The controversial link between exchange rate volatility and exports: Evidence from Tunisian case

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Abstract: This paper tries to revisit the interaction between exchange uncertainty and exports in the Tunisian case. By using various GARCH extensions (i.e. Standard GARCH, Integrated GARCH, Exponential GARCH and Weighted GARCH) we show that the effect of exchange returns on changes in exports depends on time varying between low and high volatility in real terms (i.e. either structural breaks or shifts) and leverage effect (i.e. either good or bad news) in nominal terms. Our results also reveal that all considered links either in nominal or real terms are highly persistent, which means a great tendency to long memory process.

Keywords: Exchange rate; exports; volatility; GARCH specifications.

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1. Introduction

Economic agents act in an uncertain economic environment. This uncertainty is largely related to changes in input prices, especially commodities. In fact, the volatility of commodity prices on the market increases the exchange volatility that can be transmitted to exports leading to a decrease of its level (e.g. Bailey and al. (1986), Chowdhury (1993) and Dell'Ariccia (1999), Bahmani-Oskooee (2002)). The empirical literature suggests that exchange adjustment can threaten the trade performance (e.g. Bahmani-Oskoee and Ltaifa (1992), McKenzie (1998), McKenzie (1999), Achy and Sekkat (2003), etc…). Up to now, there are several studies investigating the interaction between exchange volatility and exports (e.g. Bélanger and Gutiérrez (1990), Nabli et al. (2004), Rey (2006), etc…). Meanwhile, very few studies advance convincing arguments on the ambiguous link that can characterize the link between exchange volatility and exports.

To explain these patterns (i.e. the ambiguous effect of exchange risk on total, sectoral and bilateral exports), the economists mentioned above have advanced the risk-averse, the absence of hedging instruments, the specialization and the degree of competitiveness as key reasons of the controvercial relationship between exchange volatility and trade, except Egert and Zumaquero (2007), Arezki et al. (2011) and Bouoiyour and Selmi (2012). They argue that this effect can also be due to the differential price volatility which is itself closely linked to energy commodity price uncertainty. Hence, to what extent these arguments are valid? Were the economists right? Has the effect of exchange volatility on exports varied with how well local economy is associated to price commodities? Is differential price more volatile than nominal exchange rate? Does this have a potential effect on real exchange rate volatility? Does this make a difference in the relationship between real exchange volatility and real exports ? Does developing exchange market breed more or less relative price volatility?

Furthermore, the existing empirical research in this area suggests that the current financial crisis can be a major source of weaknesses in the financial system, which can itself increase intensely the effect of exchange volatility on trade performance (e.g. Bouoiyour and Selmi, 2012). By following this logic, we will try to clarify the possible effects of shifts, weights and leverage effects on the considered linkage. More precisely, what does it reveal about the leverage effect, switching regime, exchange volatility and exports connection?

To answer these various questions, especially the last one, choosing a good measure of volatility appears crucial, particularly because this process is not observable and its definition is based on an unknown model. Thus, different methods were used to measure the volatility of nominal and real exchange rate. Under the assumption of constant variance, we can define it as the absolute percentage change of exchange rates or the moving average standard deviation of its growth rate. Many economists use these volatility measures to study its effect on trade (e.g. Vergil (2002) and Rey (2006)). Otherwise, these models may ignore the information on stochastic processes through which exchange rates are generated. Therefore, these models do not take into account the exchange uncertainty which is an essential element of volatility for several reasons (e.g. these specifications address the realized and new variations of the sample in the same way, while the intuition that the first one would be better able to explain the volatility than the second one). This implies that GARCH extensions are more appropriate to determine volatility (e.g. Meese and Rogoff, 1983).

Our main aim here is to contribute to the pool of existing literature to verify whether the link between exchange returns and those of exports in both nominal and real is symmetrical (using Standard-GARCH, Bollerslev (1986)), asymmetrical (by using Exponential-GARCH, Nelson (1991)), depends on time varying (by using Weighted GARCH model, Bauwens and Storti (2008)) or follows a long memory process (by using Integrated GARCH, Engle and Bollerslev (1986)).

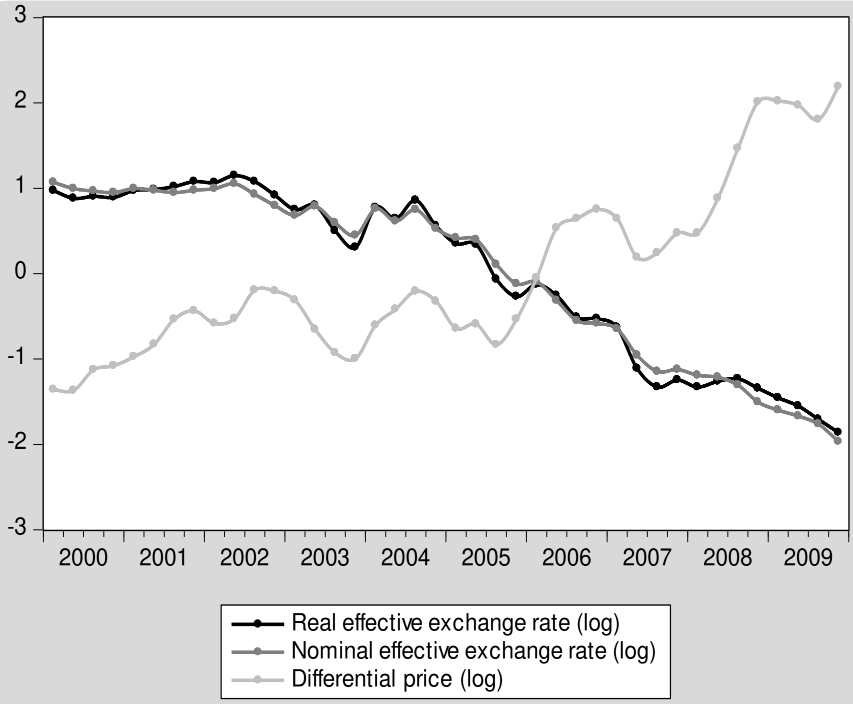
Hence, the remainder of the paper is organized as follows: Section 2 is a brief overview of exchange and trade policies of Tunisia. In section 3, we present the empirical models respectively and the data used in the analysis. In section 4, we proceed to estimate the relationship between returns of nominal exchange rate and nominal exports, those of price differential and nominal exports and those of real effective exchange rate and real exports by using several GARCH extensions outset mentioned. Section 5 concludes our results.

