JOURNAL OF ECONOMIC DEVELOPMENT
Volume 31, Number 2, December 2006

EFFECTIVE EXCHANGE RATE VOLATILITY AND MENA COUNTRIES' EXPORTS TO THE EU

SERGE REY*

University of Pau et Pays de l'Adour

This paper investigates the impact of nominal and real effective exchange rate volatility on exports of six Middle Eastern and North Africa (MENA) countries to 15 member countries of the European Union (EU), for the period 1970Q1-2002Q4. Moving average standard deviation and conditional standard deviation at ARCH model are used to generate four different measures of volatility for each country. The cointegration results indicate a significant relationship, negative for four countries (Algeria, Egypt, Tunisia, and Turkey), positive for the last two (Israel and Morocco), between MENA exports and exchange rate volatility. The short run dynamics, using an error correction model, shows that the Granger – causality effects of the volatility on real exports are significant, whereas the effects of real exchange rate and the gross domestic product of EU are more contrasted. Indications on appropriate exchange rate regime are derived from these results.

Keywords: Effective Exchange Rate, Volatility, Export, MENA Countries, GARCH Model, Cointegration, Error-Correction model
JEL classification: C13, C22, F31, F32

1. INTRODUCTION

Since the 1970s, Mediterranean countries have engaged in a liberalization process, concerning both the financial and the real sectors of their economies. Recently, the Barcelona Conference in November 27-28, 1995, established a new Euro-Mediterranean partnership between the 15 Members States of the European Union (EU) and 12 countries of the Middle Eastern and North Africa (MENA), including in particular

* The author wishes to thank Jacques Le Cacheux and an anonymous referee for very helpful comments and suggestions. This paper also benefited of discussions with A. Bouët, G. Denis, C. Emonnot, O. Peron, K. Sekkat and participants at the SESAME Conference, September 23-25, 2004, University of PAU. However, the usual disclaimer applies.

Morocco, Tunisia, Algeria, Egypt, Israel, Turkey.[1] This partnership is founded on three aspects: political and security aspects; a social and human aspect and an economic and financial aspect which is the more important here. The Council put forward an action plan for achieving a Euro-Mediterranean economic area based on free trade, before 2010. In this perspective, the choice of an exchange rate regime is very important.

The theoretical literature provides broad guidance on this choice. According to the theory of optimal currency areas, real shocks are better accommodated through flexible exchange rates, and nominal shocks through fixed exchange rates. But other considerations are important: trade policy, the flexibility of labor markets, the size of the economy, openness to trade and capital flows, macroeconomics policies… Hence, a criterion by which one can judge an exchange rate regime concerns the sensitivity of trade flows to exchange rate variability. If this sensitivity is high, a good exchange rate arrangement must permit to limit the negative impact on trade flows of an excessive variability. But which variability? Marston (1988) notes: "*There are two types of exchange rate variability, volatility and misalignment. Volatility is the day-to-day, month-to-month variability of exchange rates. Misalignment, in contrast, is the persistent departure of an exchange rate from its long run competitive level.*"

Both volatility and misalignments may have important effects on trade flows, on direct investments, on output and so on.

On the one hand, an overvaluation of the exchange rate should lead to a deterioration of the economic situation. An overvalued currency brings about resources shifts in favor of the non-tradable sectors, which reduces growth (see for example, De Grauwe (1983), Marston (1988), for a detailed analysis). The major difficulties concern the measurement of the misalignment, which depends on the choice of the long run equilibrium exchange rate model (see Edwards (1989), Hinkle and Montiel (1999), Stein (2006)).

On the other hand, the effects of a greater volatility are more contrasted, both at the theoretical and the practical levels. Theoretically, we may expect negative or positive effects of the exchange rate volatility on international trade. Empirically, we have to choose between an unconditional measure of volatility and a conditional measure.

Central banks may want to obtain both stability and some target level of exchange rate. But they may be confronted with a dilemma.

Countries that suffer very high rates of inflation may peg their currency to a single foreign currency (the dollar for example, after the breakdown of the Bretton Woods system) or to a basket of currencies. This allows to reduce both the volatility of the exchange rate (nominal and real) and the volatility of the inflation rate and may be also to minimize fluctuations in output, consumption, or some other macroeconomic variables. Furthermore, adopting a pegged exchange rate can help establish the credibility of a program to bring inflation down. But in return, the risk is that the peg becomes unsustainable, and generates serious misalignments.

[1] Other countries are: Jordan, Lebanon, Syria, Cyprus, Malta and the Palestinian territories.

In contrast, a flexible exchange rate provides greater room for maneuver (autonomy of the monetary policy, etc.). It permits the stability of the real exchange rate (real anchor) and may avoid misalignments. But in return, inflation may be higher and more variable, with as a main consequence a loss of credibility. In the same way, it will lead to greater volatility of the exchange rates. In principle, a flexible exchange rate is preferable if the shocks impinging on the economy are predominantly real, which affects the relative prices.

In the face of such difficulties, an empirical study can help to choose the exchange rate regime. The purpose of this paper is to provide estimates of the short-and-long run impacts of exchange rate volatility on export flows for six MENA countries (Algeria, Egypt, Israel, Morocco, Tunisia, and Turkey) to EU, over the period 1970Q1-2002Q4[2] (quarterly data).

It is organized as follows. Section 2 summarizes the economic situation of the MENA and proposes a short review on the relationship between the volatility and the trade flows. In section 3, we return to the expected effects of volatility on export flows. Section 4 measures the volatility of real and nominal effective exchange rates of MENA countries, which constitutes a multidimensional concept. We estimate the effects of exchange rate variability on the export flows to the EU in section 5. Section 6 contains some concluding remarks.

2. STYLIZED FACTS

2.1. MENA Trade

This study considers the real exports from MENA countries to the EU. This choice is guided by the observation that the European Union constitutes an important destination for MENA countries, as confirmed by the data of the Table 1.

Algeria, Morocco, Tunisia, Turkey and Egypt send half or more of their exports to the EU. The case of Israel is different: her exports are more diversified. But the strategies of diversifications are also linked to the specialization.

In the Table 2, if we consider eleven categories of products (SITC classification), we can observe differences amongst MENA countries. Algeria for 98%, and Egypt for 50%, mostly export hydrocarbons (oil and natural gas) to Europe. Egypt, Morocco, Tunisia and Turkey export also consumption goods and especially textiles which is the most important sector in terms of exports, except energy sector.

[2] 1974Q1-2002Q4 for Algeria.

Table 1. Share of EU in Total Exports of MENA Countries (in % of the total)

	1970	1980	1990	1995	2000	2003
Algeria	81.2	42.9	67.9	67.3	62.5	59.0
Egypt	25.5	65.8	59.1	55.0	27.1	33.0
Israel	44.3	44.6	38.0	32.8	26.9	26.7
Morocco	76.0	69.0	71.5	71.7	74.1	74.8
Tunisia	64.8	84.2	77.7	79.6	80.0	79.4
Turkey	53.6	47.7	55.9	50.9	54.6	52.3

Source: Data base CHELEM - CEPII 2005 and author calculations

Table 2. Sectoral Contribution to Total Exports of MENA Countries to Europe (in %)

	Algeria		Egypt		Israel		Morocco		Tunisia		Turkey	
	1993	2003	1993	2003	1993	2003	1993	2003	1993	2003	1993	2003
Energy	98.18	97.67	37.47	49.27	0.06	0.07	3.17	1.70	13.47	9.15	1.27	0.92
Food & Agric.	0.28	0.23	9.17	10.47	**20.45**	**12.38**	**29.40**	**19.97**	10.82	5.38	20.20	9.18
Textiles	0.16	0.10	34.63	12.92	13.98	5.11	37.22	46.55	55.74	55.65	57.47	40.77
Wood & paper	0.10	0.09	0.42	0.52	2.76	3.91	2.04	1.95	1.11	2.18	1.46	1.85
Chemicals	0.82	1.24	5.35	14.91	**28.76**	**37.72**	**17.42**	**7.67**	5.44	6.23	8.07	7.56
Iron steel	0.34	0.21	2.99	6.18	0.11	0.61	0.63	0.65	0.16	0.26	0.83	3.98
Non ferrous	0.09	0.33	8.59	3.63	1.22	1.69	4.06	1.66	0.29	0.46	1.12	1.18
Mechanical	0.01	0.10	1.24	1.97	13.47	14.62	0.82	1.19	3.63	2.38	3.18	8.64
Vehicles	0.00	0.00	0.03	0.04	0.14	0.10	0.63	0.58	0.36	2.20	1.32	14.34
Electrical	0.01	0.00	0.05	0.07	3.61	4.54	2.72	7.79	6.94	13.66	3.26	4.83
Electronic	0.00	0.01	0.07	0.03	0.06	19.23	1.89	10.29	2.05	2.44	1.83	6.75

Source: Database CHELEM - CEPII 2005 and author calculations

For Israel, we can see that specialization has evolved during the period. This reflects the long run decline in traditional sectors (clothing, textiles, food, beverage and tobacco) relative to high-tech sectors (equipment, machinery and assorted electronic equipment) (Clifton (1998)). Note also that, except for Algeria and Egypt, the evolution of the structure of exports shows a decline in primary goods exports in favor of foods and equipment.

Finally, these trade data reveal a common characteristics to Morocco and Israel that are the countries for which two sectors are a strong contribution: food/agricultural and chemicals.

2.2. MENA Exchange Rate Regimes

The exchange rate may be used as a policy tool, to reach real targets. In particular, the exchange rate should be devalued when current account needs to improve. So, exchange rate policy may be important in a stabilization program. Generally for the developing countries, the choice is between real anchor and nominal anchor.

