Impact of Terms-of-Trade on Slovak Business Cycles

Martin Lukáčik, Karol Szomolányi, Adriana Lukáčiková

Abstract: Terms-of-trade is intuitively significant source of business cycles and it causes shifts in trade balance. However different theoretical and empirical studies lead to different results. Different theories suggest positive as well as negative relation between the terms-of-trade and trade balance. Empirical studies do not support statistically significant impact of terms-of-trade on output in developing countries. This result can support theoretical business cycle models considering non-tradable goods. Using structural vector auto-regression analysis of the terms-of-trade, trade balance, output, consumption and investment cyclical components we show that the terms-of-trade to trade-balance relationship is negative and that terms-of-trade shocks explain only small fraction of business cycles in the Slovak economy. We use quarterly data in constant prices with the range of years 1997-2014. The results are in line with theoretical and empirical studies in the contemporary world economic literature. Data exhibit Obstfeld-Svensson-Razin effect of the terms-of-trade on the trade balance and suggest considering non-tradable goods in the theoretical models.

Key words: Terms of Trade · Business Cycle · Slovak Economy · Trade Balance

JEL Classification: C32 · E32 · F14

1 Introduction

Terms-of-trade is theoretically significant source of business cycles and it causes shifts in trade balance. However different theoretical and empirical studies lead to different results of the short-run terms-of-trade impact on output and on trade balance. There are two theoretical effects of terms-of-trade impact on trade balance. Harberger (1950) and Laursen and Metzler (1950) used traditional Keynesian model to show that trade balance grows with terms-of-trade. On the contrary, dynamic optimizing models of Obstfeld (1982) and Svensson and Razin (1983) leads to a conclusion that positive effect of terms-of-trade on the trade balance is weaker the more persistent is a terms-of-trade shock. Uribe and Schmitt-Grohé (2015) showed that in small open economy real business cycle model (or dynamic stochastic general equilibrium model) with capital costs sufficiently permanent terms-of-trade shocks have negative impact on the trade balance. Empirical studies of Aguirre (2011), Broda (2004) and Uribe and Schmitt-Grohé (2015) surprisingly do not support statistically significant impact of terms-of-trade on output in poor and emerging countries. In general authors can confirm an intuition that the more open the economy is the higher effect of terms-on-trade on trade balance is. This result may be achieved in theoretical general equilibrium models only if non-tradable goods are considered. Uribe and Schmitt-Grohé developed so called TNT model (endowment economy model with tradable and non-tradable goods) to show that an existence of non-tradable goods “reduce the importance of terms-of-trade shocks.”

We verify an impact of terms-of-trade on the Slovak business cycle and on the trade balance. We provide an empirical measure based on structural vector auto-regression (SVAR) econometric specification similar to one presented by Uribe and Schmitt-Grohé using Slovak quarterly data since 1997 to 2014. We compute responses on terms-of-trade impulse and variance decompositions of terms-of-trade shocks. In result we will show that a terms-of-trade shock leads to the immediate decrease in trade balance and has no impact on aggregate output.

2 Methods

We used vector autoregressive (VAR) models for our analysis. It is well known that in VAR models every endogenous variable is a function of all lagged endogenous variables in the system. See Lütkepohl (2005) for more details about VAR models.

doc. Ing. Martin Lukáčik, PhD. University of Economics in Bratislava, Faculty of Business Economics, Department of Operations Research and Econometrics, Dolnozemská 1, 851 04 Bratislava, Slovakia, e-mail: lukacik@euba.sk
doc. Ing. Karol Szomolányi, PhD. University of Economics in Bratislava, Faculty of Business Economics, Department of Operations Research and Econometrics, Dolnozemská 1, 851 04 Bratislava, Slovakia, e-mail: szomolan@euba.sk
Ing. Adriana Lukáčiková, PhD. University of Economics in Bratislava, Faculty of Business Economics, Department of Operations Research and Econometrics, Dolnozemská 1, 851 04 Bratislava, Slovakia, e-mail: adriana.lukacikova@euba.sk
The mathematical representation of the unrestricted VAR model of order \( p \) is:

\[
y_t = A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + \varepsilon_t
\]

(1)

where \( y_t \) is a \( k \) vector of endogenous variables; \( A_1, A_2, \ldots, A_p \) are matrices of coefficients to be estimated; and \( \varepsilon_t \) is a vector of innovations that may be contemporaneously correlated but are uncorrelated with their own lagged values.

