STUDIA EKONOMICZNE ● ECONOMIC STUDIES
NR 1 (XCII) 2017

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SUSTAINABILITY OF PUBLIC DEBT STOCK IN TRANSITION ECONOMIES IN CENTRAL AND EASTERN EUROPE COUNTRIES IN TERMS OF SOLVENCY

(Artykuł nadesłany: 20.03.2017 r.; Zaakceptowany: 25.05.2017 r.)

ABSTRACT

In this article we examine the sustainability of public debt stock in terms of solvency in CEE countries using Ata Ozkaya's Stepwise Algorithm modified by Zivot-Andrews test to establish the level of integration variables. Such an approach allows us to examine the presence of structural breaks which occurred since the global financial crisis in the fourth quarter of 2008. We find that despite temporal fiscal turbulences during the crisis, all countries of Central and Eastern Europe have stabilised their fiscal policies.

Keywords: public debt sustainability, intertemporal budget constraint, time series analysis, transition economies, CEE countries.

JEL Classification: C22, E60, H63

1. INTRODUCTION

Since the Maastricht Treaty and the Stability and Growth Pact (SGP) fixed the maximum values of the EU member states' public debt stock at 60% of GDP

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and budget deficit at 3% of GDP, the question of sustainable fiscal policy has gained importance in the European economic policy recommendations (Buiter, 2003). Moreover, this problem has become even more significant after the financial turmoil in 2008, when both developed and emerging economies rapidly increased their levels of fiscal stimulation, which in GIIPS countries (Greece, Ireland, Italy Portugal and Spain) evoked a serious crisis on the sovereign debt market (Arnold & van Ewijk, 2014).

After the financial crisis the problem of public debt stock sustainability has been examined quite deeply for advanced economies, especially in the European Monetary Union (Ozkaya, 2014), as well as for transition economies of Central and Eastern Europe (Krajewski, Mackiewicz, Szymańska, 2016).

The aim of this article is to examine the sustainability of the public debt stock in transition economies of Central and Eastern Europe and to cross-validate the results with the recent research in this area by Krajewski, Mackiewicz & Szymańska (2016).

The method used in this study corresponds to Ozkaya's (2013) econometric stepwise test algorithm. This method could be described as a creative compilation of the stationarity and co-integration tests and is deeply rooted in previous influential works by Trehan &Walsh (1991), Hakkio &Rush (1991), and Bohn (1995). Furthermore, because of the fact that Ozkaya combined integration tests and co-integration test of the relation between government expenditures and revenues, there is no need to introduce in his step wise test algorithm distinction between sustainability in a weak and a strong sense. For this reason we have decided to use this method. However, contrary to Ozkaya, we propose using the Zivot-Andrews test of the level of integration of time series, which includes non-exogenous testing of occurring structural breaks. Actually, the possibility of the usage of the Zivot-Andrews test has been signaled in the work by Krajewski, Mackiewicz & Szymańska (2016). However, in the part dedicated to integration and co-integration tests the authors limited their analysis only to standard tests (ADF and PP) and divided their time series into two periods: which included the crisis data (years 1990–2012) and without the crisis data (years 1990–2008).

2. MOTIVATION

The question of sustainable fiscal policy and public debt stock was addressed in economic policy recommendations by European Commission, International Monetary Fund (IMF) and The Organisation for Economic Co-operation and Development (OECD), as well as in the academic discussion. As global financial crisis begun in 2008, many countries all over the world increased their government expenditures, while at the same time their tax revenues dropped. In 2009 vast majority of EU member states exceeded the limit for deficit and public debt provided by the Art. 126 in Stability and Growth Pact (SGP), what implied imposing on them a fiscal policy corrective mechanism – Excessive Deficit

Procedure (EDP). Despite the fact that practically no country was seriously punished by the European Commission, the economic policy in the European Union addressed the problem of unsustainable public debt stock, which could be seen in 2011 in a proposal of package of fiscal reforms in 2011 (Six Pack) and in 2013 (Two Pack), (Nawrot et al., 2014). Moreover, the EU Council strongly recommended introducing numeric fiscal rules in Directive 2011/85/EU. Noteworthy, similar fiscal rules had been recommended by the OECD even before the crisis (OECD, 2007).

In *Fiscal Sustainability Report,* European Commission assesses fiscal sustainability of the EU member states in the medium and long run, using horizontal fiscal sustainability assessment framework – Debt Sustainability Analysis (European Commission, 2015). European Commission's framework distinguishes two approaches: (1) the analysis of fiscal sustainability indicators and deterministic projections of the level of debt over the 10-year horizon, and (2) stochastic projections over the 5-year horizon (Berti, 2013).

Also International Monetary Fund pays close attention to sustainable fiscal policy. That has been expressed in IMF's framework Debt Sustainability Analysis (IMF, 2011, 2013) and in annual *Article IV consultations*, which focuses on member countries' fiscal surveillance.

The influence of sovereign debt crisis upon economic policy has been reflected in academic discussion. One of the possible outcomes of excessive level of public debt stock is distortive effect. Such an outcome can appear especially in a country's fiscal or monetary policy. High levels of public debt could force governments to impose distortive taxes (either through conventional taxes or through inflation) with an aim of servicing their debt stocks (Shadler, 2016).

For the purposes of the analysis, a distinction between advanced and emerging economies should be stressed. For instance, there are differences in the relationship patterns between high level of public debt stock and inflation in advanced economies and in emerging ones. Moreover, there is a significantly much more restrictive threshold point for total gross external debt stock (both public and private) in advanced than in emerging economies (Reinhart & Rogoff, 2010). That is one of the premises for examining more closely sustainability of public debt stock in transition economies in Central and Eastern Europe.

There is no controversy in a statement that if public liabilities continuously accumulate, they may endanger a country's economic policy in the future (Polackova-Brixi et al., 2001). That is for us yet another reason for analysing this question, as unsustainable path of public debt stock could be an important warning indicator of potential debt crisis.

Finally, we would like to make use of Ata Ozkaya's recent work which analyses sustainability of public debt in selected OECD countries including Poland (Ozkaya, 2013). The author proposed an econometric procedure, a Stepwise Algorithm, that was actually based on a few former influential heuristics (Trehan & Walsh, 1991; Hakkio & Rush, 1991; Bohn, 1995). However, Ozkaya focused only on the biggest economies and omitted smaller countries, specifically transition economies in Central and Eastern Europe. Furthermore, for the data for 4th quarter of 2008 (and in case of Poland also 1st quarter of 2014) a structural break in the level of public debt stocks in relation to GDP can be observed, which suggest that for the tests of the level of integration Zivot-Andrews test should be used instead of classic ADF, KPSS and PP tests (Burke & Hunter, 2005; Pfaff, 2008; Glynn et al., 2007; Kirchgässner et al., 2013; Neusser, 2016).

