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AKADÉMIAI KIADÓ

Asymmetric and nonlinear dynamics in trade flows sustainability: Serbia and Romania

MILE BOŠNJAK*

Department of International Economics, Faculty of Economics and Business, University of Zagreb, Trg J. F. Kennedyja 6, 10 000 Zagreb, Croatia

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ABSTRACT

The research examines the sustainability of trade flows for two European post-communist economies: Serbia and Romania. We analysed two nonlinear forms of the relationship between exports and imports that cannot be explained by frequently applied linear model specifications. Newly developed nonlinear autoregressive distributed lag approach revealed the asymmetric and nonlinear long-run equilibrium between Serbian exports and imports. Nonlinearity tests indicated and the SETAR model specification confirmed threshold nonlinearity form in the Serbian trade flows pattern. Serbian trade flows still approach its sustainable equilibrium but the development pattern is promising. The results for Romania revealed another nonlinear form of the relationship between exports and imports, indicating a dependent cointegration. The paper provides robust results and supports the hypothesis that the relationship between exports and imports can be nonlinear and symmetric.

KEYWORDS

asymmetric cointegration, nonlinearity, international trade, sustainability

JEL CLASSIFICATION INDICES

C01, C05, C34, F1, F4

* Corresponding author. E-mail: mile.bosnjak76@gmail.com

1. INTRODUCTION

In the last two decades, Serbia and Romania experienced trade and financial liberalization followed by persistent trade deficit that can violate balance of payment constraints over time. It's a well-known fact that in the case of the persistent trade deficits the domestic interest rates can be very high. Such an economy may transform into a heavily indebted country which may affect the welfare of the citizens.

Boljanović (2012) provided extensive overview of the current account deficit problem in Serbia. Industrial production highly depends on imported goods while imported goods are mostly financed by inflow of foreign capital. Consequently, the decline in inflow of foreign capital as a result of the global economic crisis raised the question about current account sustainability. Others pointed out the other role of foreign capital inflows in current account deficit of the European post-communist countries. The inflow of foreign loans boosted the consumption. Consequently, the increase in consumption stimulated imports demand and current account deficit (Aristovnik 2008; Zakharova 2008; Bakker – Gulde 2010; Obadić et al. 2014). Following the extensive review of literature provided by Antwi-Boateng (2015) examining trade flow sustainability mainly relies on the linear model specifications. However, in some cases the relationship between exports and imports can hardly be established using the linear specification forms. Furthermore, in other cases a linear relationship between exports and imports can be established, but the linear model form is miss-specified.

Our research aims to make a step further and test the existence of a nonlinear relationship between the imports and exports. Some rationale behind the hypothesis might be the transaction costs, interventions in macroeconomic policy after the economy reach some point or differences in product supply and demand.

We examine Section 1 the properties and dynamics of Serbian and Romanian net exports under the framework of sustainability. Afterwards and following the univariate approach the dynamics of net exports is analysed and robustness of the results is obtained. While bringing these two cases, the paper argues a few empirical issues related to the topics under consideration in light of the contemporary methodological development. Section 2 brings some facts on externally financed trade deficit in Serbia and Romania. Section 3 provides the theoretical background and briefly summarises existing literature on the related topics. Section 4 shows research data and empirical strategy, while Section 5 brings corresponding methodology. Section 6 gives empirical results and discussion. The final section provides an overview of the main findings.

2. EXTERNALLY FINANCED TRADE DEFICIT IN SERBIA AND ROMANIA

The issue of trade sustainability is of special importance for both the countries displaying persistent trade deficits. Figs. A1 and A2 in the Appendix illustrate development of net exports in both countries. The persistent trade deficit is a problem for each country, and the foreign debt level in both countries makes the situation even worst. Malović (2008) pointed out a long time ago that with external deficit of more than 16% of GDP and foreign debt of 16 billion €, Serbia is at the verge of balance of payments crisis. Dđulovo-Todorović et al. (2017) reported over-consumption followed the process of the accumulation of public debt. Zaman (2014) analysed some aspects of Romania's foreign trade impact on the sustainability of the national economy during the periods before and after accession to the EU and pointed out excessive levels of the external debt and critical debt-to-GDP ratio in Romania. Zaman – Georgescu (2015) highlighted that the sharp increase in the external debt level, both sovereign and private, threatens Romania's financial stability. External debt and public debt accompanied by persistent trade deficit make these two countries extremely vulnerable to external shocks.

3. THEORETICAL BACKGROUND AND BRIEF RELATED LITERATURE OVERVIEW

Various empirical evidences started to emerge since Husted (1992) found a tendency in US exports and imports to converge in the long-run and laid down the foundations for examining cointegration between imports and exports. Following the works of Husted (1992), Arize (2002), Al-Khulaifi (2013) and Pillay (2014), we present a simple framework that implies a long-run equilibrium relationship between exports and imports. The baseline assumption states that the representative agent of a small open economy produces and exports a single composite good with no government involvement. The representative agent can borrow and lend in international markets at the world interest rate using one-period financial instruments with the objective of maximising lifetime utility subject to the budget constraints. The representative agent's current-period budget constraint is given by:

$$C_t = Y_t + B_t - I_t - (1 + r_t) \cdot B_{t-1} \tag{1}$$

where C_t, Y_t, B_t, I_t represent current consumption, output, international borrowing and investment, respectively, r_t represents the one-period world interest rate, and $(1 + r_t) \cdot B_{t-1}$ is the debt of the agent from the previous period. Equation (1) must hold in every time period. In addition, the period-by-period budget constraints can be combined to form the country's intertemporal budget constraint which states that the amount a country borrows (lends) in international markets equals the present value of future trade surpluses or deficits. The intertemporal international budget constraint is stable when there is a long-run equilibrium between imports and exports.

