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Empirical evidence of an S-curve in Croatia

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ABSTRACT

The impact of currency depreciation on the trade balance is still an empirically unanswered question within international and financial economics. This paper is pointed towards partial clarification of that question as the author analyses trade perspectives in Croatia through the concept of an S-curve. The S-curve is an extension of the J-curve, for the impact of exchange rate depreciation wears out after a while and there is no further improvement when all impacts are realised, meaning that at the top of the curve the slope is zero or negative. By focusing on the relationship between the terms of trade (exchange rate) and trade balance the author is trying to provide some new insights into trade dynamics over a business cycle in Croatia. The main result is that both unconditional and conditional relations (conditional to technology's role identified in the vector error correction model) are consistent with the empirical S-curve pattern of cross-correlations between the trade balance and the terms of trade (exchange rate). Nonetheless, the inability of the S-curve to depict the strength and/or the speed of the adjustment process before and after the terms of trade/exchange rate depreciation explains its limitation within policy recommendations for Croatia.

1. Introduction

Trade balance, terms of trade and the exchange rate are important indicators of macroeconomic stability and development policy perspectives. Trade balance absorbs net foreign exchange receipts, while the terms of trade (and the exchange rate) determine the purchasing power of a country's export and evaluated net trade gains. The point of understanding the international finance and trade dynamics is closely related to comprehension of the terms of trade (exchange rate)–trade balance nexus, i.e., what features of an economy determine whether an increase in the relative import prices is or will be associated with improvement or deterioration in the balance of trade.[1] The role of trade is important for economic growth as the exchange rate behaviour and terms of trade play crucial roles in transmitting external shocks to the domestic economy. Despite theoretical developments on the relationship between these variables, its dynamics remain fuzzy.

The uncertainty of the range in which economic policy in Croatia can influence these economic variables suggests it is desirable to analyse, test and reproduce regularities such as the J- or S-curve in order to evaluate dominant forces behind trade balance movements. Though the macroeconomic performance has improved since the first shock of the world economic crisis, the economy is still confronted with serious challenges, including persistent trade and budget deficits, indebtedness, lack of international competitiveness and latent economic policies, which have led to further macroeconomic instability. The European Union (E.U.) accession has not had the desired results so that trade with exports lagging behind imports has resulted in consistent trade deficits, all of which has important implications for economic growth. The average share of export to gross domestic product (GDP) since 2000 is around 45%, which indicates that the Croatian economy is an open economy (Tomić, 2016a). However, this export share was insufficient in respect to demand and preferences towards import products (average share of import to GDP was around 55%), thereby generating a constant trade deficit (average share of the trade deficit to GDP was around 10%). Thus, in order to ensure macroeconomic stability and growth, some scholars and decision-makers saw a managed float exchange rate system as being vital for an improvement in productivity and export competitiveness, fiscal discipline and proper management of reserves. The Croatian central bank critically monitors exchange rate movements to ensure swift policy action to counteract any inflationary pressures from the external sector. In particular, the central bank is paying much attention to the events that could result in a large depreciation of the Croatian kuna (HRK), something that would lead to debt chaos due to the heavily indebted economy. Considering a plausible relationship between the exchange rates and the trade balance in Croatia, appreciation and depreciation episodes did not have a favourable impact on the trade balance. Namely, if we consider the J-curve behaviour, we could expect an initial worsening and later improvement of the trade balance following a term of trade depreciation. However, Croatia has a long history of a persistently widening trade deficit and a near-continual improvement in both barter and income terms of trade. A very limited number of papers on the J-curve phenomenon in Croatia leaves an opportunity to test the existence of an S-shaped curve, which could contribute to the debate on the international price adjustment processes vis-à-vis the large trade imbalance and macroeconomic instability in Croatia.

As a tool to approach the current empirical debate, this paper uses an adapted macroeconomic analysis related to international price adjustments and trade dynamics in order to put new and updated insights into the relationship between balance of trade, the terms of trade, and exchange rate developments in Croatia, because understanding the sources behind the rise of the Croatian external deficit is crucial for understanding whether the large deficit is sustainable and what policy measures are needed to ensure an orderly adjustment process. Hence, the goal of the paper is to test the validity of the so-called S-curve pattern in the Croatian economy. In a manner, this paper is a continuation of the work by Tomić (2016a) on the topic of an S-curve. Besides unconditional cross-correlation functions, I calculated cross-correlation functions conditional on the technology impact from the vector error correction model (VECM) assuming that technology is the only factor that affects the long-run

level of labour productivity, similar to Enders and Müller (2009). Analysis is carried out using the quarterly time series data for the period 2000–2018. The results confirm the existence of the S-curve behaviour of the variables, leading us to some indicative conclusions regarding the trade dynamics in Croatia. The rest of the paper is organised as follows. Section 2 provides the theoretical background of the topic and surveys the empirical literature. Section 3 gives a full perspective to the analytical part by describing the methodology and data and explaining the results. Section 4 provides some policy implications, and, finally, Section 5 offers concluding remarks.

2. Theoretical background and literature review

2.1. S-curve phenomenon: a conceptual background

The relationship between the terms of trade and trade balance has been discussed thoroughly in the literature of international finance, and it is extended to include the exchange rate in the analysis of Rhee (2014), which elevated discussions on the Marshall–Lerner condition, J-curve phenomenon and more recently an asymmetric cross-correlations function that may resemble an S-curve pattern. The Marshall–Lerner condition states that currency depreciation improves the trade balance as long as the sum of import and export demand elasticity is at least equal to unity. However, empirical evidence suggests that there have been cases in which trade balance continued to deteriorate even though this condition was satisfied. This fact led researchers to focus on the short-run effect of the currency depreciation and on the post-depreciation/devaluation time path of the trade balance, which established grounds for a J-curve phenomenon (Akkay, 2015). Namely, the theory states that a country's trade deficit will worsen initially after the depreciation of its currency because higher prices on foreign imports will be greater than the reduced volume of imports. The effects of such change in the price of exports compared with imports will eventually induce an expansion of exports and a cut in imports, which, in turn, should improve the balance of payments. This is known as the J-curve effect since a graph of a trade surplus will resemble a J if this happens. Empirical evidence of the J-curve phenomenon in the short and long run has been mixed, especially if the analyses are divided into those utilising aggregate data and those utilising bilateral data (Kimbugwe, 2006). Though there is a vast body of empirical literature dealing with the topic, the findings are still quite negative, i.e., there is little statistical evidence of a J-curve pattern in general, at least when we are considering a symmetric relationship. Most of the studies that tried to test J-curve existence have relied upon a reduced form trade balance model and regression analysis with not much support. Yet in some countries and in specific periods, the J-curve phenomenon has been recognised (for an extensive review of the literature see Akbostanci, 2004, Šimáková, 2014, or Bahmani-Oskooee & Kutan, 2009). Considering frequent contrariety between these two concepts, we can conclude that the effects of exchange rate depreciations on exports, imports, and hence on trade balance are neither guaranteed nor instant.