To sum up, based on Ozkaya's framework (including additional testing of structural breaks in establishing the level of integration of the variables with Zivot-Andrews test) our research objective is to answer the question whether public debt stock in transition economies in Central and Eastern Europe is sustainable in terms of solvency.

3. LITERATURE REVIEW

There are three main approaches to analysing fiscal sustainability (Dreher et al., 2006):

- unwillingness-to-pay,
- illiquidity,
- insolvency.

From the macroeconomic point of view, the most interesting is the insolvency approach. The question of solvency could be analysed in two further ways. The first one assumes a short–term perspective and concentrates on evaluating and analysing a large number of aggregated macroeconomic ratios, eg. public debt stock/GDP or primary budget surplus/GDP (Croce & Juan-Ramon, 2003). The second approach could be associated with long-term prospects and was rooted in econometric analysis. The essence of this method is to examine the solvency condition, which means that the flow of future primary surpluses will not be lower than the net value of current liabilities. Specifically, the analysis of stationarity enables examining government's intertemporal budget constraint (intertemporal country's solvency). Such an analysis provides a useful tool, which helps establishing whether a country will be able to handle the public debt stock without defaulting (Hamilton & Flavin, 1986; Wilcox, 1989; Trehan & Walsh, 1991; Hakkio & Rush, 1991; Bohn, 1995; Makrydakis et al., 1999).

It should be noted that from the point of view of econometric analysis the term of sustainability is equal to the stationarity (I(0)), thus, specifically, if public debt stock is stationary, then *ceteris paribus* we can assume that country's fiscal policy is sustainable. If public debt stock is non-stationary, then there are two possible cases: either the condition of non-Ponzi game (transversality) is not fulfilled or the sum of the present values of future deficits is non-stationary. Trehan and Walsh (1991) noted that the convergence of the present values of the future deficits was equivalent to the fulfilling of the non-Ponzi game condition. In turn, Hakkio and Rush (1991) pointed out that the existence of at least one co-integration relationship (with a co-efficient vector of specific type) between total tax revenues and total government expenditures was a necessary and sufficient condition for sustainability of fiscal policy. Eventually, Bohn (1995) proposed that the existence of at least one co-integration relationship (with any co-efficient vector) between primary budget surplus and public debt stock was sufficient for preserving of public debt sustainability.

One of the alternative approaches to examining fiscal sustainability has been built on the framework of fiscal reaction functions (Bohn, 1998; de Mello, 2005; Mendoza and Ostry, 2008). Moreover, even Bohn (2007) argued against credibility of unit root tests and co-integration analysis in evaluating fiscal sustainability. However, recently Ozkaya (2013, 2014) proposed a synthesis of the earlier frameworks, which used unit root tests and co-integration analysis.

It is worth to mention, that testing of fiscal sustainability would require perfect knowledge of the distribution of sovereign debt stock in the future throughout different, unknown states of nature (Ciżkowicz, Rzońca, Trzeciakowski, 2015).

Last but not least, a very interesting example of a complex examination of public debt stock sustainability was dedicated to Central and Eastern European countries (Krajewski, Mackiewicz, Szymańska, 2016). The authors used panel stationarity and co-integration tests, as well as fiscal reaction functions. This research requires a few remarks. Firstly, the authors limited their research sample to the years 1990–2012. One can argue that data before the year 2004 (EU enlargement) could not be reliable enough, mostly because of the differences in the methodology of national accounts. Secondly, such a sample did not include the further post-crisis years, which could have a significant impact upon final conclusions. Furthermore, despite the fact that the authors signaled a possibility of using the Zivot-Andrews test in establishing the level of the integration of the variables, they limited their analysis to standard tests such as ADF and PP. Since the financial crisis of 2008 strongly influenced the results of the analysis of the integration tests, the authors decided to divide the research sample into two periods:

- 1990 to 2012 (including the crisis data),
- excluding the crisis period 1990 to 2008.

However, when we use the Zivot-Andrews test, there is no need to divide the analysis into two periods, because the impact of a potential structural break would have been already included (Zivot & Andrews, 1992).

4. THEORETICAL BACKGROUND AND RESEARCH METHOD

In his recent work Ozkaya (2013) revisited classic works by Trehan & Walsh, Hakkio & Rush and Bohn. He made a creative synthesis of the aforementioned approaches, proposing an econometric, sequential procedure, a compact Stepwise test Algorithm. We will look more closely to this procedure and focus on the theoretical background used in this article.

Ozkaya's Stepwise test algorithm is sequential and consists of four steps (see graph 1):

- Step 1: unit root test of public debt stock over GDP,
- Step 2: unit root test of primary surplus over GDP,
- Step 3: examining co-integration relationship between government expenditures over GDP and tax revenues over GDP,
- Step 4: examining co-integration relationship between primary balance over GDP and public debt stock over GDP.

Step 1 of this framework was rooted in a standard approach to the analysis of sustainability of public debt stock, with origins in a general budget identity (Burda & Wyplosz, 2013):

$$D_T = (1 + i_T)D_{T-1} + E_T - R_T \tag{1}$$

where:
D_T – volume of public debt stock at the end of period T,
i_T – nominal ex-post interest rate during period T,
E_T – volume of total public expenditures in period T,
R_T – volume of total tax revenues in period T.

It is worth noting that for the sake of simplification we include the revenues from seignorage in the ex-post interest rate i_T. By forward induction (and provided that the period goes to infinity) we can show general budget identity (1) as:

$$D_T = \lim_{k\to\infty}\left(D_{T+k}\cdot\rho_{T,k}\right) - \sum_{n=1}^{k=\infty}\left(E_{T+n} - R_{T+n}\right)\cdot\rho_{T,n} \tag{2}$$

where:
$\rho_{T,k} = \prod_{j=1}^{k}\left(1 + i_{T+j} - \pi_{T+j} - \mu_{T+1}^{r}\right)^{-1}$,
π_T – rate of change in level of prices in period T,
μ_{T+1}^{r} – real growth rate.

We can describe $\rho_{T,k}$ as k-period forward discount factor adjusted by ex-post interest rate, inflation and nominal rate of growth.

As it has been already mentioned in a previous section, the first part of equation (2) on the right side represents transversality condition (non-Ponzi game) and this expression should converge to 0. In turn, the second part. This equation on the right side stands for the sum of the present values of expected future budget deficits and represents intertemporal budget constraint. In an econometric analysis the notion of sustainability is equal to stationarity. In particular, fiscal policy is assessed as sustainable, if public debt stock is stationary I(0). Otherwise, we should consider the case of non-stationarity. In such cases in step wise algorithm we should move to the step 2.