Antwi-Boateng (2015) provided an extensive literature overview of different estimation methods with various findings and pointed out that the empirical literature did not reach the conclusion that export and import have a long-run relationship in both developed and developing economies. Shuaibu – Oyinlola (2017) examined sustainability of the current account in Nigeria over four decades using time-series analysis on annual data from 1981 to 2013. The results suggested that there is a current account sustainability in Nigeria and structural changes were not very potent during the period under consideration. Keskin (2017) employed co-integration analysis, *Vector Error Correction model* (VECM), Autoregressive Distributed Lag (ARDL) and Granger causality test to examine the structure and financing of the current account deficit for its sustainability in Turkey. The results revealed that Turkey is dependent on import for its economic growth on the one hand, and it needs external financing for import on the other hand. Tunay (2017) applied panel Vector Autoregression (VAR) model and panel causality tests on the annual data covering the period of 2000–2014 of Azerbaijan, Kazakhstan, Kyrgyz Rebuplic, Tajikistan, Turkmenistan, Uzbekistan and Turkey. The results suggest that the shocks arising from current account inconsistencies are highly likely to trigger a severe recession. Hassan – Holmes (2017) examined the role of remittances in current account balances using quantile regression analysis and found that the presence of remittances supported the cointegrated relationship between exports and imports. Furthermore, the presence of remittances is found to accelerate the adjustment between exports and imports towards the level of their long-run sustainability. Chen – Xie (2015) assumed and tested the presence of smooth breaks and nonlinearity in current account sustainability of 9 European countries. The results revealed the difference in the adjustments of current account sustainability followed by positive and negative shocks. Singh (2015) used an optimal single-equation system and maximum-likelihood method as an estimator. The obtained estimates on annual data for the period of 1950–2010 provided empirical evidence to support the existence of a long-run relationship between imports and exports in India.

The above-mentioned papers follow multivariate approach to examine the cointegration relationship between exports and imports and mostly rely on the linear econometric specification. However, some recently emerged researches that follow univariate approach and observe net exports while taking into account the possible nonlinear property of the observed series. Topalli – Dogan (2016) used the Markov-switching method to examine the current account deficit dynamics and sustainability of the Turkish economy between 1990 and 2014. The results revealed the weak sustainability for the Turkish economy and even weaker during the economic contraction. Khadaroo (2016) used Self Exciting Threshold Autoregressive (SETAR) model and found that Mauritian economy converges to either of the two current account equilibria, a deficit of 9% or a surplus of 2.5%. Financial crisis that started in 2007 affected the dynamics of the net exports in many countries, so it is reasonable to take into account potential nonlinearity of the net exports development or regime change in its dynamics.

Following the results of the nonlinearity tests provided in this section of the paper, we moved towards the nonlinear specifications and contributes to the debate with estimated results from the SETAR and Markov-Switching Autoregressive (MS-AR) specifications of Serbian and Romanian net exports, respectively. Furthermore, and unlike previous studies, we employed the newly developed nonlinear autoregressive distributed lag (NARDL) and threshold vector error correction model (TVECM) approach to take into account the possible asymmetries in the long-term and short-term relationship between exports and imports.

4. RESEARCH DATA AND EMPIRICAL STRATEGY

The research is based on the quarterly data on imports and exports. The time span for the Serbian case ranges from the first quarter of 2004 to the second quarter of 2017, for Romania from the 1996Q1 to the 2017Q4 for the imports and exports series. Trade and GDP data are collected from the respective national statistical offices.

First step in any time series analysis is a stationarity diagnostic since economic time series often exhibit non-stationarity properties. Stationarity diagnostic is provided by unit root tests (ADF, PP, KPSS). Additionally, to take into account the issue of structural change and so ensure the non-spurious results of unit root tests, Zivot – Andrews (1992) unit root test is applied. The series under considerations are imports (M), exports (X) and net exports as the exports to imports ratio (NX). The series are taken in (natural) log values. Figs. A1 and A2 in the Appendix provide plots of the observed series. The results out of standard unit root tests are provided in

Tables A1 and A2, and Zivot – Andrews (1992) unit root test results are in Tables A3 and A4, also in the Appendix. Afterwards, the research is carried out in multiple directions.

Firstly, and following the multivariate approach, the Johansen (1995) cointegration tests is implemented to examine the linear cointegration between exports and imports in Serbia. The results do not reject the null hypothesis of no cointegration, as summarised in Table 1. However, the cointegration might exist in its nonlinear and asymmetric form. So, to examine and estimate the nonlinear and asymmetric cointegration form, the paper employs the NARDL model developed by Shin et al. (2011) and explained it in the methodology section of this paper. For Romania, the null hypothesis of no cointegration between imports and exports is rejected using the Johansen (1995) procedure. Hansen – Seo (2002) test of linear versus threshold cointegration rejected the null hypothesis of linear cointegration indicating the threshold cointegration relationship between the considered series.