In 1994, a paper by Backus, Kehoe, and Kydland caught the attention by showing that the terms of trade (or alternatively exchange rate) tend to be positively correlated to future movements of the trade balance, but also tend to be negatively correlated

with past movements, thus resulting in an S-shaped curve which was in fact an extension of the J-curve phenomenon. An S-curve is related to the J-curve in the sense that the impact of exchange rate depreciation wears out after a while and there is no further improvement when all impacts are realised. Though conceptually intertwined, these two concepts are methodologically different. Note that the S-curve, which is a description of unconditional cross-correlations between the two variables, is not the same concept as the J-curve, which describes the conditional dynamic response of one variable following a shock to the other. Thus, it is possible to depict an S-curve in the data, even without a detectable J-curve (Baxter, 1995). Bahmani-Oskooee and Hegerty (2010) and Ghosh (2012) accentuate that existing studies on the S-curve can be classified, and in that way differently evaluated under three categories: (1) aggregate level (one country against the rest of the world); (2) disaggregate level (to reduce aggregation bias considers bilateral relation); and (3) industry-level analyses (to further reduce aggregation bias considers trade flow on the bilateral level but disaggregated by commodities). An aggregate-level approach presents the line of logic we shall follow in assessing empirical relevance of the S-curve concept.

2.2. What do empirics say?

A rich body of literature argues that trade flows respond to currency changes with some delays focusing both on J- and S-curve patterns and their short- and long-run relationship. The seminal paper by Backus, Kehoe, and Kydland (1994), in which they developed an international real business cycle model and found that the trade balance is countercyclical and the cross-correlation function of the trade balance and the terms of trade display an S-shape, focused on aggregate data for 11 developed O.E.C.D. countries. Roberts (1995) initially investigated the impact of exchange rate on trade balance in a dynamic model where import expenditure depends on wealth and found that besides the usual J-curve, a second independent one emerges. So, when two curves are considered in conjunction, an S-shaped curve is formed. In their empirical study, Marwah and Klein (1996) evaluated trade balance equations for the U.S. and Canada and also found an S-shaped pattern within the adjustment process in trade balances. Senhadji (1998) who also used the real business cycle model to show that, for most of the 30 less-developed nations, productivity shocks are a key factor in generating an S-curve. Parikh and Shibata (2004) analysed the relationship using annual data from 1970 to 1999 for 59 less-developed nations, all with mixed results. Using vector autoregressions on U.S. time series and an aggregate of industrialised countries, Enders and Müller (2009) found that technology shocks appreciate the terms of trade and lower the trade balance so they induce an S-shaped cross-correlation function for both variables. In addition, when calibrating a prototypical international business cycle model under complete and incomplete markets, they found that the underlying transmission mechanism of technology shocks is fundamentally different. Dmitriev and Roberts (2013) showed that a complete markets model with capital adjustment costs is consistent with the S-curve, while a model with investment adjustment costs is not. The specification of adjustment costs had little effect on the ability of the model to reproduce international co-movements.

Nadenichek (2012) introduced a basic general equilibrium model and found that both trade balance and terms of trade are driven by productivity shocks and that the subsequent behaviour generates an S-curve pattern, reminiscent of the J-curve. He concluded that the fact that productivity shocks generate a pattern similar to the J-curve underscores the importance of properly identifying the shocks generating movements in the trade balance in the broader J-curve literature. Rather heterogeneous results suggested that there could potentially exist the problem of 'aggregation bias'. The aggregation could smooth out the fluctuations observed in bilateral trade (Bahmani-Oskooee & Ratha, 2007b). This led to a number of papers dealing with disaggregate data re-examining the relationship between the terms and balance of trade on a bilateral basis (see Akkay 2015; Bahmani-Oskooee & Ratha, 2007a, 2007b; Ghosh, 2012; Ono & Baak 2014; Rhee, 2014). Most of the studies found support for the S-curve relationship; however, for most of the countries analysed this nexus was shown to be relatively weak. This again led to a further disaggregation, papers now focusing mainly on industry-level relations (see Bahmani-Oskooee & Ratha, 2008, 2009, 2010; Bahmani-Oskooee & Xi, 2015, etc.). Since the focus of this paper is an aggregate-level type of the analysis, I shall not evaluate the literature on the other two approaches thoroughly (for a deeper literature review on this topic see Akkay, 2015). A comprehensive review of empirical investigations into the existence of both the J-curve and the S-curve can be also found in Bahmani-Oskooee and Hegerty (2010).

There is a very limited number of papers dealing with the J-curve phenomenon[2] and just one (to the author's knowledge) that analysed the possibility of an S-shaped curve in Croatia. Tomić (2016a) demonstrated the existence of an S-curve pattern for the Croatian economy (period 2000–2014) with a particular set of data (current account measure only for goods as a proxy for the balance of trade, income terms of trade for goods and real effective exchange rate) focusing only on goods and excluding services from the analysis. The logic behind that approach was that by using a broader measure of current account balance the author would be able to depict visible exports and imports (plus invisible exports/imports) contrary to trade balance that depicts only visible and really traded exports and imports. On the other hand, a similar analysis between various trade variables revealed the opposite conclusion, casting some doubt on the existence of the S-curve relation. The ambiguity of the results and general inconclusiveness in the literature offered enough research curiosity to investigate and provide new insights into the existence and relevance of an S-shaped curve for the Croatian economy.

3. Methodological issues and the results

3.1. Data

Quarterly data for the terms of trade, real exchange rate and trade balance (as well as other auxiliary variables; labour productivity, unit labour costs, national output) were collected from the Croatian National Bank (http://www.hnb.hr), Croatian Bureau of Statistics (http://www.dzs.hr) and Eurostat (https://ec.europa.eu/eurostat) for the period 2000:Q1–2018:Q1. First, all variables were seasonally adjusted using the Census X13 seasonal adjustment procedure and then transformed into their

logarithmic form (except the balance of trade variable due to negative values) in order to model continuous outcomes. Second, instead of barter terms of trade we used the income terms of trade measure because Škare, Šimurina, and Tomić (2012) and Tomić (2014, 2016a) found that this variable is more relevant in macroeconomic modelling for Croatia. Whereas the 'basic' barter terms of trade just measures variations in prices, the income terms of trade includes the effect of the changes in volume of quantities exported. This means that the terms of trade could decline even though income terms of trade improve since the quantities of export could grow at the larger scale. Income terms of trade measure reveals whether the country would end up with a net gain or net loss as a result of changes in terms of trade and export volume, which de facto depends on the elasticity of demand for its export or in broader terms on the Marshall–Lerner condition. Third, in order to evaluate labour productivity in the model that will enable us to extract cross-correlation functions conditional on the technology we introduced an approximated variable as we scaled national product by labour productivity, similar to Enders and Müller (2009).

Therefore, this analysis is based on these variables: ln$ITOT$ – log of income terms of trade (based on national accounts data on nominal and real exports and imports in HRK) is calculated by multiplying the basic terms of trade measure (the ratio of export deflator to import deflator) with the volume of exports; ln$REER$ – log of the real effective exchange rate deflated with the consumer price index (2010 = 100); and TB – seasonally adjusted trade balance index (2010 = 100). Other mediating variables are: ln$Y$ – log of labour productivity as real gross domestic product is scaled by real labour productivity per person employed (2010 = 100); and lnLEF – log of unit labour costs in the economy (2010 = 100). Since all the variables have changed over time, we had to test them for the presence of a unit root, and we used the augmented Dickey–Fuller test, Phillips–Perron test and Kwiatkowski–Phillips–Schmidt–Shin test. Using a battery of conventional unit root tests, we could not reject non-stationarity of variables over the sample period (available on request). Graphical displays of the observed variables also suggest that they are not stationary in levels. Based on the results obtained we concluded that all series are integrated of order $I(1)$, i.e., they are stationary in their first differences. This assumption enabled us to consider a cointegration method and VECM analysis in estimating counterfactual time series for the estimation of conditional cross-correlation functions. To calculate adequate cross-correlation coefficients, we also detrended the data (using the Hodrick–Prescott filter with common smoothing parameter λ of 1600 for quarterly data).[3]

