Public revenues and public expenditure nexus: evidence of Eurozone heterogeneity

Веза између јавних прихода и јавне потрошње: докази о хетерогености Еврозоне[*]

Olgica Glavaški[*]
University of Novi Sad, Faculty of Economics in Subotica, Subotica, Republic of Serbia,
olgica.glavaski@ef.uns.ac.rs

Emilija Beker Pucar
University of Novi Sad, Faculty of Economics in Subotica, Subotica, Republic of Serbia,
emilija.beker.pucar@ef.uns.ac.rs

Stefan Stojkov
University of Novi Sad, Faculty of Economics in Subotica, Subotica, Republic of Serbia,
stefan.stojkov@ef.uns.ac.rs

Abstract: After the global economic crisis, a broad consensus has emerged that membership in the Eurozone exerts a strong pressure on fiscal policy, since it is characterized by the dichotomy of common monetary policy and heterogeneous fiscal policies. This paper analyzes the performance of fiscal policies, highlighting the nexus between the public revenues and public expenditure from the angle of 19 Eurozone economies in the period 2010q1-2020q4. The research is based on Dumitrescu & Hurlin (2012) and Juodis, Karavias & Sarafidis (2021) Granger non-causality tests in macro panels in order to test causality direction, as well as Westerlund error-correction-based panel cointegration test to analyze fiscal sustainability. Having in mind the heterogeneity and divergency of the Eurozone members, sub-samples were estimated, concerning the core, the periphery and the emerging Eurozone economies. The results imply that all Eurozone economies achieve weak fiscal sustainability, while all economies from the group of Eurozone periphery applied "*tax and spend*" hypothesis. The empirical finding could be related to the fact that Eurozone periphery economies were hit harder by the global and sovereign debt crisis, and that implemented austerity and bail-out programs were adequate, thus resulting in sustainable fiscal position, reducing heterogeneity of fiscal performance within the Eurozone economies.
Keywords: Eurozone, public revenues and expenditure, causality, heterogeneity, macro panel.
JEL classification: C33, H50, H61.

Сажетак: После глобалне економске кризе, широк консензус је постигнут да је чланство у Еврозони оставило снажан притисак на фискалну политику, узимајући у обзир да је карактерише дихотомија у вези са јединственом монетарном политиком и хетерогеним фискалним политикама. Овај рад анализира перформансе фискалне политике, наглашавајући везу између јавних прихода и јавне потрошње из угла 19 економија Еврозоне у периоду 2010q1-2020q4. Истраживање је базирано на радовима Dumitrescu & Hurlin (2012) и Juodis, Karavias, & Sarafidis (2021) Granger-ове не-узрочности у макро панелима са циљем тестирања правца каузалности, као и на Westerlund панел коинтеграционом тесту са корекцијом равнотежне грешке како би се анализирала фискална одрживост. Услед хетерогености и дивергенције у

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[*] Corresponding author.

економијама Еврозоне, подузорци се оцењени за језгро, периферију и емергентне економије Еврозоне. Иако све економије Еврозоне имају *слабу* фискалну одрживост, специфично је да све економије из групе периферије Еврозоне примењују хипотезу *„опорезуј па троши“*. Овај резултат се може довести у везу са чињеницом да су земље периферије Еврозоне биле снажније погођене глобално кризом и сувереном дужничком кризом, те да су програми штедње и спасавања у периферним земљама Еврозоне били адекватни и да су довели до одрживе фискалне позиције, конвергирајући ка земљама језгра Еврозоне.
Кључне речи: Еврозона, јавни приходи и јавна потрошња, узрочност, хетерогеност, макро панели.
ЈЕЛ класификација: C33, H50, H61.

Introduction

The architecture of the Economic and Monetary Union (EMU) is based on single currency area and represents one of the most important accomplishments of European integrations. However, sharing the same currency is not easy and enough to achieve desired macroeconomic goals, such as low inflation and greater employment, investments, public expenditure levels, in the circumstances of low level of fiscal integration. EMU is characterized by dichotomy in relation to common monetary policy and heterogeneous fiscal policies (Dan, 2014). Dichotomy in the EMU could have divergent and negative macroeconomic effects due to difficulties in coordination of independent European Central Bank providing monetary policy and national governments directing fiscal policy. In order to take initial steps in potential coordination of the two macroeconomic instruments, it is necessary to identify common points of fiscal policies in the EMU economies, as well as sources of their heterogeneity. Common factors are related to fiscal policy framework in the European Union (EU) and Eurozone[1] based on Maastricht Treaty (1992), Stability and Growth Pact (1997), Fiscal Compact (2012), and independent fiscal institutions established to monitor fiscal rules implementation, such as European Fiscal Board (established in 2015). The success of common fiscal rules in the EMU and common monetary policy were checked during the global financial crisis, and results showed divergence within Eurozone economies, and possibilities for the Eurozone periphery economies to either leave EMU or to negotiate bail-out programs (Beljić & Glavaški, 2020). The idea of this paper is to analyze fulfillment of criteria for fiscal sustainability achievements in Eurozone economies after the global crisis, taking into a consideration the direction of causality between public expenditure and public revenues (nexus). Namely, identification of the causal direction between public expenditure and public revenues is very important, because it provides useful insights into how each economy and Eurozone as a whole could manage their unsustainable budget deficits in the future (Richter & Dimitrios, 2013). Since the vulnerability of the Eurozone is partially the result of heterogeneity and economic divergence of its members, the analysis in this paper is based on sub-samples of the Eurozone economies, namely core, periphery and emerging Eurozone economies. The main hypotheses in the paper are:

H_1: The Eurozone economies achieve fiscal sustainability in the period after the global crisis, 2010q1-2020q4;

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[1] EMU, Eurozone and Euro area will be used interchangeably in the paper, since they are synonyms.

