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Monetary Adjustment Heterogeneity in the EU under the Perils of Quantitative Easing: A Non-Stationary Heterogeneous Panel Approach

Abstract. *This paper investigates the impact of quantitative easing (QE) on the money supply (MS) and examines how liquidity control affected gross domestic product (GDP) in the EU under different exchange rate regimes in the 2014Q1-2023Q1 time horizon. The sample is structured of two groups of EU countries differentiated by the level of monetary autonomy: EZ members (Austria, Belgium, France, Germany, Netherlands, Italy, and Spain) and emerging monetary autonomous EU economies (Czech, Hungary, Poland, and Romania). Using the Pooled Mean Group (PMG) dynamic heterogeneous panel approach we test if a positive impact on GDP depends on QE, assuming this relationship is sensitive to QE's influence on MS. Our findings suggest that ECB's disciplined monetary framework ensured higher liquidity control mitigating inflationary pressures while supporting economic stability. In contrast, the flexible monetary policy of autonomous EU countries contributed to excess liquidity hindering economic growth.*

Keywords: *quantitative easing, money supply, gross domestic product, PMG, heterogeneous panels.*

JEL Classification: E52, E58, C23, O42.

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1. Introduction

This paper is motivated by ongoing debate regarding the long-term and short-term impacts of quantitative easing (QE) on the money supply (MS) and, consequently, on gross domestic product (GDP) in the heterogeneous European Union (EU). During the Great 2008 Recession, the conventional monetary apparatus became predictable while the financial sector and domestic demand did not respond accordingly (Baumeister & Benati, 2013; Hesse et al., 2018). Fundamentally, the

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Federal Reserve (FED) implemented the primary objective of stimulating aggregate consumption through variations in asset purchases. The European Central Bank (ECB) followed suit by implementing its own liquidity injection by expanding the central bank's balance sheet assets (Bhattarai et al., 2021). Unlike the US, the EU is a heterogeneous union with the absence of fiscal consolidation which limits the positive effects on the real economy (Glavaški & Beker Pucar, 2020; Beljić et al., 2023; Pejčić et al., 2024). Furthermore, a monetary union such as the eurozone (EZ) presents asymmetrical policy challenges, particularly between the core and peripheral countries (Beker Pucar & Glavaški, 2021).

Balance sheet policies under the zero lower bond conditions positively affect money market funds in various ways: overnight rates decrease, short-run nominal interest rates are lower, or through increased financial asset prices. On the other hand, there are potentially negative repercussions, such as excess liquidity lowering real interest rates and increasing consumption which might result in elevated prices (Williamson, 2012; Bernanke, 2020). Increased prices can slow down or constrain the initial positive impacts on economic activity (Stanišić et al., 2012). Despite rich literature regarding, the QE transmission mechanism, there are significant gaps in understanding short-run and long-run effects but also policy repercussions on macroeconomic variables. The research expands existing literature in various ways: First, we understand the impact of balance sheet expansion on MS in different monetary regimes. Comparing supranationalists against monetary autonomy exemplifies differences in policy transparency and institutional governance, but also highlights the relevance of developed capital markets. Second, empirical confirmation of the necessary lagged balance sheet policy effects on GDP. These findings emphasise the necessity for long-term adjustments and are of high importance for designing economic policy in different monetary regimes. Third, confirmation of positive unconventional policy effects through increased market liquidity and consumption on GDP.

This paper is structured as follows: after a brief introduction, Section 2 explores related literature, theoretical concepts regarding unconventional policy transmission mechanisms, and descriptive analysis. Section 3 presents data and estimation methodology. The estimation results are explored and discussed in Section 4. Section 5 provides the conclusion of the article.

2. Literature review and descriptive analysis

Monetary policy during the past two decades has adopted an institutionalist approach, in which prompt central bank actions were deemed necessary to counter recessions. Consequently, ideological discourses that elucidate the short-run and long-run dynamics between MS and GDP have garnered increased attention. Monetarist and classical schools of thought argue that long-run changes in MS affect prices rather than GDP (Sims, 1972; Friedman, 1974). However, monetarists take into account short-run rigidities allowing for faster GDP adjustment to increased money circulation relative to prices and wages. Recent studies supported this theory

of money non-neutrality, suggesting that MS manoeuvres can affect GDP and employment (Hussain & Haque, 2017; Paries & Papadopoulou, 2020). In contrast, Keynesians adopted an approach that an increased amount of liquid money affects primarily consumers, which increases consumption, which finally positively affects production. From a Post-Keynesian perspective, the MS is endogenous rather than exogenous, with the ultimate objective of increasing long-term GDP (Krugman, 1999; Nayan *et al*. 2013).