In the Table 3, we describe the exchange rate regimes since the 1970's. We distinguish *de jure* regimes (IMF classification) and *de facto* regimes. A *de facto* classification may provide interesting complement to the *de jure* classification, because "*many countries that in theory have a flexible rate intervene in exchange rate markets so pervasively that in practice very little difference exists (in terms of observable performance) with countries that have fixed exchange rate regimes"* (Levy-Yeyati and Sturzenegger (2002)). Thus, in the majority of cases, MENA countries have progressively adopted more flexible exchange rate regimes. And, when they have had fixed exchange rate regimes, periodic devaluations have made the effective regime resembles a flexible arrangement. For these reasons, we may assume that these changes will be reflected in changes in exchange rate (nominal or real) volatilities.

But, as Clark *et al*. (2004) note: "*It is important to realize that the degree of exchange rate variabilility a country is exposed to is not necessarily closely related to the type of exchange rate regime it has adopted. A country may peg its currency to an anchor currency, but it will float against all other currencies if the anchor does as well.*" In our work, we choose to study an effective exchange rate between MENA countries and the European Union.[3]

So that, if some currencies are linked, even partially (Moroccan dirham for example), to the US dollar which floats vis-à-vis the Euro, their effective exchange rate will exhibit a large volatility.

[3] The European Commission (2006) classifies the Tunisian regime as a managed floating with the euro as reference currency, the Israeli and Moroccan regimes as peg arrangements based on currency baskets involving the euro.

Table 3. Exchange Rate Regimes

	De facto classification		IMF classification
	Bubula and Otker-Robe (2002) 1990-2001 (a)	Levy-Yeyati and Sturzenegger (2002) 1974-2000 (b)	Jbili and Kramarenko (2003 a,b)
Algeria	1990-1993 Fixed vis-à-vis a basket 1994-2001 Managed float	1994-1997 D.F. 1998-2000 Fl.	Managed floating with no preannounced path for the exchange rate
Egypt	Since 1960s Fixed vis-à-vis dollar (a) 1991-1996 Horizontals bands 1997-1998 Fixed pegs 1999-2000 Floating regime	1974-1988 Fx. 1989-1991 D.F 1992-1999 I. 2000 Fl.	Managed floating with no preannounced path for the exchange rate
Israel	Before 1985 Fixed vis-à-vis dollar (a) 1985-1990 Horizontal band 1991-2000 Crawling pegs	Alternatively D.F. and Fl. during the period	Exchange rate within crawling bands
Morocco	Early 1970s Fixed vis-à-vis french franc (a) 1973-2001 Fixed vis-à-vis a basket	Alternatively D.F. and Fl. during the period	Fixed peg arrangement against a composite
Tunisia	Early 1970s Fixed vis-à-vis French Franc (a) 1978 Fixed vis-à-vis a basket (a) 1990-1999 Crawling bands 2000-2001 Managed float	Alternatively D.F. and Fl. during the period	Crawling peg
Turkey	1990-1997 Crawling bands 1998-2000 Crawling pegs 2001 Independent floating	1974- 1980 D.F. 1981- 2000 Fl.	Independent floating

(a) Other references; Fanizza *et al.* (2002), Domaç and Shabsigh (1999). (b) Levy-Yeyati and Sturzenegger distinguish five regimes: Inconclusive (σ_e low; $\sigma_{\Delta e}$ low; σ_r low), noted I.; Flexible (σ_e high; $\sigma_{\Delta e}$ high; σ_r low), noted Fl.; Dirty Float (σ_e high; $\sigma_{\Delta e}$ high; σ_r high), noted D.F.; Crawling Peg (σ_e high; $\sigma_{\Delta e}$ low; σ_r high), noted C.P.; Fixed (σ_e low; $\sigma_{\Delta e}$ low; σ_r high), noted Fx., with σ_e the exchange rate volatility (as the average of absolute monthly percentage changes in nominal exchange rate); $\sigma_{\Delta e}$ the volatility of exchange rate changes(standard deviation of the monthly percentage changes in the exchange rate), and σ_r the volatility of international reserves.

2.3. Exchange Rate Volatility and Exports: Some Results

If many studies in the literature are concerned by the relationship between trade flows and exchange rates, the majority explores the impact of volatility in the case of developed countries. A reduced number is interest by emerging countries, and especially

MENA countries. However, we can note some empirical analysis. So, Özbay (1999) finds a negative relation between the Turkish lira volatility (measured by a GARCH model on real exchange rate) and the total exports of Turkey. With a volatility measured by moving average standard deviation (MASD), Vergil (2002) confirms a negative effect for the exports of this country to USA, Italy, France and Germany. Achy and Sekkat (2003) analyze the volatility effects for the exports of five MENA countries (Algeria, Egypt, Morocco, Tunisia and Turkey) to Euroland. Their study concerns eleven sectors and retains two measures of the real exchange rate volatility (MASD and GARCH model). The estimates of a panel model conclude that the volatility affects positively the exports of food/agricultural and, in some cases,[4] chemical sectors, and negatively the exports of the other sectors.

If we retain a more extensive panel of emerging countries, we can quote the work of Sekkat and Varoudakis (1998) which concludes to a negative effect of the exchange rate volatility on textile and chemical exports of five African countries (Ghana, Kenya, Zimbabwe, Tanzania and Zambia), while no effect is revealed for the metal sector. Arize *et al.* (2005), Todani and Munyama (2005), Siregar and Rajan (2004) find also negative effects of the volatility for respectively, the global exports of eight Latina America countries, the global exports of South Africa, and the Indonesian exports to the world and to Japan. Conversely, McKenzie (1997) find that the effects of the nominal exchange rate volatility on Australian exports change according to the direction of trade; positive effects for exports to USA, Japan, Singapore and United Kingdom; negative effects for exports to Germany, Honk Kong and New Zealand.

Firstly, these studies confirm a significant impact of the volatility on the exports, and particularly MENA countries. Secondly, these results show that the effects can be different according to the sectors.

3. MODELING THE EFFECTS OF EXCHANGE RATE VOLATILITY ON REAL EXPORTS

At the theoretical level, the effects of a greater volatility of exchange rates on trade flows are much debated. The literature gives results which contrast strongly. On the whole, the authors have presented models which show that exchange rate volatility may impact trade flows, either positively or negatively, depending on the underlying assumptions.

We retain an imperfect substitute model, in which domestic exports, i.e., MENA countries' exports, and goods produced abroad (here, European Union) are imperfect substitutes.[5] We consider that exports are determined by supply and demand factors. We

[4] The results depend on the specification of models.

[5] See Goldstein and Kahn (1985 p. 1044) for a discussion of this model, and Klaassen (2004) for an

focus on real exports, i.e., nominal exports expressed in domestic currency deflated by the price of domestically produced goods.[6]

On the demand side, real exports depend on: a measure of real foreign economic activity (generally the gross domestic product, noted Y^f); a relative price, and an indicator of exchange rate volatility (noted *V*).

Insofar as we are interested in trade between a MENA country and the European Union, the relative price is therefore $\frac{P_X}{P^{eff} / E^{eff,i}}$, where $E^{eff,i}$ represents the nominal effective exchange rate of every MENA country *i* against the European Union currencies (see section 4), and P^{eff}, the effective price (weighted average) of European Union produced goods. P_X is the domestic currency price of domestically produced exportable goods. In logarithms, this equals $Log(P_X / P \cdot (P \cdot E^{eff,i} / P^{eff})) = p_x + reer$, where $reer = Log(P \cdot E^{eff,i} / P^{eff})$ is the real effective exchange rate (the logarithm of) between MENA country i and European currencies, *P* is the domestic general price level and $p_x = Log(P_X / P)$ is the domestic relative price (the logarithm of) of exportable goods.

One could expect that an increase in real GDP of importing country results in a greater volume of exports, whilst an increase in relative domestic prices, i.e., a real appreciation of the MENA currency, would reduce the level of real exports. If risk-adverse importer's decisions are made upon the base of relative prices, a greater volatility of exchange rates, i.e., a greater uncertainty, reduces the demand of exports.

The quantity of MENA country *i*' exports demanded by the EU may thus be expressed as

$$x^d = x^d(y^f, p_x + reer, v), \quad (1)$$

where all the variables are expressed in logarithms, and $\partial x^d / \partial y^f \rangle 0$, $\partial x^d / \partial reer \langle 0$,[7] and $\partial x^d / \partial v \langle 0$.

On the supply side, the traditional model includes only the price of exports relative to that of domestic product as determinant of real exports (P_X / P, with P_X for exportable prices and P for domestic prices) and an indicator of exchange rate uncertainty. The impact of exchange rate volatility is ambiguous from a theoretical point of view.

Traditional models examine the behavior of firms under uncertainty. Generally, these models retain the four assumptions following: we have competitive firm with no market power; the firm is paid in foreign currency; no hedging possibilities exist; the

application to the bilateral US exports to the other G7 countries.

[6] We have no observations of the bilateral exports prices. See annex 1 for more details.

[7] A rise of *reer* is a real appreciation of the MENA currency. See section 4.

firm cannot change its output in response to shifts in profitability exports, directly related to the movements in exchange rates. A higher volatility leads to higher cost for risk-averse traders and to less foreign trade. Uncertainty about exchange rates translates into uncertainty on future export receipts in domestic currency. Hence, "*by reducing sales, both expected profits and the variance of profits decline, but expected utility increases*" (Côté (1994)). The literature (see for example Ethier (1973), Clark (1973), Dumas (1978), Hooper and Kohlhagen (1978), Cushman (1983, 1988), Chowdhury (1993), Arize (1995)…) shows that these effects depend on the properties of the utility function of the producer.