3.2. An unconditional S-curve

In order to analyse the dynamic relationship between terms of trade/exchange rate and trade balance, we first tested the phenomenon by evaluating an unconditional S-curve pattern. Accordingly, an S-curve depicts negative cross-correlations between past values of the trade balance (*TB*) and the income terms of trade (*ITOT*) or real effective exchange rates (*REER*), but positive cross-correlations between future values
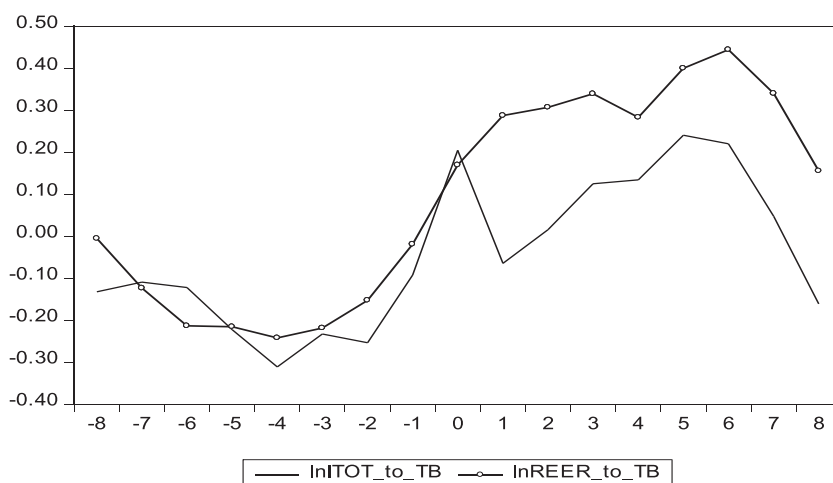
Figure 1. An unconditional cross-correlation function with lags/leads up to eight periods. Source: author's calculation.

of the *TB* and the *ITOT* or *REER*. In order to test the validity of a possible S-curve pattern for the Croatian economy, we calculated cross-correlations for both terms of trade as well as real exchange rate. Cross-correlation coefficients (ρ_{k-ITOT}, ρ_{k-REER}) are defined as in Rhee (2014):

$$\rho_{k-ITOT} = \frac{\sum \left(ITOT_t - I\overline{TOT} \right) \left(TB_{t+k} - \overline{TB} \right)}{\sqrt{\sum \left(ITOT_t - I\overline{TOT} \right)^2 \left(TB_{t+k} - \overline{TB} \right)^2}} \tag{1}$$

$$\rho_{k-REER} = \frac{\sum \left(REER_t - \overline{REER} \right) \left(TB_{t+k} - \overline{TB} \right)}{\sqrt{\sum \left(REER_t - \overline{REER} \right)^2 \left(TB_{t+k} - \overline{TB} \right)^2}} \tag{2}$$

where marked values of the variables present the mean of all observations over a study period. By placing cross-correlation coefficients on the vertical axis and the different lags and leads (k) on the horizontal axis, we can graphically interpret and confirm the existence of the S-curve pattern. We shall display the cross-correlation function for the terms of trade/real exchange rate and the trade balance ($t + k$) for k ranging from −8 to 8 quarters, i.e., lags and leads up to two years.

First, the S-curve relation reflects the income terms of trade and trade balance nexus (straight line), whereas the second S-shaped curve displays the real effective exchange rate to trade balance relationship (dotted line), all at the aggregate level, respectively (see Figure 1). Both relations demonstrated that while the cross-correlation between the current values of ln*ITOT* or ln*REER* and the future values of *TB* is positive, the same cross-correlation between the current values of the ln*ITOT* or ln*REER* and past values of the *TB* is negative. When we plot cross-correlation functions against the lags and leads, relations resemble the letter S, meaning that we have

found evidence of an asymmetric S-curve phenomenon in both cases (the function is typically negative for negative values of k, but turns positive for k between zero and eight, only the second S-curve turning into a negative value in $k = 8$). Importantly, both curves hit the lowest and highest values in almost similar time points, suggesting the compliance of cyclicality in movements.

3.3. A conditional S-curve

Theoretical frameworks that feature the balance of trade led to a number of dynamic general equilibrium interpretations. International business cycle models have been largely used to analyse the international mechanism of technology shocks because they are directly related to short-term fluctuations in the trade balance and terms of trade. For example, in the standard transmission mechanism when a country experiences a positive technology shock domestic output expands and its terms of trade deteriorate. However, a surge of investment could induce a trade deficit, which will turn into a surplus once the domestic capital stock is built up. Empirical success of models based on such a transmission mechanism has provided mixed results (Enders & Müller, 2009). Unlike many authors, such as Galì (1999), Corsetti, Martin, and Pesenti (2007), Dedola and Neri (2007), Altig et al. (2011), and especially Enders and Müller (2009), our empirical strategy is not to replicate various theoretical business cycle models and/or vector autoregression approach (VAR) studies (that have tried to identify technology, monetary or fiscal shocks and their effects on trade balance) in the literature, but to extend the analysis by introducing VECM analysis which will allow us to debate on the role of productivity within a business cycle analysis. Hence the notion that productivity shocks are a key determinant of the joint dynamics of the terms of trade/exchange rate and trade balance at business cycle frequency. Theoretical models suggest, hence, that international transmission of technology shocks should deliver an S-curve. In that manner, we shall evaluate one such empirical model in order to test the existence of an S-curve pattern on that ground. The logic of our empirical analysis follows the work of Enders and Müller (2009).

Since we want to evaluate short-run and, indirectly, long-run implications we shall evaluate the VAR. Engle and Granger (1987) indicated that a linear combination of two or more non-stationary series may be stationary. If so, these series are said to be cointegrated. This linear stationary combination shows the long-run relationship among the variables and is called a cointegrated equation. In order to test for cointegration, the methodology proposed by Johansen and Juselius (1990) and Johansen in 1991 (Johansen, 2002) is used. Following that, the unrestricted VAR model is then defined:

$$\boldsymbol{y}_t = \mathbf{A}_1 \boldsymbol{y}_{t-1} + \cdots + \mathbf{A}_p \boldsymbol{y}_{t-p} + \mathbf{B} \boldsymbol{x}_t + \boldsymbol{\varepsilon}_t, \quad \boldsymbol{\varepsilon}_t \approx IN(0, \boldsymbol{\Sigma}) \tag{3}$$

where $\boldsymbol{y}_t$ is a k-vector of non-stationary $I(1)$ variables, $\boldsymbol{x}_t$ is a d-vector of deterministic variables, $\boldsymbol{\varepsilon}_t$ is a vector of independently normally distributed errors with mean zero and covariance matrix $\boldsymbol{\Sigma}$, while $\mathbf{A}$ and $\mathbf{B}$ are matrices of parameters. Model (1) can be reformulated into a VECM:[4]

Table 1. Long-run relationship based on selected variables.