H₂: Causality in relation public revenues – public expenditure differs in groups of the Eurozone economies;

H₃: Most of the Eurozone economies use hypothesis "*tax and spend*", after the global crisis and austerity measures, therefore, heterogeneity in fiscal policies in Eurozone economies is reduced.

In order to shed more light into these beliefs, an empirical study is based upon descriptive analysis and macro panel models covering all the Eurozone economies in the period after global financial crisis 2010q1-2020q4 (quarterly data from Eurostat database are used). Dumitrescu & Hurlin (2012) and Juodis, Karavias & Sarafidis (2021) Granger non-causality tests are used to detect direction of causality and Westerlund (2007) test is use to estimate cointegration relationship, in this case, fiscal sustainability. The research has confirmed significant heterogeneity in fiscal policy of Eurozone economies, and detected causality nexus in each Eurozone economy, suggesting often use of "*tax and spend*" hypothesis, especially in Eurozone periphery economies.

The paper is structured as follows. After the Introduction section, Section 1 reviews existing evidence in the empirical literature, Section 2 deals with theoretical background of public expenditure – public revenues nexus. In Section 3, divergences and heterogeneity within EZ are emphasized, while Section 4 discusses estimation results based on causality and cointegration analysis, and final section outlines concluding remarks.

1. Literature review

Vast literature deals with the question of fiscal sustainability, using different econometric techniques for estimation, different groups of countries and different periods of time in studies. Two traditional approaches of fiscal sustainability exist, first, based on stationarity analysis, and second, based on cointegration analysis. Hamilton & Flavin (1986) and Wilcox (1989) approach are related to the empirical analysis of public debt and primary deficit stationarity. On the other hand, approach based on papers by Hakkio & Rush (1991) and Quintos (1995) are related to cointegration analysis between public expenditure and public revenues. Quintos (1995) distinguished *strong* sustainability condition (when cointegration parameter is b=1), from *weak* sustainability condition (when cointegration parameter is in the range from 0 to 1). Otherwise, fiscal policy is unsustainable.

Beside the methodological definition of *strong / weak* fiscal sustainability and fiscal unsustainability, causality in relation public expenditure - public expenditure were often been addressed. Namely, nexus in this relation provides diversity in defined hypotheses used in different economies. Many economists (Friedman, 1978; Darrat, 2002; Afonso & Rault, 2009) argued that it is very important to investigate whether the public expenditure determines the revenues and / or whether public revenue determines public expenditure. In empirical scientific papers, the cointegration relationship was most often tested under the assumption of Barrow's (1979) hypothesis that public expenditure determines public revenues ("*spend and tax*" hypothesis). This pattern is defined by Hakkio and Rush in the context of fiscal sustainability analysis (1991), and has been empirically implemented in most papers analyzing fiscal sustainability (Westerlund & Prohl, 2007; Campo-Robledo &

Melo-Velandia, 2015; Afonso & Rault, 2015, Pešić & Miljković, 2020). On the other hand, some papers confirm Musgrave's hypothesis ("*tax and spend*" hypothesis) on the determination of public expenditure by public revenues (Bravo & Silvestre, 2002). Alfonso & Jalles (2012, 2015) present two-way results, i.e. for the case when public expenditure causes public revenue and when public revenue causes public expenditure, referring to "*fiscal synchronization*" hypothesis. Narayan and Narayan (2006) gave three reasons why causality between public expenditure and revenue is very important: (1) if the "*tax and spend*" hypothesis is supported, budget deficits can be avoided by implementing policies that stimulate public revenue; (2) if the "*spend and tax*" hypothesis is valid, it means that the government spends first and pays for this expenditure later by raising taxes; and (3) if the simultaneous causality does not hold, it means that government revenue decisions are made independent from expenditure decisions, which could cause high budget deficits.

This analysis becomes especially interesting in the group of economies that are part of the Eurozone, that is, in economies that work closely together, and which have renounced their monetary sovereignty. Monetary policy was changed during the global crisis circumstances (Đorđević & Perović, 2016). In the Eurozone economies, there is an additional pressure on fiscal policy that is not unified, and becomes increasingly important how fiscal sustainability is determined and whether it is achieved. Since within the EMU any national monetary changes or exchange rates policies are not available, the main alternative actions of the EMU countries are to make the labour and product market more flexible (Richter & Dimitrios, 2013). According to Beker Pucar & Glavaški (2020), EMU was not initiated as an Optimum Currency Area (OCA), and through functioning (despite visible shifts) the fulfilment of key OCA criteria was still not ensured. Krogstrup (2002) showed that cross-country differences in public debts are found to lead to asymmetries in taxes and primary expenditures across the EU countries – high-debt countries having lower expenditures and higher taxes than low debt countries. Analyzing nexus for the period 1960-2006 in EU economies, Afonso & Rault (2009) found "*spend and tax*" causality in Italy, France, Spain, Greece, and Portugal, while "*tax and spend*" hypothesis evidence in Germany, Belgium, Austria, Finland and the UK, and for several EU New Member States. Moreover, Greece, Italy and Portugal are shifting away from a "*spend and tax*" strategy implying adjustments of fiscal behavior due to the run-up to the EMU. Vamvoukas (2011) analyzed 12 EMU economies for the period 1970-2006 using Generalized Two-Stage Least Squares (GTSLS) and Generalized Method of Moments (GMM), and results strongly supported the "*fiscal synchronization*" hypothesis. Kollias & Makrydakis (2010) were focused on periphery Eurozone economies, showing heterogeneous results in pre-global crisis period: Greece and Ireland tax and expenditure decisions are taken simultaneously, the "*tax and spend*" hypothesis is supported in the case of Spain, while absence of any causal ordering between public expenditure and tax revenues has been established for Portugal. Stanišić (2012) evaluated income convergence in the EU, between "old" and "new" member states from Central and East Europe, and among the countries within these two groups. covering the period from 2000 to 2020. The results in paper by Kostin, Runge & Adams (2021) provide evidence that emerging markets do not perform in a better way than developed markets in the period 2000-2020. The idea of this paper is to fill the gap that exists in the literature regarding fiscal sustainability in the context of the direction of