But a more recent literature considers that the changes in exchange rates do not represent only a risk, but also constitute opportunities to make profits (De Grauwe (1988, 1994)). These works emphasize the "*entry/exit costs and evaluate* "*real options*" *to participate in exports markets*" (Franke (1991), Baum *et al.* (2004)). In this case, "*one view maintains that the capacity to export is tantamount to holding an option and when exchange rate volatility increases, the value of that option also increases, just as it would for any normal option*" (McKenzie and Brooks (1997)).[8] If the firm can adjust one or more factors of production, when the domestic currency depreciates, the prices measured in this currency rise (the firm is price taker and sell its products in foreign currency), that is favored to expected profits. The production and the export supply increase.[9] Firms benefit from an increase in exchange rate volatility since their expected profits grow at a higher rate than their entry/exit costs. These models which focus on the firm's flexibility tend to conclude that a higher exchange risk stimulates real exports.

We write the supply of MENA countries' exports as

$$x^s = x^s(p_x, v)\,, \tag{2}$$

where all the variables are expressed in logarithms, and $\partial x^s / \partial(p_x) \rangle 0$ and $\partial x^s / \partial v$ may be negative or positive. The market for MENA countries' exports is in equilibrium if

$$x = x^s = x^d\ . \tag{3}$$

Solving (1)-(3) for p_x yields

[8] Baum *et al.* show that exporters are also sensitive to the volatility of foreign income. See also, Franke (1991), Sercu and Van Hulle (1992), Sercu and Uppal (2003).

[9] In a model where the firm produces for foreign and domestic markets, De Grauwe (1988) distinguishes two effects, when risk increases: whether the firm reduces its activities, it is the *substitution effect*; whether it increases the output to make profits by exporting more. It is the *income effect*. If this effect dominates, higher exchange rate volatility leads to greater exports.

$$x = x(y^f, reer, v)\ , \qquad (4)$$

where $\partial x / \partial v$ may be negative or positive.

4. ALTERNATIVE MEASURES OF EXCHANGE RATE VOLATILITY

4.1. Real versus Nominal Exchange Rates

One important question is whether it is real or nominal exchange rate volatility that is relevant. This choice is not obvious. There are both theoretical and empirical problems.

At the empirical level, any discussion of exchange rate volatility must be in reference to the time horizon under consideration. At short horizons, in a world of integrated financial markets, greater volatility of the nominal exchange rate may be associated with greater volatility of the real exchange rate (rigidity of prices). But at longer horizon, if the nominal exchange rate adjust to inflation differentials (purchasing power parity), the real exchange rate volatility will be reduced.

At the theoretical level, this choice depends on the behaviors of exporters and importers. For Gotur (1985) "*the real exchange rate is the more relevant measure because the effects of uncertainty on a firm's revenues and costs that arise from fluctuations in the nominal exchange rate are likely to be offset in large part by movements in costs and prices.*" De Grauwe (1994 p.67) note: "*It should be stressed that the exchange rate uncertainty discussed here has to do with real exchange uncertainty. That is, the uncertainty comes about because the exchange rate changes do not reflect price changes.*"[10]

Finally, there is no unique way of measuring exchange risk. No consensus has emerged. So, we choose both nominal and real exchange rates. As far as we are interested in exports from MENA countries to EU, we retain an effective exchange rate.

For a base period noted 0, the real effective exchange rate (*REER*) of a MENA country *i* against a European currency *j*, with $\theta_{j/i}$ the weight of the currency I,[11] can be defined as

$$REER^i_{t/0} = \prod_{j=1}^{n} \left[\frac{RER_t^{j/i}}{RER_0^{j/i}} \right]^{\theta_{j,i}}\ , \qquad (5)$$

[10] See the survey of CÔTE (1994) for more details.

[11] If $X_{j,i}$ ($M_{j,i}$) represents the exports (imports) from *i* MENA country to *j* country, (from *j* to *i*), we define for a currency *j*, the weight $\theta_{j,i}$ as: $\theta_{j,i} = \dfrac{X_{j,i} + M_{j,i}}{\sum_{j=1}^{n} (X_{j,i} + M_{j,i})}$ See annex 2 for weights values.

where $RER^{j/i}$ represents the bilateral real exchange rate between MENA country i and j (here European currencies). Let $RER^{j/i} = \frac{E^{j/i} \cdot P^i}{P^j}$, where P^i and P^j are the consumer prices indexes (CPI, proxy of general price level) in the MENA country and in the European country. A rise of *REER* reflects a real appreciation of the MENA currency.

4.2. Volatility Estimates

One difficulty in any study of the effect of exchange rate volatility is in specifying the appropriate measure of volatility.

Former studies used the variance and/or standard deviations of the exchange rate as measure of variability. The problem with such approaches is that they ignore information on the stochastic process by which exchange rates are generated (Jansen (1989)). They constitute an unconditional measure. Hence since Engle (1982), the exchange rate volatility is essentially defined by ARCH (*Autoregressive Conditional Heteroskedasticity*) models, and subsequent generalizations (GARCH, IGARCH, etc.). But, as Baillie and McMahon (1989) and others show, ARCH type effects remain very strong in high-frequency data, but diminish with monthly or quarterly series. As Siregar and Rajan (2004) point out: "*the ambiguous results obtained in the empirical literature may also be partly due to the adverse effect of a uniform definition or means of computing volatility.*" For these reasons, we retain two measures of exchange rate volatility; a moving average standard deviation and a GARCH model. Here, we use quarterly data.

In the first step, we calculate a moving average standard deviation (noted *MASD*) of the growth rate of quarterly effective exchange rate on *m* quarters:

$$h_t = \left[(1/m) \sum_{i=1}^{m} (\ln e_{t+i-1} - \ln e_{t+i-2})^2 \right]^{1/2}, \quad (6)$$

where *m* is the order of the moving average, the window width, and e is the effective exchange rate (nominal or real). *ln* represents the natural logarithm. Our estimations make use of *m* equal to 8 quarters, i.e., two years which constitute a standard measure in the literature.

The second measure is the conditional variance of the first difference of the log of the exchange rate (noted *CSD*). We use the ARCH (*Autoregressive Conditional Heteroskedasticity*) model suggested by Engle (1982, 2001), completed by a GARCH (*Generalized ARCH*) model proposed by Bollerslev (1986), which extends the ARCH model to allow the conditional variance (noted h_t) to be an ARMA process. By deriving residuals ε_t from an underlying process,[12] for the information set Ψ, a GARCH) (*p*,*q*) process is given by $\varepsilon_t / \Psi_{t-1}$ ~*N*(*0*, h_t) with the conditional autoregressive variance specified as specified as

$$h_t = \delta + \sum_{j=1}^{q} \alpha \cdot \varepsilon_{t-1}^2 + \sum_{j=1}^{p} \beta_j \cdot h_{t-1}. \quad (7)$$

$s = \sqrt{h}$ represents the standard deviation, i.e., the volatility. $\delta > 0$, $\alpha \geq 0$ and $\beta \geq 0$ are imposed to ensure that the conditional variance (h_t) is positive. The unconditional expected variance exists when the process is covariance stationary, i.e., $\sum \alpha_i + \sum \beta_i < 1$.[13]

In figures 1 to 12, we present the charts of the natural logarithm of the volatilities measured by moving average standard deviation (*MASDN* for *NEER* and *MASDR* for *REER*) and conditional standard deviation[14] (*CSDN* for *NEER* and *CSDR* for *REER*).

[12] If r_t is equal to $\ln(e_t / e_{t-1})$, we have $r_t = \mu + \varepsilon_t$ with μ the mean r_t conditional on past information (Ψ_{t-1}),

[13] Note that to obtain some information about the degree of persistence, it may be useful to calculate the *half-life* of a shock. This is determined by the sum of the ARCH and GARCH coefficients in the variance equation (Pindick, 2003), i.e., *Half-life*=log(1/2)/log($\sum \alpha_i + \sum \beta_i$).

[14] To start, we estimated GARCH(1,1) models for all exchange rates. The estimation was performed by QMLE (Quasi-Maximum Likelihood Estimation), using the optimization algorithm of BERNDT *et al.* (1974, BHHH).[14] GARCH effects are significant in four cases for real exchange rates, and three cases for nominal exchange rates. When no significant GARCH effect appears, we return to ARCH(1) model. In three cases for real exchange rates (Egypt, Israel and Tunisia), and four cases for nominal exchange rates (Algeria, Israel, Morocco and Turkey), the sum $\alpha + \beta$ is very close to unity or greater than one. So, the GARCH process is non stationary. Also, for these countries, we estimate IGARCH(1,1) model, i.e., the relationship $h_t = \delta + \alpha \cdot \varepsilon_{t-j}^2 + (1-\alpha) \cdot h_{t-j}$. See annex 3 for more details.