Eventually, our paper observed net exports as the single variable and followed univariate approach to explain its dynamics and provide robustness of the results. Following Keenan (1985), Tsay (1986) and Tong (1990), three nonlinearity forms of the Serbian net exports series are tested, and the results revealed the existence of threshold nonlinearity. The results of the nonlinearity tests are summarized in Table 3. Directed by the nonlinearity test results, the SETAR model is fitted to explain the Serbian net exports dynamics. In case of Romania, MS-AR model is found to be the best suited to explain the dynamics of net exports.

5. METHODOLOGY

Shin et al. (2011) developed the NARDL approach in which short- and long-run nonlinearities are represented through positive and negative partial sum decompositions of the explanatory variables. Furthermore, contrary to the standard linear cointegration approach, this model specification does not depend on the degree of integration of the variables.

So, the increase ($\log(X)_t^+$) and decrease ($\log(X)_t^-$) of exports ($\log(X)_t$) can be defined with the application of partial sum process as given by equations (2) and (3).

$$\log(X)_t^+ = \sum_{j=1}^{t} \Delta\log(X)_j^+ = \sum_{J=1}^{t} \max\left(\Delta\log(X)_j,\, 0\right) \tag{2}$$

$$\log(X)_t^- = \sum_{j=1}^{t} \Delta\log(X)_j^- = \sum_{J=1}^{t} \min\left(\Delta\log(X)_j,\, 0\right) \tag{3}$$

NARDL model in our case can be represented by Eq. (4):

$$\Delta\log(M)_t = \alpha_0 + \beta_1 M_{t-1} + \beta_2 \log(X)_{t-1}^+ + \beta_3 \log(X)_{t-1}^- + \sum_{i=1}^{p-1} \gamma_i \Delta\log(M)_{t-i} + \sum_{i=1}^{q} \delta_i^+ \log(X)_{t-i}^+ + \sum_{i=1}^{q} \delta_i^- \log(X)_{t-i}^- + \varepsilon_t \tag{4}$$

where $\log(M)_t$ and $\log(X)_t$ are imports and exports in Croatia in its log values, respectively.

After the NARDL model estimates are obtained, following Pesaran et al. (2001) the long-run and short-run asymmetric effects are tested. NARDL approach is employed to estimate the nonlinear and asymmetric cointegration between Serbian imports and exports and the results are summarized in Table 2.

The general form of SETAR model for the time series Y_t can be represented by Eq. (5):

$$Y_t = \mu_1 I(Y_{t-k}>y) + \mu_2 I(Y_{t-k} \leq y) + [\alpha_1 I(Y_{t-k}>y) + \alpha_2 I(Y_{t-k} \leq y)]Y_{t-k} + u_t \tag{5}$$

where k and y represent delay and threshold, respectively. Equation (5) provides the specification for the two regime SETAR process. The delay values are obtained by minimising the sum of squared errors among values between 1 and 10, while the threshold value is given by the variation of the variable under consideration. We follow the SETAR procedure to examine the dynamics of Serbian net exports. The obtained estimates are summarised in Table 5. Univariate approach to Romanian net exports indicated MS-AR model as the best suited model to explain the dynamics of net exports of Romania.

Following Hamilton (1989) the two state Markov-Switching model assumes that expected net exports are different in stated periods:

$$E(y_t) = \mu_1 \tag{6}$$

$$E(y_t) = \mu_2 \tag{7}$$

where:

y_t – denotes the observed time series at time t,
μ_1 – denotes the expected mean of the series during the one identified state and
μ_2 – denotes the expected mean of the series during the another identified state.

Therefore, it can be represented by Eq. (8):

$$E(y_t) = \mu_{s_t} \tag{8}$$

where $s_t = \{0, 1\}$ indicates state of the economy i.e. expansion or recession.

Therefore, the basic of the Markov switching model can be formulated as:

$$y_t = \mu_{s_t} + \varepsilon_t \tag{9}$$

However, since the economic time series often exhibit the dependence between the past observations, in that case autocorrelation among residuals in the estimated model is present and obtained estimates may not be valid. With the assumption of the residuals being AR(1) process the expression takes the form:

$$\begin{aligned} &\varepsilon_t = \rho \cdot \varepsilon_{t-1} + u_t \\ &y_t = \mu_{s_t} + \rho \cdot (y_{t-1} - \mu_{s_{t-1}}) + u_{s_t,t} \\ &u_{s_t,t} \sim \text{IIN}(0, \sigma^2) \end{aligned} \tag{10}$$

The essential idea of the model is that the observable time series vectors depend on the unobserved regime variable. The residuals of the estimated regression models are normally distributed. Variance of the residuals in Eq. (10) $(u_{s_t,t})$ is either regime dependent or constrained to be the same in both regimes.

The first order assumption assumes that the probability of being in a regime depends on the previous state. So, the first order assumption may be expressed by the following equation:

$$P(s_t = k|s_{t-1} = i) = p_{i,k} \quad (11)$$

Even though it is not required, it is often assumed that the transition probabilities are not time dependent, time invariant or constant. In that case, Eq. (12) holds:

$$p_{i,k}(t) = p_{i,k} \quad (12)$$

Transition probabilities to stay in the same state are given by Eqs. (13) and (14):

$$P(s_t = 0|s_{t-1} = 0) = p \quad (13)$$

$$P(s_t = 1|s_{t-1} = 1) = q \quad (14)$$

Following the total probability theorem, transition probabilities to change the state can be expressed in Eqs. (15) and (16):

$$P(s_t = 1|s_{t-1} = 0) = 1 - p \quad (15)$$

$$P(s_t = 0|s_{t-1} = 1) = 1 - q \quad (16)$$

The estimates are obtained by maximising a conditional log likelihood function $\ln[f(y_t|y_{t-1,\ldots,}y_1)]$.