causality in Eurozone economies, given the obvious scarcity of scientific papers dealing with this topic after the global crisis.

2. Theoretical background: the nexus between public revenues and public expenditure

It seems simple to determine the causality between public expenditure and public revenue. On one hand, as much as the state revenues are, so much can be spent, meaning that causality goes in the direction from public revenues to public expenditure. However, we can look at the same problem from the other angle: how much the state spends, so much revenue it must provide (opposite causality: form public expenditure to public revenue). Finally, some theories show that there is no link between these two variables. Therefore, the nexus between public revenue and public expenditure is the subject of the debate that follows.

Dynamics of public expenditure growth in the period 1890-1955 in the United Kingdom showed that there was a significant increase in public expenditure, from an initial value of 9% of GDP to 37% of GDP in 1955. This public expenditure growth is the consequence of the First and Second World Wars and the Great Depression, i.e. exogenous factors according to which public expenditure grew, and then public revenues were adjusted to them. In this way, "*spend and tax*" hypothesis means that public expenditure is generated first, and then, public revenues are adjusted to increased public expenditure (public expenditure → public revenues), meaning incomplete control of the budget. However, Barro (1979) supplemented this hypothesis with an explanation related to rational expectations. If economic agents have rational expectations, the current increase in public expenditure for them means worsening the budget position in the future and consequently tax growth to ensure sufficient inflows. Therefore, they are adjusting their spending today by reducing personal spending. The idea is to increase personal savings, with the goal of servicing growing liabilities in the future. It is about the intertemporal effect of substitution that ensures the fulfillment of the "*Ricardian equivalence hypothesis*". The hypothesis of Ricardian equivalence starts from the assumptions: 1) that the movement of public expenditure over time is the same; 2) that the capital market is perfect; and 3) that individuals behave in accordance with intergenerational altruism. Namely, they are aware that if they spend more now, their descendants will have to pay the current consumption through future higher taxes. According to the hypothesis of Ricardian equivalence, it turns out that todays or future higher taxes do not have a direct impact on the size of private investments nor on the interest rate.

Contrary to the "*spend and tax*" hypothesis, the "*tax and spend*" hypothesis is defined based on the assumption that it is possible to curb the growth of public expenditure share in GDP by limiting the share of public revenues in GDP. Given the growth of public expenditure if it is not limited by public revenues and borrowing opportunities, economic theory draws a parallel between causality public revenue → public expenditure, with the phrase "starving the Leviathan", meaning that public expenditure can be curbed only by starvation, that is, tax cuts. Tax control, according to this theory, leads to adjustment of the

public expenditure levels to available public revenues. Also, according to this theory, it is believed that tax cuts will encourage economic growth and reduce crowding-out effects.

Contrary to the previously presented theories on the positive relationship between public expenditure and public revenues (with different causality), the hypothesis of "*fiscal illusion*" (James Buchanan) is formed. In comparison to rational expectations, irrational expectations of individuals arise from a complicated system of taxation according to which the individual is not fully aware of how much tax he pays and which part of the state costs. This situation leads to the assumption that budget variables are politically determined. Namely, it is easier for the political elite to provide higher public expenditure through new borrowings to be re-elected, than to increase taxes. Therefore, the same taxes or reduction of taxes are actually related to the growth of public expenditure ($\downarrow$ public revenues $\rightarrow$ $\uparrow$ public expenditure) according to the hypothesis of fiscal illusion. The next theory starts from the assumption of two-way causality, according to which policy makers simultaneously make decisions on the side of public revenues and public expenditure. The idea is that it is possible to maximize the utility function based on equality of marginal costs and marginal revenues. There is a positive link between public expenditure and public revenue, which is the essence of the "*fiscal synchronization*" hypothesis. There are opinions that there is neither simultaneity nor harmonization between the movement of public revenues and public expenditure, due to institutional separation, that is, the separation of the state's allocative function from the taxation function. The hypothesis of "*institutional separation*" of public expenditure and public revenues indicates that political leaders, according to their interests, influence changes in parts of the revenue and expenditure side of the budget, independently of each other. Based on the review of causality in the relation public expenditure - public revenues, it turns out that the hypotheses are very diversified because they focus on budget movements in different periods and in different deadlines. In the short run, discretionary changes on the revenue side seem most feasible if the political elite assumes that tax cuts cost them less than the new indebtedness in terms of the likelihood of re-election.