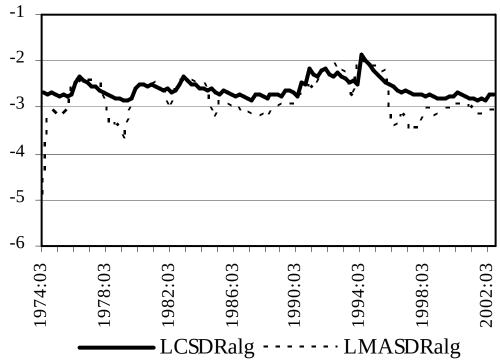

Figure 1. Log of volatility - REER Algeria -

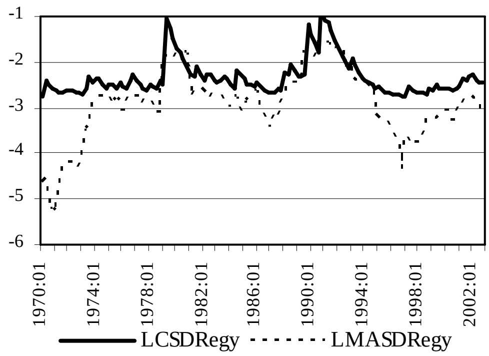

Figure 2. Log of volatility - REER Egypt -

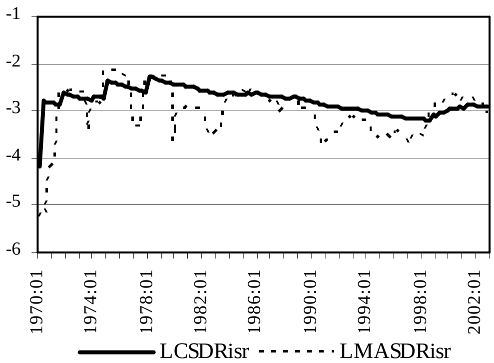

Figure 3. Log of volatility - REER Israel -

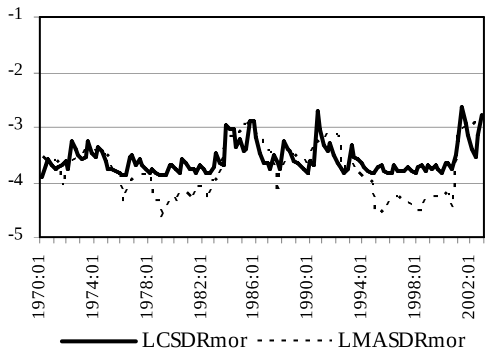

Figure 4. Log of volatility - REER Morocco -

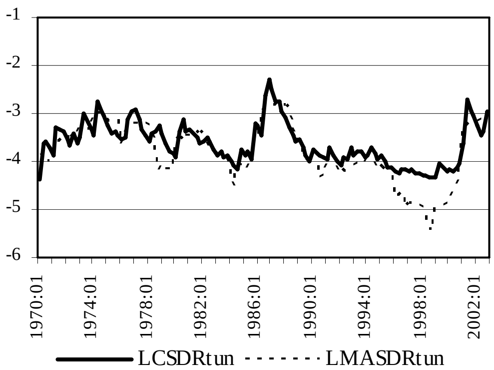

Figure 5. Log of volatility - REER Tunisia -

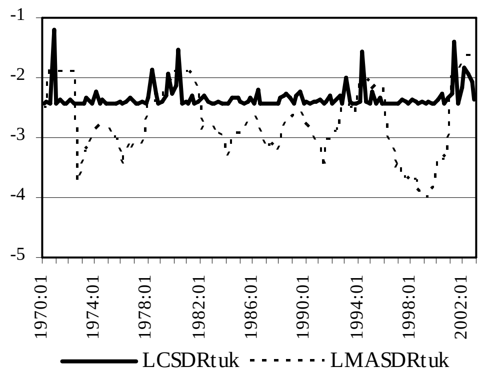

Figure 6. Log of volatility - REER Turkey -

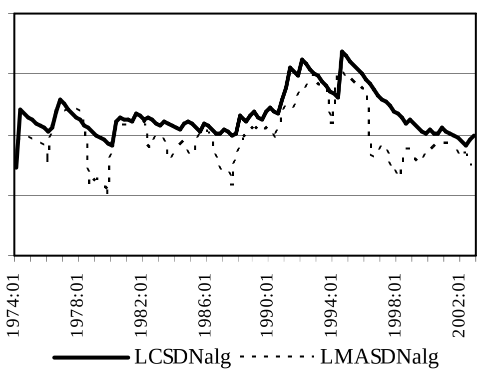

Figure 7. Log of volatility - NEER Algeria -

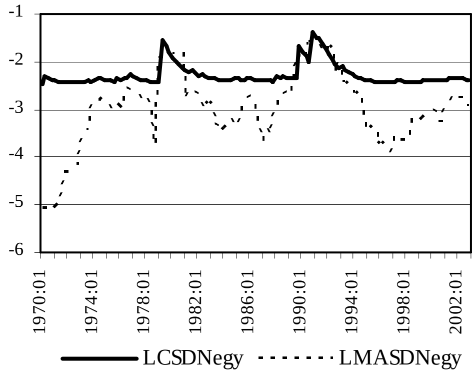

Figure 8. Log of volatility - NEER Egypt -

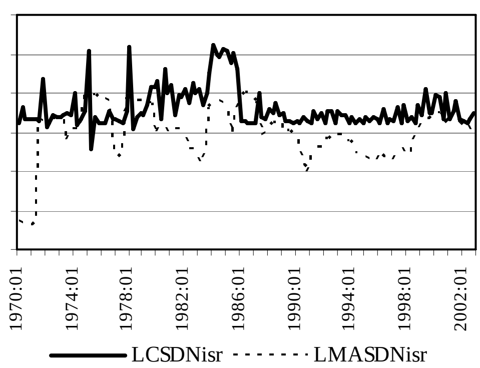

Figure 9. Log of volatility - NEER Israel -

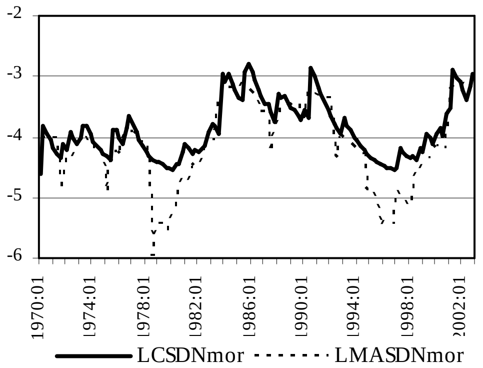

Figure 10. Log of volatility -NEER Morocco-

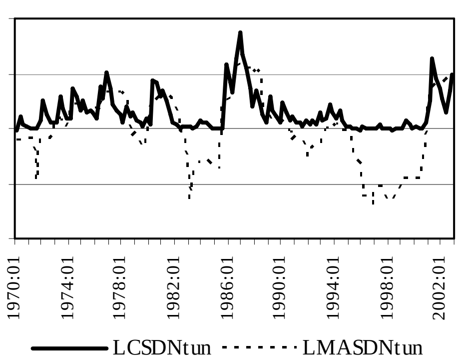

Figure 11. Log of volatility - NEER Tunisia -

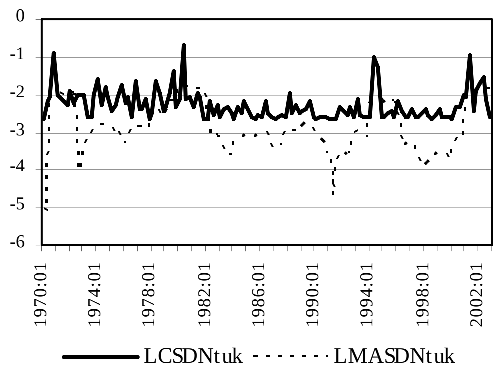

Figure 12. Log of volatility -NEER Turkey-

5. EMPIRICAL EVIDENCE

In applying the cointegration technique, the first task is to determine the order of integration of each variable. To this end, we rely upon test developed by Kwiatkowski, Phillips, Schmidt and Shin (1992), known as KPSS test in which the null hypothesis is stationarity of a variable versus an alternative of a unit root, and the ADF test. The data are taken at a quarterly frequency over the period 1970:1 to 2002:4 (1974:1 to 2002:4 for Algeria).[15] All the variables are transformed in logarithm.[16]

In all cases with KPSS test, the null hypothesis of stationarirty is rejected for GDP, real exports and real effective exchange rates. ADF test confirm this conclusion, i.e., these variables follow a random walk ($I(1)$ variable).

For the volatility measures, the results are more contrasted. For the KPSS test, they depend on the definitions of the volatility and the lag truncation parameter. But when we consider the ADF test without trend, in all cases, the null hypothesis of nonstationary is not rejected. This hypothesis is rejected in some cases for the model with trend, but in no case is the trend term statistically significant. Therefore we treat volatilities as $I(1)$ variables. But even if certain variables were not nonstationary, the conditions would be satisfied for the existence of cointegration relations. In fact, as Hansen and Juselius (1995) note: "*not all the individual variables need be I(1), as is often incorrectly assumed. To find cointegration between nonstationary variables, only two of the variables have to be I(1). Often a stationary variable might a priori play an important role in a hypothetical cointegration relation…Note that, for every stationary variable included, the cointegration rank will increase accordingly.*"

5.1. Cointegration Analysis

Cointegration tests are conducted by means of the method developed by Johansen and Juselius (1990) and Johansen (1998).

We start with a *p*-dimensional vector autoregressive model with Gaussian errors:

$$\Delta Z_t = C + \sum_{i=1}^{k} \Gamma_i \Delta Z_{t-i} + \Pi Z_{t-1} + \eta_t , \qquad \eta \sim \text{niid}(0, \ \Sigma), \tag{8}$$

where Z is a *px1* vector of stochastic variables. Δ implies first difference, C is the constant term. The parameters $(\Gamma_1, \ldots \Gamma_k)$ define the short-run adjustment to the changes of the process, whereas $\Pi = \alpha\beta'$ defines the short-run adjustment, α , to the cointegration relationship, β . For all the countries and all the definitions of the volatility, we cannot

[15] See annex 1 for details.