β coefficients	Model I (Equation (6))	Model II (Equation (7))
Independent variable lnY		
ln*LEF*	2.46***	1.62***
ln*ITOT*	1.83***	–
ln*REER*	–	0.64***
TB	0.03***	0.02***
@trend	−0.03***	−0.01***
Constant	25.87	7.23
Dummy for the shock in 2008:Q3 was introduced in both models		
Model I: Portmanteau test (4) = 42.02 (p-value = 0.95***), LM autocorrelation test (4) = 11.79 (p-value = 0.76***), normality joint test $\chi^2(4)$ = 11.70 (p-value = 0.50***)		
Model II: Portmanteau test (3) = 56.26 (p-value = 0.55***), LM autocorrelation test (3) = 23.13 (p-value = 0.11***), normality joint test $\chi^2(4)$ = 6.92 (p-value = 0.55***)		
0.06		
0.03		
Error correction model I: Cointeq1 0.01 d(lnY)** 0.02 d(ln*LEF*)*** 0.08 d(ln*ITOT*) 14.76 d(TB)		
Error correction model II: Cointeq1 0.03 d(lnY)** 0.08 d(ln*LEF*) − 0.02 d(ln*REER*)*** 7.36 d(TB)***		

***, ** represent 1% and 5% of statistical significance.
Source: author's calculation.

$$\Delta \boldsymbol{y}_t = \boldsymbol{\Pi}\boldsymbol{y}_{t-1} + \sum_{i=1}^{p-1} \boldsymbol{\Gamma}_i \Delta \boldsymbol{y}_{t-i} + \mathbf{B}\boldsymbol{x}_t + \boldsymbol{\varepsilon}_t \tag{4}$$

where

$$\boldsymbol{\Pi} = \sum_{i=1}^{p} \mathbf{A}_i - I, \quad \boldsymbol{\Gamma}_i = -\sum_{j=i+1}^{p} \mathbf{A}_j \tag{5}$$

Number of lags in the VAR model is determined using standard information criteria (AIC, HQ, SC, FPE, LogL and LR tests).[5] Although the criteria indicated roughly similar number of lags, the final model was estimated using two lags as suggested by SC and HQ tests. For determining the number of cointegrating vectors the Johansen's reduced rank procedure was introduced. Considering five different models, estimations were made by including constant and trend in the cointegration space following the results of the LR test. These models showed the best modelling properties. The operational form of equations, hence the long-run empirical models, are specified as follows:

$$\ln Y_t = \beta_{10} + \beta_{11}\ln LEF_t + \beta_{12}\ln ITOT_t + \beta_{13}TB_t + \varepsilon_{1,t} \tag{6}$$

$$\ln Y_t = \beta_{20} + \beta_{21}\ln LEF_t + \beta_{22}\ln REER_t + \beta_{23}TB_t + \varepsilon_{2,t} \tag{7}$$

Long-run relationship models based on Equations (6) and (7) can be found in Table 1 with additional short-run analysis and diagnostic test in continuation. Long-run dynamics and VECM analysis exhibits expected theoretical relationships. Diagnostic tests implied that models are adequately estimated, i.e., that characteristics of the models are acceptable.[6] Estimations show almost no problem of heteroscedasticity, normality of residuals and of stability, which in fact enables stable conclusions.

The swings in the Croatian balance of trade, income terms of trade and real effective exchange rate have statistically significant and positive implications for the movement in labour productivity, both in the short and long term, however with different strength.

Since we are interested in finding the S-curve patterns, we focused mainly on the results from a mutual relationship between the variables trade, and income terms of trade/real effective exchange rate. To ensure that our analysis is not led by a plurality of candidates for structural impulse responses (from either monetary or fiscal policy), we did not impose any restrictions on the signs in the short-run analysis. Rather than a shortcoming, this is a potentially important advantage of our approach, for it did not have an impact on the degrees of freedom. With inconclusive impulse response results, our conclusion relied partially on variance decomposition identification (see the Appendix). Within Equation (6), variance decomposition results support the empirical findings because trade balance itself causes more than 70% of its variability on average, with a declining tendency so that after 12 quarters it explains around 62% of own variability. Income terms of trade shocks account for 20% of trade balance variance after 12 quarters. Variance decomposition results are consistent because the income terms of trade variable itself causes more than 60% of its variability through the whole period, with trade balance explaining over 26% of income terms of trade variance after 12 quarters. We also found consistency in the results from Equation (7). We see that trade balance explains over 86% of its own variability, with real effective exchange rate explaining around 7% of trade balance variance, on average. On the other hand, though the real effective exchange rate is responsible for most of its own variability, interestingly, trade balance shocks account for roughly 20% of exchange rate variability after 12 quarters. Variance decomposition analysis confirms the importance of the technology role within the international relationship for the joint dynamics of the trade balance and terms of trade/real effective exchange rate. In the next step, we focus on explaining that relationship on a business cycle frequency.

Given the estimated models, we computed in-sample counterfactual time series for variables of interest to us.[7] After we had filtered simulated time series, we calculated the cross-correlation functions for the relations trade balance vs. income terms of trade and trade balance vs. real effective exchange rate. The conditional cross-correlation functions (straight line) display a pattern that is similar to the unconditional cross-correlation functions (dotted line) for both relations. Similarity implied that unconditional cross-correlation functions, against the lags and leads for $k = 8$, indeed resembled an S-curve behaviour. Overall, we concluded that technology, through the increase in labour productivity, has an important impact and implication for the existence of the unconditional S-curve pattern in the Croatian economy (Figures 2 and 3).

We employed two variables to test the S-curve hypothesis in order to answer the robustness requirements and came to the conclusion that there indeed exists an S-curve pattern in the Croatian data. We intentionally did not apply moving averages to smooth graphical presentation in order to utilise some diversity in movements between conditional and unconditional cross-correlation functions, especially between the balance of trade and income terms of trade. It is time to see what the results are telling us!
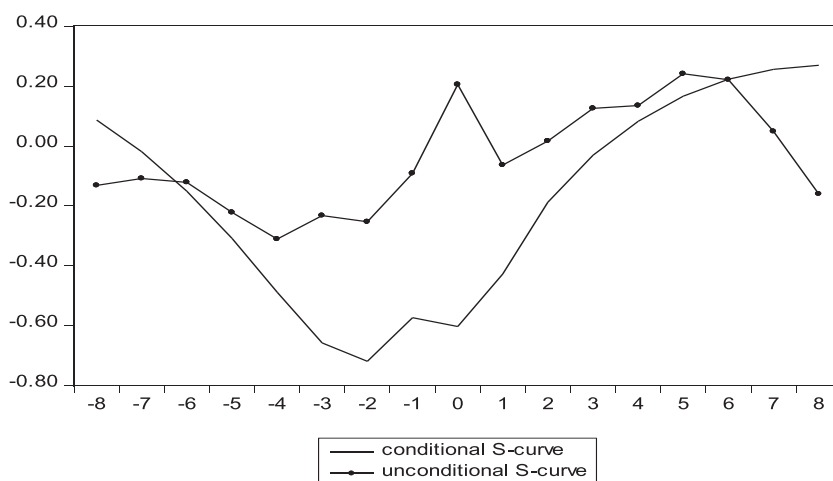
Figure 2. Unconditional vs. conditional S-curve (ln*ITOT* to *TB*). Source: author's calculation.
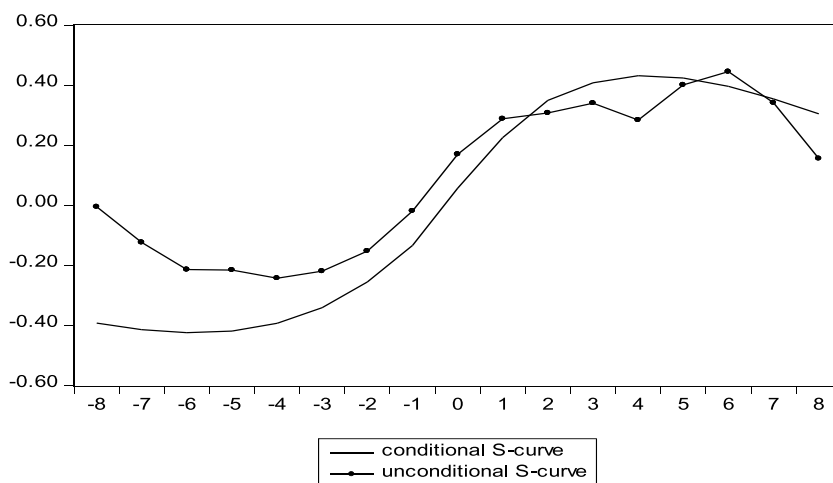
Figure 3. Unconditional vs. conditional S-curve (ln*REER* to *TB*). Source: author's calculation.