3. Fiscal divergences of the Eurozone members

Although similarity of economies in the Eurozone justifies "one-size-fits-all" monetary policy, fiscal policy is under attack due to its decentralization. The divergences of key macro indicators in Eurozone economies put pressure on fiscal policy, and therefore, fiscal policy functioning is becoming heterogeneous. Especially, after the global crisis outbreak, all Eurozone economies went into recession, so it was expected that monetary and fiscal policy measures would be implemented to overcome the crisis. Fiscal policy has faced a challenge of post-crisis adjustments. In different Eurozone economies, heterogeneous fiscal measures were implemented with different effects in the post-crisis period. Figure 1 reveals average position in Eurozone economies of public revenues and public expenditure in the quarters of the period 2010-2020, pointing to the improvement of the budgetary position till 2020, namely pandemic crisis.
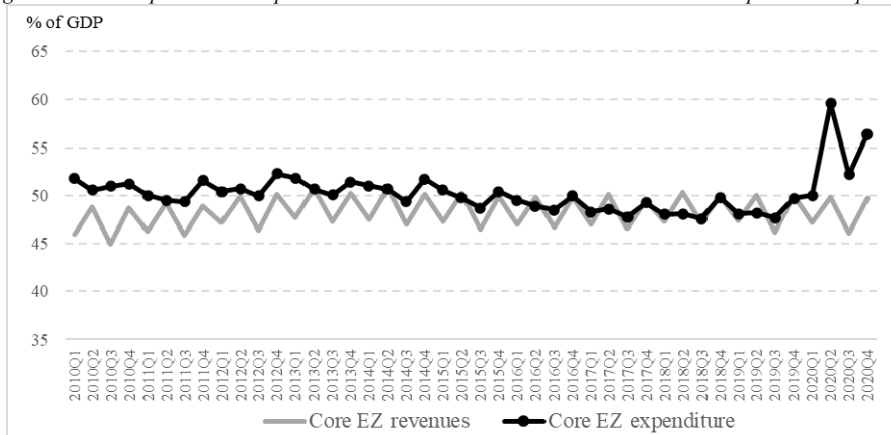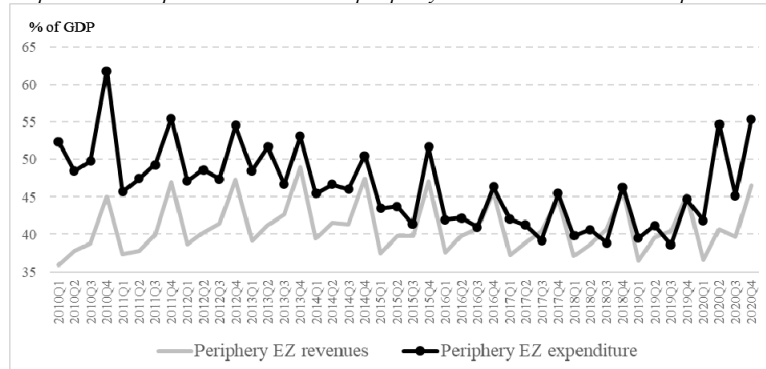
Figure 1: Public expenditure, public revenues and deficit in Euro area in the period 2010q1-2020q4
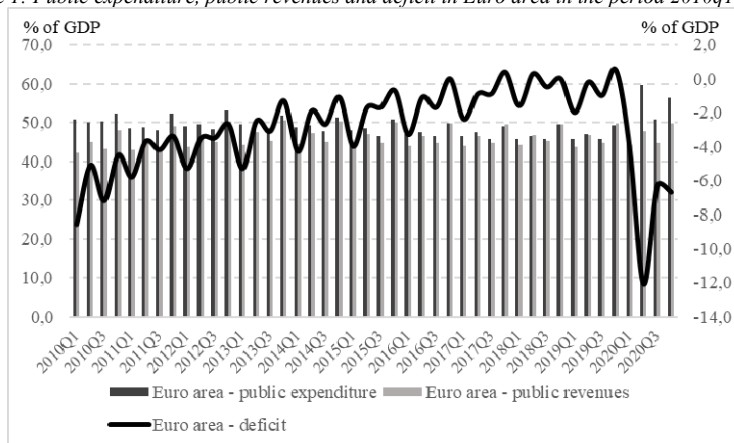
Source: Authors using Eurostat quarterly data (https://ec.europa.eu/eurostat/web/main/data/database, 2021).

Although it seems that there has been an improvement in all Eurozone economies, economies of the Eurozone periphery were particularly affected by the crisis. Therefore, we separated in our analysis economies on: the core, the periphery and the emerging Eurozone economies. The core countries are Austria, Belgium, Germany, Finland, France, Luxembourg and Netherlands, while the periphery Eurozone economies are Greece, Ireland, Italy, Spain and Portugal. The emerging part of Eurozone consists of Estonia, Cyprus, Latvia, Lithuania, Malta, Slovakia and Slovenia.

Figure 2: Public expenditure and public revenues in the core Eurozone economies in the period 2010q1-2020q4

Source: Authors using Eurostat quarterly data (https://ec.europa.eu/eurostat/web/main/data/database, 2021)

Figure 2 shows public revenues and public expenditure in the core Eurozone economies, indicated slightly higher public expenditure in comparison to public revenues in 2010-2015, and rapid increase of public expenditure since the beginning of the pandemic crisis.