The VAR model (1) can be interpreted as a reduced form model. A structural vector autoregressive (SVAR) model is structural form of VAR model and is defined as:

\[
A y_t = B_1 y_{t-1} + B_2 y_{t-2} + \ldots + B_p y_{t-p} + \varepsilon_t
\]

(2)

It is assumed that the structural errors, \( \varepsilon_t \), are white noise and the coefficient matrices \( B_1, B_2, \ldots, B_p \) are structural coefficients that in general differ from their reduced form counterparts and \( B \) is matrix of restrictions on \( \varepsilon_t \).

A SVAR model can be used to identify shocks and trace these out by employing impulse response analysis and forecast error variance decomposition through imposing restrictions on used matrices. Uribe and Schmitt-Grohé proposed a specification of the SVAR, through which we can determine responses on terms-of-trade impulse:

\[
A t_{tot} = B_1 t_{tot-1} + B_2 t_{tot-2} + \ldots + B_p t_{tot-p} + \varepsilon_t
\]

(3)

where:

- \( tot \) relative cyclical component of the terms of trade
- \( tb \) relative cyclical component of the trade balance to output ratio
- \( y \) relative cyclical component of output
- \( c \) relative cyclical component of consumption
- \( i \) relative cyclical component of investment

The \( u_t^{rb}, u_t^{tot}, u_t^{c}, u_t^{i} \) and \( \varepsilon_t \) are structural shocks of given variables. We estimated the parameters of the SVAR specification (3) using Amisano and Giannini (1997) approach. The class of commonly used models may be written as:

\[
A e_t = B u_t
\]

(4)

The structural innovations \( u_t \) are assumed to be orthonormal, i.e., its covariance matrix is an identity matrix \( \Sigma_u = I \).

The assumption of orthonormal innovations imposes the following identifying restrictions on \( A \) and \( B \):

\[
\Sigma A^T = B B^T
\]

(5)

Noting that the expressions on both sides of (5) are symmetric, this imposes \( k(k+1)/2 = 15 \) restrictions on the \( 2k^2 = 50 \) unknown elements in \( A \) and \( B \). Therefore, in order to identify \( A \) and \( B \), we need to impose \( (3k^2- k)/2 = 35 \) additional restrictions. The matrix \( A \) of unrestricted specification is a lower triangular matrix with unit diagonal (10 zero and 5 unity restrictions) and matrix \( B \) is a diagonal matrix (20 zero restrictions) in this just-identified specification. Other tested restrictions are imposed on elements of matrix \( A \) (matrix of contemporary effects between endogenous variables), which means that our specification becomes over-identified and also testable.

The selected lag of model (3) is validated by sequential modified likelihood ratio test statistic and information criteria and by the LM test for autocorrelations. We can test them in the Table 1 and 2. Significant values of serial correlation for lower lags could be a reason to increase the lag order of an unrestricted VAR, but this is not our case. We verified the stability of a VAR model (i.e., whether all roots have modulus less than one and lie inside the unit circle). The result of this computation is in the Table 3. We estimated the parameters of restricted and unrestricted specifications. Using the logarithm of the maximum likelihood functions of both specifications we calculated the likelihood ratio statistics and verified the significance of restrictions in the Table 4. All tests are explained in Greene (2003) for example.