The idea behind step 2 is rooted in examining of intertemporal budget constraint, particularly examining the level of integration of primary surplus (Trehan & Walsh, 1991). We consider 3 cases:

a) if primary surplus is stationary I(0), then we have to move to step 3,

b) if primary surplus is non-stationary and in particular is I(1), then we move to step 4,

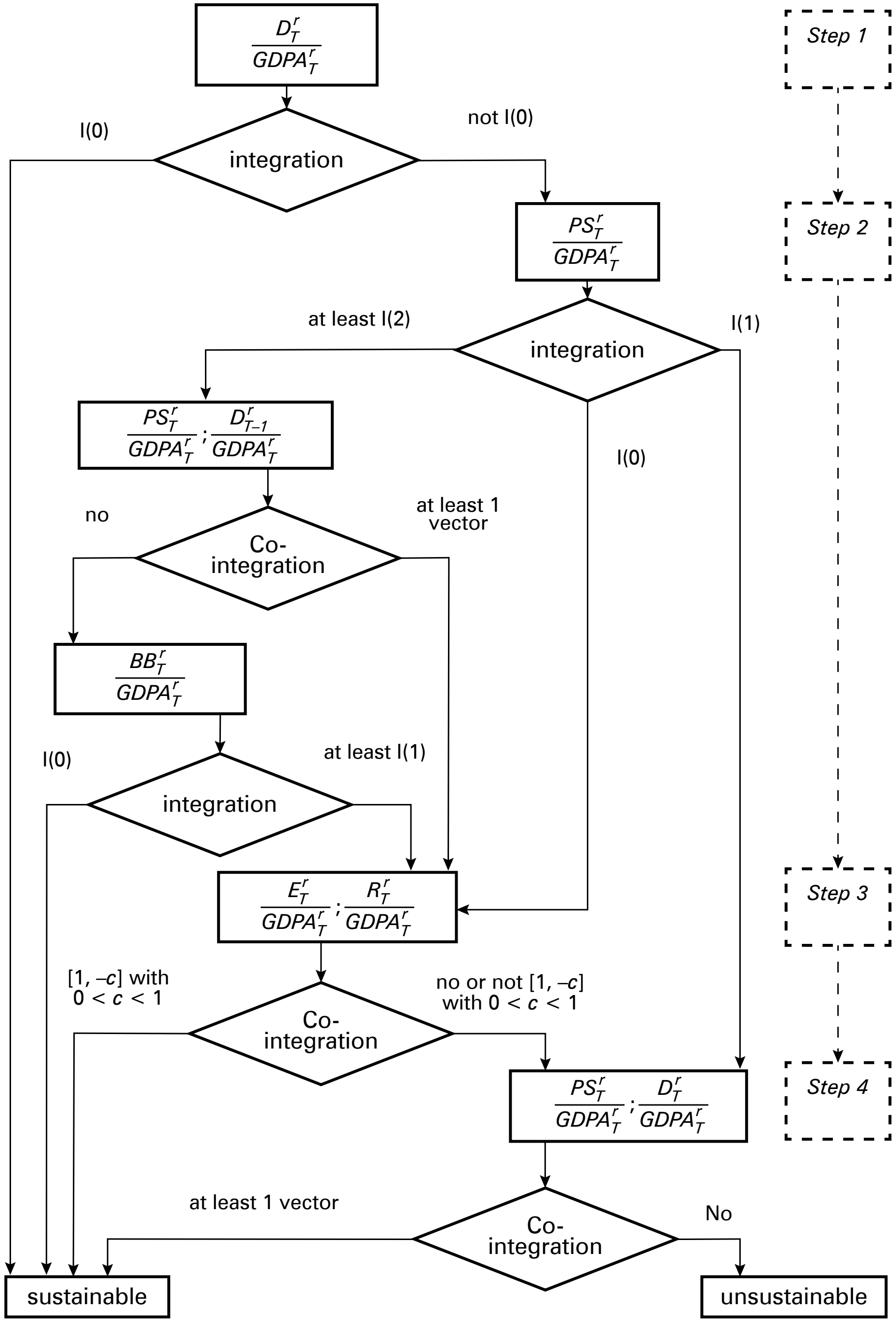
c) if primary surplus is non-stationary and the level of integration is at least I(2), then according to Johansen's procedure we seek at least 1 co-integration relation between the primary surplus over GDP and the public debt stock (1-period lagged) over GDP. If there is such a relation then we can assess that public debt stock is sustainable. In turn, if there is no co-integrating vector, then we check the level of integration of budget balance. If budget balance is stationary I(0), then public debt stock is sustainable. Otherwise we move to step 3.

Step 3 of the algorithm is a test of co-integration relation between total government expenditures over GDP and total tax revenues over GDP. If co-integrating vector is of the form $(1, -c)$, provided that c fulfils inequality $0 < c < 1$, then public debt stock could be assessed as sustainable (Hakkio & Rush, 1991). Otherwise, we move to step 4.

In step 4 the main idea is to test if there is at least one co-integration relationship between primary surplus and public debt stock. Such a test allows to examine both intertemporal budget constraint and transversality conditions (Bohn, 1995). If there is no co-integration relation, public debt stock is unsustainable. It is worth noting that due to including both integration test of public debt stock and co-integration test of the relation between government revenues and expenditures there is no need in Ozkaya's algorithm to distinguish strong from weak sustainability.

We would like to stress that contrary to Ozkaya we have used Zivot-Andrews unit root test. The rationale is that in many European countries we could observe structural breaks in the fiscal policy in the data for 4th quarter of 2008, and in Poland also in 1st quarter of 2014 as a consequence of redemption of the government bond portion of the assets of pension funds. As a result, using standard unit root tests such as ADF, KPSS and PP we cannot definitively conclude that after such a break a government's fiscal policy was unsustainable (Burke & Hunter, 2005; Pfaff, 2008; Glynn et al., 2007; Kirchgässner et al., 2013; Neusser, 2016). Furthermore, the importance of structural breaks in the level of integration public debt stock time series has been noticed in academic debate even before financial crisis (Uctum, Thurston, Uctum, 2006). In order to check co-integration relationships we have chosen to use Johansen's test (both eigen values test and trace test) (Johansen, 1991; Pfaff, 2008).