[16] The detailed results are not presented but can be obtained on request.

reject the hypothesis that there is at least one cointegration relationship.[17]

Table 5 reports the estimated cointegration vectors. We note *Lgdpeu* the log of real European GDP, *Lx* the log of real exports of MENA countries to EU15, *Lreer* the log of real effective exchange rate, and *Lv* the log of volatility, where *v* represents alternatively the four definitions of the volatility, i.e., *CSDR, MASDR, CSDN and MASDN.* The normalized equations of real exports are obtained by dividing each cointegrationg vector by the negative of the coefficient on real exports. These equations yield estimates of long run equilibrium parameters. We can impose restrictions on the cointegration vector. We successively test whether each explanatory variable can be excluded. For this, we use a likelihood ratio test. The statistics is distributed as $\chi^2(rk)$ where k is the number of restrictions and r the number of cointegration vectors. This indicates that not all the variables are significant. In particularly, *Lreer* for Morocco (3 cases), Tunisia (all cases), Turkey (2 cases) and Algeria (2 cases) is not significant. The same is true for *Lgdpue* which is not significant for Egypt and Morocco.

Nevertheless, the most important concerns the effects of the volatility on the MENA countries exports.

We have followed the literature by using two definitions of the volatility, i.e., an ARCH/GARCH measure and a moving average standard deviation. The findings presented in the Table 5 show that the ARCH specifications do not give satisfactory results. Indeed, the volatilities measured by ARCH models pose two problems. Firstly, for eleven models on twelve we obtain chi-square for the volatility coefficients higher when we retain a MASD measure than with an ARCH, i.e., the hypothesis of significant volatility effect is better verified with MASD. Secondly, in three cases, Egypt, Morocco and Israel, the signs of the conditional volatility coefficients are different according to we have to deal with real or nominal exchange rates. This observation is not coherent with the theory. This is confirmed by the weak correlation between the volatilities measured by MASD and the volatilities measured by ARCH/GARCH models (see annex 4). Therefore, we consider that an ARCH specification is not relevant taking into account the frequency of data (quarterly data). Consequently, in our comments the estimates results with the MASD will be privileged, even if in many cases MASD and ARCH measures lead to similar conclusions.

[17] For the majority of the countries we have two, even three cointegration relationships. The detailed results are not presented here.

Table 5. Normalized Cointegrating Equations

Algeria

Real Effective Exchange Rate volatility

$$Lx^{**} = -0.488\,Lreer + 1.089\,Lgdpeu^{**} - 2.00\,Lv_1^{**} - 8.720$$

(14.18) (6.89) (13.72) (17.47)

$$Lx^{**} = 0.068\,Lreer^{*} + 2.692\,Lgdpeu^{**} - 0.480\,Lv_2^{**} - 12.475$$

(17.55) (8.26) (21.31) (22.80)

Nominal Effective Exchange Rate volatility

$$Lx^{**} = -0.227\,Lreer + 2.034\,Lgdpeu^{**} - 0.498\,Lv_3^{**} - 9.550$$

(19.80) (7.26) (16.06) (16.90)

$$Lx^{**} = -0.684\,Lreer^{**} + 0.857\,Lgdpeu^{**} - 1.040\,Lv_4^{**} - 6.125$$

(16.21) (9.77) (15.64) (23.16)

Egypt

Real Effective Exchange Rate volatility

$$Lx^{*} = -0.749\,Lreer^{**} - 1.224\,Lgdpeu - 0.773\,Lv_1^{*} + 9.419$$

(7.97) (14.86) (5.52) (8.68)

$$Lx = 2.564\,Lreer^{**} + 0.074\,Lgdpeu - 1.405\,Lv_2^{**} + 4.216$$

(7.21) (16.69) (4.82) (14.74)

Nominal Effective Exchange Rate volatility

$$Lx^{*} = -1.024\,Lreer^{**} - 0.602\,Lgdpeu + 0.103\,Lv_3^{*} + 7.405$$

(8.98) (14.79) (4.97) (8.49)

$$Lx^{*} = 2.129\,Lreer^{**} + 0.305\,Lgdpeu - 1.385\,Lv_4^{**} + 2.127$$

(7.50) (16.64) (5.72) (19.91)

Israel

Real Effective Exchange Rate volatility

$$Lx^{**} = -2.007\,Lreer^{**} + 1.426\,Lgdpeu^{**} - 1.054\,Lv_1^{**} - 7.786$$

(9.39) (12.68) (11.93) (14.37)

$$Lx^{**} = -1.305\,Lreer^{**} + 2.508\,Lgdpeu^{**} + 0.506\,Lv_2^{**} - 8.816$$

(9.51) (14.69) (11.10) (20.53)

Nominal Effective Exchange Rate volatility

$$Lx = 1.714\,Lreer + 1.802\,Lgdpeu + 0.484\,Lv_3^{**} - 4.626$$

(6.69) (7.33) (7.12) (12.84)

$$Lx^{*} = -0.527\,Lreer^{**} + 2.239\,Lgdpeu^{**} + 0.089\,Lv_4^{**} - 7.731$$

(8.26) (11.80) (9.71) (16.39)

Table 5. Normalized Cointegrating Equations (continued)

Morocco

Real Effective Exchange Rate volatility

$Lx** = -1.424\ Lreer - 0.071\ Lgdpeu + 1.151\ Lv_1** + 5.299$

(9.56) (7.05) (5.54) (9.98)

$Lx* = -0.902\ Lreer + 0.524\ Lgdpeu + 0.609\ Lv_2 + 1.208$

(8.03) (6.13) (3.05) (6.75)

Nominal Effective Exchange Rate volatility

$Lx* = -3.997\ Lreer ** + 0.634\ Lgdpeu - 1.628\ Lv_3 ** - 12.017$

(9.03) (9.57) (3.88) (10.38)

$Lx* = 0.278\ Lreer + 1.203\ Lgdpeu + 0.612\ Lv_4 ** - 1.119$

(8.79) (5.60) (4.57) (14.05)

Tunisia

Real Effective Exchange Rate volatility

$Lx** = 0.407\ Lreer + 3.241\ Lgdpeu ** - 0.202\ Lv_1 ** - 12.621$

(16.15) (6.26) (12.04) (11.73)

$Lx** = 0.268\ Lreer + 3.238\ Lgdpeu ** - 0.024\ Lv_2 ** - 12.000$

(20.19) (4.39) (15.13) (13.96)

Nominal Effective Exchange Rate volatility

$Lx** = 0.291\ Lreer + 3.300\ Lgdpeu ** - 0.139\ Lv_3 ** - 12.664$

(16.40) (5.62) (13.24) (11.77)

$Lx** = 0.243\ Lreer + 3.179\ Lgdpeu ** - 0.117\ Lv_4 ** - 12.100$

(15.02) (4.78) (10.82) (12.12)

Turkey

Real Effective Exchange Rate volatility

$Lx* = 0.195\ Lreer * + 4.975\ Lgdpeu ** - 1.965\ Lv_1 ** - 25.508$

(8.36) (7.50) (10.98) (9.33)

$Lx** = -0.498\ Lreer + 5.431\ Lgdpeu ** - 0.682\ Lv_2 ** - 17.218$

(13.80) (1.98) (19.20) (34.30)

Nominal Effective Exchange Rate volatility

$Lx* = 0.654\ Lreer * + 4.832\ Lgdpeu ** - 0.963\ Lv_3 ** - 22.350$

(8.30) (7.93) (10.34) (9.45)

$Lx** = -0.135\ Lreer + 4.029\ Lgdpeu ** - 0.584\ Lv_4 ** - 18.103$

(17.12) (1.13) (24.32) (41.59)

Notes: v_1 for CSD real; v_2 for MASD real; v_3 for CSD nominal and v_4 for MASD nominal Data in parenthesis are $\chi^2(4)$ statistics (likelihood ratio test).** significant at the 5%level; * significant at the 10% level.

For Algeria, Egypt, Tunisia and Turkey, the exchange rate volatility affects negatively the exports. Our estimates confirm the conclusions of Ozbay and Vergil for Turkey, of Achy and Sekkat for five MENA countries (our panel without Israel). These results are robust when we consider different definitions of the volatility. So, we can consider that uncertainty about the prices, expressed in domestic currency, has a negative effect on the exports to EU. For Morocco and Israel, the volatility is positively linked to the exports. The coefficients of the volatility variable obtained for Morocco and Israel confirm some conclusions of Achy and Sekkat (2003) who find positive effects of volatility for the food/agricultural[18] and chemicals exports of the MENA countries. Precisely, the share of these goods is the most important in Moroccan and Israeli exports. Nevertheless, without a detailed analysis by sector, it is difficult to provide a clear conclusion in terms of opportunity of profits. However, we can consider that these countries are price-taker in euros on the European market, especially for agricultural products. Therefore, it is possible that they try to increase their profits when the exchange rate is favorable, i.e., when their currency depreciates. For that, they raise the exports supply, whether by reducing the supply on the domestic market in favor of the European market, or by increasing the production. In the latter case, even if these countries have labor available, they will be able to increase their production with a delay and the response time will not be the same for all the sectors.

Having established that real exports, relative prices (real effective exchange rate), European *GDP* and exchange rate volatility are cointegrated, we next examine the interaction between these variables using an error-correction model.