Using matrix polynomial in lag operator \( A(L) = B_1 L + B_2 L^2 + \ldots + B_p L^p \) we can rewrite (2) as SMA representation:

\[
y_t = [A - A(L)]^{-1} B u_t = C(0) u_t + C(1) u_{t-1} + \ldots + C(h) u_{t-h} + \ldots
\]

(6)

Hence, \( C(0) \) is the coefficient matrix on impact, \( C(1) \) at a one period lag, \( C(2) \) at a two period lag, and so on. Generally, \( C_{ij}(h) \) element is the impulse response of variable \( i \) to shock \( j \) at horizon \( h \). The forecast error of \( y \) at horizon \( s \) is:
\[ y_{t+h} - \hat{y}_{t+h} = C(0) u_{t+h} + C(1) u_{t+h-1} + C(2) u_{t+h-2} + \ldots + C(h) u_t \] (7)

Variance of the forecast error (assuming orthogonality) is expressed as sum of the individual variances of shocks:

\[ \text{var}(y_{t+h} - \hat{y}_{t+h}) = C(0) IC(0)^T + C(1) IC(1)^T + C(2) IC(2)^T + \ldots + C(h) IC(h)^T \] (8)

The fraction of the forecast error variance of variable \( i \) due to shock \( j \) at horizon \( h \), is then the \((i,j)\) element of expression (8) divided by the total forecast error variance and is expressed as a percentage. We calculated the impulse response functions and realized variance decomposition to quantify the short-term impact of shocks. Generally, the impulse response function traces the effect of a one-time shock in one of the innovations on current and future values of the endogenous variables and variance decomposition is a way to quantify how important each shock is in explaining the variation of each of the variables in the system.

Table 1: VAR Lag Order Selection Criteria

<table>
<thead>
<tr>
<th>Lag</th>
<th>LogL</th>
<th>LR</th>
<th>FPE</th>
<th>AIC</th>
<th>SC</th>
<th>HQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>849.7127</td>
<td>NA</td>
<td>7.70e-18</td>
<td>-25.21530</td>
<td>-25.05077</td>
<td>-25.15020</td>
</tr>
<tr>
<td>1</td>
<td>940.1206</td>
<td>164.6234*</td>
<td>1.10e-18*</td>
<td>-27.16778*</td>
<td>-26.18060*</td>
<td>-26.77715*</td>
</tr>
</tbody>
</table>

Source: Own processing

Table 1 shows the VAR lag order selection criteria. All criteria: sequential modified likelihood ratio test statistic (LR), Akaike information criterion (AIC), Schwarz information criterion (SC) and Hannan-Quinn information criterion (HQ) confirmed lag order 1 (asterisk nearby extreme value).

Table 2: VAR Residual Serial Correlation LM Tests

<table>
<thead>
<tr>
<th>Lags</th>
<th>LM-Stat</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>37.42832</td>
<td>0.0525</td>
</tr>
<tr>
<td>2</td>
<td>25.41611</td>
<td>0.4393</td>
</tr>
<tr>
<td>3</td>
<td>20.92892</td>
<td>0.6966</td>
</tr>
<tr>
<td>4</td>
<td>28.31958</td>
<td>0.2710</td>
</tr>
<tr>
<td>5</td>
<td>30.50831</td>
<td>0.2058</td>
</tr>
<tr>
<td>6</td>
<td>31.12115</td>
<td>0.1850</td>
</tr>
<tr>
<td>7</td>
<td>30.88250</td>
<td>0.1929</td>
</tr>
<tr>
<td>8</td>
<td>33.16054</td>
<td>0.1271</td>
</tr>
</tbody>
</table>

Probs from chi-square with 25 df.

Source: Own processing

We realized the autocorrelation test in order to eliminate possible wrong VAR lag order decision. Table 2 shows the results of the tests. The LM tests for autocorrelations did not reject the null hypothesis of any residual autocorrelations up to lag \( h \).

Table 3: VAR Stability Condition Check

<table>
<thead>
<tr>
<th>Root</th>
<th>Modulus</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.681944</td>
<td>0.681944</td>
</tr>
<tr>
<td>0.539852 - 0.256891i</td>
<td>0.597857</td>
</tr>
<tr>
<td>0.539852 + 0.256891i</td>
<td>0.597857</td>
</tr>
<tr>
<td>0.270690</td>
<td>0.270690</td>
</tr>
<tr>
<td>0.121938</td>
<td>0.121938</td>
</tr>
</tbody>
</table>

No root lies outside the unit circle.
VAR satisfies the stability condition.