2. A brief overview of exchange and trade policies

Following the demise of the Bretton Woods system in 1973, Tunisia had pegged to the French Franc, given the importance of France as a main trading partner (e.g. Emmonot and Rey, 2008). Until the early 1980s, different developing countries (e.g. Morocco, Egypt, Jordan, Syria, Tunisia, etc…) maintained the nominal effective exchange rate fixed or within a stable band. Then and until 1996, Tunisia chose to adopt managed float regime to preserve its external competitiveness.

During that period, the flexibility relative to the nominal exchange rate was limited. Despite this, the specialization in more volatile products yielded more volatile the price of commodities a major source of real exchange volatility [2](e.g. Arezki et al. 2011), especially in economies which adopted managed float such as Tunisia. As presented below, the nominal exchange rate of this country did not move largely with the adoption of crawling peg.

Figure 1. Evolution of exchange rate in nominal and real terms (Normalized data)



Source: Econstats and IMF

In addition, when a country's exports are largely dominated by raw materials and energy, this can lead to an increase of national currency value against the U.S dollar when prices are high. In this case, the other country's products become more expensive, which erodes the performance of exports. For Tunisia, its competitiveness on mining sector leads to lower vulnerability into international mining prices (e.g. Bouoiyour and Selmi, 2012) but the lack of competitiveness on energy sector (see Figure 2) leaves it vulnerable to oil price uncertainty and then to relative price volatility.[3]

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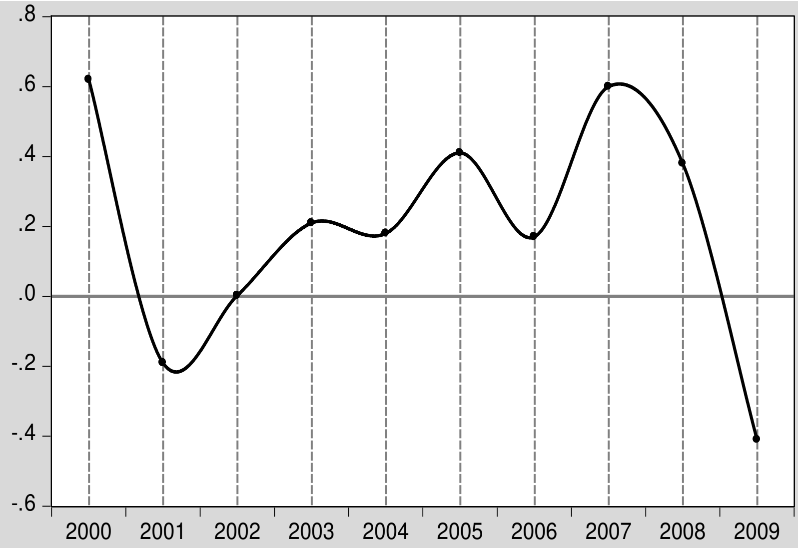
[2]For floating regime, the nominal exchange floats excessively, this means that it should play a main role of changes in real effective exchange rate. However, for fixed exchange rate regime where each currency maintains a stable value against an anchor currency or composite of currencies or crawling peg regime where the nominal exchange rate moves into a target, the inclusion of the differential price uncertainty seems quite legitimate.

[3] To verify this vulnerability to relative price uncertainty, Bouoiyour and Selmi (2012) substracted the share of energy sector from the total of exports which make changes in the sign of the link between exchange rate and exports. This result implies that the volatility of differential price may neutralize the sign of the relationship between exchange uncertainty and trade performance. In the same vein, Egert and Zumaquero (2007) add that a boom of oil prices outweighs the positive sign.

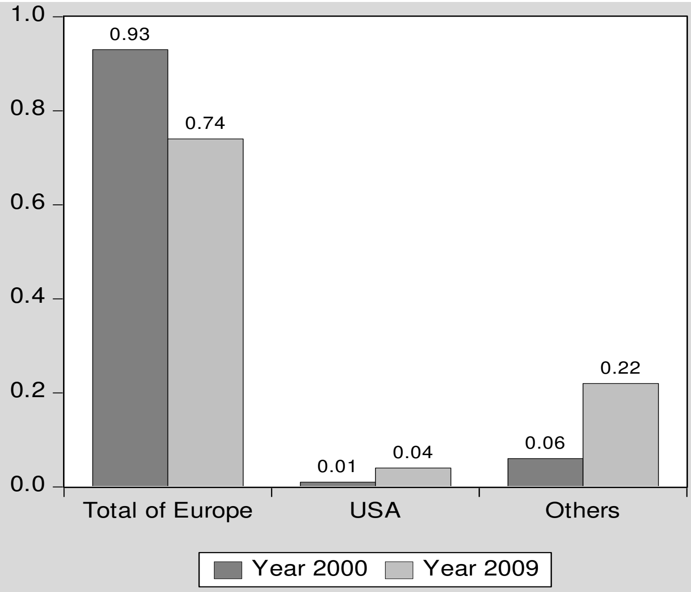
Figure 2. The percent change of oil price of Tunisian exports



Source : CIA, World Factbook.

Intuitively, it should be added that Europe is the predominant destination for Tunisian exports, while the rest of the world' partners destination accounts for nearly one-fourth of this country' imports. During 1996-2009, nearly 86 percent (as average) of Tunisian exports were destined to Europe. This can mitigate the impact of exchange volatility on exports' returns.

Figure 3. Share of principal partners' destination (Overall exports)



Source: CIA, World Factbook.

3. The linkage between changes in exchange rate and exports'returns

As started outset, to investigate possible links between changes in exchange rate and exports'returns for Tunisian case and verify if this effect is ambiguously significant, we estimate various GARCH specifications taking into account these effects: symmetrical (i.e. absence of leverage effect) versus asymmetrical (i.e. presence of leverage effect) and linear (i.e. absence of structural breaks) versus nonlinear (i.e. presence of structural breaks). Thus, we try here to evaluate the interaction between exchange risk and that of exports using a bivariate GARCH model without taking into account other determinants of exports because we thought according to several works that when we use various explanatory variables, the studied linkage can be a reflect of underlying factors that can carry another effect [4].