5.2. Error - Correction Model

The Engle-Granger representation theorem proves that if a cointegration relationship exists among a set of $I(1)$ series, then a dynamic error-correction representation also exists. For real exports, the equation is given by

$$\Delta Lx_t = \alpha_0 + \alpha_1 EC_{t-1} + \sum_{i=1}^{k} \Delta Lx_{t-i} + \sum_{i=0}^{k} \Delta Lreer_{t-i} + \sum_{i=0}^{k} \Delta Lgdpue_{t-i} + \sum_{i=0}^{k} \Delta Lv_{t-i} + \varepsilon_t \, , \tag{9}$$

where *EC* is the error correction term generated from the Johansen method. The

[18] These results are in accordance with the conclusions of the study realized by Bonroy *et al.* (2006) upon the hog exports of Quebec. Indeed, these authors remind that the raw agricultural goods and the processed foods products are negotiated on markets for which production decisions must be made before marketing decisions. In this context, exchange rate volatility can produce important gaps between expected and realized profits. In particular, when the export price is too far below its expected value, a lower volatility can be associated with more sales on domestic market and less exports. This positive effect is coherent with the option value effect and the case of risk neutral firms. But when this volatility rises strongly, this effect can be reversed if the firms/processors are risk averse. So, two opposite effects on exports are possible, according to the level of volatility. A positive effect would be associated with low volatility, while the effect would be negative for high levels of volatility.

disequilibrium adjustment of each variable towards its long run equilibrium value is captured by the error correction term. The coefficient α_1 represents the speed of adjustment towards the long run equilibrium, with

$$EC_{t-1} = Lx_{t-1} - \delta_1 Lreer_{t-1} - \delta_2 Lgdpue_{t-1} - \delta_3 Lv_{t-1} - \delta_4 \,, \qquad (10)$$

and the estimates δ_1, δ_2, δ_3 and δ_4. The estimation of this model poses some problems. First, most of variables are endogenous. Second, the volatility measure was generated from an auxiliary model (see section 3). We therefore chose to estimate a simultaneous-equation model by SUR (Seemingly Unrelated Regressions) method, where the volatility is treated as an instrumental variable which gives an estimator that is consistent (Pagan and Ullah (1988)). The volatility measure is included as one of the regressors in each equation of the system. We have three dependent variables: the real exports, the real effective exchange rate and the gross domestic product of the EU. Initially, zero to eight lags (k maxi=8) of the first difference of each variable, a constant term and one lagged error-correction term generated from the Johansen method are applied.[19] As required by the general-to-specific method (Hendry (1987)), the dimensions of the parameter space were reduced to final by eliminating insignificant coefficients**.** So for example, the relationship of Algerian exports with MASDN as measure of the volatility is

$$\begin{aligned} \Delta Lx_t &= -0.073 - 0.089 EC_{t-1} + 0.228 \Delta Lx_{t-1} \\ &\quad\;\; (-3.00) \quad (-4.08) \qquad\quad (2.58) \\ &\quad - 0.429 \Delta Lreer_{t-5} + 0.100 \Delta Lv_{t-6} \quad ; \quad t-statistics\ \ in\ \ parentheses, \\ &\quad\;\; (-2.60) \qquad\qquad (1.88) \end{aligned} \qquad (11)$$

with the adjusted coefficient of determination $\overline{R}^2$ =0.54 and DW=1.95.

In order to save space, only a synthesis of results with the real exports as the dependent variable is provided.[20] The estimates lead to the following results:

a. Adjustment of real exports towards long-run equilibrium

For Algeria (all cases), Egypt (*CSDN* and *MASDN*), Morocco (*CSDN*), Tunisia (all cases) and Turkey (*CSDR* and *MASDR*), the coefficient of the lagged error term (*EC1*) is significant and has the proper negative sign, thereby confirming the cointegration found earlier and the validity of the error correction representation. The significance of the error term implies causality from all independent variables to the real exports in the long run. The second error term (*EC2*) has a significant effect for Egypt (*MASDN* and

[19] When we have two cointegration vectors, we choose to normalize the second vector on GDP.

[20] The detailed results of estimates can be obtained on request.

MASDR) only. Except for Tunisia (coefficients between 26% and 33%), the size of the coefficients on the lagged error term indicates that less than 10% of the adjustment of real exports towards the long run equilibrium take place per quarter. This is a relatively slow rate of adjustment.

b. Short-run effects

The relative prices

For Algeria (all cases), Egypt (all cases), Israel (all cases), Morocco (*CSDN*), Tunisia (all cases) and Turkey (all cases), changes in the relative price (*REER*) have appropriate negative significant effects.

Gross Domestic Product

Significant short-run effects are found for the EU GDP in all cases for Israel, Morocco, and Turkey; in three cases for Egypt and Tunisia, and two cases for Algeria. For these last three countries, the short run effect depends on the choice of the volatility measure in the export equation.

Volatility

The Table 6 summarizes the short run effects of volatility. Focusing only on MASD measures,[21] we remark that real exchange rate volatility has no significant effect for Algeria and Morocco, while for Israel the sum of coefficients is close to zero. For Tunisia and Egypt, the signs of the coefficients are positive. Nominal exchange rate volatility has no significant effect for Turkey and the sum of coefficient is close to zero for Tunisia. We obtain positive effects for Morocco and Algeria (significance 10%) and negative effects for Israel and Egypt.

In the short run, the positive effects of volatility could mean that firms benefit from the drop of their currency, i.e., depreciation or devaluation, to increase exports. We know that in some sectors as textile/clothing, the reactivity of the firms is strong. They are able to adjust quickly their supply. Finally, the adjusted R^2 are higher for Israel (range between 0.91 and 0.92), Morocco (0.83-0.87), and Turkey (0.72-0.81) than Algeria (0.52-0.54), Egypt (0.51-0.56) or Tunisia (0.58-0.63), that is fairly satisfactory, when we compare with results of the literature.

On the whole if we concentrate on the long run relationship between exports and volatility, two economic factors play a fundamental role; the exchange rate regime and the specialization.

[21] The other estimates are provided for information.

Table 6. Regression Results for Error-Correction Models -Real Exports Equation-Volatility Coefficients

	Algeria				Egypt			
ΔLv_t	CSDR	MASDR	CSDN	MASDN	CSDR	MASDR	CSDN	MASDN
t					0.173**		0.483**	
t-1							0.273*	
t-2								
t-3				0.100*				-0.150**
t-4								
t-5							-0.487**	
t-6			-0.223**					
t-7						0.213**		
	Israel				Morocco			
t	0.400**		0.012**					0.083**
t-1								
t-2							0.082**	
t-3	0.313**		0.052**					
t-4		0.059**	0.064**					
t-5	-0.491**						0.103**	
t-6		-0.077**		-0.056**				
t-7							-0.088**	
	Tunisia				Turkey			
t	0.114**		0.083**		-0.238**		-0.079**	
t-1		0.117**		0.082**				
t-2								
t-3						-0.072*		
t-4			0.111**	-0.087*				
t-5								
t-6	0.103*							
t-7					0.079**			

Note: We retain the coefficients significant at the 5 % level (**) and significant at the 10 % level (*).

The choice of exchange rate regime is essential insofar as it determines the level of volatility. Indeed, the firms have an exchange risk for the future conversion of their sales revenues into their currency, risk which increases with the volatility. Also, if these firms are risk-averse and if they don't dispose of effective hedging instruments, this risk not hedged will induce a negative relationship between exports and volatility/uncertainty. We cannot exclude the possibility that producers direct their resources to less risky economic activities, from traded goods sector to non-traded goods sector for example. This will have negative consequences for the economic growth.

The specialization is also an important factor, because it dictates the competitiveness of the economy but also its ability to adjust the supply to changes in real exchange rates. In some sectors as the agricultural/food products sector, it is essential to take into account the lags between production and marketing. The expected profits at the initial period (capacity decision) can be different from the observed profits at the final period (marketing decision), and this gap will increase with the volatility. Also, a country which produces and exports these goods will have to limit the fluctuations in the relative prices.

6. SUMMARY AND CONCLUSIONS

The choice of exchange regime for MENA countries is a subject of debate insofar as it determines the behavior of the exchange rates. One major concern has been whether exchange rate volatility has affected trade flows, and particularly the exports of MENA countries to UE, which constitute their main destination. In order to analyze this, we built four measures of volatilities; moving average standard deviations and time-varying standard deviation, with both nominal effective exchange rate and real effective exchange rate. We show that the MASD measures provide better statistical results than conditional variances.

The results based on cointegration show that real exports are cointegrated with the relative price (real effective exchange rate, *REER*), European *GDP* and exchange rate volatility. The direction of the relationship also indicates that the exports volumes are, in the long run, negatively related with volatilities for Algeria, Egypt, Tunisia and Turkey, while the relationship is positive for Morocco and Israel. The likelihood ratio test for exclusion indicates that the volatility variables are significant. The short run dynamics of these relationships is based on the error-correction models. The variables *REER* and *GDP* are significant with appropriate signs. The exchange rate volatility is significant in most of cases, but the signs of the coefficients are positive or negative, depending on the definition of the volatility (real or nominal exchange rate) and the country. Therefore, our analysis shows that exchange rate volatility affects the real exports of MENA countries, in the long run and in the short run. Moreover, we were able to identify a link between the sensitivity of exports to volatility and the composition of exports, i.e., the specialization of MENA countries.