The VECM specification for the case of two time series and both integrated to the same order can be represented by Eq. (17):

$$\Delta x_t = A' X_{t-1}(\beta) + u_t \quad (17)$$

where:

x_t – p-dimensional I(1) cointegrated time series with p x 1 cointegrating vector β
A – coefficient matrix $k \times p | k = p + 2$
$(X_{t-1}(\beta))$ – regressor and a $k \times 1$ matrix are given by equation (18):

$$X_{t-1}(\beta) = [1 \quad w_{t-1}(\beta) \quad \Delta x_{t-1} \quad \cdots \quad \Delta x_{t-l} \,]' \quad (18)$$

$w_{t-1}(\beta) = \beta' x_{t-1}$ – error-correction term that needs to be stationary
u_t – vector martingale difference sequence with a finite covariance matrix is presented in Eq. (19):

$$\sum = E(u_t u_t') \quad (19)$$

The VECM estimates are provided in Table 7.

Threshold cointegration model Hansen – Seo (2002) is presented in equation (20):

$$\Delta x_t = \begin{cases} A_1' x_{t-1}(\beta) + u_t, \; w_{t-1}(\beta) \leq \gamma \\ A_2' x_{t-1}(\beta) + u_t, \; w_{t-1}(\beta) > \gamma \end{cases} \quad (20)$$

where A_1 and A_2 – coefficient matrix for regime one and two, respectively.

x_t – p-dimensional $I(1)$ cointegrated time series with $p \times 1$ cointegrating vector β

$w_{t-1}(\beta) = \beta' x_{t-1}$ – error-correction term that needs to be stationary
γ – threshold parameter

Our paper observes bivariate ($p = 2$) case of exports and imports in Romania, so $\Delta x_t = [\Delta\log(X) \quad \Delta\log(M)]$.

All of the coefficients in Eq. (9) except β are allowed to switch between the regimes. Threshold effect has only content in the case of $0<P(w_{t-1}(\beta) \leq \gamma)<1$, otherwise we have a form of linear cointegration. It is assumed that $\pi_0<P(w_{t-1}(\beta) \leq \gamma)<1 - \pi_0$ where π_0 is triming parameter set to 0.05. The model estimates are obtained using maximum likelihood (ML) method as an estimator holds the assumptions that the residuals are iid (independent and identically distributed) Gaussian. The threshold cointegration between exports and imports is tested using Hansen – Seo (2002). They tested the presence of linear versus threshold cointegration:

$$\text{SupLM} = \sup_{\gamma_L<\gamma<\gamma_U} \text{LM}(\widetilde{\beta, \gamma}) \tag{21}$$

While $[\gamma_L, \gamma_U]$ present the search region where γ_L is the π_0 percentile of $\tilde{w}_{t-1}$ and γ_U is the $(1 - \pi_0)$ percentile. Following Hansen – Seo (2002), the threshold cointegration SupLM test is applied with 48 gridpoints, and the P-values are calculated by the parametric bootstrap. The lag length selection based on the AIC and BIC applied to the threshold VECM leads to the value of $l = 1$. The model with the lowest value of $\log|\sum(\beta, \gamma)|$ out of grid-search algorithm is used to provide maximum likelihood estimation $(\text{MLE}(\tilde{\beta}, \tilde{\gamma}))$. Taking $\tilde{A}_1 = \tilde{A}_1(\tilde{\beta}, \tilde{\gamma})$ and $\tilde{A}_2 = \tilde{A}_2(\tilde{\beta}, \tilde{\gamma})$, with $\text{MLE}(\tilde{A}_1, \tilde{A}_2)$ out of grid-search algorithm parameter estimates are obtained and the results are summarized in Table 5.

6. EMPIRICAL RESULTS AND DISCUSSION

The results of the Johansen (1995) tests of the cointegration between X-13 ARIMA seasonally adjusted Serbian and Romanian exports and imports are provided in Table 1.

The results in Table 1 show no linear cointegration between Serbian exports and imports. For Romania the cointegration is not rejected[1] and the Granger causality test results are provided in Table 2.

Granger causality test results in Table 2 indicate the causal relationship from exports to imports in the Romanian case. Following the VECM approach the linear cointegration estimates for the relationship between Romanian exports and imports are obtained and reported in Table 3.

Table 3 reports linear cointegration estimates for the relationship between Romanian exports and imports. Error correction term is found to be significant but positive and so the linear model might be mis-specified. Since the Johansen's test did not reject the cointegration and linear specification is found to be mis-specified it was reasonable to test for the threshold dependent cointegration relationship between the variables under cointegration. So firstly, the test of linear versus threshold cointegration of Hansen – Seo (2002) is employed and results support the threshold dependent cointegration between the variables under consideration. Test statistic amounts 18.17896

[1]Engle Granger cointegration is rejected in case of Romania. Test results are available upon request.