4. Implications of the research

Empirical evidence reveals that there is a regularity or systematic pattern between the cyclical movements in income terms of trade/real effective exchange rate and the balance of trade. Accordingly, trade positions will be improved systematically via depreciation of an income terms of trade or a real effective exchange rate for an S-curve effect to take place, ultimately improving trade balance and international competitiveness. Competitiveness is still one of the key elements of the performance assessment of the economy and a 'mirror' of the success of a country on a global level (Kiseláková et al., 2018). Of course, the question of efficiency and effectiveness of sound public spending is also of utmost importance (Žižka et al., 2018).

Our results indicate that income terms of trade movements could provide insurance against negative movements in the balance of trade if they lead to an increase in

domestic output relative to foreign output due to the technological improvement. Terms of trade deteriorate as the price of domestically produced products falls relative to foreign products, which initially leads to a wealth transfer outside the economy. From the short-run analysis in our model, we see that the balance of trade initially worsens for both income terms of trade and real effective exchange rate depreciation. However, as both unconditional and conditional S-curve relations suggest, the cross-correlation between the current values of income terms of trade or real effective exchange rate and the future values of the current account is positive. We trace an almost immediate positive effect after three quarters for the income terms of trade variable and just one quarter for the real effective exchange variable. Therefore, the positive change in relative prices should lead to a positive wealth effect through the trade balance improvement. Similarity in movements (percentage change in income terms of trade and real effective exchange rate vs. trade balance; see the Appendix), especially after a volatile period of economic crisis, implies that an S-curve pattern could indeed exist.

Also, we found evidence of an S-curve pattern between the income terms of trade for goods and trade balance. We additionally checked the cross-correlation functions between the income terms of trade and the volume of exports/import, and found both to be positive. When we observed a graphical display of the relationship between the real effective exchange rate and the volume of exports/imports we found an allusion to the S-curve pattern in the data, which is in conformity with our previous conclusions.

The finding of an S-curve pattern does not necessarily mean we confirmed the J-curve pattern, thus it is possible to depict an S-curve in the analysis without finding any evidence of the J-curve. Our conclusions should be affiliated in that manner. In addition, the inability of an S-curve to depict the strength and/or the speed of the adjustment process before and after the exchange rate/terms of trade depreciation explains its limitation within policy recommendations. Though we trace an S-curve pattern in the data (unconditional relation) and model (conditional relation), there are many reasons which are, *au contraire*, a large deviation in the form of depreciation. Characteristics of the Croatian economy, such as high indebtedness across all sectors (private and public), underlying uncompetitiveness of an export sector, persistent trade deficit, exogeneity of the terms of trade, the havoc that can be caused by the complete pass-through effect, stability of a monetary system as a cornerstone of policy by the Croatian central bank counteracting any inflationary pressures, inefficient public finance and public debt management, appeasement to Maastricht criteria, and so on, raise some doubts on the possible depreciation as a foreign exchange policy recommendation.[8] Nonetheless, complemented with other types of research (correlations between other trade variables, exchange rate misalignment – Marshall–Lerner conditions – J-curve pattern, pass-through effect – terms of trade dynamics and its causal relation to trade balance or output, analysis on disaggregated level, etc.), the S-curve confirmation could be of great help in achieving long-term policy goals, suggesting that there indeed exists a nexus of some kind between the terms of trade/exchange rate and the balance of trade. Further research on this topic should be aimed at developing a business cycle model for a small open economy with

similar characteristics to Croatia which would test theoretical international transmission of different shocks such as technology shocks, terms of trade shocks, and monetary or fiscal shocks that would confront the standard business cycle model parameters with real time series evidence.

5. Conclusion

Our results provide a new perspective on the cyclical links between the trade and economic activity in a pre- and post-economic crisis period, a crisis whose magnitude and resilience had severe consequences on the E.U. and Croatian economy. Croatia's high volume of external debt and import dependency can increase the speed and dimension of transmission of any adverse external (oil, financial, exchange rate, etc.) shock in the future, meaning that research of this kind can help in either the narrowing of recommendations for economic policy (relevance of the quasi-fixed exchange rate and possible depreciation of Croatian kuna, loss of competitiveness, further deterioration the trade balance, business process management; see, e.g., Zemguliene & Valukonis, 2018) or increased cost of financing the current account deficit. By employing two variables (income terms of trade and real effective exchange rate) within two distinct approaches (unconditional cross-correlation functions against modelled computed in-sample counterfactual cross-correlation functions conditional on the role of technology), we found evidence of the so-called S-curve phenomenon but immediately cast some doubt on its relevance for the Croatian economy considering the immense internal and external problems this country faces. Access to the large E.U. market did not provide the desired economic effects for Croatia, hence it accentuated the importance of raising its competitiveness (rather than manipulation of the exchange rate), which could generate both opportunities and challenges for any government. There are two major shortcomings of this paper that a reader can detect. First is the relatively short time series and second is the generalisability of some conclusions. Both can impose scant economic reasoning; however, we find this argument an incentive for further research that might include more complex methods of analysis (for example, by introducing a general equilibrium business cycle model) and international comparison (especially with E.U. countries).

How well a country can balance its international trade engagements over international price changes, composition of exports and imports, terms of trade shocks, exchange rate flexibility and adjustments, competitiveness aspirations, and so on, is of great importance, especially for small, open, indebted and import-dependent country such as Croatia. The relevance of external trade position should be a cause of concern for economic policy-makers in Croatia, especially now within the aftermath of an economic crisis when net export is expected to become a driver of new economic growth.

Notes

1. There are many other factors that influence the balance of trade, such as: the cost and availability of raw materials, intermediate goods, i.e., thus the factor endowments, the cost of production between an importing vs. exporting country, trade policies related to

the restriction on trade plus taxes and incentives, prices in the domestic country (inflation) and exchange rate dynamics, foreign currency reserves, etc. World income in a broader sense also has a huge influence on trade dynamics. Similar factors tend to cause the change in the terms of trade in the short and long run, making the nexus between the trade balance and terms of trade even more interrelated.