Figure 1. Stepwise Algorithm



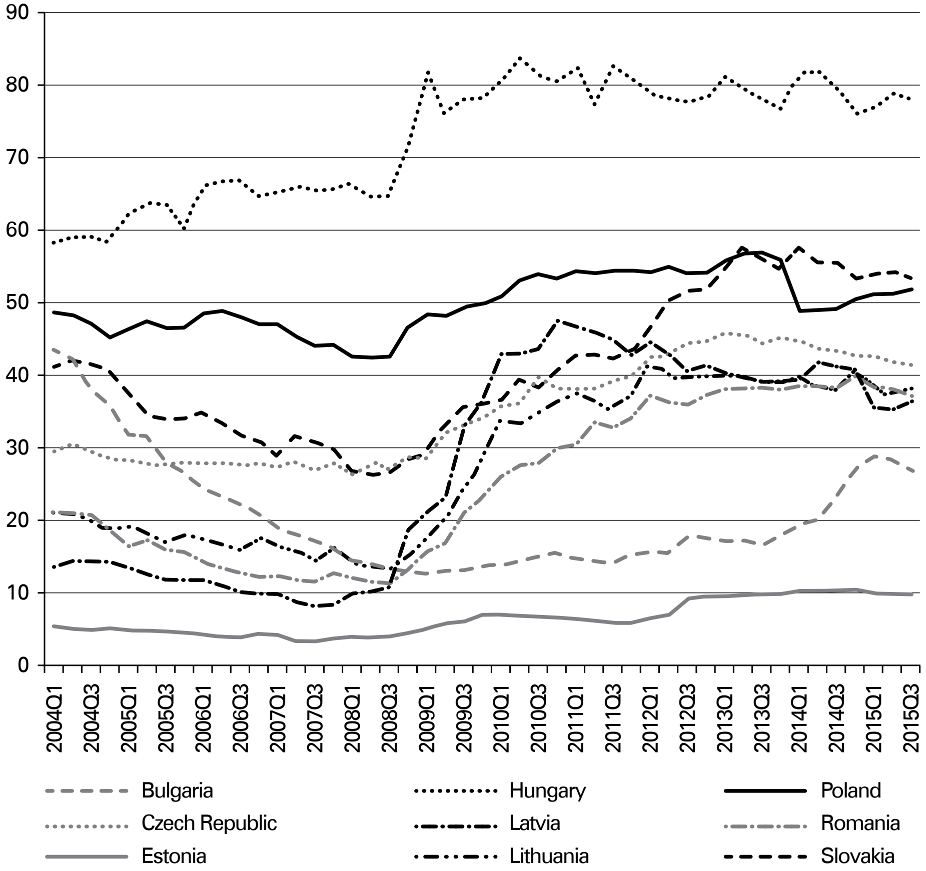
Source: own elaboration based on Ozkaya (2013).

5. DATA

We collected quarterly data from Eurostat for the period from 1st quarter of 2004 to 3rd quarter of 2015 for transition economies in Central and Eastern Europe for the following categories: government consolidated gross debt (D), total general government expenditure (E), total general government tax revenue (R), primary budget surplus (PS) and budget balance (BB). The unit of all the variables was percentage of GDP. The group of CEE states in our research included 9 countries: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania and Slovakia. We decided to collect the data beginning from the year 2004 because then many Central and Eastern European states joined the European Union and their economic transition to the large extent came to an end.

Figure 2 shows a significant increase in the level of public debt stock in CEE countries since the 4th quarter of 2008. It resulted from fiscal expansion and

Figure 2. Government consolidated gross debt (D) in CEE countries as percentage of GDP

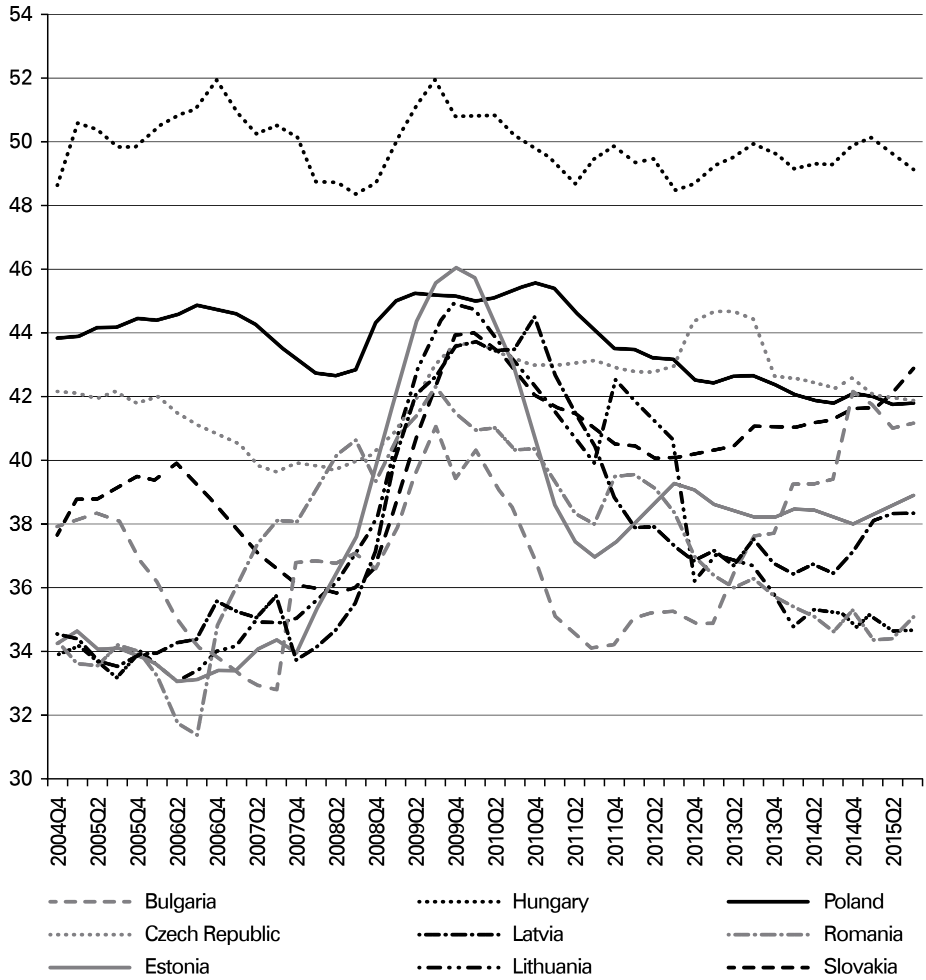


Source: Eurostat.

a drop in tax revenues after outbreak of global financial crisis. Noteworthy, public debt stocks of Slovakia, Poland, Czech Republic, Lithuania, Romania, Latvia, Bulgaria and Estonia did not exceed the level of 60% of their GDP after the crisis. In Hungary, public debt stock stabilized in 2009 at around 80% of GDP. A rapid drop in Poland's debt in 1st quarter of 2014 was a result of the redemption of the government-bond share of pension funds' assets.