Table 1. Johansen tests for non-cointegration between imports and exports for Serbia and Romania

	Hypothesized no. of CE(s)	Eigenvalue	Trace statistic	0.05 Critical value	*P*-value
Serbia	None	0.178975	13.19981	15.49471	0.1077
	At most 1	0.055066	2.945290	3.841466	0.0861
	Max-Eigen statistic				
	None	0.178975	10.25452	14.26460	0.1957
	At most 1	0.055066	2.945290	3.841466	0.0861
Romania	None	0.385398	47.16942	15.49471	0.0000
	At most 1	0.053890	4.819524	3.841466	0.0281
	Max-Eigen statistic				
	None	0.385398	42.34990	14.26460	0.0000
	At most 1	0.053890	4.819524	3.841466	0.0281

Table 2. Granger causality test for the Romania

Null hypothesis	No. of obs.	*F*-statistic	*P*-value
X does not Granger Cause *M*	87	5.44425	0.0220
M does not Granger Cause *X*		0.26118	0.6107

Table 3. Linear VECM estimates – Romanian exports and imports

Variables	$\Delta\log(X)_t$	$\Delta\log(M)_t$
Intercept	0.3782*** (0.0751)	0.3210*** (0.0680)
w_{t-1}	0.0675*** (0.0148)	0.0593*** (0.0134)
$\Delta\log(X)_{t-1}$	−0.1975 (0.1308)	0.2724** (0.1184)
$\Delta\log(M)_{t-1}$	0.2128 (0.1286)	0.0215 (0.1164)
AIC: -955.9247	BIC: -933.8355	SSR: 0.7385758

Notes: Estimations are performed using the Maximum Likelihood (ML) estimator; standard errors are in brackets; ***, **, denote significance at 1 and 5% level, respectively.

with corresponding *P*-value of 0.03 indicating the rejection of the null hypothesis in favour of the alternative hypothesis that assumes a threshold cointegration relationship. Therefore, the estimates are obtained for the threshold dependent relationship between Romanian exports and imports. The estimates for the threshold VECM are summarised in Table 4.

The estimates in Table 4 illustrate a threshold dependent relationship between Romanian exports and imports. The relationship is found to be more prominent in the second regime that

Table 4. Threshold VECMs – Romanian exports and imports

Variables	1st regime – (12.8% obs.) $w_{t-1}(\beta) \leq \gamma = -0.203213$		2nd regime – (87.2% obs.) $w_{t-1}(\beta) > \gamma = -0.203213$	
	$\Delta\log(X)_t$	$\Delta\log(M)_t$	$\Delta\log(X)_t$	$\Delta\log(M)_t$
Intercept	0.1917 (0.2182)	0.0587 (0.6679)	0.0522*** (1.9e−05)	0.0373*** (0.0004)
w_{t-1}	0.7391 (0.2244)	0.3442 (0.5198)	-0.1819** (0.0220)	-0.1440** (0.0392)
$\Delta\log(X)_{t-1}$	-1.7809** (0.0010)	-1.6590*** (0.0006)	0.1317 (0.3141)	0.5490*** (7.9e−06)
$\Delta\log(M)_{t-1}$	2.2314*** (1.6e−06)	1.7535*** (1.5e−05)	0.0827 (0.5506)	-0.0486 (0.6906)
SSR: 0.6732514		AIC: -958.1988	BIC: -916.4749	
Threshold value (γ): -0.203213				
Cointegrating vector: (1, -0.9804072)				
Diagnostic tests				
Exports equation			**Imports equation**	
ARCH test statistic: 0.011379		*P*-value: 0.9153	ARCH Test statistic: 0.068947	*P*-value: 0.7935
Breusch-Godfrey serial correlation		*P*-value: 0.6838	Breusch-Godfrey serial correlation	*P*-value: 0.5662
LM Test statistic (12): 0.790365			LM Test statistic (12): 0.884327	
Jarque-Bera test statistic: 2.59974		*P*-value: 0.201732	Jarque-Bera Test statistic: 5.91989	*P*-value: 0.14727

Notes: Standard errors are in brackets; ***, ** denote significance at 1 and 5% level, respectively.

accounts for 87.2% of the observations. Most of the adjustment is governed by exports and disequilibrium occurred is being adjusted in a preceding sixteen month. Conclusively, the relationship between Romanian exports and imports is established using a threshold dependent cointegration form and linear model is mis-specified in this case.

The results in Table 1 show no linear cointegration between Serbian exports and imports. However, the relationship might be nonlinear and asymmetric. So, we estimated and tested for an asymmetric cointegration relationship following Shin et al. (2011). The NARDL estimates are provided in Table 5.

The estimated and test results reported in Table 5 show a nonlinear and asymmetric long run relationship between Serbian exports and imports. Following the Bound test, the long run relationship is significant. The results show higher import elasticity to negative exports change (1.39) than to positive exports change (0.94) in the long-run. Significant short run effects are