We built an indicator which replaces the simple changes of exports in accordance with exchange rate returns[5] in both nominal and real terms. This indicator is constructed using the variance between the real exports returns and those of real exchange rate, the nominal exports returns and those of nominal exchange rate and then changes in nominal exports and those of differential price. We used here data set for the period from the first quarter 2000 to the fourth quarter 2009 collected from Econstats and International Monetary Fund (IMF).

$$r_{XPN_t} = \log(XPN_t / XPN_{t-1}) \tag{1}$$

Where r_{XPN_t} is the return of nominal exports which is determined with the value of exports in current price.

$$r_{XPR_t} = \log(XPR_t / XPR_{t-1}) \tag{2}$$

Where r_{XPR_t} is the return of real exports which is determined using the ratio between nominal exports and the export unit value.

$$r_{NEER_t} = \log(NEER_t / NEER_{t-1}) \tag{3}$$

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[4] Bouoiyour and Selmi (2012) proposed complete model regressing total and sectoral exports rate on several fundamentals such as volatility (optimal model), the Tunisian GDP and GDP of main trade' partners. They argue that there is an ambiguous effect of exchange uncertainty on exports (i.e. negative for the total of exports, positive for manufacturing and agricultural sectors and negative for mining and phosphates and energy sectors). To explain this controversial link and based on the study of Egert and Zumaquero (2007), they advance that an excessive volatile primary commodity prices, especially oil price uncertainty and the current financial crisis can lead to an opposite effect of exchange volatility on exports.

[5]This method has been largely used recently to evaluate the linkage between the variability of dollar vis-à-vis various currencies and oil price returns (e.g. Narayan et al. (2008) and Mansor (2011)).

Where r_{NEER_t} is the return of nominal exchange rate. We measure the nominal effective exchange rate with nominal parities.

$$r_{(P/P^*)_t} = \log\left((P/P^*)_t / (P/P^*)_{t-1}\right) \tag{4}$$

Where $r_{(P/P^*)_t}$ is the return of the differential between the national price (P) and the foreign price (P^*).

$$r_{REER_t} = \log(REER_t / REER_{t-1}) \tag{5}$$

Where r_{REER_t} is the return of real effective exchange rate[6], expressed as follows:

$$REER_t = NEER_t \times (P/P^*)_t \tag{6}$$

To examine the linkage between exchange rate returns r_{EXCH_t} and those of exports r_{EXP_t}, we will begin by a linear model considering the link between both last series.

$$r_{EXP_t} = \alpha + \beta r_{EXCH_t} + \varepsilon_t \tag{7}$$

Where β is the focal parameter in equation (7), which can be negative and significant, negative and insignificant, positive and significant or positive and insignificant depending on whether exchange rate returns are linked to changes in exports; ε_t is the error term.

More precisely, we incorporate a once-lagged exchange rate changes in the above mean equation either in nominal or in real terms (i.e. r_{XPN} and r_{NEER} , r_{XPN} and $r_{(P/P^*)}$ and r_{XPR} and r_{REER}, presented outset*)* to whiten the noise process (e.g. Mansor, 2011).

The model is run using a realized volatility of both nominal and real exports for time *t* that is unknown to exchange rate at time *t* to determine if their respective influences vary. To do this, we use a Standard-GARCH model (Bollerslev, 1986) presented as follows:

$$h_{k,t} = \alpha_{0k} + \alpha_{1k}\mu_{t-1}^2 + \beta_{1k}h_{k,t-1}, k = 1,2 \tag{8}$$

$$\varepsilon_t = h_t^{1/2} z_t \tag{9}$$

[6]The real exchange rate is constructed by dividing the trade-weighted foreign price level index by the corresponding domestic price level index, after prior conversion to a common numeraire using nominal exchange rate.

Where α_{0k} : the reaction of shock; α_{1k} : ARCH term; β_{1k} : GARCH term; μ : innovation; z_t : the standardized value of error term where $z_t = \varepsilon_t / h_t^{1/2}$.

This model is not able to capture a long memory process of conditional volatility to verify if the link between trade and exchange uncertainty is highly persistent. Thus, we thought to use an Integrated-GARCH model[7] introduced by Engle and Bollerslev (1986), assumed the existence of a unit root in the conditional variance process.

$$h_{k,t} = \alpha_{01} + \mu_{t-1}^2 + \alpha_{1k}(\mu_{t-k}^2 - \mu_{t-1}^2) + \beta_{1k}(h_{k,t-1} - \mu_{t-1}^2) \tag{10}$$

These two models presented above do not include a cyclic behavior, sudden shocks and asymmetric volatility (i.e. restrictive specifications). Therefore, we apply The Exponential-GARCH initiated by Nelson (1991) able to describe the behavior of the conditional variance based on both good and bad news.

$$\log h_{k,t} = \alpha_{0k} + \alpha_{1k}\left|\mu_{t-1} / h_{k,t-1}{}^{1/2}\right| + \gamma h_{k,t-1}{}^{1/2} + \beta_1 \log h_{k,t-1} \tag{11}$$

Where γ : the leverage effect (i.e. sign of innovation after good or bad news).

Thereafter, to verify if there are weights or shifts in conditional variance we can present a Weighted GARCH recently proposed by Bauwens and Storti (2008). They suggest that there are relevant settings in which the process of volatility cannot be adequately captured by linear or asymmetrical models. This model is able to identify time varying parameters, structural breaks and their dependence of volatility response[8].

$$h_t = w_{t-d} h_{1,t} + (1 - w_{t-d}) h_{2,t} \tag{12}$$

Where: w_{t-d}: the weights; d: the delay needed to affect the conditional variance.

$$w_{t-d} = 1/[1 + \exp(\gamma \delta h_{t-d}{}^{1/2})] \tag{13}$$

[7] For this GARCH extension, volatility tends to zero much slower for a long memory than a short memory process. This is specifically a GARCH model that is characterized by an effect of persistence in variance.

[8] The difference between Weighted GARCH model and other nonlinear models (e.g. Bauwens and Storti (2008) and Anderson et al. (2009)) is due to the fact that the aim of Weighted GARCH is to provide an approach to construct state dependent features in its persistence.

where: α_{01}: the reaction of shock; α_{11}: the first component associated to turbulent period; α_{12}: the second component associated to tranquil period; $\alpha_{11}+\beta_{11}$: the first volatility component in turbulent period; $\alpha_{11}+\beta_{12}$: the second volatility component in tranquil period; δ : denotes the information set available at time *t*.

4. Empirical findings and discussion

4.1. Prelimanary analysis

Before estimating the linkage between trade performance and exchange volatility, we start by examining the descriptive statistics of the considered series. The results are summarized in Table 1: The coefficient of kurtosis appears superior to 3 for series which indicates that the distribution is more flattened than the Gaussian distribution (except the differential price). The Skewness coefficient is negative for all series indicating that the symmetrical distribution is plausible. The Jarque Bera test revealed a low value for the returns which leads to accept the assumption of normality.

