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Non Linear Adjustment in the MLR Condition Evidence from Threshold Cointegration

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This paper investigates the long-run equilibrium relationship between real net exports and exchange rate in Morocco by threshold cointegration test. The threshold cointegration approach provides clear evidence of the cointegration relationship characterized by asymmetric adjustment, introduced by Enders and Siklos (2001). By allowing for asymmetric adjustment, we obtain the results showing the stability of the Marshall-Lerner-Robinson MLR condition. In particular, the estimated results show that the adjustment process is persistent toward equilibrium above an appropriately threshold parameter, whereas the adjustment process toward equilibrium quickly converges below the estimated threshold. This finding indicates that the deviations from equilibrium resulting from increases in real effective exchange rate (i.e. devaluation) are highly persistent, but the deviations from equilibrium resulting from decreases in real effective exchange rate (i.e. reevaluation) converge quickly toward equilibrium.

1 Introduction

Most of the research addressing the issue of equilibrium has not taken into account the asymmetric properties of the adjustment process in equation of Marshall-Lerner-Robinson condition. One way of examining the long-run equilibrium of the MLR condition is to test for a cointegration relationship between the real net exports and real effective exchange rate.

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As pointed out by Balke & Fomby (1997), movement toward the long-run equilibrium is not necessarily constant and the power of representation cointegration tests fall under an asymmetric adjustment process. It is important to use the threshold cointegration approach, which allows for asymmetric adjustment, introduced by Enders & Siklos (2001). We show that while Engle-Granger's test does not obtain the results of the cointegration relationship, the threshold cointegration test provides the existence of the long run relationship. Using cointegration approaches particularly Engle & Granger test (1987) and Johansen (1988), many studies have investigated the long-run equilibrium of MLR condition with the usual cointegration tests (Bahmani-Oskooee, 2001 ; Boyd & *al.*, 2001 ; Upadhyaya, 1997). These tests assume only symmetric adjustment and found in most cases the instability of the MLR condition. Our recent study (Ghassan, 2005) has concluded that the equilibrium relationship did not exist using a more powerful GLS approach for unit root tests (Ng & Perron, 2001) and cointegration tests (Perron & Rodriguez, 2001).

The contribution of this paper examines the MLR condition using a threshold cointegration method. Investigating the stability of the Moroccan MLR condition using this method has a significant role in the analysis of the persistent climb in trade deficit. If the cointegration relationship characterized by asymmetric adjustment toward equilibrium exists, deviations from equilibrium resulting from increases or decreases in real exchange rate (i.e. devaluation or reevaluation, respectively) might be highly persistent, although exchange policy can influence fluctuations of net exports and real effective exchange rate.

The paper is organized as follows. Section 2 presents the MLR condition and outlines the threshold cointegration test proposed by Enders & Siklos (2001). Section 3 shows the data and compares the empirical results. Section 4 provides a conclusion.

2 The MLR condition and the threshold cointegration test

2.1 The MLR condition

Conventional macroeconomic theory argues that the MLR condition should hold at least in the long run, i.e. the volume effect should supersede the price effect. However, this may not happen in the short run, as the price effect following depreciation is immediate, whereas it takes time for the volume effect to improve the trade balance. The equilibrium relationship between the exchange rate and net exports is determined from the theorem of critical elasticities as theoretical foundation:

$$\frac{\partial LnNX_t}{\partial LnQ_t} = \lambda\beta_X + \beta_Z(1-\phi) - \lambda := \zeta_1 \text{ , with } \quad 0 < \zeta_1 < 1 \qquad (1)$$

where NX_t is the real net export on period t, Q_t is the real exchange rate. β_X and β_Z are respectively the constant elasticity (positive) of exports X_t and import Z_t. λ is the relative price elasticity. The factor $(1-\phi)$ is the elasticity of X_t to Z_t, this factor reduce the positive effect of imports[1]. It is assumed that the net exportation is expressed as follows:

$$LnNX_t = cste + \zeta LnQ_t + \varepsilon_t \text{ ,} \qquad \varepsilon_t \sim iid(0, \sigma_\varepsilon^2) \qquad (2)$$

where ε_t is a random error. So, the integration degree of $LnNX_t$ depends especially on the integration property of LnQ_t. Although $LnNX_t$ and LnQ_t have to be cointegrated with unspecified vector $\beta' = (1, -\zeta)$ in order to interpret the equation accurately when LnQ_t and $LnNX_t$ are nonstationary, the absence of such proportional relationship does not necessarily invalidate the MLR condition[2]. If the relationship is stable, that is, cointegrated with symmetric or asymmetric adjustment, the MLR condition is checked. Then, we test for cointegration with unspecified vector. We assume that the adjustment will be asymmetric, e.g. either because the exchange rate could be rigid downwards but not

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[1] It remains that the devaluations are not the only factors. Boyd, Caporale and Smith (2001) used the real exchange rate, the national and foreign output to estimate the same relation in next equation (2).