Table 5. NARDL estimates of the relationship between Serbian imports and exports

	Estimate	*t*-value	*P*-value
Intercept	12.70468 (2.14202)	5.931	7.78e-07
$\log(M)_{t-1}$	−1.070670 (0.18169)	−5.893	8.77e-07
$\log(X)^{+}_{t-1}$	0.94622 (0.17779)	5.322	5.20e-06
$\log(X)^{-}_{t-1}$	1.39738 (0.30344)	4.605	4.74e-05
$\Delta\log(M)_{t-1}$	−0.04816 (0.17773)	−0.271	0.78792
$\Delta\log(M)_{t-2}$	0.39647 (0.17591)	2.254	0.03022
$\Delta\log(M)_{t-3}$	0.16475 (0.16175)	1.019	0.31501
$\Delta\log(X)^{+}_{t-1}$	−0.38021 (0.26250)	−1.448	0.15593
$\Delta\log(X)^{+}_{t-2}$	−0.85171 (0.23459)	−3.631	0.00085
$\Delta\log(X)^{+}_{t-3}$	−0.69575 (0.19479)	−3.572	0.00101
$\Delta\log(X)^{-}_{t-1}$	−0.55696 (0.35638)	−1.563	0.12661
$\Delta\log(X)^{-}_{t-2}$	−0.30923 (0.33030)	−0.936	0.35524
$\Delta\log(X)^{-}_{t-3}$	−0.69829 (0.30800)	−2.267	0.02931
Residual standard error: 0.05384	Adjusted *R*-squared: 0.6767	*F*-statistic: 9.548	*P*-value: 4.756e−08
Asymmetric cointegration test (Bounds test)			
Critical values	*I*(0)	*I*(1)	*F* statistic
10%	2.205	3.421	10.2580
5%	2.593	3.941	
1%	3.498	5.149	
Asymmetry statistics			
Wald *F*-statistic: 11.00526		*P*-value: 0.002045733	
Diagnostic tests			
ARCH Test statistic: 0.4334792		*P*-value: 0.9332429	
Breusch-Godfrey Serial Correlation LM Test statistic (12): 10.21703		*P*-value: 0.2251188	
Jarque-Bera Test statistic: 0.1316622		*P*-value: 0.936289	

found out of positive change in exports with lag two and three, whilst a significant short run effect is found out of negative change in exports with lag three. Diagnostic checking shows the proper model specification. The higher imports elasticity or imports adjustment to negative change in exports than to positive change in exports means faster adjustments of imports towards exports in the periods of recession and slower relative imports growth in the periods of

Table 6. Tests of nonlinearity in Serbian net exports series

Observed series	Keenan one-degree test for nonlinearity		Tsay test for nonlinearity		Tong likelihood ratio test for threshold nonlinearity	
	Test statistic	*P*-value	Test statistic	*P*-value	Test statistic	*P*-value
Serbia	4.190708	0.0459193	4.109	0.0480	17.95346	0.0030774
	1.077358	0.3025805	3.389	0.0003	33.35176	0.0002797

growing exports. Therefore, the results revealed persistent and still present deficit in Serbia. But the converging trade flows pattern is promising to enable Serbia obtaining the sustainable level of trade flows. In the case of potential higher imports elasticity to negative exports change than to positive exports change, the account deficit would be increased in the times of economic slowdown. But unfortunately, it is not the case in Serbia. So conclusively, the results revealed that the Serbian trade flows still approach its sustainable equilibrium and the trade flows pattern is promising. Kurtovic et al. (2017) tested the effects of exchange rate of the Serbian currency on trade balance and found that elasticity to income has a greater impact on the Serbian export and import demand functions than the elasticity to the exchange rate.

To get a better picture and obtain robust results, the net exports is examined using a univariate approach. The decision about the univariate model specification to follow in this case relies on the results of nonlinearity tests. Namely, Keenan test examines the quadratic nonlinearity hypothesis (Keenan 1985), Tsay nonlinearity test (Tsay 1986) and Tong's likelihood ratio test examine for the threshold nonlinearity (Tong 1990). The results are summarised in Table 6.

The results in Table 6 indicate the threshold nonlinearity form.[2] So, the SETAR Hyper parameters are firstly estimated. The procedure starts from correlogram that showed slow decay in autocorrelation function and cut off after lag one in partial correlation function. So, lag order (m) was set to one and pooled AIC criteria are chosen to be followed. The results are presented in Table 7.

Table 7. SETAR hyper parameters

Variable	SETAR hyper parameters						Number of possible threshold value	Number of threshold values tested with hyper parameters
	m	Threshold Delay	mL	mH	Threshold value	Pooled AIC		
NX	3	0	1	2	−0.5553783	−130.5946	35	945

Notes: m denotes the autoregressive level of the whole model; Threshold delay denotes the delay level of the Self-excited model, mL denotes low regime level, and mH denotes high regime level.

[2]SETAR specification outperforms other tested models and estimates for LSTAR and Markov Switching model specification are available upon request.

Table 8. SETAR Model with one threshold for the Serbian net exports

Regime	Variable	Coefficient	*t*- Statistic	*P*-value
Low	μ_1	-0.7521849 (0.3272364)	-2.2986	0.02602
	Trend	-0.0034733 (0.0037138)	-0.9352	0.35444
	α_1	-0.2755519 (0.4391080)	-0.6275	0.53335
High	μ_2	-0.5236200 (0.1181531)	-4.4317	5.575e-05
	Trend	0.0086254 (0.0018704)	4.6116	3.086e-05
	α_2	0.3785036 (0.1598818)	2.3674	0.02208
	α_3	-0.1138781 (0.1342775)	-0.8481	0.40069
Threshold value = -0.616	Residuals variance = 0.0028	AIC = -301	MAPE = 12.33%	
			Proportion of points in each regime	
			Low regime = 17.31%	High regime = 82.69%
Diagnostic tests for the estimated SETAR specification				
ARCH test statistic: 9.814			*P*-value: 0.6323	
Breusch-Godfrey Serial Correlation LM test statistic (12): 1.197			*P*-value: 0.2739	
Jarque-Bera test statistic: 4.7577			*P*-value: 0.9266	

The results in Table 7 report no threshold delay and lag one in high and low regime as well. So, what precede is the estimation of the SETAR model with one threshold, two regimes and lags one in both regimes. The estimates are summarised in Table 8.