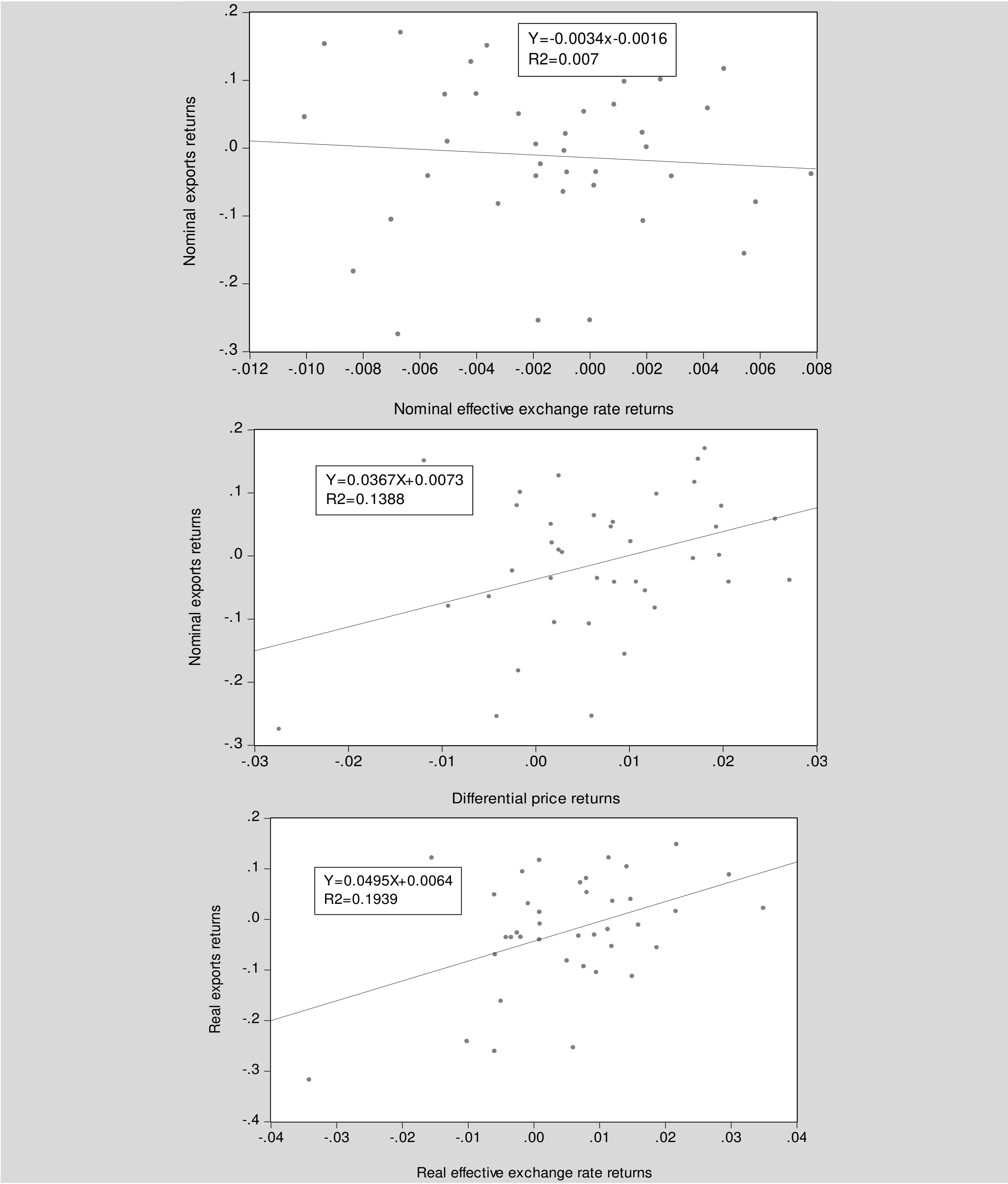
Table 1. Descriptive statistics

	r_{XPN}	r_{NEER}	$r_{(P/P^*)}$	r_{XPR}	r_{REER}
Mean	-0.010873	0.006862	-0.001567	-0.022405	0.005296
Median	0.001170	0.006590	-0.000933	-0.019806	0.006809
Maximum	0.170184	0.027107	0.007814	0.148266	0.034921
Minimum	-0.274750	-0.027376	-0.010060	-0.317259	-0.034139
Std. Dev.	0.110721	0.010915	0.004471	0.111344	0.012508
Skewness	-0.646257	-0.585986	-0.087051	-0.860660	-0.354534
Kurtosis	3.062917	3.969282	2.450913	3.417328	4.518423
Jarque-Bera	2.721148	3.758667	0.539188	5.097794	4.563629

Source : Econstats and IMF.

A preliminary analysis (see Figure 4 presented below) shows that the interaction between the changes in exports and those of exchange rate differs depending on its nature either nominal or real terms. Indeed, in nominal terms, we observe a negative relationship between nominal exports and nominal exchange rate returns. However, we see that the interaction between changes in nominal exports and those of relative price is rather negative. The coefficient associated to the first link is very low and that of the second link is more important. In real terms, we notice a positive linkage that can imply that the controversial link between real exchange returns and those of real exports in Tunisia can be driven by differential price uncertainty more than that of nominal effective exchange rate.

Figure 4. First correlation between exports and exchange rate returns



To confirm if the asymmetric effects exist on conditional volatility, we try to measure the correlation between returns and squared returns (e.g. Zivot et al. 2008). A positive value of this coefficient indicates the absence of leverage effect.

$$Correlation = \rho(r^2, r_{t-1}) \tag{14}$$

Then, the sum of the squared high frequency returns (*Sum-HFR*) is taken as a measure of the volatility and, in the limit as the interval goes to zero, the measure converges to the integrated volatility which able to capture a long memory process in conditional volatility (e.g. Ohanissian et al. 2004). A value almost equal to 1 of this coefficient indicates that the series in question follow a long memory process which characterizes in our case of study particularly the link between real exchange returns and those of real exports.

$$Sum\text{-}HFR = \sum_{t=1}^{n} r_t^2 + 2\sum_{t=2}^{n} r_t r_{t-1} \tag{15}$$

Therefore, Table 2 shows the absence of leverage effect for the series considered verified in both nominal and real terms. The results reveal also that the conditional variance of the three links in question follow a long memory process. However, in any case, we cannot confirm this at this stage (i.e. the links cannot be affected by bad or good news, following a long memory process). With regard to the various specifications presented above, it is time to examine carefully the interaction between exchange volatility, differential uncertainty and changes in exports in both nominal and real terms.