[2] From the model (2), we obtain with only constant $\zeta = 0.982$ and with constant and trend $\zeta = 0.805$. These plausible coefficients are not significant at the 1%. Thus, the absence of cointegration relationship by assuming a symmetric adjustment explains the difficulties to anticipate the components of $LnNX_t - \zeta LnQ_t$.

upwards or because the central bank has different preferences regarding deviations from the long run equilibrium.

2.2 Threshold cointegration

We employ the threshold cointegration approach (Enders & Siklos, 2001) to test for a cointegration relationship with asymmetric adjustment. As the assumption of tests for threshold cointegration, let $\{x_{it}\}_1^T$ denote observable random variables I(1). The long run equilibrium relationship is given by:

$$x_{1t} = \hat{\beta}_0 + \hat{\beta}_2 x_{2t} + \cdots + \hat{\beta}_n x_{nt} + e_t \qquad (3)$$

where $\hat{\beta}_i$ are estimated parameters, and e_t is the disturbance term i.e. residue. The existence of the long-run equilibrium relationship involves stationary e_t. To accept stationarity of e_t, we have to obtain $-2 < \rho < 0$ in the second step procedure given by:

$$\Delta e_t = \rho e_{t-1} + u_t \qquad (4a)$$

where u_t is the white-noise disturbance. If $-2 < \rho < 0$ then the long-run equilibrium relationship (3) with symmetric adjustment (4a) is accepted. However, the standard cointegration framework in (4a) is misspecified if the adjustment process is asymmetric. Therefore, Enders & Siklos (2001) proposed the following asymmetric adjustment, called the threshold autoregressive TAR model:

$$\Delta e_t = I_t \rho_1 e_{t-1} + (1 - I_t)\rho_2 e_{t-1} + u_t \qquad (4b)$$

where ρ_1 and ρ_2 are speed-adjustment coefficients and I_t is the indicator function such that:

$$I_t = \begin{cases} 1 & if \quad e_{t-1} \geq \tau \\ 0 & if \quad e_{t-1} < \tau \end{cases}$$

and τ is the threshold parameter. To satisfy the necessary and sufficient conditions of the stationarity of e_t, $\rho_1 < 0$, $\rho_2 < 0$, $(1+\rho_1)(1+\rho_2) < 1$ are required. The threshold parameter τ, which is restricted to the ranges of the remaining 70% of e_t or Δe_t when the largest and smallest 15% values are discarded, is selected as an unknown value so as to minimize the sum of the squared residuals obtained from (4b) and (4c) (see, Chan 1993). Although, Enders & Siklos (2001) proposed tests for cases when the threshold parameter is known $(\tau = 0)$ and unknown, we use an unknown threshold parameter because we do not have an a priori reason to believe that τ is known.

As an alternative adjustment process, the momentum threshold (MTAR) model is as follows:

$$\Delta e_t = M_t \rho_1 e_{t-1} + (1 - M_t)\rho_2 e_{t-1} + u_t \tag{4c}$$

$$M_t = \begin{cases} 1 & if \quad \Delta e_{t-1} \geq \tau \\ 0 & if \quad \Delta e_{t-1} < \tau \end{cases}$$

The MTAR model can capture the properties such that the threshold depends on the previous period's change in e_t, whether the Δe_{t-1} is increasing or decreasing. When the adjustment process (4b) is serially correlated, we can re-write it[3]:

$$\Delta e_t = I_t \rho_1 e_{t-1} + (1 - I_t)\rho_2 e_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta e_{t-1} + u_t \tag{4d}$$

To test for threshold cointegration, Enders & Siklos (2001) proposed two types of tests, called Φ and t-max statistics. The Φ statistic using an F-statistic involves procedure testing for the null hypothesis $\rho_1 = \rho_2 = 0$ and the t-max statistic employing a t-statistic requires the test for the null hypothesis with the largest $\rho_i = 0$ between ρ_1 and ρ_2. If the null hypothesis of no cointegration is rejected, we can test for the null hypothesis $\rho_1 = \rho_2$ by a standard F statistic because the system is stationary. In this case, the Engle-Granger model characterized by symmetric adjustment is supported.

[3] Although, it is possible that γ_i is asymmetric, we do not consider this case for the sake of simplicity, similarly to Enders & Siklos (2001).