The main economic lesson which can be drawn from this work concerns the choice of exchange rate regime. If the exporting activity is depressed by exchange rate volatility/uncertainty, we can consider that the exchange rate regime is not appropriate. This is true for Tunisia, Turkey, Egypt and Algeria. In that case, the suitable policy would be the one which avoids strong erratic movements in real exchange rates. For example, a peg arrangement based on currency basket involving the euro, as adopted by Israel and Morocco could constitute a reference. In this perspective, a crawling basket peg could be favourable for these countries, i.e., would enhance their export performance. On one hand, choose a basket with the euro as principal currency would stabilise the effective exchange rates of MENA currencies, i.e., would reduce the exchange rate volatility vis-à-vis the principal partners. On the other hand, the crawl could be adjusted in order to facilitate needed real exchange rates adjustments to limit the misalignments.

However, to obtain a complete view of exchange rate variability effects, it would thus be necessary to complete this study in four directions. Firstly, a study of exports by sector would make it possible to specify the differences in reactions of trade flows according to the type by products. Secondly, it could be useful to compare the influence of the misalignments and the volatility on exports. Thirdly, it could be beneficial to analyze the determinants of volatility that differ according to the countries: rigidity of the prices, openness, macroeconomic and exchange rate policies. Finally, the econometric model which analyses the effects of volatility on exports could be re-examined. Indeed, it is possible that a positive effect is associated with low volatility, while this effect would be negative for high levels of volatility. In that case, the relationship between exchange rate volatility and exports would be non-monotone, and therefore non-linear.

ANNEX 1. Data, Definitions and Sources

All data were extracted from International Monetary Fund's CD-Rom and OECD's CD-Rom (Monthly Statistics of International trade). Data for individual country export volume are not directly available for bilateral trade. Therefore we proceed in two steps: Firstly, we retain export values between each MENA country and UE15. But these data are only available for Turkey. For Algeria, Egypt, Israel, Morocco and Tunisia, we consider European countries imports from each MENA country as a proxy for the MENA exports. Secondly, in order to obtain the volume of MENA exports, we divide the value series by price indexes. Because of the absence of complete series for export prices, we divide export values of Tunisia, Egypt and Israel by a wholesale price index, and export value of Turkey, Algeria and Morocco by a consumer price index.

ANNEX 2. Weights of European Currencies Used to Construct the Effective Exchange Rates

Table A2. Weight of Currencies: 1970-1999 Average

	Algeria	Egypt	Israel	Morocco	Tunisia	Turkey
French franc	0.3228	0.1667	0.1059	0.4444	0.3828	0.1124
Mark	0.1688	0.2005	0.2169	0.1208	0.1722	0.3692
Lira	0.2096	0.2405	0.1133	0.0912	0.2224	0.1608
Sterling	0.0363	0.1207	0.2148	0.0697	0.0305	0.1263
Belgium Franc	0.0482	0.0348	0.1471	0.0529	0.0527	0.0488
Florin	0.0603	0.0559	0.0840	0.0436	0.0365	0.0583
Peseta	0.0993	0.0546	0.0117	0.1172	0.0042	0.0078
Escudo	0.0087	0.0098	0.0133	0.0120	0.0049	0.0039
Ireland pound	0.0023	0.0102	0.0083	0.0059	0.0416	0.0314
Finland markka	0.0049	0.0141	0.0130	0.0064	0.0109	0.0279
Schilling	0.0179	0.0153	0.0074	0.0044	0.0037	0.0111
Greek drachma	0.0059	0.0352	0.0260	0.0044	0.0113	0.0234
Danish krone	0.0041	0.0138	0.0104	0.0069	0.0035	0.0073
Swedish krone	0.0109	0.0278	0.0281	0.0206	0.0230	0.0112

Source: Data base Chelem CEPII

ANNEX 3. ARCH Models

Table A3.1. Test Results from ARCH Models (Real Effective Exchange Rates)

Algeria		
$r_t = -0.011 + \varepsilon_t$ (-1.54)	$h_t = 0.0005 + 0.1466\varepsilon_{t-1}^2 + 0.7702^{**} h_{t-1}$ (1.38) (1.52) (7.04) GARCH(1,1)	*half-life* = 11.6
$\alpha_1 + \beta_1 = 0.942$		
Egypt		
$r_t = 0.0062 + \varepsilon_t$ (1.40)	$h_t = 0.0014^{**} + 0.3761^{**}\varepsilon_{t-1}^2 + 0.6239h_{t-1}$ (5.07) (5.72) IGARCH(1,1)	
$\alpha_1 + \beta_1 = 1$		
Israel		
$r_t = -0.0028 + \varepsilon_t$ (-0.56)	$h_t = 0.0002 + 0.0512^{**}\varepsilon_{t-1}^2 + 0.9488h_{t-1}$ (0.51) (2.43) IGARCH(1,1)	
$\alpha_1 + \beta_1 = 1$		
Morocco		
$r_t = -0.0025 + \varepsilon_t$ (-1.03)	$h_t = 0.0002 + 0.3540^{**}\varepsilon_{t-1}^2 + 0.4378^{**} h_{t-1}$ (1.69) (2.36) (1.95) GARCH(1,1)	*half-life* = 3.0
$\alpha_1 + \beta_1 = 0.792$		
Tunisia		
$r_t = -0.0002 + \varepsilon_t$ (-0.13)	$h_t = 0.00006 + 0.3890^{**}\varepsilon_{t-1}^2 + 0.6110h_{t-1}$ (2.51) (4.86) IGARCH(1,1)	
$\alpha_1 + \beta_1 = 1$		
Turkey		
$r_t = -0.0103 + \varepsilon_t$ (-1.06)	$h_t = 0.0075 + 0.3359^{**}\varepsilon_{t-1}^2$ (14.24) (2.43) ARCH(1)	*half-life* = 0.6
$\alpha_1 + \beta_1 = 0.336$		

Note: * significant at the 10% level, ** significant at the 5% level

Table A3.2. Test Results from ARCH Models (Nominal Effective Exchange Rates)

	Algeria	
$r_t = -0.0089 + \varepsilon_t$ (-1.35)	$h_t = 0.0001 + 0.1738^{**}\varepsilon_{t-1}^2 + 0.8262 h_{t-1}$ (1.43) (6.27) IGARCH(1,1)	
$\alpha_1 + \beta_1 = 1$		
	Egypt	
$r_t = -0.0085 + \varepsilon_t$ (-0.70)	$h_t = 0.0021 + 0.1176\varepsilon_{t-1}^2 + 0.7148^{**} h_{t-1}$ (1.26) (1.10) (3.33) GARCH(1,1)	*half-life* =3.8
$\alpha_1 + \beta_1 = 0.832$		
	Israel	
$r_t = -0.0321^{**} + \varepsilon_t$ (-9.14)	$h_t = 0.0040 + 1.0193^{**}\varepsilon_{t-1}^2 - 0.0193 h_{t-1}$ (8.94) (3.58) IGARCH(1,1)	
$\alpha_1 + \beta_1 = 1$		
	Morocco	
$r_t = -0.0009 + \varepsilon_t$ (-0.73)	$h_t = 0.00003 + 0.2950^{**}\varepsilon_{t-1}^2 + 0.7050\ h_{t-1}$ (2.32) (4.61) IGARCH(1,1)	
$\alpha_1 + \beta_1 = 1$		
	Tunisia	
$r_t = -0.0032^{*} + \varepsilon_t$ (-1.77)	$h_t = 0.0002 + 0.4124^{**}\varepsilon_{t-1}^2 + 0.4114^{**} h_{t-1}$ (3.76) (3.64) (3.17) GARCH(1,1)	*half-life* = 3.6
$\alpha_1 + \beta_1 = 0.824$		
	Turkey	
$r_t = -0.1048^{**} + \varepsilon_t$ (-21.31)	$h_t = 0.0051 + 0.9971^{**}\varepsilon_{t-1}^2 + 0.0029 h_{t-1}$ (8.32) (14.60) IGARCH(1,1)	
$\alpha_1 + \beta_1 = 1$		

Note: * significant at the 10% level, ** significant at the 5% level

ANNEX 4. Correlation Matrices of Volatilities

Table A4.1. Correlation Matrix - Algeria

	MASDN	MASDR	CSDN	CSDR
MASDN	1.000	0.886	0.664	0.766
MASDR		1.000	0.806	0.792
CSDN			1.000	0.915
CSDR				1.000

Table A4.2. Correlation Matrix - Egypt

	MASDN	MASDR	CSDN	CSDR
MASDN	1.000	0.988	0.772	0.712
MASDR		1.000	0.776	0.711
CSDN			1.000	0.983
CSDR				1.000

Table A4.3. Correlation Matrix - Israel

	MASDN	MASDR	CSDN	CSDR
MASDN	1.000	0.907	0.281	0.679
MASDR		1.000	0.306	0.618
CSDN			1.000	0.294
CSDR				1.000

Table A4.4. Correlation Matrix - Morocco

	MASDN	MASDR	CSDN	CSDR
MASDN	1.000	0.888	0.729	0.625
MASDR		1.000	0.804	0.608
CSDN			1.000	0.857
CSDR				1.000

Table A4.5. Correlation Matrix - Tunisia

	MASDN	MASDR	CSDN	CSDR
MASDN	1.000	0.889	0.517	0.736
MASDR		1.000	0.606	0.733
CSDN			1.000	0.888
CSDR				1.000

Table A4.6. Correlation Matrix - Turkey

	MASDN	MASDR	CSDN	CSDR
MASDN	1.000	0.923	0.366	0.326
MASDR		1.000	0.383	0.300
CSDN			1.000	0.809
CSDR				1.000

REFERENCES

Achy, L., and K. Sekkat (2003), "The European Single Currency and MENA's Export to Europe," *Review of Development Economies*, 7(4), 563-582.