Figure 3 shows that Hungary had on average the most expansionary economic policy in 2004–2015 and the biggest fluctuations were in Bulgaria and Latvia. It should be mentioned that government expenditures in every country are cyclical and differ between quarters. Local peaks are usually at the end of a year

Figure 3. Moving average of total general government expenditure (E) in CEE countries as percentage of GDP

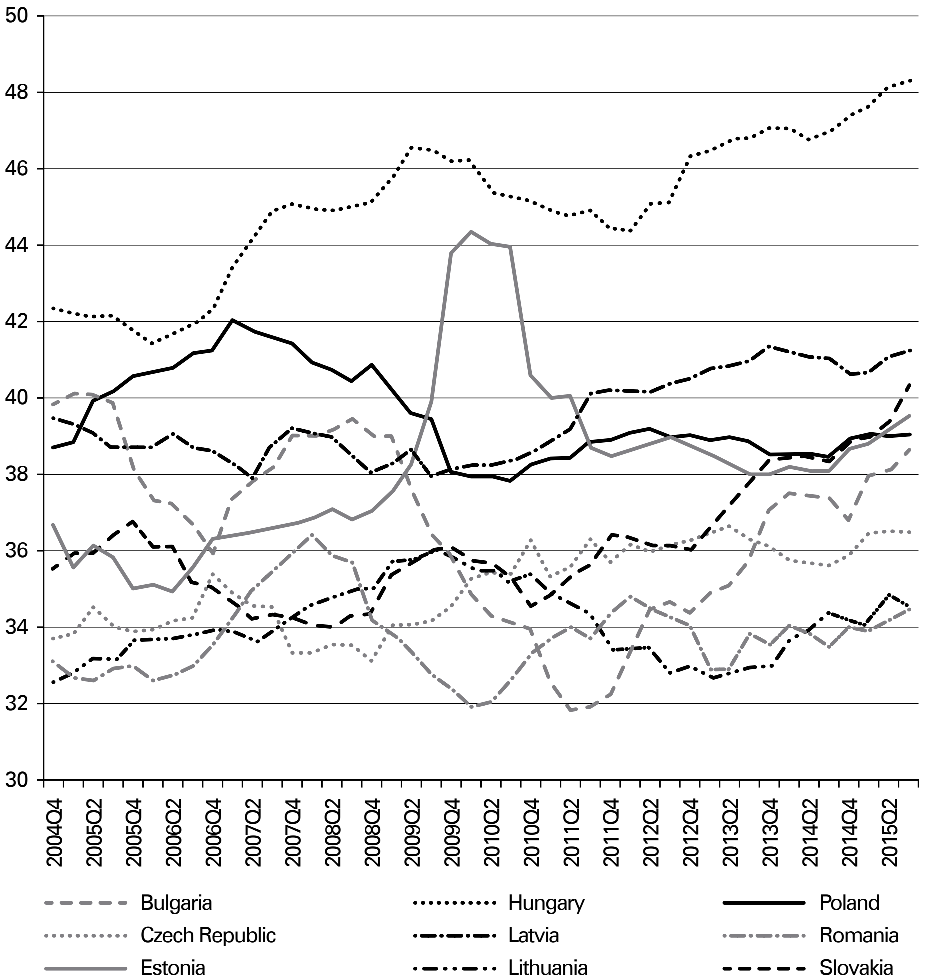


Source: Eurostat.

(4th quarter) and local minimums are in the 3rd quarter. In line with this, there are significant increases in government spending in 4th quarter of 2008 in almost every CEE country.

Figure 4 shows indirectly the effectiveness of tax collection. On average, the biggest share of tax revenues in GDP in 2004–2015 was achieved in Hungary and the smallest was registered Romania and Lithuania. It should be noted that Estonia had extraordinary high tax inflows in 4th quarter of 2009, however it was a one-time event. Similarly to government expenditures, tax collection in every country is a cyclical process throughout the year and inflows to the state's budget are higher in some quarters than in others. The peaks are usually in the 1st quar-

Figure 4. Moving average of total general government tax revenue (R) as percentage of GDP



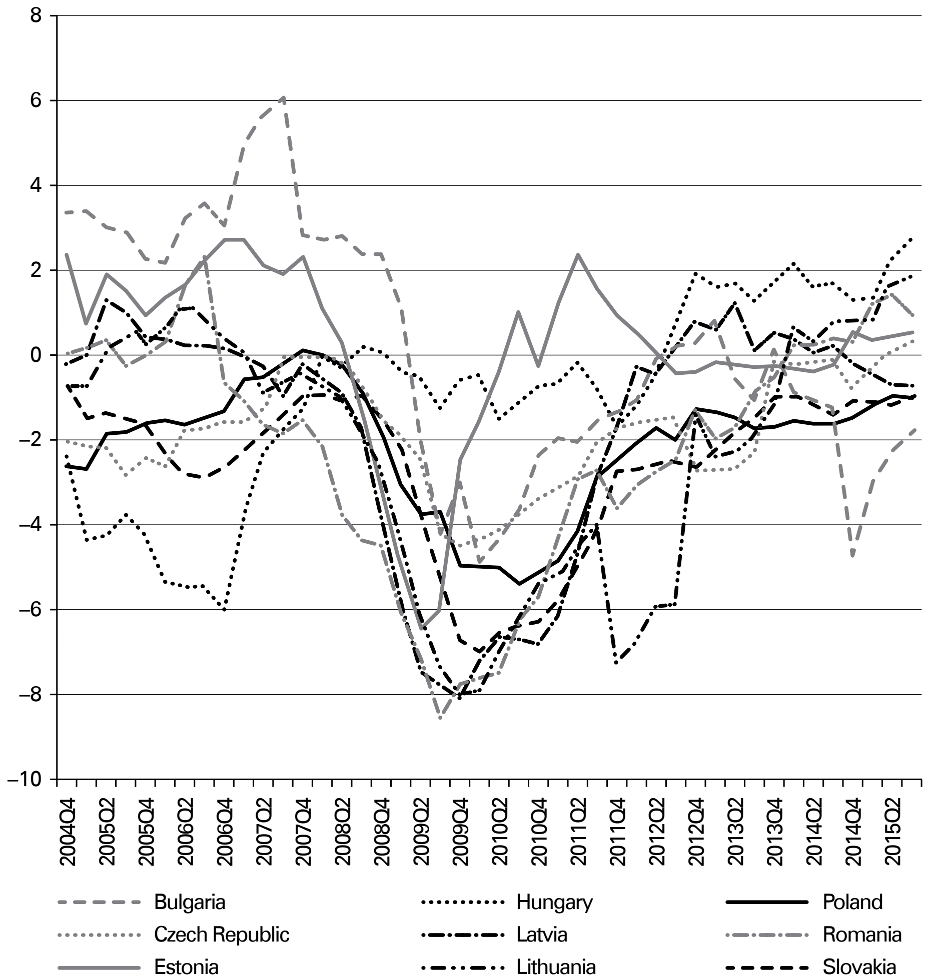
Source: Eurostat.

ter and local minimums are in 3rd and 4th quarter, but the second half of the year 2009 was the worst for state budget in the majority of CEE countries.

The amplitude of fluctuations of primary surplus in the crisis years 2008–2011 in CEE countries (see Figure 5) was clearly higher than in ordinary times. Almost every country achieved local extreme values in primary budget surplus (minimum and maximum) that followed quarter by quarter. Hungary and Bulgaria were exceptions. The former had its serious budgetary problems in 2006, before the global financial crisis, while the latter had its budgetary turmoil also in the 4th quarter of 2012.