3 Empirical results

3.1 Data and unit root tests

In this paper, we use the real effective exchange rate, which is an indicator of economic and monetary policies in Morocco. As the real net exports, we employ the nominal trade flows using the export and the import prices indices[4]. The quarterly data, obtained from the statistic Department (DS, Rabat), the exchange office (OC, Rabat) and the Projection Department (DEPF, Rabat), consisted of 100 periods from 1980:q1 to 2004:q4. These variables are not seasonally adjusted. Table 1 displays the results of unit root tests for the null hypothesis I(1) and ADF^{GLS} is the Ng & Perron's test (2001). We chose the lag order by employing the data dependent method, denoted by t-sig, to check for possible size distortions for ADF-type tests, proposed by Ng & Perron (1995)[5]. We set the maximum lag $k_{\max} = 8$.

Table 1: Unit root tests with constant and trend [6]

	LRNX	ΔLRNX	LREER	ΔLREER
ADF^{GLS}	-2.369	-17.367**	-0.475	-15.895**
$\overline{MZ}_{\alpha}^{GLS}$	-9.356	-35.358**	-0.741	-37.658**

[4] The deflator prices of nominal trade variables are confectioned by Data Base Bureau in DEPF (Rabat, Morocco).

[5] t-sig selects the lag order k via top-down testing. More accurately, we estimate the equation with the maximum lag (here, the max lag is 8). We use the lag length if the absolute t-statistic of the parameters of the maximum lag is larger than 1.65 i.e. significant. If the t-statistic in the maximum lag is smaller than 1.65 i.e. not significant, we estimate the equation with the $lag = k_{\max} - 1$. That is, when the absolute t-statistic of the parameter of the $lag = k_{\max} - q$ is significant at a conventional level, we employ the lag length.

[6] In all Tables †, *, ** indicate significance at the 10, 5 and 1 percent levels, respectively. The Akaike Information Criterion (AIC) has better theoretical and empirical properties. In the ADF-GLS test: one-sided (lower-tail) test of the null hypothesis that the variable is nonstationary; at the 1, 5 and 10 percent asymptotic critical values equal -3.46, -2.91 and -2.59, respectively. For the Modified Phillips-Perron test: one-sided (lower-tail) test of the null hypothesis that the variable is nonstationary; at the 1, 5 and 10 percent asymptotic critical values equal -19.95, -17.30 and -11.16, respectively (Rapach & Weber, 2004).

where LRNX and LRRER denote the logarithm of real net export and the logarithm of real effective exchange rate, respectively. Since neither level of EER and NX are significant at the 1%, the results from Table 1 show that these variables have a unit root process.

3.2 Cointegration tests

Whether the long-run equilibrium relationship between net exports and exchange rate, represented by the MLR condition, exists has significant implications for exchange policy. The existence of the equilibrium relationship implies that trade policies using exchange rate as a policy instrument can influence fluctuations in exports, imports and prices. This is especially important for the recent Moroccan economy characterized by a permanent trade deficit and an appreciation of real exchange rate in tendency caused by a passive exchange policy.

Table 2 illustrates the results of cointegration tests. Each cointegration test includes a constant and trend as a deterministic component since by the theorem of critical elasticities and by visualizing data does support a constant and trend. For the estimation of e_t, we chose the lag order by AIC and t-sig. EG and PR denote Engle & Granger's (1987) and Perron & Rodriguez's (2001) methods assuming only symmetric adjustment, respectively. These tests presuppose a linear adjustment, which is not realistic considering the frictions of exchange market and the presence of transactions costs in foreign trade.

From two first columns of Table 2, we cannot reject the null hypothesis of no cointegration using the ADF cointegration test. There is thus no evidence of cointegration at the 5% or 1% significance level according to the conventional Engle & Granger (1987) ADF test. Again, we employ the Perron & Rodriguez (2001) cointegration tests with good size and power. The null hypothesis of no cointegration is only rejected at the 5 percent level. There is no vigorous evidence of a plausible cointegrating relationship between the net export and effective exchange rate. The contrast between the results in Table 2 suggests that the rejections using EG test entail a Type II error. As tabulated in Table 3, the threshold cointegration approach clearly rejects the null hypothesis particularly in MTAR model. For example, the Φ and t-sig statistics based on AIC are 11.106 and -4.516, respectively. These statistics are significant at the 1% level.