Figure 3: Public expenditure and public revenues in the periphery Eurozone economies in the period 2010q1-2020q4

Source: Authors using Eurostat quarterly data (https://ec.europa.eu/eurostat/web/main/data/database, 2021)

Opposite to the core Eurozone economies, Figure 3 shows that gap between public expenditure and public revenues was higher in the periphery Eurozone economies after the global crisis. Governments were forced to take very strict fiscal adjustments measures achieved as combination of measures on both revenues and expenditure side. Implementation of fiscal adjustments, bail-out programs in all periphery economies except Italy, conditioned more favorable fiscal situation, after 2015, finance by the European Financial Stability Facility (EFSF) and the European Stability Mechanism (ESM). Finally, divergence is recognized in the group of the emerging Eurozone economies, usually small open economies with more efficient public sector in comparison to the core and the periphery Eurozone economies (Figure 4).

Figure 4: Public expenditure and public revenues in the emerging Eurozone economies in the period 2010q1-2020q4
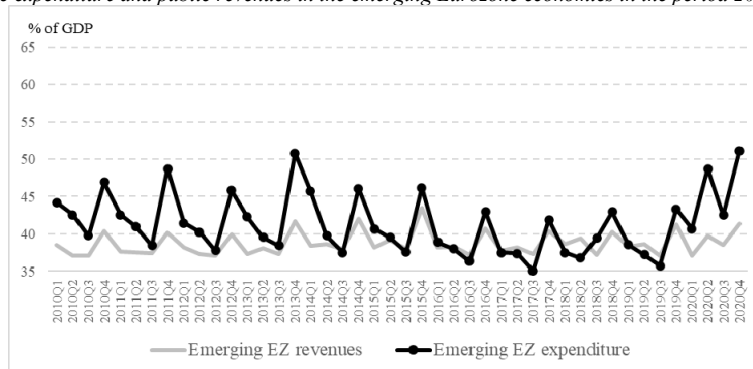
Source: Authors using Eurostat quarterly data (https://ec.europa.eu/eurostat/web/main/data/database, 2021)

4. Empirical results: causality and cointegration analysis

Econometric framework for fiscal sustainability estimation is determined by potential problems of causality, heterogeneity, (non)stationarity and cross-sectional dependency (CSD) in the macro panel (T>N). Although focus in this paper is related towards causality, namely, estimation of the nexus in relation public revenues – public expenditure, other potential problems in macro panels have also been addressed.

In the beginning, CSD in key variables is tested using Pesaran CD test (Table 1). CSD is estimated in public revenues and public expenditure in the whole sample of Eurozone, and due to detected divergency and heterogeneity within the Eurozone, in selected sub-samples: Eurozone core, Eurozone periphery and emerging Eurozone economies. Results indicated that in all cases null hypothesis of CSD has to be rejected. Detected dependency is expected, due to the fact that all economies in the sample are members of the EMU, linked by strong institutional framework. Primary, due to unique monetary policy, and then dependency is supported by other economic policy synchronisation: customs union, common market and tax harmonization.

Table 1: Cross-sectional dependency test

Pesaran CD test	CD-test	p-value	Corr.	Aps. (corr.)	CD-test	p-value	Corr.	Aps. (corr.)
Eurozone	N=19; T=40				*Eurozone periphery economies*		N=5; T=40	
Public expenditure	63.27	0.000	0.509	0.510	10.71	0.000	0.510	0.510
Public revenues	17.63	0.000	0.142	0.335	9.21	0.000	0.439	0.488
Eurozone core economies	N=7; T=40				*Emerging Eurozone economies*		N=7; T=40	
Public expenditure	17.61	0.000	0.579	0.579	16.07	0.000	0.529	0.529
Public revenues	8.65	0.000	0.285	0.413	6.83	0.000	0.225	0.359

Source: the authors' calculations

After the diagnose of CSD in the sample, panel unit root tests have to be oriented towards second generation panel unit root test – Pesaran CIPS test (2007). According to Westerlund and Prohl (2007) in cases when variables are represented in the form of share in GDP, inclusion of trend is redundant, so decisions are made on the basis of models with constant and no trend. Taking into consideration Akaike information criterion that optimal leg number in variables is 4, Pesaran CIPS test results indicated that variables are nonstationary (Table 2, level of variables). Once again, results showed Pesaran CIPS test for the whole sample and sub-samples. With the intention to identify stationary representation of variables, the stationarity of first differences of variables is tested (Table 2, first difference). The results of Pesaran CIPS test indicated that all variables in the model are integrated of order 1, namely, variables are stationary in first differences.