The results in Table 8 report the SETAR model estimates for the specification with one threshold. Fig. A3 in the Appendix plots the series development pattern through the regimes. Diagnostic checking confirmed that the estimated model meets the required conditions and therefore proper model specification. The estimated results in Table 3 revealed the difference in dynamics of Serbian net exports after the threshold was reached. Furthermore, the positive trend towards equilibrium is found in high regime indicating that Serbia approaches its equilibrium in trade flows. Therefore, a nonlinear pattern in Serbian trade flows can be captured using the univariate specification as well. Additionally, compared to the results from the NARDL approach, the results from the SETAR specification revealed faster convergence to the equilibrium after the estimated threshold was reached. So, these two approaches are not competing but complement each other and jointly make the picture complete.

The rational for these results might lie in Serbian exports and imports structure. If Serbia imported the products of higher complexity level and exported mostly primary commodities, then income-elasticity of demand for imported products would be higher than the income-elasticity of demand for the products they exported. Holding on this assumption, the global economic crisis helped to improve the performance of the Serbian current account. In this case, cointegrating the relationship between exports and imports can hardly be confirmed using the linear model specification. Therefore, following the linear approach the relationship between exports and imports in Serbia and similar countries remains unexplained. Furthermore, a persistent trade deficit in combination with a high level of external debt is a serious problem for the Serbian economy.

However, Romanian net exports is best explained using MS-AR in spite of the Tong (1990) Likelihood Ratio Test results for Threshold Nonlinearity, reported in Table 4. The MS-AR estimates for the Romanian case are summarised in Table 9.

The estimates in Table 9 indicate regime dependent dynamics in Romanian net exports. Diagnostic tests point no mis-specification and following the transition probabilities low regime is more likely to persist, comparing to the high regime. The regime change occurred in 2008 and afterwards the Romanian trade deficit started to decrease, however, Romania is still experiencing a trade deficit. A high external debt level persistent trade deficit is yet a problem for the

Table 9. MSAR Model for the Romanian net exports

Regime	Variable	Coefficient	*t*- Statistic	*P*-value
Low	μ_1	-0.0092 (0.0098	-0.9388	0.3478
	α_1	0.8744 (0.0918)	9.5251	<2e−16
	α_2	0.1105 (0.0933)	1.1844	0.2363
	Residual standard error: 0.04459604		Multiple *R*-squared: 0.8953	
High	μ_2	-0.0310 (0.0286)	-1.0839	0.2784
	α_3	-0.5619 (0.1125)	-4.9947	5.893e−07
	α_4	0.9962 (0.1209)	8.2399	2.220e−16
	Residual standard error: 0.02695354		Multiple *R*-squared: 0.9153	
AIC = -256.6468		Transition probabilities	Low regime	High regime
		Low regime	0.8913233	0.7312864
		High regime	0.1086767	0.2687136
Diagnostic tests for the estimated SETAR specification				
ARCH Test statistic: 0.405753			*P*-value: 0.5259	
Breusch-Godfrey Serial Correlation			*P*-value: 0.3668	
LM Test statistic (12): 1.108357				
Jarque-Bera Test statistic: 3.266803			*P*-value: 0.195264	

Romanian economy, therefore the Romanian policy should pay attention to external and public debt management and support the competitiveness of the economy.

Eventually, comparison of the Romanian and Serbian trade flows dynamics revealed some differences. Firstly, the relationship between Romanian exports and imports is more stable even though the net exports is regime dependent. Conclusively, our paper found and illustrated the two nonlinear form of the relationship between exports and imports and supported the research hypothesis.

7. CONCLUSION

The literature dealing with the issue of sustainability in international trade flows mostly relies on the linear model specification. If only linear model specifications were applied, the Romanian and Serbian case would remain unexplained. Following our research, the relationship between exports and imports might exhibit different nonlinear forms, therefore linear model form might be mis-specified.

We illustrated two nonlinear forms of the relationship between exports and imports. Firstly, contrary to the estimates out of linear model specification, the Nonlinear Autoregression Distributed Lag (NARDL) model specification indicates nonlinear and asymmetric cointegration between Serbian exports and imports. Furthermore, NARDL estimates provided deeper insights and revealed different imports elasticities to positive and negative exports change. SETAR(1) specification used in this research illustrated the dynamics of Serbian net exports and revealed a change in pattern of development after the net exports reached the estimated threshold. Following provided estimates, the two of the employed model specifications revealed robust estimates. The results indicate that Serbian net exports still approaches its sustainable equilibrium level. The Romanian case exhibited different nonlinearity forms. The relationship between exports and imports is threshold dependent while most of the adjustment is governed by exports and disequilibrium occurred is being adjusted in a preceding 16 months. The net exports from Romania shows regime dependent dynamics that is best explained using the MS-AR model. The differences in trade flows pattern between the considered countries might arise out of the fact that Romania is integrated into the European Union. Eventually, our research supported the hypothesis that assumes the nonlinear relationship between exports and imports. As illustrated, Serbia and Romania face serious trade deficit accompanied with high level of external debt. This is a serious problem for both countries. Even though the deficit decreased, there is still a need to direct the measures toward improvement of competitiveness and careful management of external and public debt.