Table 2: Cointegration tests (dependent variable: LRNX) [7]

	EG		PR	
	AIC	t-sig	AIC	t-sig
ρ	-0.3785	-0.4369	-0.3152†	-0.4263*
τ_{ρ}	(-2.829)	(-3.086)	(-2.612)	(-2.948)

Table 3: Threshold cointegration tests (dependent variable: LRNX)

		ρ_1 (τ_{ρ_1})	ρ_2 (τ_{ρ_2})	Φ **(P-Value)**	F **(P-Value)**	τ
TAR	AIC	-0.259† (-1.527)	-0.483** (-3.873)	7.882** (0.006)	1.347 (0.248)	0.146
	t-sig	-0.243 (-1.144)	-0.533** (-3.341)	5.643* (0.019)	2.054 (0.155)	0.146
MTAR	AIC	0.106 (0.477)	-0.498** (-4.516)	11.106** (0.001)	6.956** (0.009)	0.214
	t-sig	-0.019 (-0.074)	-0.521** (-3.428)	6.770* (0.011)	4.092* (0.046)	0.317

Parentheses show t statistics in the first two columns. Φ denotes the tests for the null hypothesis $\rho_1 = \rho_2 = 0$. F shows the tests for the null

[7] In the EG's test: one-sided (lower-tail) test of the null hypothesis that the variables are not cointegrated; at the 1, 5 and 10 percent levels asymptotic critical values equal -4.02, -3.40 and -3.09. In the PR's test: one-sided (lower-tail) test of the null hypothesis that the variables are not cointegrated; at the 1, 5 and 10 percent levels asymptotic critical values equal -3.33, -2.76 and -2.47, respectively (Perron & Rodriguez, 2001 and Rapach & Weber, 2004).

hypothesis of symmetry $\rho_1 = \rho_2$. The coefficient τ indicates the estimated threshold[8].

The null hypothesis of $\rho_1 = \rho_2 = 0$ can therefore be rejected, indicating that the series are cointegrated. Given that the series are cointegrated, the null hypothesis of symmetric adjustment (i.e. $\rho_1 = \rho_2$) can be tested using the standard F-distribution (Enders & Granger, 1998). The simple value of $F = 6.956$ (MTAR, AIC) has a P-value of 0.009[9]. Then the null hypothesis of symmetric adjustments is rejected at the 1 percent level of significance. Hence, the two series are cointegrated, supporting the previous results. When we consider e_t or Δe_t as a shock to real net exports, this finding suggests that adjustment is asymmetric in the sense that positive shocks to the real net exports margin tend to persist but negative shocks revert quickly towards the attractor i.e. long-run equilibrium.

From the estimated equation in Table 3, we confirm that the adjustment process is persistent toward equilibrium above the threshold parameter ($\tau = 0.214$), whereas deviations from equilibrium are almost quickly eliminated below this threshold parameter. The adjustment process toward equilibrium above the estimated threshold is almost persistent in TAR comparatively to MTAR, and that there is relatively rapid convergence in MTAR below the estimated threshold. The results mean that long-run equilibrium relationship below the threshold parameter between the real net exportation and real effective exchange rate is stable with asymmetric adjustment and implies asymmetries in real exchange rate changes to net exportation shocks or real net exports changes to exchange rate shocks.

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[8] The test statistics of t-sig and Φ are obtained from Enders & Siklos (2001). In the TAR and MTAR tests: one-sided (lower-tail) test of the null hypothesis that the variables are not cointegrated; the 1, 5 and 10 percent critical values equal -2.30, -1.73 and -1.52, respectively.

[9] The MTAR model yields the best overall fit by comparing AIC-values and t-sig values. It is therefore preferable to the TAR model for explaining asymmetric adjustment of the real net exports margin. This implies that positive discrepancies from long-run equilibrium (such that $\Delta\hat{e}_{t-1} \geq 0.214$) do not adjust deviations from long-run equilibrium. Therefore, a TAR adjustment responds to the previous changes to the negative deviation (such that $\Delta\hat{e}_{t-1} < 0.214$).

4. Conclusions

By allowing for asymmetric adjustment, we obtained results showing an effective stability of the MLR condition: that the devaluation improves trade balance below threshold parameter. So, the adjustment process toward equilibrium above the threshold is persistent, but quickly reverting below the threshold.

This paper has investigated the equilibrium relationship between the real exchange rate and net exports in Morocco using the threshold cointegration method, which allows for asymmetric adjustment. The results have shown that the approach provides clear evidence of the equilibrium relationship with asymmetric adjustment: the long-run equilibrium relationship below the threshold parameter between the trade gap and exchange rate is stable and reliable with asymmetric adjustment. This finding is important for foreign trade policies to control the exchange rate's fluctuations.

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