Table 2: Pesaran unit root test

Pesaran CIPS test H_0: I(1) H_1: I(0)	Lags	Level of variables		First difference		Level of variables		First difference	
		Eurozone				*Eurozone periphery*			
		Z(t)-stat.	p-values	Z(t)-stat.	p-values	Z(t)-stat.	p-values	Z(t)-stat.	p-values
Public expenditure	0	-18.142	0.000	-24.433	0.000	-6.360	0.000	-10.490	0.000
	1	-11.060	0.000	-24.046	0.000	-2.208	0.014	-10.490	0.000
	2	-5.711	0.000	-22.224	0.000	-2.776	0.003	-9.295	0.000
	3	-2.911	0.000	-15.025	0.000	-2.920	0.002	-6.982	0.000
	4	**-1.772**	**0.083**	**-8.233**	**0.000**	**-1.546**	**0.061**	**-4.420**	**0.000**
Public revenues	0	-18.333	0.000	-23.580	0.000	-6.538	0.000	-10.490	0.000
	1	-15.279	0.000	-24.348	0.000	-0.728	0.233	-10.490	0.000
	2	-5.472	0.000	-22.715	0.000	-0.053	0.479	-10.376	0.000
	3	2.128	0.983	-16.784	0.000	0.866	0.807	-8.346	0.000
	4	**1.945**	**0.974**	**-9.299**	**0.000**	**0.689**	**0.755**	**-5.002**	**0.000**
		Eurozone core				*Emerging Eurozone*			
Public expenditure	0	-8.353	0.000	-12.413	0.000	-8.514	0.000	-12.413	0.000
	1	-6.193	0.000	-12.413	0.000	-4.934	0.000	-12.387	0.000
	2	-2.339	0.010	-11.965	0.000	-2.486	0.006	-11.106	0.000
	3	-0.067	0.473	-9.038	0.000	-1.268	0.102	-7.538	0.000
	4	**-0.115**	**0.454**	**-3.438**	**0.000**	**-0.460**	**0.323**	**-4.117**	**0.000**
Public revenues	0	-10.212	0.000	-12.413	0.000	-9.012	0.000	-12.342	0.000
	1	-8.578	0.000	-12.413	0.000	-8.343	0.000	-12.413	0.000
	2	-4.378	0.000	-12.413	0.000	-3.071	0.001	-11.684	0.000
	3	1.719	0.957	-9.593	0.000	-0.682	0.248	-8.476	0.000
	4	**1.023**	**0.847**	**-4.470**	**0.000**	**0.442**	**0.671**	**-4.128**	**0.000**

Source: the authors' calculations

The results of Pesaran's unit root test are the base for cointegration analysis, which is a useful method to test for fiscal sustainability. According to the results of cross-sectional dependency, the cointegration analysis could be continued using Westerlund (2007) cointegration test, between variables integrated of order 1, public revenues and public expenditure. However, in the application of Westerlund (2007) cointegration test, an important assumption is related to the causality of variables, namely, assumption of regressor exogeneity. It is necessary to satisfy the assumption about the direction of relationship, that is, if x causes y, x is weakly exogenous. However, the question which

precedes the cointegration analysis is causality testing in relation public revenues – public expenditure.

In order to check causality nexus, Dumitrescu-Hurlin (2012) test and Juodis, Karavias & Sarafidis (2021) Granger non-causality tests were undertaken (Table 3). In order to check the homogeneity vs. heterogeneity of influences in Eurozone economies, Dumitrescu & Hurlin (2012) panel heterogeneous causality test was applied. The null hypothesis refers to the assumption of homogeneous non-causality (HNC) according to which there is no causality in any unit of the panel from exact direction, as opposed to the alternative hypothesis, according to which there is causality at least in one panel unit, i.e. there is a heterogeneous effect per panel unit. According to Lopez and Weber (2017), Dumitrescu and Hurlin test could implement an extension of the test based on Bayesian information criteria (BIC), and compute robust p-values using bootstrap procedure (in our case 400). However, this test could suffer from substantial size distortions since their test statistic is theoretically justified only when T is sufficiently smaller than N (Xiao et al. 2021). On the other hand, Juodis, Karavias & Sarafidis (2021) Granger non-causality test has a number of advantages relative to existing causality approaches, using polled estimator with faster convergence rate. This test is valid in models with heterogeneous and homogeneous coefficients, and it is based on Wald test statistic and Half Panel Jackknife (HPJ) bias-corrected pooled estimator.

Table 3: Dumitrescu-Hurlin (2021) and Juodis, Karavias & Sarafidis (2021) non-causality testing

Dumitrescu & Hurlin (2012) Granger non-causality test						
Public expenditure → Public revenues H0: expenditure does not Granger-cause revenues H1: expenditure does Granger-cause revenues for at least one economy				**Public revenues → Public expenditure** H0: revenues do not Granger-cause expenditure H1: revenues do Granger-cause expenditure for at least one economy		
Groups of economies	W-stat.	$\bar{Z}$- stat.	$\bar{Z}$- stat. Tilde	W-stat.	$\bar{Z}$- stat.	$\bar{Z}$- stat. Tilde
Eurozone core	7.332	1.951 (p-value=0.317)	0.331 (p-value=0.327)	8.767	8.952 (p-value=0.000)	7.862 (p-value=0.000)
	Optimal number of lags (BIC): 5			Optimal number of lags (BIC): 2		
Eurozone periphery	5.374	1.086 (p-value=0.4850)	0.734 (p-value=0.542)	23.778	18.968 (p-value=0.000)	16.378 (p-value=0.000)
	Optimal number of lags (BIC): 4			Optimal number of lags (BIC): 3		
Emerging Eurozone	7.871	3.621 (p-value=0.000)	2.846 (p-value=0.004)	17.939	13.038 (p-value=0.000)	10.814 (p-value=0.000)
	Optimal number of lags (BIC): 4			Optimal number of lags (BIC): 4		
Juodis, Karavias and Sarafidis (2021) Granger non-causality test (Optimal number of lags: 4)						
	HPJ Wald test		p-value	HPJ Wald test		p-value
Eurozone core	9.574		0.0582	62.915		0.000
Eurozone periphery	47.063		0.000	10038.324		0.000
Emerging Eurozone	32.631		0.000	19.843		0.005

Source: authors' calculations

In Eurozone core economies, results of both Granger non-causality tests indicated that in context of hypothesis "*spend and tax*" (Public expenditure → Public revenues) null hypothesis has to be accepted, namely public expenditure did not cause public revenues. However, causality testing from another direction (Public revenues → Public expenditure)

referred that "*tax and spend*" hypothesis was valid in some of the Eurozone core economies. Namely, alternative hypothesis has to be accepted meaning that public revenues caused public expenditure in at least one of the core Eurozone economies. A similar conclusion could be drawn for periphery Eurozone economies relying on Dumitrescu-Hurlin (2012) test. However, according to Juodis, Karavias & Sarafidis (2021) test, alternative hypothesis could be accepted in both cases, suggesting that "*spend and tax*" hypothesis was identified in at least one Eurozone periphery economy in the observed period, and "*tax and spend*" hypothesis in at least one economy.

