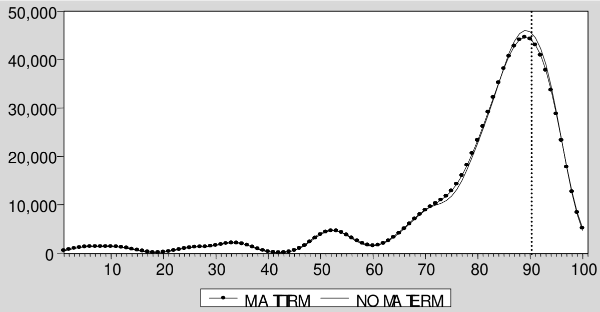


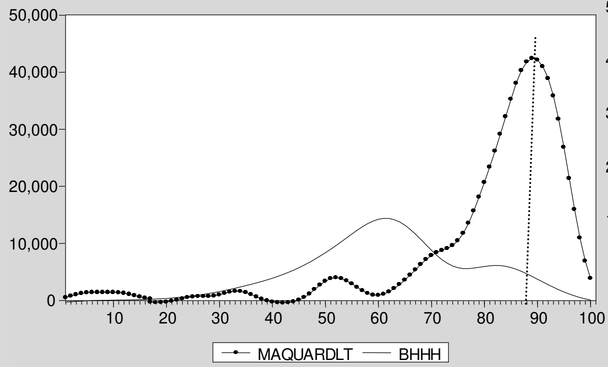


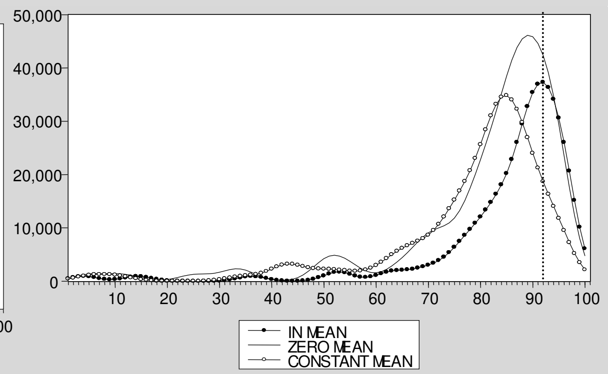


VOLN



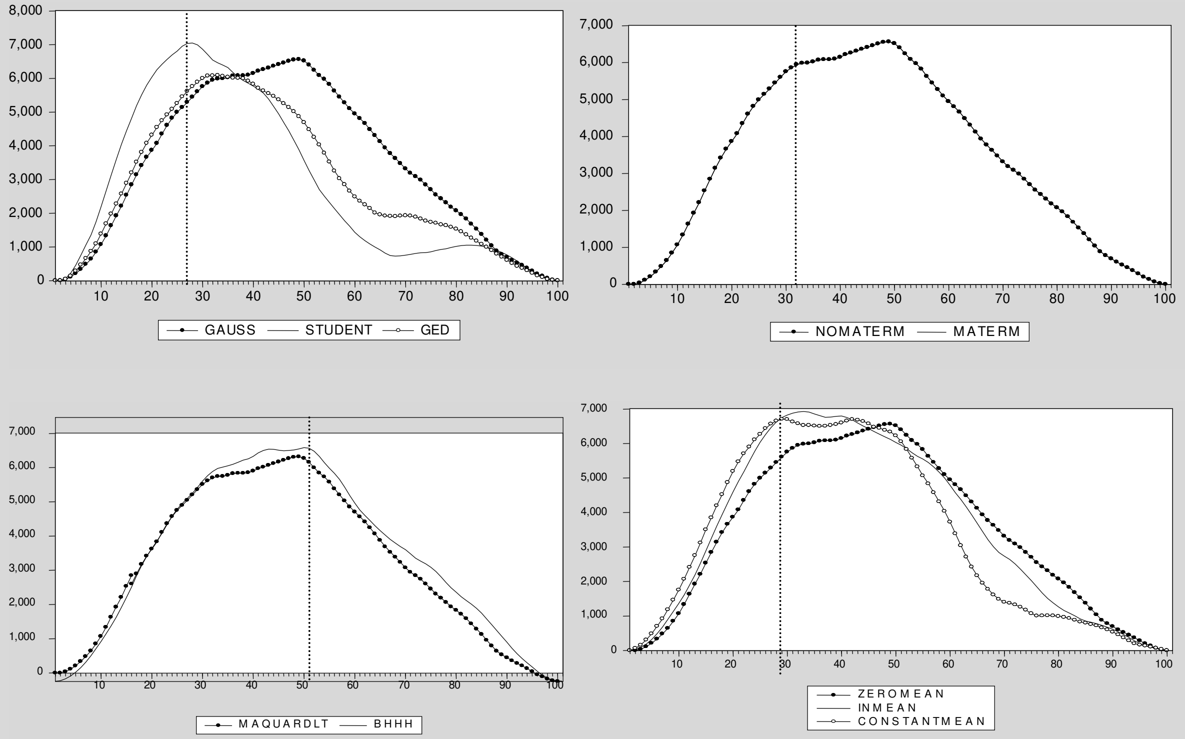






Tunisia

VOLR



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