2. The first to find evidence of the J-shaped curve for Croatia was Stučka (2004) for the period 1994–2002. He employed a reduced form model to estimate the impact of a permanent shock on the merchandise trade balance and found that a 1% depreciation in the exchange rate improves the equilibrium trade balance in the range of 0.94–1.3% and it took 2.5 years for equilibrium to be established. Bahmani-Oskooee and Kutan (2009) did an extensive study on the emerging European countries (Bulgaria, Croatia, Cyprus, Czech Republic, Hungary, Poland, Romania, Russia, Slovakia, Turkey and Ukraine; period 1990–2005) and found empirical support for the J-curve pattern in three countries: Bulgaria, Croatia and Russia. On the other hand, Cota, Erjavec, and Botrić (2006) examined whether bilateral real exchange rate changes in Croatia have any significant impact on trade balance changes between Croatia and six main trading partners (Slovenia, Austria, Germany, Italy, U.K. and France for the period 1995–2005), and found no empirical support for the J-curve. Hsing (2009) examined the bilateral trade between Croatia, Czech Republic, Hungary, Poland, Slovakia or Slovenia and the U.S.A., and found that the J-curve cannot be empirically confirmed for any of these six countries. As we can see, the J-curve literature for Croatia also offered some mixed results. Interestingly, all studies were made for the pre-crisis period and could be considered obsolete. We could say that there is a need for newer and conceptually wider studies which would approach the delicate topics of real exchange rate misalignments (see, e.g., Palić, Dumičić, & Šprajaček, 2014), depreciation (Koški, 2009; Sorić, 2008), trade dynamics (Tica & Nazifovski, 2012), changes in international prices (Tomić, 2012, 2016b), terms of trade volatility (Škare, Šimurina, & Tomić, 2012), etc. This is especially true if we know that the Croatian economy inherently suffers from a lack of international competitiveness and internal structural problems (Benazić & Tomić, 2014).

3. For this purpose we again tested the presence of a unit root with the same three tests (available on request). Generally, all tests confirmed the absence of a unit root for all the variables (graphical displays of the variables also suggest that they are stationary in levels). In conclusion, variables reveal a stationary behaviour after the trend has been removed. Stationarity of a variable within a business cycle analysis is an important property, otherwise a spurious cycle (if the data are difference stationary) might lead to artificial conclusions.

4. Granger's representation theorem asserts that if the coefficient matrix $\mathbf{\Pi}$ has reduced rank $r < k$, then there exist $k \times r$ matrices α and β each with rank r such that $\mathbf{\Pi} = \alpha\beta'$ and $\beta'y_t$ is $I(0)$. r is the number of cointegrating relations (the cointegrating rank) and each column of β is the cointegrating vector. The elements of α are known as the adjustment parameters in the VECM and p is the number of lags.

5. AIC: Akaike information criterion; FPE: final prediction error; HQ: Hannan–Quinn information criterion; SC: Schwarz information criterion; LogL: log likelihood criterion; LR: likelihood ratio criterion. In both cases (income terms of trade and real effective exchange rate) we evaluated VAR(2), which showed adequate properties for proceeding to the next step (results available on request).

6. Model I: Portmanteau test (4) = 42.02 (p-value = 0.95***), LM autocorrelation test (4) = 11.79 (p-value = 0.76***), normality joint test $\chi^2(4)$ = 11.70 (p-value = 0.50***).
   Model II: Portmanteau test (3) = 56.26 (p-value = 0.55***), LM autocorrelation test (3) = 23.13 (p-value = 0.11***), normality joint test $\chi^2(4)$ = 6.92 (p-value = 0.55***).

7. In this part we also compared forecasting errors such as the Theil inequality coefficient (Theil), root mean square error (RMSE), mean absolute per cent error (MAPE) and mean absolute error (MAE) because, on the basis of those parameters, we can test

forecasting capacity, i.e., confirm the quality of forecasting assessments. Most of these indicators suggested small values of errors (except for *TB*) compared with other models. Model I: for ln*ITOT* 0.01 (Theil), 0.10 (RMSE), 0.84 (MAPE) and 0.09 (MAE); and for *TB* 0.40 (Theil), 11.31 (RMSE), 260.37 (MAPE) and 8.52 (MAE). Model II: for ln*REER* 0.01 (Theil), 0.07 (RMSE), 1.31 (MAPE) and 0.06 (MAE); and for *TB* 0.50 (Theil), 12.86 (RMSE), 1108.40 (MAPE) and 9.73 (MAE).

8. Loss of production capacity, weakening of general competitiveness of national economy, tax evasion, the unemployment level, decrease of general national standard of living, uncertainty about the future, etc. (great systematisation of problems that lead to serious macroeconomic issues can be found in Mackevičius, Šneidere, & Tamulevičiene, 2018) can be considered as the main economic and social problems in Croatia.

Disclosure statement

No potential conflict of interest was reported by the author.

References

Altig, D., Christiano, L., Eichenbaum, M., & Linde, J. (2011). Firm-specific capital, nominal rigidities and the business cycle. *Review of Economic Dynamics*, *14*(2), 225–247. doi:10.1016/j.red.2010.01.001

Akbostanci, E. (2004). Dynamics of the trade balance: The Turkish J-curve. *Emerging Markets Finance and Trade*, *40*(5), 57–73. doi:10.1080/1540496X.2004.11052584

Akkay, R. C. (2015). S-curve dynamics of trade between Turkey and her trading partners. *International Journal of Economics and Administrative Studies*, *8*(15), 179–192.

Backus, D. K., Kehoe, P. J., & Kydland, F. E. (1994). Dynamics of the trade balance and the terms of trade: The J-curve? *American Economic Review*, *84*(1), 84–103.

Bahmani-Oskooee, M., & Hegerty, S. W. (2010). The J- and S-curves: A survey of the recent literature. *Journal of Economic Studies*, *37*(6), 580–596. doi:10.1108/01443581011086639

Bahmani-Oskooee, M., & Kutan, A. M. (2009). The J-curve in the emerging economies of Eastern Europe. *Applied Economics*, *41*(20), 2523–2532. doi:10.1080/00036840701235696

Bahmani-Oskooee, M., & Ratha, A. (2007a). Bilateral S-curve between Japan and her trading partners. *Japan and the World Economy*, *19*(4), 483–489. doi:10.1016/j.japwor.2006.09.005

Bahmani-Oskooee, M., & Ratha, A. (2007b). The S-curve dynamics of U.S. bilateral trade. *Review of International Economics*, *15*(2), 430–439. doi:10.1111/j.1467-9396.2007.00640.x

Bahmani-Oskooee, M., & Ratha, A. (2008). S-Curve at the industry level: Evidence from US-UK commodity trade. *Empirical Economics*, *35*(1), 141–152. doi:10.1007/s00181-007-0147-0

Bahmani-Oskooee, M., & Ratha, A. (2009). S-curve dynamics of trade: Evidence from US-Canada commodity trade. *Economic Issues*, *14*(1), 1–16.

Bahmani-Oskooee, M., & Ratha, A. (2010). S-Curve dynamics of trade between U.S. and China. *China Economic Review*, *21*(2), 212–223. doi:10.1016/j.chieco.2009.06.006

Bahmani-Oskooee, M., & Xi, D. (2015). A note on the S-curve dynamics of commodity trade between Brazil and the United States. *Latin American Journal of Economics*, *52*(2), 307–394. doi:10.7764/LAJE.52.1.79

Baxter, M. (1995). International trade and business cycle. In G. M. Grossman & K. Rogoff (Eds.), *Handbook of international economics* (Vol. 3, 1st ed., pp. 1801–1864). Amsterdam, the Netherlands: Elsevier.

Benazić, M., & Tomić, D. (2014). The evaluation of fiscal and monetary policy in Croatia over a business cycle. *Proceedings of Rijeka Faculty of Economics: Journal of Economics and Business*, *32*(1), 75–99.