Arize, A.C. (1995), "The Effects of Exchange-Rate Volatility on U.S. Exports: An Empirical Investigation," *Southern Economic Journal*, 62, 34-41.

Arize, A.C., T. Osang, and D.J. Slottje (2005), "Exchange Rate Volatility in Latin America and its Impact on Foreign Trade," Southern Economic Theory and International Trade Conference, September.

Baillie, R.T., and P.C. McMahon (1989), *The Foreign Exchange Market: Theory and Econometric Evidence*, Cambridge University Press.

Baum, C.F., M. Caglayan, and N. Ozkan (2004), "Nonlinear Effects of Exchange Rate Volatility on the Volume of Bilateral Exports," *Journal of Applied Econometrics*, 19(1), 1-23.

Berndt, E.K., B.H. Hall, R.E. Hall, and J.A. Hausman (1974), "Estimation Inference in Nonlinear Structural Models," *Annals of Economic and Social Measurement*, 4, 653-665.

Bollerslev, T. (1986), "Generalized Autoregressive Conditional Heteroskedasticity," *Journal of Econometrics*, 31(3), 307-327.

Bonroy, O., J-F Gervais, and B. Larue (2006), "Are Exports a Monotonic Function of Exchange Rate Volatility? Evidence from Disaggregated Pork Exports," *Canadian Journal of Economics*, (forthcoming).

Bubula, A., and I. Ötker-Robe (2002), "The Evolution of Exchange Rate Regimes since 1990: Evidence from De Facto Policies," IMF Working Paper, 02/155.

Chowdhury, A. (1993), "Does Exchange Rate Volatility Depress Trade Flows? Evidence from Error-Correction Model," *Review of Economics and Statistics*, 75, 700-706.

Clark, P., N. Tamirisa, S.-J. Wel, A. Sadikov, and L. Zeng (2004), "Exchange Rate Volatility and Trade Flows - Some New Evidence," IMF Working Paper.

Clark, P. (1973), "Uncertainty, Exchange Risk, and the Level of International Trade," *Western Economic Journal*, 11, 302-313.

Clifton, E. (1998), "The Decline of Traditional Sectors in Israel: The Role of the

Exchange Rate and the Minimum Wage," IMF Working Paper, 98/167.

Côté, A. (1994), "Exchange Rate Volatility and trade: A Survey," Bank of Canada Working Paper, 94/5.

Cushman, D.O. (1983), "The Effects of Real Exchange Rate Risk on International Trade," *Journal of International Economics*, 45-63.

_____ (1988), "U.S. Bilateral Trade Flows and Exchange Risk during The Floating Period," *Journal of International Economics*, 25, 317-330.

Diebold, F.X. (1986), "Modeling Persistence in Conditional Variances: A Comment," *Econometric Reviews*, 5, 51-56.

Domac, I., and G. Shabsigh (1999), "Real Exchange Rate and Economic Growth: Evidence from Egypt, Jordan, Morocco, and Tunisia," IMF Working Paper, 99/40.

Dumas, B. (1978), "The Theory of the Trading Firm Revisited," *Journal of Finance*, 33, 1019-1029.

Edwards, S. (1989), *Real Exchange Rates, Devaluation and Adjustment: Exchange Rate Policy in Developing Countries*, Cambridge, MIT Press.

Engle, R. (1982), "Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of United Kingdom Inflation," *Econometrica*, 50(4), 987-1007.

_____ (2001), "GARCH 101: The Use of ARCH/GARCH Models in Applied Econometrics," *Journal of Economic Perspectives*, 15, 157-168.

Ethier, W. (1973), "International Trade and the Forward Exchange Market," *American Economic Review*, 63, 494-503.

European Commission (2006), "Euro: our currency", http://www.europa.eu.int.

Fanizza, D., Laframboise, N., Martin, E., R. Sab, and I. Karpowicz (2002), "Tunisia's Experience with Real Exchange Rate Targeting and the Transition to a Flexible Exchange Rate Regime," IMF Working Paper, 02/190.

Franke, G. (1991), "Exchange Rate Volatility and International Trade," *Journal of International Money and Finance*, 10, 292-305.

Gotur, P. (1985), "Effects of Exchange Rate Volatility on Trade: Some Further Evidence," IMF Staff Papers, 32(3), 475-512.

Goldstein, M., and M.S. Kahn (1985), "Income and Price effects in Foreign Trade," in R.W. Jones, and P.B. Kenen ed., *Handbook of International Economics*, 2, North-Holland, New York.

De Grauwe, P. (1983), "Symptoms of an Overvalued Currency: The Case of the Belgium Franc," in De Cecco ed., *International Economic Adjustment: Small Countries System*, Basic Blackwell, England.

_____ (1988), "Exchange Rate Variability and The Slowdown in Growth of International Trade," IMF Staff Papers, 35(1), 63-84.

_____ (1994), *The Economics of Monetary Integration*, 2nd ed., Oxford University Press.

Hansen, H., and K. Juselius (1995), *CATS in RATS manual*, *Cointegration Analysis of Time Series*, Institute of Economics, University of Copenhagen.

Hendry, D.F. (1987), "Econometrics Methodology: A Personal Perspective," in

BEWLEY, T. ed., *Advances in Econometrics*, 2nd ed., Cambridge Univ. Press, 29-48.

Hinkle L.E., and P.J. Montiel (1999), *Exchange rate misalignment, Concepts and measurement for developing countries*, A World Bank Research Publication, Oxford University Press.

Hooper, P., and S.W. Kohlhagen (1978), "The Effects of Exchange Rates Uncertainty on the Prices and Volume of International Trade," *Journal of International Economics*, 8(4).

Jansen, D.W. (1989), "Does Inflation Uncertainty Affect Output Growth?" *The Federal Reserve Bank of St Louis Review*, July-August, 43-54.

Jbili, A., and V. Kramarenko (2003), "Should MENA Countries Float or Peg?" *Finance and Development*, 40(1).

_____ (2003), "Choosing Exchange Regimes in the Middle East and North Africa," IMF publication.

Johansen, S. (1998), "Statistical Analysis of Cointegration Vectors," *Journal of Economic Dynamic and Control*, 12, 231-254.

Johansen, S., and K. Juselius (1990), "Maximum Likelihood Estimation and Inferences on Cointegration with Applications to the Demand for Money," *Oxford Bulletin of Economics and Statistics*, 52, 169-210.

Klaassen, F. (2004), "Why is it so Difficult to Find an Effect of Exchange Rate Risk on Trade?" *Journal of International Money and Finance*, 23, 817-839.

Kwiatkowski, D., P.C.B. Phillips, P. Schmidt, and Y. Shin (1992), "Testing the Null Hypothesis of Stationarity Against the Alternative of a Unit Root: How Sure Are We That Economic Time Series Have a Unit Root," *Journal of econometrics*, 54, 159-78.

Levy-Yeyati, E., and F. Sturzenegger (2002), "A *de Facto* Classification of Exchange Rate Regimes: A Methodological Note," Working paper, Business School, Universidad Torcuato Di Tella, Argentina.

Marston, R.C. (1988), "Exchange Rate Policy Reconsidered," *Economic Impact*, 6.

McKenzie, M. (1997), "The Impact of Exchange Rate Volatility on Australian Trade Flows," *Journal of International Financial Markets, Institutions and Money*, 8, 21-38.

McKenzie, M., and R. Brooks (1997), "The Impact of Exchange Rate Volatility on German-US Trade Flows," *Journal of International Financial Markets, Institutions and Money*, 7, 73-88.

Özbay, P. (1999), "The Effect of Exchange Rate Uncertainty on Exports: A Case Study of Turkey," Working Paper, March, the Central Bank of the Republic of Turkey.

Pagan, A., and A. Ullah (1988), "The Econometric Analysis of Models with Risk Terms," *Journal of Applied Econometrics*, 3, 87-105.

Pindick, R.S. (2003), "Volatility in Natural Gas and Oil Markets," Working Paper, 03/12, Massachusetts Institute of Technology, Cambridge.

Sercu, P., and C. Van Hulle (1992), "Exchange Rate Volatility, International Trade, and the Value of Exporting Firms," *Journal of Banking and Finance*, 16, 155-182.

Sercu, P., and R. Uppal (2003), "Exchange Rate Volatility and International Trade: A General Equilibrium Analysis," *European Economic Review*, 47, 429-441.

Sekkat, K., and A. Varoudakis (1998), "Exchange-Rate Management and Manufactured Exports in Sub-Saharan Africa," Technical Papers, OECD Development Center, 134.

Siregar, R., and R.S. Rajan (2004), "Impact of Exchange Rate Volatility on Indonesia's Trade Performance in the 1990s," *Journal of the Japanese and International Economies*, 18, 218-240.

Stein, J. (2006), *Stochastic Optimal Control, International Finance and Debt Crisis*, Oxford University Press.

Todani, K.R., and T.V. Munyama (2005), "Exchange Rate Volatility and Exports in South Africa," South African Reserve Bank, November.

Vergil, H. (2002), "Exchange Rate Volatility in Turkey and its Effect on Trade Flows," *Journal of Economic and Social Research*, 4(1), 63-79.

Mailing Address: Department of Economics, C.A.T.T, University of Pau et Pays de l'Adour, Avenue du Doyen Poplawski, B.P. 1633, 64016 Pau Cedex, France. E-mail: Serge.rey@univ-pau.fr

Manuscript received August 2005; final revision received October 2006.