The results of budget balance usually to a large extent derive directly from primary budget surplus. In CEE countries, a massive impact of the global financial

Figure 5. Moving average of primary budget surplus (PS) as percentage of GDP

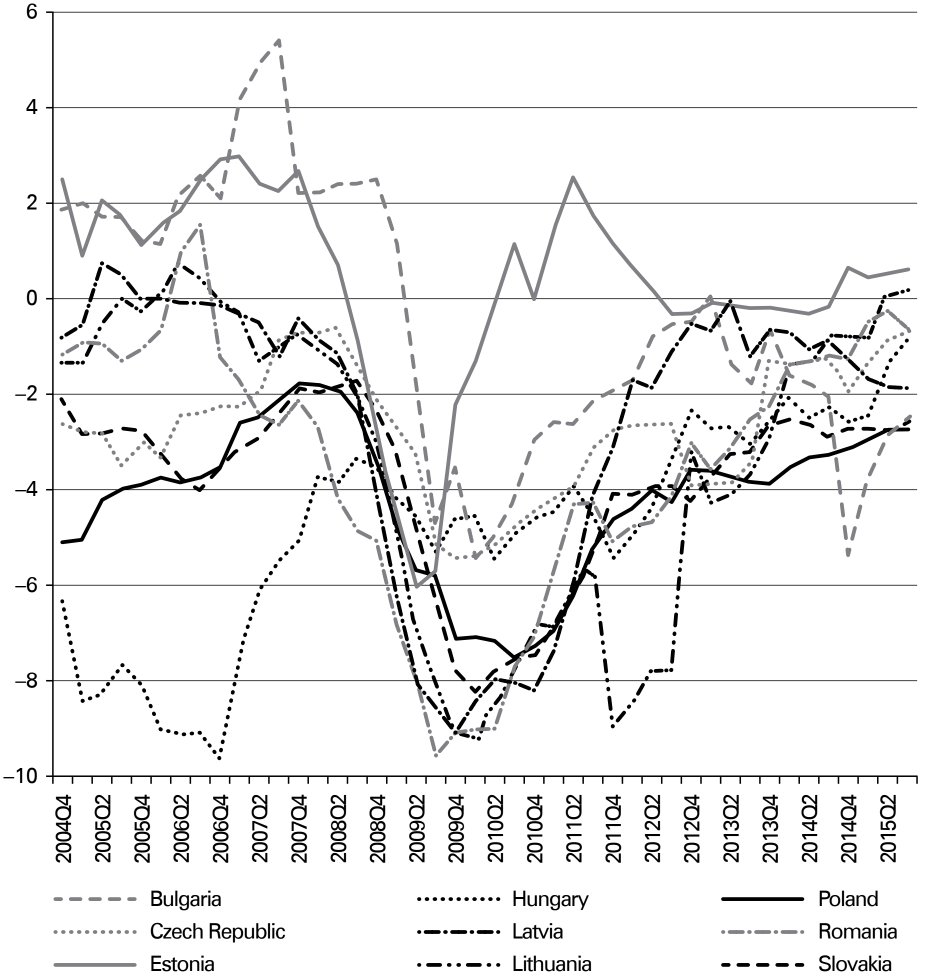


Source: Eurostat.

crisis on the levels of budget deficits can be seen (see Figure 6). However, since 1st quarter of 2012 fiscal condition began to improve gradually, with the exception of Bulgaria at the end of 2012.

To sum up, quarterly budgetary data of CEE countries in 2004–2015 show many significant ups and downs that often followed quarter by quarter. This could be the premise that in many cases we had to deal with structural breaks. However, in majority of countries fiscal condition since 1st quarter of 2012 begun to stabilise. As a result, we argue that in order to examine the level of integration of time series standard unit root tests (ADF, PP and KPSS) would be insufficient and some other approach (especially Zivot-Andrews test) would be required.

Figure 6. Moving average of budget balance (BB) as percentage of GDP



Source: Eurostat.

6. RESULTS

We used 4 different unit root tests, i.e. ADF, PP, KPSS and Zivot-Andrews to establish the level of integration of every variable for each state from the peer group of CEE countries. However, for us the ultimate criterion was the result of Zivot-Andrews test.

The idea behind estimation algorithm in Zivot-Andrews test is to choose the date of the structural break for the point in time which gives the least favourable result for the null hypothesis of a random walk with drift. Contrary to Perron, Zivot and Andrews (1992) proposed that this break point is set endogenously, because then the risk of data mining is minimised.

The test statistic in Zivot-Andrews test is Student t ratio:

$$t_{\hat{\alpha}} = \inf_{\lambda \in \Delta} t_{\hat{\alpha}}\left(\lambda\right) \tag{3}$$

where Δ is a subset of (0;1).

In a model with break both in intercept and trend the test statistic is inferred from the following test regression (Pfaff, 2008):

$$y_t = \hat{\mu} + \hat{\theta} DU_t\left(\hat{\lambda}\right) + \hat{\beta} t + \hat{\gamma} DT_t^*\left(\hat{\lambda}\right) + \hat{\alpha} y_{t-1} + \sum_{i=1}^{k} \hat{c}_i \Delta y_{t-1} + \hat{\varepsilon}_t \tag{4}$$

where

$DU_t\left(\lambda\right) = 1$ if $t > T$ and 0 otherwise;

$DT_t^*\left(\lambda\right) = t - T\lambda$ for $t > T\lambda$ and 0 otherwise.

For our calculations we used GNU R and a package urca (see Appendix 1). In every test we chose the level of significance of 5%. In line with our previous data exploration in all cases we accepted hypothesis about occurrence of structural break. This indicates that the use of Zivot-Andrews test was justified.

The results of unit root tests for steps 1 and 2 of Stepwise Algorithm for public debt stock and primary surplus, respectively, are depicted in Table 1.

In all CEE countries but Hungary, debt stock was non-stationary. Public debt stock in Hungary is stationary with structural break in 1st quarter of 2009. In other CEE countries public debt stock was non-stationary and structural breaks occurred since 4th quarter of 2008. In turn, primary surplus in all cases was stationary and in almost every CEE country there was a structural break in 4th quarter of 2008.

Results of Zivot-Andrews test suggest that both government expenditures and government revenues in CEE countries were stationary (see Table 2). However, for expenditures, there was a structural break in 4th quarter of 2008 in 6 out of 9 countries. As for government revenues, structural breaks usually occurred later than for expenditures. The fact that Zivot-Andrews test indicates that both expenditures and revenues are stationary means that fiscal policy is sustainable in terms of Stepwise Algorithm (Ozkaya, 2013).