Cota, B., Erjavec, N., & Botrić, V. (2006). The effect of real exchange rate changes on Croatian bilateral trade balances. *Ekonomska Istraživanja*, *19*(2), 75–90.

Corsetti, G., Martin, P., & Pesenti, P. (2007). Productivity, terms of trade and the 'home market effect'. *Journal of International Economics*, *73*(1), 99–127. doi:10.1016/j.jinteco.2006.08.005

Dedola, L., & Neri, S. (2007). What does a technology shock do? A VAR analysis with model-based sign restrictions. *Journal of Monetary Economics*, *54*(2), 512–549. doi:10.1016/j.jmoneco.2005.06.006

Dmitriev, A., & Roberts, I. (2013). The cost of adjustments: On comovement between the trade balance and the terms of trade. *Economic Modelling*, *35*, 689–700. doi:10.1016/j.econmod.2013.08.027

Enders, Z., & Müller, G. (2009). On the international transmission of technology shocks. *Journal of International Economics*, *78*(1), 45–59. doi:10.1016/j.jinteco.2009.02.010

Engle, F. R., & Granger, C. W. J. (1987). Co-integration and error correction: Representation, estimation and testing. *Econometrica*, *55*(2), 251–276. doi:10.2307/1913236

Galì, J. (1999). Technology, employment, and the business cycle: Do technology shocks explain aggregate fluctuations? *American Economic Review*, *89*(1), 249–271.

Ghosh, A. (2012). Is there an S-curve relationship between U.S. trade balance and terms of trade? *An Analysis across Industries and Countries*, *32*(1), 325–337.

Hsing, Y. (2009). Test of the J-curve for six selected new EU countries. *International Journal of Economic Policy in Emerging Economies*, *2*(1), 76–85. doi:10.1504/IJEPEE.2009.022942

Johansen, S. (2002). *The interpretation of cointegration coefficients in the cointegrated vector autoregressive model* (Reprint No. 14). Reprints of Departments of Theoretical Statistics, University of Copenhagen.

Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration – With applications to the demand for money. *Oxford Bulletin of Economics and Statistics*, *52*(2), 169–210.

Kimbugwe, H. (2006). *The bilateral J-curve hypothesis between Turkey and her 9 trading partners* (MPRA Paper No. 4254). Munich Personal RePEc Archive.

Kiseláková, D., Šofranková, B., Čabinová, V., & Onuferová, E. (2018). Competitiveness of sustainable growth analysis of the EU countries with the use of Global Indexes' methodology. *Entrepreneurship and Sustainability Issues*, *5*(3), 581–599. doi:10.9770/jesi.2018.5.3

Koški, D. (2009). Utjecaj promjene deviznoga tečaja na bilancu roba Republike Hrvatske: Ekonometrijska analiza. *Ekonomski Pregled*, *60*(3–4), 152–167.

Mackevičius, J., Šneidere, R., & Tamulevičienė, D. (2018). The waves of enterprises bankruptcy and the factors that determine them: The case of Latvia and Lithuania. *Entrepreneurship and Sustainability Issues*, *6*(1), 100–114. doi:10.9770/jesi.2018.6.1

Marwah, K., & Klein, L. R. (1996). Estimation of J-curve: United States and Canada. *Canadian Journal of Economics*, *9*(3), 523–539.

Nadenichek, J. (2012). The S-curve revisited: The terms, volume and balance of trade over the business cycle. *International Journal of Applied Economics*, *9*(2), 39–57.

Ono, M., & Baak, S. (2014). Revisiting the J-curve for Japan. *Modern Economy*, *5*(1), 32–47. doi:10.4236/me.2014.51005

Palić, I., Dumičić, K., & Šprajaček, P. (2014). Measuring real exchange rate misalignment in Croatia: A cointegration approach. *Croatian Operational Research Review*, *5*(2), 135–148. doi:10.17535/crorr.2014.0003

Parikh, A., & Shibata, M. (2004). Dynamics of the relationship between the terms of trade and the trade balance in developing countries of Asia, Africa and Latin America. *Journal of Quantitative Economics*, *2*(2), 104–121. doi:10.1007/BF03404611

Rhee, H.-J. (2014). Trade balance between Korea, China and Japan implemented by the S-curve. *Advanced Science and Technology Letters*, *57*, 5–9.

Roberts, M. A. (1995). The second J-curve and trade account dynamic. *Applied Economics Letters*, *2*(2), 31–33. doi:10.1080/135048595357645

Senhadji, A. S. (1998). Dynamics of the trade balance and the terms of trade in LDCs: The S-curve. *Journal of International Economics*, *46*(1), 105–131. doi:10.1016/S0022-1996(97)00043-3

Sorić, P. (2008). *On the impact of exchange rate on Croatian foreign trade results: Elasticity approach*. Paper presented at the Young economist's seminar to 14th Dubrovnik Economic Conference, Croatian National Bank.

Stučka, T. (2004). *The effects of exchange rate change on the trade balance in Croatia*. (IMF Working Paper 04/65), International Monetary Fund.

Šimáková, J. (2014). The effects of exchange rate change on the trade balance Slovakia. *European Financial and Accounting Journal*, 9(3), 50–66. doi:10.18267/j.efaj.124

Škare, M., Šimurina, J., & Tomić, D. (2012). Income terms of trade trend and volatility in Croatia. *Economic Research*, 25(4), 905–924. doi:10.1080/1331677X.2012.11517538

Tica, J., & Nazifovski, L. (2012). Utjecaj tečajne politike na ekonomsku aktivnost u visoko zaduženoj zemlji. Serija članaka u nastajanju br, 1202. Ekonomski fakultet Sveučilišta u Zagrebu.

Tomić, D. (2016a). *An alternative approach to the trade dynamics in Croatia*. Proceedings from the 12th International Scientific Conference on Economic and Social Development in Bangkok, Varaždin Development and Entrepreneurship Agency and University North.

Tomić, D. (2016b). A more complex approach to the terms of trade dynamics; the case of Croatia. In M. Benazić, M. Božina Beroš, G. Gimigliano, A. Novak, & D. Učkar (Eds.), *The EU economic environment post-crisis: Policies, institutions and mechanisms* (pp. 95–108). Pula, Croatia: Juraj Dobrila University of Pula.

Tomić, D. (2014). Peta interfakultetska znanstvena konferencija, Konkurentnost, ekonomski rast i blagostanje. In *Može li Hrvatska tražiti izlaz iz 'gospodarske agonije' kroz izvoz?* Osijek, Croatia: Ekonomski fakultet u Osijeku.

Tomić, D. (2012). Croatian terms of trade: Historical perspective, movements and welfare effect. *Economic Research*, 25(1), 117–139.