Emerging Eurozone economies are heterogeneous in comparison to core and periphery Eurozone economies. While in the core Eurozone economies there were no economies that use "*spend and tax*" hypothesis, in emerging Eurozone economies public expenditure Granger-caused public revenues for at least one economy ("*spend and tax*"), and public revenues Granger-caused public expenditure for at least economy ("*tax and spend*") according to both tests: Dumitrescu-Hurlin (2012) and Juodis, Karavias & Sarafidis (2021) test. The conclusion could be twofold: 1) heterogeneity of nexus in periphery Eurozone economies if different economies use different hypothesis, or 2) fiscal synchronization hypothesis if the same economy use both hypotheses. This result has two implications: (a) the possibility of an exact causality check per panel unit; (b) the need to apply heterogeneous panel techniques in estimation of cointegration relationship, namely, fiscal sustainability. Therefore, Westerlund (2007) test is a good solution for cointegration testing, due to the fact that one of the assumptions of Westerlund test is existence of heterogeneous panels.

Table 4: Westerlund cointegration test in groups of Eurozone economies

Test	Eurozone core economies				Eurozone periphery economies			
	Value	Z-value	p-value	Bootstrapped p-value	Value	Z-value	p-value	Bootstrapped p-value
	Public revenues → Public expenditure							
H_0: no cointegration; H_1: at least one panel unit is cointegrated								
Gt	-2.399	-3.618	0.000	0.000	-2.330	-2.910	0.002	0.005
Ga	-23.69	-11.57	0.000	0.000	-12.32	-4.188	0.000	0.005
H_0: no cointegration; H_1: all panel units are cointegrated								
Pt	-5.077	-3.193	0.001	0.005	-4.987	-3.295	0.001	0.005
Pa	-18.91	-16.33	0.000	0.000	-10.342	-7.195	0.000	0.005
AIC selected lag length: 1; AIC selected lead length: 2				AIC selected lag length: 1; AIC selected lead length: 2				
Emerging Eurozone economies								
Public revenues → Public expenditure				Public expenditure → Public revenues				
Gt	-2.467	-3.791	0.000	0.000	-3.290	-5.883	0.000	0.000
Ga	-10.37	-3.826	0.000	0.005	-19.167	-8.938	0.000	0.000
Pt	-5.762	-3.780	0.000	0.028	-9.007	-6.560	0.000	0.000
Pa	-8.972	-7.261	0.000	0.018	-21.422	-18.638	0.000	0.000

Source: the authors' calculations

Westerlund (2007) cointegration test is used to test fiscal sustainability in groups of Eurozone economies, taking into a consideration the results of CSD, stationarity analysis and causality testing. Results of Westerlund cointegration test is based on four error-

correction panel-based tests, which could allow for a large degree of heterogeneity, short-run dynamics, long-run cointegration relationship and CSD. Null hypothesis in Westerlund test is "no cointegration", while alternative hypothesis is related to the homogeneous vs. heterogeneous assumption: "all panel units are cointegrated" in homogeneous assumption (Pt and Pa), and "at least one panel unit is cointegrated" in heterogeneous assumption (Gt and Ga). Due to identified different hypotheses in groups of Eurozone economies, application on Westerlund test is based on "*tax and spend*" hypothesis in Eurozone core and periphery economies, and "*tax and spend*" and "*fiscal synchronization*" hypotheses in emerging Eurozone economies. CSD in the panel is handled by bootstrap method (400 replications). Robust p-values related to Westerlund test using group mean tests (Gt and Ga) and pooled panel tests (Pt and Pa) indicated that at least one panel unit is cointegrated or all panel units are cointegrated in groups of core, periphery and emerging Eurozone economies (Table 4). Therefore, we estimated heterogeneous coefficients in Westerlund cointegration test with the intention to find out in which panel units (countries) exist cointegration, and in which countries not.