Table 2. Test of asymmetry and of long memory process in conditional volatility

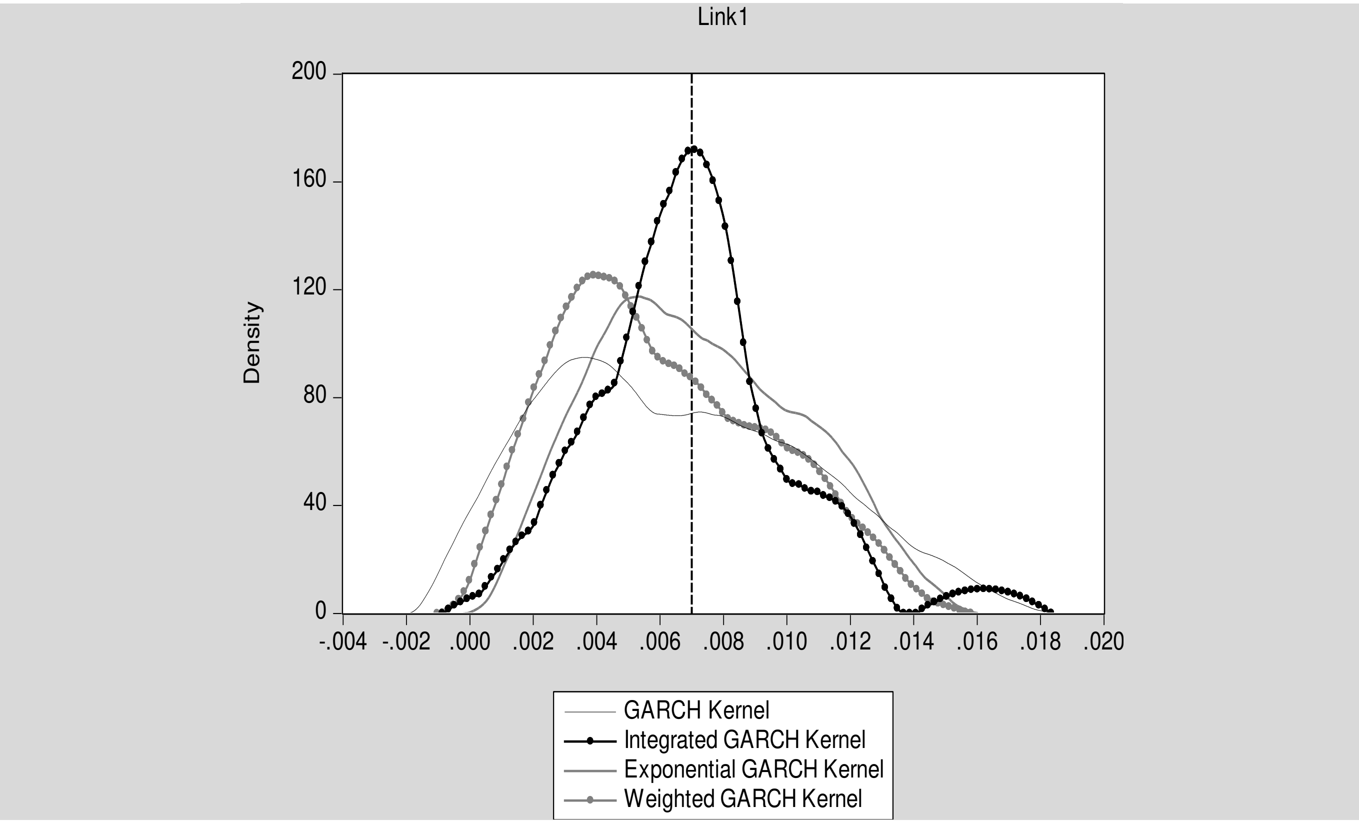
	Link1	Link2	Link3
$\rho(r^2, r_{t-1})$	0.07265316	0.05836829	0.00119338
$\sum_{t=1}^{n} r_t^2 + 2\sum_{t=2}^{n} r_t r_{t-1}$	0.72387408	0.76369374	1.01836521

Note: Link1: between nominal exports and nominal exchange rate returns; Link2: between changes in nominal exports and those of differential of prices; Link3: between real exports returns and those of real exchange rate.

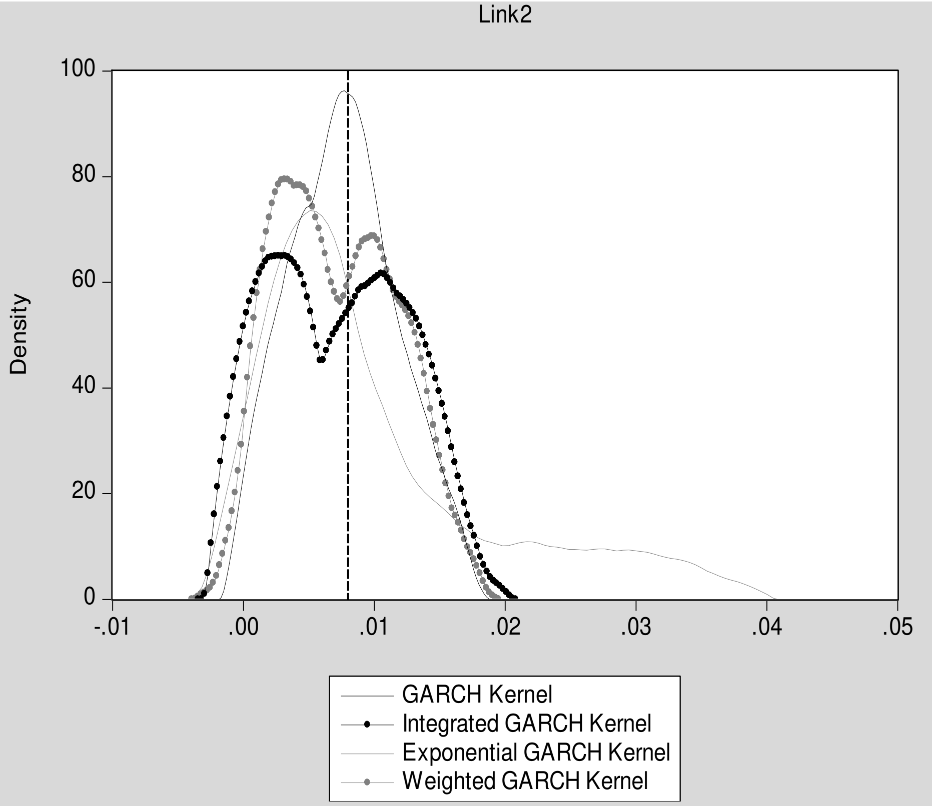
4.2. Estimates of the link between exchange uncertainty and changes in exports