Zemguliene, J., & Valukonis, M. (2018). Structured literature review on business process performance analysis and evaluation. *Entrepreneurship and Sustainability Issues*, 6(1), 226–252. doi:10.9770/jesi.2018.6.1

Žižka, M., Hovorková Valentová, V., Pelloneová, N., & Štichhauerová, E. (2018). The effect of clusters on the innovation performance of enterprises: Traditional vs new industries. *Entrepreneurship and Sustainability Issues*, 5(4), 780–794. doi:10.9770/jesi.2018.5.4

Appendix
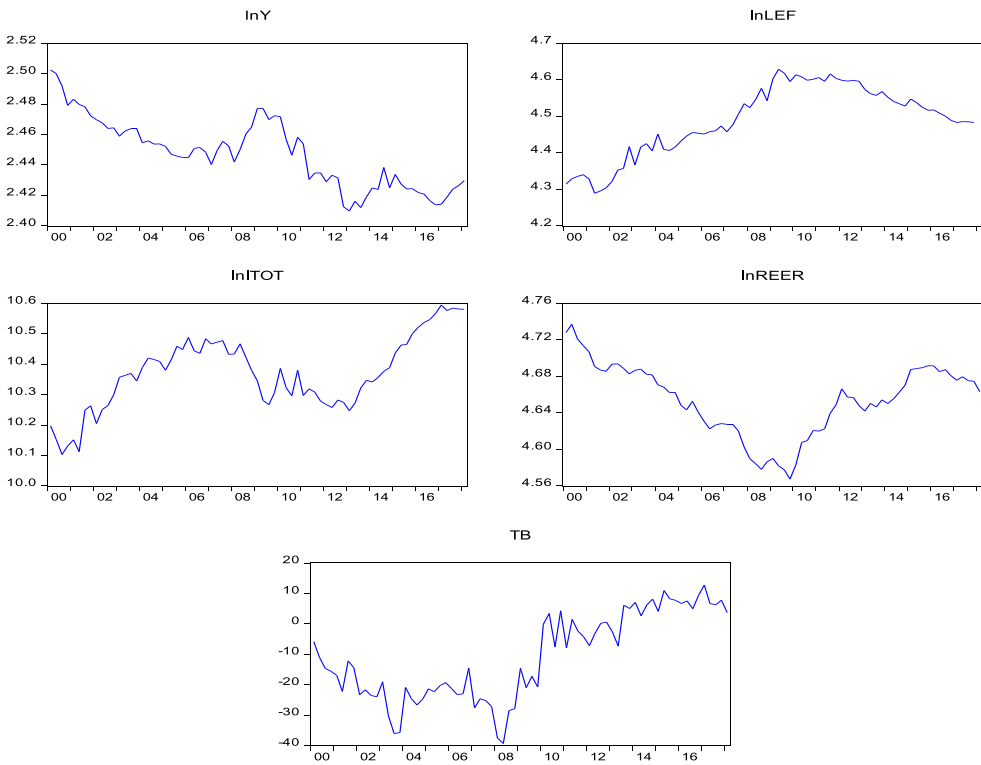
graphical display of the variables used in modelling

Figure A1. Graphical display of the variables used in modelling. Source: author's calculation.
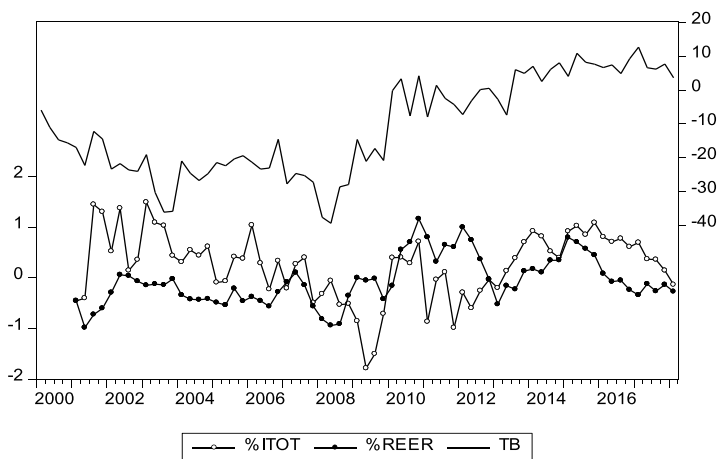
percentage change in income terms of trade and real effective exchange rate vs. trade balance

Figure A2. Percentage change in income terms of trade and real effective exchange rate vs. trade balance. Source: author's calculation.

Table A1. Variance decomposition from Model I.

Period	SE	ln*Y*	ln*LEF*	ln*ITOT*	TB
Variance decomposition of ln*ITOT*					
1	0.032600	1.148336	0.602049	98.24961	0.000000
2	0.047765	5.791124	4.899268	76.91625	12.39336
3	0.057248	7.676907	4.407920	70.32347	17.59170
4	0.064866	8.301163	4.354544	67.22664	20.11766
5	0.071693	8.623558	4.334288	65.23034	21.81181
6	0.077938	8.849957	4.331644	63.73854	23.07986
7	0.083704	9.014022	4.326140	62.62075	24.03909
8	0.089092	9.136684	4.322896	61.75964	24.78078
9	0.094170	9.232485	4.320629	61.07636	25.37053
10	0.098987	9.309788	4.318923	60.52113	25.85016
11	0.103580	9.373548	4.317532	60.06152	26.24739
12	0.107978	9.427064	4.316381	59.67500	26.58155
Variance decomposition of TB					
1	5.342580	3.377700	0.284951	14.47531	81.86204
2	5.850497	2.827096	4.090062	12.54520	80.53764
3	6.079221	2.629096	5.473781	11.95563	79.94150
4	6.301849	2.635989	6.795994	12.56498	78.00304
5	6.522672	2.776548	7.907810	13.60373	75.71191
6	6.739659	2.951361	8.921697	14.77923	73.34772
7	6.951365	3.128412	9.806785	15.94778	71.11702
8	7.157979	3.296921	10.59006	17.04244	69.07059
9	7.359311	3.452624	11.28799	18.04409	67.21530
10	7.555509	3.594621	11.91430	18.95423	65.53685
11	7.746842	3.723755	12.47934	19.78060	64.01630
12	7.933612	3.841320	12.99172	20.53231	62.63465

Source: author's calculation.

Table A2. Variance decomposition from Model II.

Period	SE	ln*OUTPUT*	ln*LEF*	ln*REER*	TB
Variance decomposition of ln*REER*					
1	0.008088	3.150575	0.001127	96.84830	0.000000
2	0.013025	1.617713	0.333547	95.67053	2.378208
3	0.016926	1.383857	0.298645	93.91233	4.405166
4	0.020522	1.227068	0.258734	91.91502	6.599181
5	0.023928	1.131597	0.216744	89.89179	8.759865
6	0.027214	1.061941	0.181589	87.94480	10.81167
7	0.030407	1.008333	0.152625	86.11685	12.72219
8	0.033521	0.965299	0.129211	84.42800	14.47749
9	0.036562	0.929763	0.110332	82.88098	16.07892
10	0.039534	0.899847	0.095104	81.47117	17.53388
11	0.042441	0.874284	0.082783	80.18971	18.85322
12	0.045283	0.852192	0.072772	79.02616	20.04887
Variance decomposition of TB					
1	5.878985	0.606450	0.005811	7.329996	92.05774
2	7.204447	1.649942	3.048787	8.770449	86.53082
3	8.308286	1.403963	3.181059	8.196950	87.21803
4	9.156346	1.420401	3.655662	7.980208	86.94373
5	9.874722	1.400470	4.000657	7.713406	86.88547
6	10.48768	1.405732	4.346387	7.472207	86.77567
7	11.02437	1.413704	4.673752	7.242245	86.67030
8	11.50090	1.426370	4.991924	7.026107	86.55560
9	11.92984	1.441084	5.301206	6.822624	86.43509
10	12.32019	1.457235	5.602708	6.631182	86.30888
11	12.67889	1.474162	5.896783	6.450993	86.17806
12	13.01129	1.491496	6.183634	6.281288	86.04358

Source: author's calculation.