Table 5: Westerlund cointegration test in each Eurozone economy and hypotheses

Eurozone core economies	Coef.	Std. Error	Z	P>|z|	Hypothesis
Belgium	0.708 (rev)	0.282	2.51	0.012	*"tax and spend"*
Germany	0.282 (rev)	0.173	1.63	0.103	-
France	0.494	0.268	1.84	0.065	-
Luxemburg	0.819	0.189	4.32	0.000	*"tax and spend"*
Netherlands	0.156	0.127	1.22	0.222	-
Austria	0.467	0.240	1.95	0.052	-
Finland	0.584	0.229	2.54	0.011	*"tax and spend"*
Eurozone periphery economies					
Ireland	0.412	0.154	2.68	0.007	*"tax and spend"*
Greece	0.373	0.182	2.04	0.015	*"tax and spend"*
Spain	0.413	0.205	2.01	0.044	*"tax and spend"*
Italy	0.771	0.295	2.66	0.008	*"tax and spend"*
Portugal	0.424	0.198	2.13	0.033	*"tax and spend"*
Emerging Eurozone economies					
Estonia	1.114 (rev)	0.224	4.96	0.000	*"fiscal synchronization"*
	0.791 (exp)	0.136	5.80	0.000	
Cyprus	1.024 (rev)	0.253	4.03	0.000	*"fiscal synchronization"*
	0.354 (exp)	0.132	2.68	0.007	
Latvia	0.777 (rev)	0.229	3.39	0.001	*"tax and spend"*
	0.232 (exp)	0.134	1.73	0.084	
Lithuania	0.674 (rev)	0.212	3.17	0.002	*"tax and spend"*
	0.104 (exp)	0.108	0.96	0.336	
Malta	0.358 (rev)	0.181	1.98	0.048	*"fiscal synchronization"*
	0.546 (exp)	0.171	3.19	0.001	
Slovenia	0.662 (rev)	0.224	2.95	0.003	*"tax and spend"*
	0.053 (exp)	0.055	0.97	0.332	
Slovakia	0.342 (rev)	0.139	2.45	0.014	*"fiscal synchronization"*
	0.183 (exp)	0.092	1.98	0.047	

Source: the authors' calculations

Since Westerlund test is based on structural rather than residual dynamics, it is possible to use completely heterogeneous specification of both short-run and long-run

relationship of the error-correction model (Persyn & Westerlund, 2008). Table 5 shows long-run relationship for each panel unit (country), according to identified direction of causality in groups of Eurozone economies, using Dumitrescu & Hurlin (2012) and Juodis, Karavias & Sarafidis (2021) Granger non-causality tests. Results indicated "*weak* fiscal sustainability" in all Eurozone economies, except Estonia with "*strong* fiscal sustainability". Namely, after fiscal consolidation started in 2008, using stronger tools and techniques for planning and monitoring, Estonia obtained a small and efficient government sector. Results showed that in the group of core Eurozone economies, Musgrave's "*tax and spend*" hypothesis is heterogeneously fulfilled, namely the cointegration relationship is significant in Belgium, Luxemburg and Finland. "*Tax and spend*" hypothesis is homogeneously fulfilled in Eurozone periphery economies, namely, Greece, Portugal, Spain, Ireland and Italy have significant cointegration relationship. This result could be surprising due to expectations that core Eurozone economies have more restricted fiscal policy in comparison to periphery Eurozone economies. On the other hand, taking into a consideration bail-out programs undertaken in periphery Eurozone economies and implemented austerity methods, this result become expected. Emerging Eurozone economies are the most heterogeneous group, and it could be characterized as the furthest from the core of the Eurozone. Cointegration relationships in Latvia, Lithuania and Slovenia are significant and indicate application of "*tax and spend*" hypothesis. On other hand, simultaneous relationships are estimated in Estonia, Cyprus, Malta and Slovakia, indicated application of "*fiscal synchronization*" hypothesis.

According to empirical findings, hypotheses are supported, namely, the Eurozone economies achieve fiscal sustainability in the period after the global crisis (H_1), although causality in relation public revenues – public expenditure differs in groups of the Eurozone economies (H_2). Most of the Eurozone economies used "*tax and spend"* hypothesis, namely, heterogeneity of fiscal performances within the Eurozone economies have been reduced since the impact of the global crisis (H_3).

Concluding remarks

The paper highlights the nexus between the public revenues and public expenditure from the angle of 19 Eurozone economies with the intention to estimate fiscal sustainability after the global crisis. The results of macro panel based on Eurozone economies for the period 2010q1-2020q4 suggested different direction of causality in relation of public expenditure-public revenues in groups of Eurozone economies. Therefore, sub-samples were estimated, concerning core, periphery and emerging Eurozone economies. According to Dumitrescu & Hurlin (2012) and Juodis, Karavias & Sarafidis (2021) Granger non-causality tests indicated that in core and periphery Eurozone economies causality went from public revenues to public expenditure, while in group of emerging Eurozone economies simultaneous relationship existed. With respect to the results of Granger non-causality tests, Westerlund error-correction-based panel cointegration test for each sub-sample indicated "*weak* fiscal sustainability" in all Eurozone economies (except Estonia with "*strong* fiscal sustainability"). Further, the results pointed to heterogeneity of sub-sample of core Eurozone economies, namely, only Belgium, Luxemburg and Finland used "*tax and spend*"

hypothesis, while all Eurozone periphery economies applied "*tax and spend*" hypothesis. This result could be related to the fact that Eurozone periphery economies were hit harder by the sovereign debt crisis in the year 2009, and that austerity and bailout programs implemented in the periphery economies (Ireland 2010-2013; Portugal 2011-2014; Greece 2011-2019; Spain 2012-2013) financed by ESM and EFSF were adequate. Previously guided irresponsible fiscal policy in Eurozone periphery economies has been replaced by "*tax and spend*" fiscal policy.

These results are in line with the authors' expectations that membership in the monetary union exerted a stronger pressure on fiscal policy due to the renunciation of sovereign monetary policy, especially in the crisis period. However, the results showed that austerity measures and bail-out programs, especially in Eurozone periphery economies, have outgrown in "*tax and spend*" hypothesis. "Starvation of the Leviatan" hypothesis in the short and medium-run, after the global crisis, created sustainable fiscal policy in vulnerable Eurozone economies. Therefore, according to empirical findings, the heterogeneity of fiscal performances within the Eurozone economies has been reduced since the impact of the global financial crisis.

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