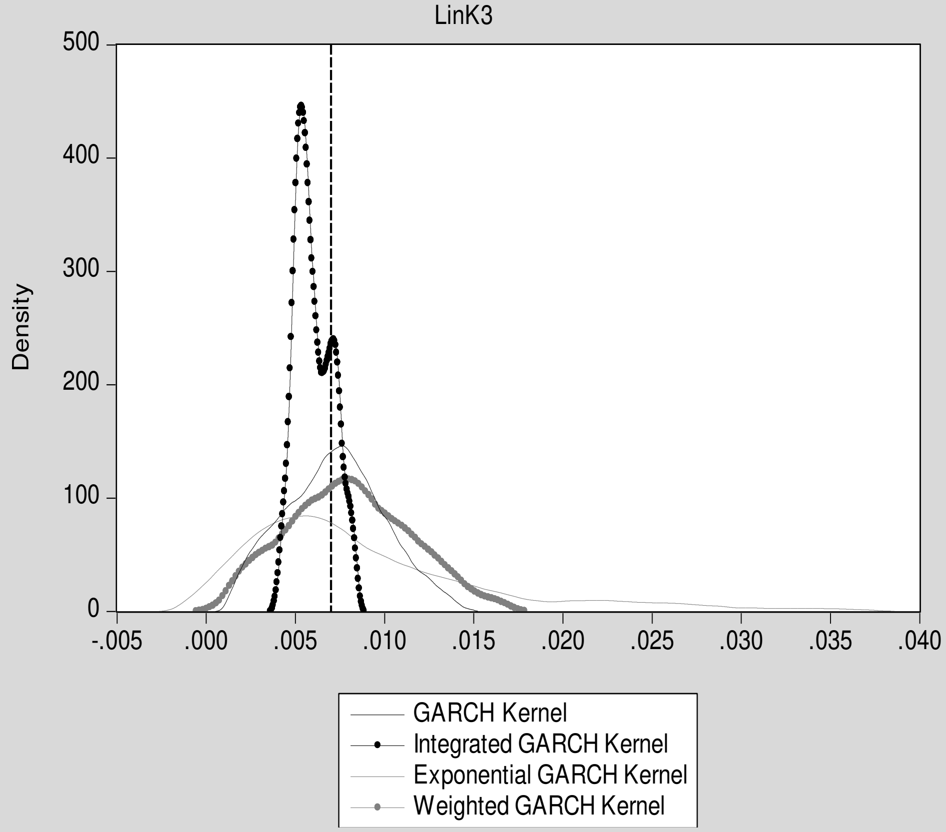
To estimate the relationship between exports returns and those of exchange rate, we used firstly the Kernel density distributions (see Figure 5) of the considered models to choose the optimal model.[9] In nominal terms, the optimal model is the Integrated-GARCH (i.e. link between nominal exchange rate and nominal exports returns) which is characterized by a long memory process in conditional variance. However, the most effective model chosen to determine the impact of differential price on nominal exports is Exponential-GARCH model distinguished by the presence of leverage effect. In real terms hereafter, the selected model is the weighted GARCH model able to capture thresholds or weights in conditional volatility.

Figure 5. Evaluation of GARCH extensions by Kernel density distribution



[9]The x-axis indicates a positive value of these effects, higher values mean the optimal model (e.g. Bullent, 2009).





Note: Link1: between nominal exports and nominal exchange rate returns; Link2: between changes in nominal exports and those of differential of prices; Link3: between real exports returns and those of real exchange rate.

What remains to be seen is whether these optimal models give the best results by regressing exports on exchange rates returns. Tables 4, 5 and 6 summarized the results from GARCH extensions estimates indicating successively our estimates of the optimal models chosen to determine the persistence of variance between changes in exports and those of exchange rates in both nominal and real terms[10].

4.2.1. The link between nominal exports and nominal exchange rate returns

As mentioned in Figure 5, the optimal model chosen to determine the linkage between nominal effective exchange rate returns and those of nominal exports is the Integrated GARCH. It is clear from Table 4 that nominal exchange rate has a statistically significant impact on exports returns. The optimal model shows that an appreciation of 10% in nominal exchange rate leads to an increase of 23.04% of the nominal exports. Theoretically, the Integrated GARCH model tests whether the conditional variance follows a long memory process, which is checked for our case (i.e. the sum of ARCH and GARCH effects is equal to 1) implying high persistence of the considered link. The difference in sign of shocks here is not important since it has not a leverage effect.

Table 4. Link between nominal exports and nominal exchange rate returns

N°	Specifications	Mean equation		Variance equation				
		r_{NEER}	C	α_{01}	α_{11}	β_{11}	β_{12}	γ
1	Integrated GARCH	2.304*** (15.944)	-0.02*** (-3.689)	-	-0.138*** (-5.661)	1.138*** (46.449)	-	-
2	Exponential GARCH	4.072*** (4.283)	-0.035** (-2.369)	-6.694** (-2.674)	-0.275 (-0.312)	-	-0.369 (-0.738)	-0.368 (-0.54)
3	Weighted GARCH	0.173 (0.155)	-0.019* (-1.584)	-0.0001 (-0.433)	0.114 (0.510)	1.09*** (17.672)	-0.230 (-0.77)	-
4	GARCH	0.636 (0.448)	-0.018* (-1.439)	-0.0002 (-0.505)	-0.170* (-1.116)	-	1.27*** (4.603)	-

Persistence of volatility using optimal GARCH extension				
Optimal model	**Duration of persistence**	**Intensity of shock**		
		Amplitude	**Negative shock**	**Positive shock**
Integrated GARCH	$\sum_{i=1}^{q}\alpha_i + \sum_{j=1}^{p}\beta_j = 1$	$\sum_{i=1}^{q}\alpha_i = -0.138$	-	-

Note: Standard deviations are in parentheses, *, **,*: significant at 1%, 5%, and 10%. For detailed analysis of GARCH specifications, we can see Anderson et al. (2009).**

[10] We estimate all the considered GARCH extensions to check the robustness of our results in terms of persistence (i.e. duration of persistence, intensity of shock and ARCH and GARCH effects) of the link between exchange risk and exports.

4.2.2. The link between nominal exports and differential price returns

The optimal model selected to evaluate how interact differential price returns with those of nominal exports using Kernel density distribution is the Exponential GARCH model (see Figure 5), which is able to detect a long memory process in conditional variance. Our estimates of the optimal model show that an increase of 10% in differential prices returns leads to a decrease of 1.50% of nominal exports. In comparison to other considered GARCH extensions, this specification behaves differently because of the leverage effect which takes into account to the sign of innovation and not only to its amplitude (e.g. Selmi et al. 2012). The leverage effect here is positive (see Table 5), implying that the effect of bad news dominate that of good news. Rather than the leverage effect, the impact of negative shock is more important than that of positive shock in terms of amplitude, which means a strong relative degree of asymmetry[11]. It should be noted also that the link between differential price and exports prices is highly persistent (i.e. more than 1), implying that this link as the first relationship reported above in Table 4 follows a long memory process.