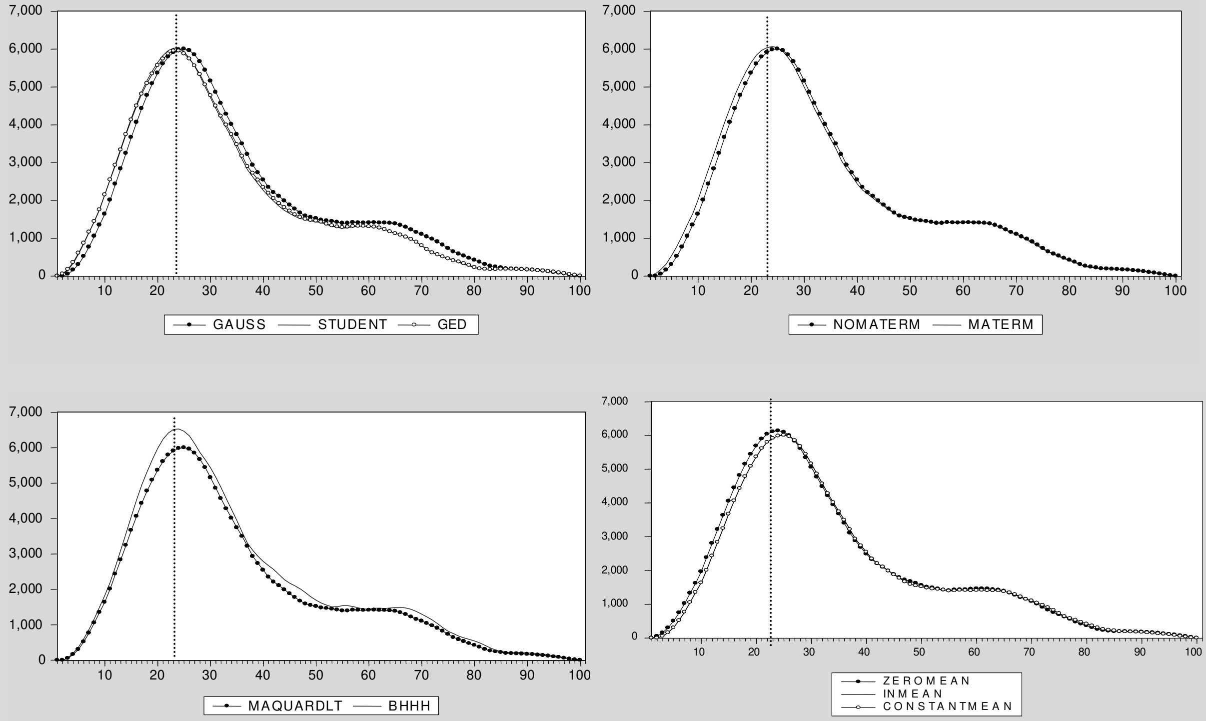

<u>Note:</u> These graphs display density estimates of the loss functions for the model considered. The x-axis is the positive values of the loss functions, so that the larger values imply better models.