Source: Own processing

Table 3 shows the verification of the stability of a VAR model. All roots have modulus less than one and lie inside the unit circle. The VAR satisfies the stability condition.

Table 4: Test of Over-Identification Restrictions

<table>
<thead>
<tr>
<th>Log likelihood</th>
<th>959.5133</th>
</tr>
</thead>
<tbody>
<tr>
<td>LR test for over-identification:</td>
<td>Chi-square(3) 4.807380</td>
</tr>
<tr>
<td>Probability</td>
<td>0.1865</td>
</tr>
</tbody>
</table>

Source: Own processing

The final specification of structural VAR model is over-identified, so we can test it using likelihood ratio statistics. The logarithm of the maximum likelihood function of unrestricted SVAR model is 961.917. We did not reject the null
hypothesis, likelihood test ratio equals to 4.8074 is less than critical value $\chi^2(3) = 7.8147$. The tested over-identifying restrictions are valid.

3 Research results

The responses to the terms-of-trade shock are in the Figure 1. As output shock elasticity coefficient is not statistically significant, the improvement in terms-of-trade has no impact on the aggregate activity and the one-quarter delayed output expansion is statistically insignificant. Investment displays a somewhat larger expansion, albeit with a one-quarter delay. Consumption expansion is slightly over the limit of statistical significance. The 10 % increase in the terms-of-trade causes an increase of 1.41 % in consumption. On the other hand, the impact of the terms-of-trade shock on trade balance is clearly statistically significant. The 10 % increase in the terms of trade causes a decrease of 6.7 % in trade balance. Furthermore a huger contraction is delayed by one quarter. The result suggests confirmation of Obstfeld-Svensson-Razin effect rather than Harberger-Laursen-Metzler effect of the terms-of-trade.

Figure 1 Impulse Response Functions to Terms-of-Trade (TOT) Shock

Source: Own processing

To gauge the importance of the terms-of-trade shock we compute the fraction of the variance of all indicators of interest explained by terms-of-trade, i.e. the variance decomposition. In the Table 5 are computed these fractions. In the first row fractions of the variance are computed immediately after the term-of-trade shock realisation. In the second row these fractions are computed 40 lags (10 years) after terms-of-trade shock realisation, when responses are stable.

Table 5 Share of Variance Explained by Terms-of-Trade Shocks in Slovakia

<table>
<thead>
<tr>
<th></th>
<th>tot</th>
<th>tb</th>
<th>y</th>
<th>c</th>
<th>i</th>
</tr>
</thead>
<tbody>
<tr>
<td>immediate</td>
<td>100</td>
<td>15.7</td>
<td>0</td>
<td>1.2</td>
<td>3.3</td>
</tr>
<tr>
<td>after 40 lags</td>
<td>83.5</td>
<td>37.8</td>
<td>1.9</td>
<td>8.2</td>
<td>14.9</td>
</tr>
</tbody>
</table>

Source: Own processing

Results in the Table 5 are in line with the papers of Aguirre (2011), Broda (2004) and Uribe and Grohé-Schmitt (2015). The terms-of-trade shocks explain a very little fraction of the output variance in Slovakia as well as in poor and emerging countries.
4 Conclusions

The terms-of-trade has significant impact on the trade balance in Slovakia. Negative correlation of the terms-of-trade with the trade balance supports Obstfeld-Svensson-Razin effect rather than Harberger-Laursen-Metzler effect. As Uribe and Grohé-Schmitt (2015) showed this correlation is in average positive in the developing countries over the world. Our result suggests that terms-of-trade shocks are relatively highly persistent in Slovakia. Our result confirm the evidence of Aguirre (2011), Broda (2004) and Uribe and Grohé-Schmitt (2015) that terms-of-trade shocks explain a very little fraction of the output variance in emerging countries including Slovakia. This evidence can be theoretically explained by an existence of non-tradable goods. A challenge is to form and calibrate theoretical dynamic stochastic general equilibrium model with non-tradable goods explaining a contribution of the trade balance on short-run macroeconomic performance.

Acknowledgement

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References