Table 5. Link between nominal exports and differential price returns

N°	Specifications	Mean equation		Variance equation				
		$r_{(P/P^*)}$	C	α_{01}	α_{11}	β_{11}	β_{12}	γ
1	Exponential GARCH	-0.015** (-2.372)	1.449 (0.506)	0.046 (0.149)	-0.211* (-1.152)	-	0.97*** (21.107)	0.594 (0.91)
2	Integrated GARCH	-2.485* (-1.216)	-0.004 (-0.773)	-	0.241** (2.603)	-	0.758*** (8.167)	-
3	GARCH	-0.012 (-0.920)	2.535 (0.698)	-0.0001 (-0.487)	-0.169* (-1.179)	-	1.27*** (4.637)	-
4	Weighted GARCH	-0.011 (-0.904)	1.419 (0.449)	-0.0001 (-0.349)	0.469* (1.894)	1.04*** (4.178)	-0.66* (-1.89)	-

Persistence of volatility using optimal GARCH extension

Optimal model	Duration of persistence	Intensity of shock		
		Amplitude	Negative shock	Positive shock
Exponential GARCH	$\sum_{i=1}^{q}\alpha_i + \sum_{j=1}^{p}\beta_j + 0.5 = 1.054$	-	$-\sum_{i=1}^{q}\alpha_i + \gamma = 0.805$	$\sum_{i=1}^{q}\alpha_i + \gamma = 0.383$

Note: Standard deviations are in parentheses, *, **,*: significant at 1%, 5%, and 10%. For detailed analysis of GARCH specifications, we can see Anderson et al. (2009).**

[11] It measures the relative influence of bad news on conditional variance (e.g. Bouoiyour et al. 2012).

4.2.2. The link between real exports and real exchange rate returns

For the link between real effective exchange rate returns and those of real exports, we observe the preponderance of the time varying affect (see Figure 5). The optimal model (i.e. Weighted GARCH) reveals that an appreciation of 10% of real exchange rate leads to an increase of 27.11% of changes in real exports. Our results presented in Table 6 show a much larger vulnerability of the volatility component (i.e. $\alpha_{11} \succ \alpha_{01}$), and the smaller sensitivity to the lagged volatility component (i.e. $\beta_{11} \prec \beta_{01}$)[12]. This means that in turbulent periods, the volatility tends to be more persistent and less vulnerable to recent shocks, mainly driven by short run factors in turbulent than in tranquil periods. We also notice that this linkage is persistent (i.e. duration of persistence almost equal to 1), which means its tendency to a long memory process.

Table 6. Link between real exports and real effective exchange rate returns

N°	Specifications	Mean equation		Variance equation				
		r_{REER}	C	α_{01}	α_{11}	β_{11}	β_{12}	γ
1	Weighted GARCH	2.711*** (4.025)	-0.034*** (-3.061)	0.013*** (3.652)	0.126* (-1.051)	0.8*** (4.788)	0.094 (0.443)	-
2	GARCH	2.623*** (24.134)	-0.02*** (-14.283)	-0.0002 (-0.474)	-0.168* (-1.037)	1.26*** (4.309)	-	-
3	Exponential GARCH	5.022*** (7.342)	-0.041*** (-3.118)	-5.906** (-2.712)	-0.159 (-0.229)	-0.195 (-0.475)	-	-0.483 (-0.896)
4	Integrated GARCH	3.116*** (9.514)	-0.030** (-2.374)	-	-0.124** (-2.603)	-	1.124*** (24.321)	-

Persistence of volatility using optimal GARCH extension				
Optimal model	**Duration of persistence**	**Intensity of shock**		
		Amplitude	**Negative shock**	**Positive shock**
Weighted GARCH	$\sum_{i=1}^{q}\alpha_i + \sum_{j=1}^{p}\beta_j = 0.77$	$\sum_{i=1}^{q}\alpha_i = 0.126$	-	-

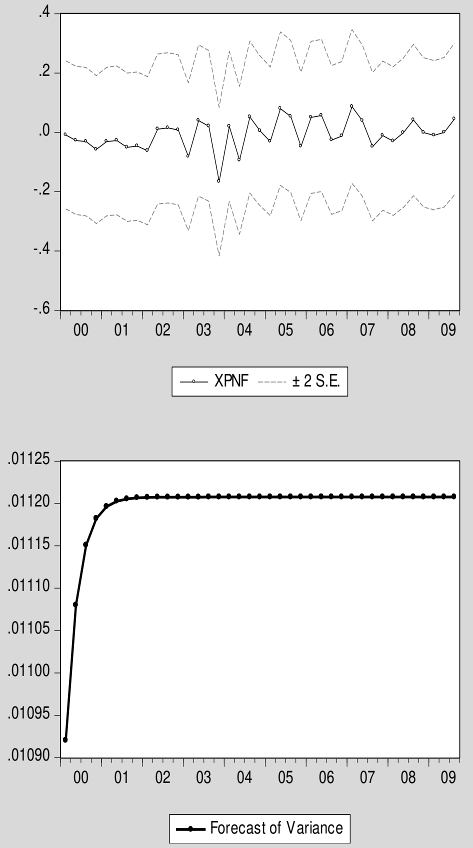
Note: Standard deviations are in parentheses, *, **,*: significant at 1%, 5%, and 10%. For detailed analysis of GARCH specifications, we can see Anderson et al. (2009).**

Figure 6 presents below the evolution of conditional variance of the link between returns of exports and those of exchange rates either in nominal or real terms. We can confirm here that the three links in question are highly persistent either by choosing linear or asymmetrical or weighted model. Although, these variances behave differently depending on the nature of relationship (i.e. nominal or real).

[12] For more details about Weighted-GARCH parameters, we can refer to Bauwens and Storti (2008).