Table 1. Unit root test results for public debt stock and primary surplus as percentage of GDP

Country	Debt stock/GDP					PS/GDP				
	ADF	PP	KPSS	ZA (intercept & trend)		ADF	PP	KPSS	ZA (intercept & trend)	
Poland	I(2)	I(1)	I(1)	I(1)	2014Q1	I(1)	I(0)	I(0)	I(0)	2008Q4
Bulgaria	I(2)	I(1)	I(2)	I(1)	2014Q4	I(1)	I(0)	I(0)	I(0)	2008Q4
Czech Republic	I(2)	I(1)	I(1)	I(1)	2009Q2	I(1)	I(0)	I(0)	I(0)	2008Q4
Estonia	I(2)	I(1)	I(1)	I(1)	2012Q1	I(1)	I(0)	I(0)	I(0)	2009Q3
Hungary	I(1)	I(1)	I(1)	I(0)	2009Q1	I(1)	I(0)	I(1)	I(0)	2007Q2
Latvia	I(2)	I(1)	I(1)	I(1)	2010Q2	I(2)	I(0)	I(0)	I(0)	2008Q4
Lithuania	I(2)	I(1)	I(1)	I(1)	2009Q1	I(1)	I(0)	I(0)	I(0)	2008Q4
Romania	I(2)	I(1)	I(2)	I(1)	2008Q4	I(1)	I(0)	I(0)	I(0)	2008Q4
Slovakia	I(2)	I(1)	I(2)	I(1)	2013Q3	I(2)	I(0)	I(0)	I(0)	2009Q2

Source: own elaboration.

Table 2. Unit root test results for government expenditure and revenues as percentage of GDP

Country	Exp/GDP					Rev/GDP				
	ADF	PP	KPSS	ZA (intercept & trend)		ADF	PP	KPSS	ZA (intercept & trend)	
Poland	I(1)	I(0)	I(1)	I(0)	2008Q4	I(1)	I(0)	I(1)	I(0)	2009Q2
Bulgaria	I(1)	I(0)	I(0)	I(0)	2007Q4	I(1)	I(0)	I(0)	I(0)	2009Q3
Czech Republic	I(1)	I(0)	I(0)	I(0)	2008Q4	I(1)	I(0)	I(1)	I(0)	2011Q1
Estonia	I(2)	I(0)	I(1)	I(0)	2008Q4	I(1)	I(0)	I(1)	I(0)	2009Q3
Hungary	I(0)	I(0)	I(0)	I(0)	2007Q2	I(1)	I(0)	I(1)	I(0)	2010Q2
Latvia	I(1)	I(0)	I(0)	I(0)	2008Q4	I(1)	I(0)	I(1)	I(0)	2010Q1
Lithuania	I(1)	I(0)	I(0)	I(0)	2008Q4	I(1)	I(0)	I(0)	I(0)	2011Q2
Romania	I(1)	I(0)	I(0)	I(0)	2006Q4	I(1)	I(0)	I(0)	I(0)	2008Q3
Slovakia	I(2)	I(0)	I(1)	I(0)	2008Q4	I(1)	I(0)	I(1)	I(0)	2006Q3

Source: own elaboration.

Table 3. Unit root test results for budget balance as percentage of GDP

Country	BB/GDP				
	ADF	PP	KPSS	ZA (intercept & trend)	
Poland	I(2)	I(0)	I(2)	I(0)	2008Q4
Bulgaria	I(1)	I(0)	I(0)	I(0)	2008Q4
Czech Republic	I(1)	I(0)	I(0)	I(0)	2008Q4
Estonia	I(1)	I(0)	I(0)	I(0)	2009Q3
Hungary	I(1)	I(0)	I(1)	I(0)	2007Q2
Latvia	I(2)	I(0)	I(0)	I(0)	2008Q4
Lithuania	I(1)	I(0)	I(0)	I(0)	2008Q4
Romania	I(1)	I(0)	I(0)	I(0)	2008Q4
Slovakia	I(2)	I(0)	I(0)	I(0)	2009Q1

Source: own elaboration.

Similarly to government expenditures, structural breaks in budget balances in vast majority of CEE countries occurred in 4^{th} quarter of 2008 (see Table 3).

It should be mentioned that on average results of PP and KPSS tests were similar to Zivot-Andrews test, however the limitation of those tests consists in their inability to indicate structural breaks.

To sum up, the results of the Stepwise Algorithm (see Table 4) indicate that public debt stock in all CEE countries is sustainable and the presence of structural breaks had significance meaning for our analysis. The majority of countries realised the following path: Step 1, Step 2a), Step 3. In Hungary, Step 1 already showed sustainability of fiscal policy.

7. CONCLUSIONS

Our analysis, which employed Ata Ozkaya's Stepwise Algorithm, modified by including Zivot-Andrews test, showed that public debt stock in CEE countries was sustainable. Despite structural breaks, which were after-effects of the global financial crisis and sovereign debt crisis in the Eurozone, transition economies in Central and Eastern Europe were able to stabilise the pace of growth of the public debt stock. These conclusions are to a large extent consistent with the research by Krajewski, Mackiewicz & Szymańska (2016), in which the authors confirmed sustainability of public finances of CEE countries in a weak sense. Further research in this area could possibly include a cross-validation with other research method like panel fiscal reactions functions (Ciżkowicz, Rzońca, Trzeciakowski, 2015).

Table 4. Results of Stepwise Algorithm for sustainability of public debt stock over GDP

Country	Debt stock/GDP		PS/GDP		BB/GDP		Exp/GDP		Rev/GDP		Steps	State
	ZA (intercept & trend)		ZA (intercept & trend)		ZA (intercept & trend)		ZA (intercept & trend)		ZA (intercept & trend)			
Poland	I(1)	2014Q1	I(0)	2008Q4	I(0)	2008Q4	I(0)	2008Q4	I(0)	2009Q2	1;2a);3	sus
Bulgaria	I(1)	2014Q4	I(0)	2008Q4	I(0)	2008Q4	I(0)	2007Q4	I(0)	2009Q3	1;2a);3	sus
Czech Republic	I(1)	2009Q2	I(0)	2008Q4	I(0)	2008Q4	I(0)	2008Q4	I(0)	2011Q1	1;2a);3	sus
Estonia	I(1)	2012Q1	I(0)	2009Q3	I(0)	2009Q3	I(0)	2008Q4	I(0)	2009Q3	1;2a);3	sus
Hungary	I(0)	2009Q1	I(0)	2007Q2	I(0)	2007Q2	I(0)	2007Q2	I(0)	2010Q2	1	sus
Latvia	I(1)	2010Q2	I(0)	2008Q4	I(0)	2008Q4	I(0)	2008Q4	I(0)	2010Q1	1;2a);3	sus
Lithuania	I(1)	2009Q1	I(0)	2008Q4	I(0)	2008Q4	I(0)	2008Q4	I(0)	2011Q2	1;2a);3	sus
Romania	I(1)	2008Q4	I(0)	2008Q4	I(0)	2008Q4	I(0)	2006Q4	I(0)	2008Q3	1;2a);3	sus
Slovakia	I(1)	2013Q3	I(0)	2009Q2	I(0)	2009Q1	I(0)	2008Q4	I(0)	2006Q3	1;2a);3	sus

Source: own elaboration.