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APPENDIX

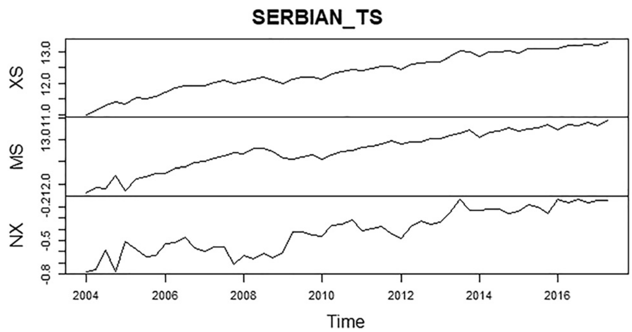

Fig. A1. Serbian exports (XS), imports (MS) and net exports (NXS) series in log values

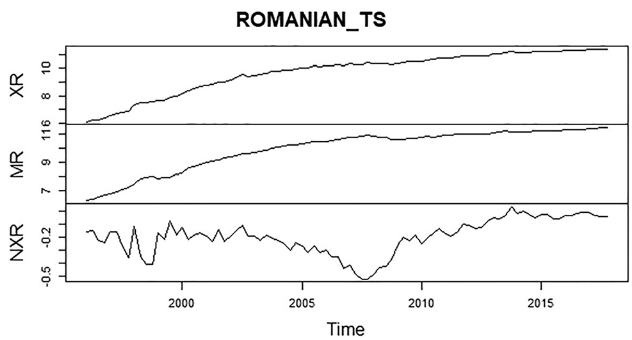

Fig. A2. Romanian exports (XR), imports (MR) and net exports (NXR) series in log values

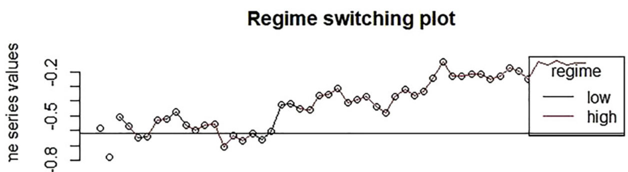

Fig. A3. SETAR (1) specification of Serbian net exports series

Table A1. Standard unit root test results (Serbia)

Variable and test	Levels		First difference	
	Constant	Constant and trend	Constant	Constant and trend
ADF test	*t-stat.*			
log(*X*)	−2.057369	−3.088503	−7.142689	−7.432368
log(*M*)	−1.423207	−2.443349	−9.635061	−9.797142
log(*NX*)	−1.765955	−3.797075	−9.690894	−9.638313
PP test	*Adj. t-stat.*			
log(*X*)	−2.157869	−3.078770	−7.142608	−7.429908
log(*M*)	−1.493736	−2.406800	−9.307682	−9.492283
log(*NX*)	−1.710480	−3.972400	−9.781908	−9.717024
KPSS test	*LM-stat.*			
log(*X*)	0.998695	0.105064	0.282859	0.089569
log(*M*)	0.961747	0.112175	0.147150	0.066099
log(*NX*)	0.968298	0.080928	0.055467	0.054021

Table A2. Standard unit root test results (Romania)

Variable and test	Levels		First difference	
	Constant	Constant and trend	Constant	Constant and trend
ADF test	*t-stat.*			
log(*X*)	−5.712696	−2.256477	−7.314295	−9.206522
log(*M*)	−6.424669	−2.456553	−3.687857	−7.255142
log(*NX*)	−1.681920	−2.228346	−7.825814	−7.812773
PP test	*Adj. t-stat.*			
log(*X*)	−6.956120	−2.510009	−7.511913	−9.209447
log(*M*)	−5.931401	−2.346899	−5.755271	−7.334530
log(*NX*)	−2.078687	−2.661615	−13.16523	−13.37602
KPSS test	*LM-stat.*			
log(*X*)	1.091715	0.280337	1.081251	0.167549
log(*M*)	1.061758	0.294323	1.033962	0.153074
log(*NX*)	0.433989	0.227868	0.257831	0.296299

Table A3. Zivot – Andrews (1992) unit root test results (Romania)

Alternative	Variable	Test statistic	Critical values (significance level)		
Level	log(X)	-3.7718	-4.58 (10%)	-4.8 (5%)	-5.34 (1%)
	log(M)	-3.5789			
	log(NX)	-4.663			
Slope of the trend	log(X)	-3.545	-4.11 (10%)	-4.42 (5%)	-4.93 (1%)
	log(M)	-3.5531			
	log(NX)	-4.2368			
Level and the slope of the trend	log(X)	-3.545	-4.82 (10%)	-5.08 (5%)	-5.57 (1%)
	log(M)	-5.843			
	log(NX)	-5.151			

Table A4. Zivot – Andrews (1992) unit root test results (Serbia)

Alternative	Variable	Test statistic	Critical values (significance level)		
Level	log(X)	-4.7651	-4.58 (10%)	-4.8 (5%)	-5.34 (1%)
	log(M)	-4.9729			
	log(NX)	-5.3856			
Slope of the trend	log(X)	-4.5094	-4.11 (10%)	-4.42 (5%)	-4.93 (1%)
	log(M)	-4.9775			
	log(NX)	-5.0443			
Level and the slope of the trend	log(X)	-4.8782	-4.82 (10%)	-5.08 (5%)	-5.57 (1%)
	log(M)	7.5452			
	log(NX)	-5.9777			