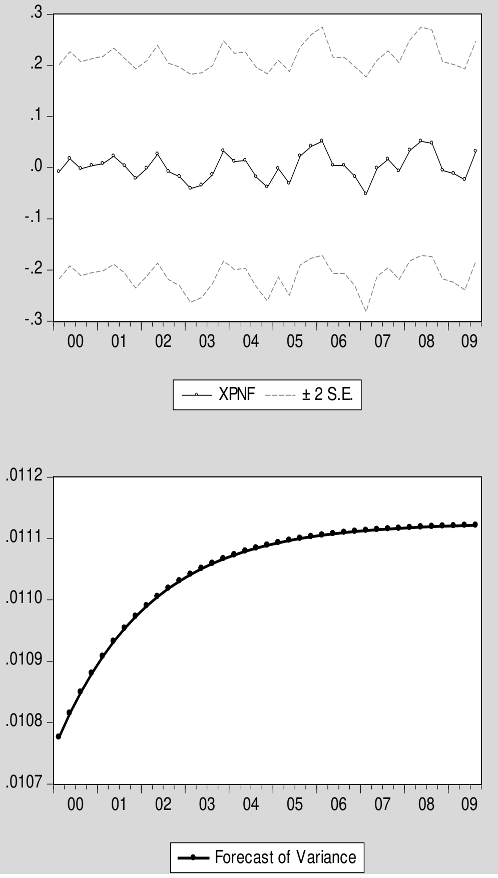
Figure 6. Persistence of the link between exports and exchange rate returns

Link1



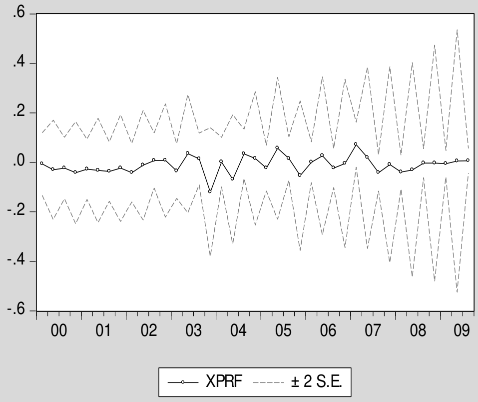
Forecast: XPNF	
Actual: XPN	
Forecast sample: 2000Q1 2009Q4	
Adjusted sample: 2000Q1 2009Q3	
Included observations: 39	
Root Mean Squared Error	0.101905
Mean Absolute Error	0.081301
Mean Abs. Percent Error	253.0225
Theil Inequality Coefficient	0.635490
Bias Proportion	0.001149
Variance Proportion	0.338810
Covariance Proportion	0.660042

Link2

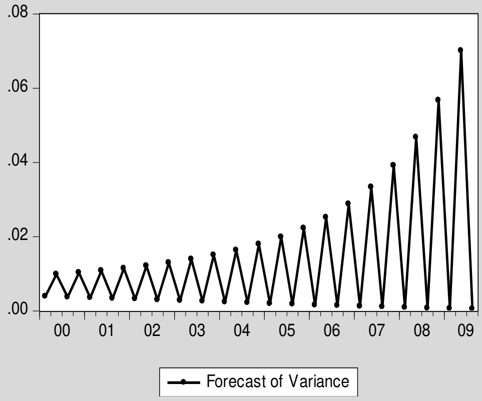


Forecast: XPNF	
Actual: XPN	
Forecast sample: 2000Q1 2009Q4	
Adjusted sample: 2000Q1 2009Q3	
Included observations: 39	
Root Mean Squared Error	0.110943
Mean Absolute Error	0.082868
Mean Abs. Percent Error	133.7146
Theil Inequality Coefficient	0.818595
Bias Proportion	0.014240
Variance Proportion	0.569251
Covariance Proportion	0.416509

Link3



Forecast: XPRF	
Actual: XPR	
Forecast sample: 2000Q1 2009Q4	
Adjusted sample: 2000Q1 2009Q3	
Included observations: 39	
Root Mean Squared Error	0.100362
Mean Absolute Error	0.077509
Mean Abs. Percent Error	103.6756
Theil Inequality Coefficient	0.677878
Bias Proportion	0.013342
Variance Proportion	0.568764
Covariance Proportion	0.417894



<u>Note:</u> Link1: between nominal exports and nominal exchange rate returns; Link2: between changes in nominal exports and those of differential of prices; Link3: between real exports returns and those of real exchange rate.

Let us summarize our results now: The main questions throughout this study are: Does nominal exchange volatility or that of differential price involve a greater or smaller cost on Tunisian trade performance? Should it only be concerned under crawling peg regime about real exchange variability driven by volatile differential price? While trying to answer these questions, several interesting results emerge from Tables 4, 5, 6 and Figure 6:

It is worth noting from our results that the effect of differential price risk on changes in exports exceeds that of nominal exchange rate by a large margin in terms of duration of persistence and intensity of shock. Hence, the more persistent effect of differential price risk on exports returns comparable to that of nominal exchange rate in Tunisia confirms the idea whereby economies with managed exchange rate should display high volatility of the real exchange rate driven by the differential price uncertainty (e.g. Bahmani-Oskooee and Ltaifa (1992) and Bahmani-Oskooee (2002), etc…). This result is well expected because under crawling peg regime, a large fraction of real exchange volatility and then its effect on trade is due to relative price movements. We also argue that the excessive volatile differential price is due to the presence of leverage effect in its relationship with nominal exports as well as the explosive behavior that characterize it (i.e. only the variance of differential price increases over time (see Figure 6)). Of course, each country generally speaking and Tunisia in particular must be unhappy to have this strong interaction beween changes in relative price and its exports.

As it stands now, the impact of real exchange volatility is largely dominated by the effect of differential price movements, under crawling peg regime. In Tunisia, instead of having nominal exchange rate that moves slightly, the differential price fluctuates widely. So, our evaluation undertaken here avoided intentionnaly to take into account the differential price volatility to investigate the linkage in question especially in economies with managed pegged exchange rate system. The sharp vulnerability of differential price uncertainty, leverage effect and structural breaks leads to a fear that these latter which will be transmitted to real exchange volatility will threaten the overall exports performance. Thus and to the extent that differential commodity price variability is costly (e.g. Arezki et al. 2011), a harder implication here is whether authorities and policymakers should attempt to mitigate it.

5. Conclusion

The aim of this paper is to determine the persistence of linkage between exports returns and those of exchange rate in both nominal and real terms in Tunisia. Our main results reveal that the size impact of realized exchange rate volatility is not affected by the use of linear and symmetrical GARCH extensions (i.e. Standard GARCH) in nominal and real terms. However, there is a substantial difference, when we move to the time varying and asymmetrical models (i.e. Weighted GARCH and Exponential GARCH, respectively). We found that the linkage between exchange rate and exports in Tunisia is dependent on switching regime or time varying between low and high volatility in real terms (i.e. structural breaks or shifts) and leverage effects (i.e. good or bad news) in nominal terms. However, the considered links either in nominal or real terms are highly persistent (i.e. equal, more or almost equal to 1), implying a tendency to long memory process (using Integrated GARCH).

The picture here is not rosy, this can lead Tunisian trade to precarious positions and high level of risk in terms of how overall exports should interact with the trend towards increasingly volatile exchange rate and differential price. This remains a great challenge that forces Tunisia to act and it is also an important challenge for future researches especially with the recent financial crisis and the current political instability.

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