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APPENDIX

GNU R code with the most important functions and objects, which were used to calculations and statistical analysis

```
library(tseries)
library(urca)
library(fUnitRoots)
library(dplyr)

  D_1<-diff(D)
PS_1<-diff(PS)
  Dt1_1<-diff(Dt1)
  PSM_1<-diff(PSM)
  BB_1<-diff(BB)
  E_1<-diff(E)
  R_1<-diff(R)

  #D

  adf<-adf.test(D)
  adf_1<-adf.test(D_1)
  pp<-pp.test(D)
  pp_1<-pp.test(D_1)
  kpss<-kpss.test(D)
  kpss_1<-kpss.test(D_1)

  zai<-summary(ur.za(D,model=c(„intercept“),lag=0))
  zai_1<-summary(ur.za(D_1,model=c(„intercept“),lag=0))

  zat<-summary(ur.za(D,model=c(„trend“),lag=0))
zat_1<-summary(ur.za(D_1,model=c(“trend”),lag=0))

  zab<-summary(ur.za(D,model=c(“both”),lag=0))
  zab_1<-summary(ur.za(D_1,model=c(“both”),lag=0))

  ID<-list(adfD=adf,ppD=pp,kpssD=kpss,zaiD=zai, zatD=zat, zabD=zab)

#list of results 2
  ID_1<-list(adfD_1=adf_1,ppD_1=pp_1,kpssD_1=kpss_1,zaiD_1=zai_1,
zatD_1=zat_1, zabD_1=zab_1)

  #PS

  adf<-adf.test(PS)
  adf_1<-adf.test(PS_1)
  pp<-pp.test(PS)
  pp_1<-pp.test(PS_1)
  kpss<-kpss.test(PS)
  kpss_1<-kpss.test(PS_1)
```

```
zai<-summary(ur.za(PS,model=c("intercept"),lag=0))
zai_1<-summary(ur.za(PS_1,model=c("intercept"),lag=0))

zat<-summary(ur.za(PS,model=c("trend"),lag=0))
zat_1<-summary(ur.za(PS_1,model=c("trend"),lag=0))

zab<-summary(ur.za(PS,model=c("both"),lag=0))
zab_1<-summary(ur.za(PS_1,model=c("both"),lag=0))

lPS<-list(adfPS=adf,ppPS=pp,kpssPS=kpss,zaiPS=zai, zatPS=zat, zabPS=zab)

lPS_1<-list(adfPS_1=adf_1,ppPS_1=pp_1,kpssPS_1=kpss_1,zaiPS_1=zai_1, zatP-
S_1=zat_1, zabPS_1=zab_1)

# BB

adf<-adf.test(BB)
adf_1<-adf.test(BB_1)
pp<-pp.test(BB)
pp_1<-pp.test(BB_1)
kpss<-kpss.test(BB)
kpss_1<-kpss.test(BB_1)

zai<-summary(ur.za(BB,model=c("intercept"),lag=0))
zai_1<-summary(ur.za(BB_1,model=c("intercept"),lag=0))

zat<-summary(ur.za(BB,model=c("trend"),lag=0))
zat_1<-summary(ur.za(BB_1,model=c("trend"),lag=0))

zab<-summary(ur.za(BB,model=c("both"),lag=0))
zab_1<-summary(ur.za(BB_1,model=c("both"),lag=0))

lBB<-list(adfBB=adf,ppBB=pp,kpssBB=kpss,zaiBB=zai, zatBB=zat, zabBB=zab)

lBB_1<-list(adfBB_1=adf_1,ppBB_1=pp_1,kpssBB_1=kpss_1,zaiBB_1=zai_1, zatB-
B_1=zat_1, zabBB_1=zab_1)

#E

adf<-adf.test(E)
adf_1<-adf.test(E_1)
pp<-pp.test(E)
pp_1<-pp.test(E_1)
kpss<-kpss.test(E)
kpss_1<-kpss.test(E_1)

zai<-summary(ur.za(E,model=c(„intercept“),lag=0))
zai_1<-summary(ur.za(E_1,model=c(„intercept“),lag=0))

zat<-summary(ur.za(E,model=c(„trend“),lag=0))
zat_1<-summary(ur.za(E_1,model=c(„trend“),lag=0))
```

```
  zab<-summary(ur.za(E,model=c(„both“),lag=0))
  zab_1<-summary(ur.za(E_1,model=c(„both“),lag=0))

  IE<-list(adfE=adf,ppE=pp,kpssE=kpss,zaiE=zai, zatE=zat, zabE=zab)

  IE_1<-list(adfE_1=adf_1,ppE_1=pp_1,kpssE_1=kpss_1,zaiE_1=zai_1, zatE
_1=zat_1, zabE_1=zab_1)

#R

  adf<-adf.test(R)
  adf_1<-adf.test(R_1)
  pp<-pp.test(R)
  pp_1<-pp.test(R_1)
  kpss<-kpss.test(R)
  kpss_1<-kpss.test(R_1)

  zai<-summary(ur.za(R,model=c("intercept"),lag=0))
  zai_1<-summary(ur.za(R_1,model=c("intercept"),lag=0))

  zat<-summary(ur.za(R,model=c("trend"),lag=0))
  zat_1<-summary(ur.za(R_1,model=c("trend"),lag=0))

  zab<-summary(ur.za(R,model=c("both"),lag=0))
  zab_1<-summary(ur.za(R_1,model=c("both"),lag=0))

  IR<-list(adfR=adf,ppR=pp,kpssR=kpss,zaiR=zai, zatR=zat, zabR=zab)

  IR_1<-list(adfR_1=adf_1,ppR_1=pp_1,kpssR_1=kpss_1,zaiR_1=zai_1,
zatR_1=zat_1, zabR_1=zab_1)

#I2
  I<-list(ID=ID,ID_1=ID_1,IPS=IPS,IPS_1=IPS_1,IBB=IBB,IBB_1=IBB_1,IE=IE,IE_1=I
E_1,IR=IR,IR_1=IR_1)

I

}
```

STABILNOŚĆ DŁUGU PUBLICZNEGO W PAŃSTWACH EUROPY ŚRODKOWEJ I WSCHODNIEJ

STRESZCZENIE

W artykule zbadano stabilność długu publicznego w kategoriach wypłacalności w państwach Europy Środkowej i Wschodniej, wykorzystując algorytm autorstwa Ata Ozkaya; algorytm ten został zmodyfikowany przez wprowadzenie testu Zivota-Andrewsa do ustalania stopnia integracji szeregów czasowych. Takie podejście umożliwiło wykrycie złamań strukturalnych, które pojawiły się po globalnym kryzysie finansowym od czwartego kwartału 2008 roku. Ponadto okazało się, że – mimo przejściowych problemów fiskalnych w czasach kryzysu – we wszystkich państwach w Europie Środkowej i Wschodniej udało się ustabilizować politykę fiskalną.

Słowa kluczowe: stabilność długu publicznego, międzyokresowe ograniczenie budżetowe, analiza szeregów czasowych, gospodarki transformujące się, państwa Europy Środkowej i Wschodniej.

Klasyfikacja JEL: C22, E60, H63