Two streams of economic research explore QE effects on macroeconomic variables. One stream focuses on QE announcements as a transparency measure of monetary policy including dummy variables in their models (Georgiadis & Grab 2016; Mamaysky, 2018). On the other hand, some research papers take central bank balance sheet assets as a QE proxy (Horvath & Voslarova, 2016; Kyungmin et al., 2020). This research paper delves into the volume of QE operations that increase money market funds, thereby having relevant repercussions on GDP based on disciplined policy governance. One of the major challenges the global economy faced was the Great Recession, which led to revisiting and investigating postulates of money neutrality in the long-run (Sulikova et al., 2019). Since conventional policy adjustment was inefficient, a new unconventional transmission channel was introduced through central bank balance sheet expansions (Guerini et al., 2018). Initially, QE can have significant short-run effects through increased market liquidity, but in the long-run higher dependency might lead to higher prices than GDP growth. Also, the QE policy will increase demand for long-term bonds, which increases their prices and lower returns. This can increase the consumption of the asset holders and consequently production. The exponential increase in liquidity lowers the price of the money, i.e., interest rates which have expansionary effects on GDP. Papers such as Kenourgios et al. (2015) included exchange rate in QE dynamics, where QE initially caused exchange rate depreciation increased domestic exports, and positively affected production in the long-run. On the other hand, Stojkov et al. (2024) concluded that QE in the EU led to real exchange rate appreciation, which resulted in a current account deficit. In their research, Blanchard et al. (2016) suggested that capital outflux in the USA resulting from QE programs, had a significant impact on domestic output. Hohberger et al. (2019) used the DSGE model to confirm the positive effects of the ECB asset purchase program on GDP. For instance, Weale and Wieladek (2016) examined how unconventional QE channels reduce economic uncertainty, thereby fostering higher private consumption, resulting in higher prices and production without definite GDP conclusions.

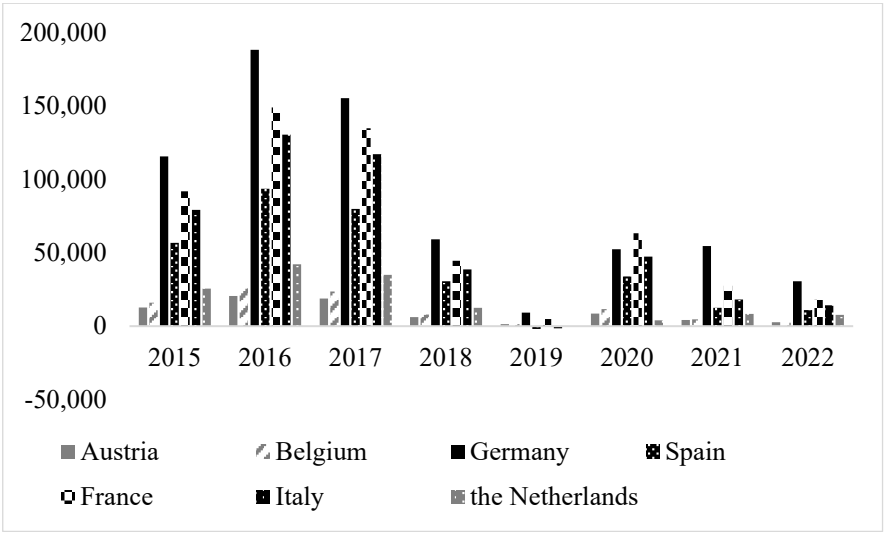

Figure 1. ECB's asset purchase volumes by country for EZ member states during 2014Q1-2023Q1 period

Source: Authors according the quarterly data of IMF.

Figure 1 illustrates the APP (Asset Purchase Programme) in EZ countries with the highest asset purchase volumes by the ECB between 2015 and 2023. (Agba et al., 2022). Throughout the presented time horizon, Germany, France, Italy, and Spain are countries with the highest volumes of asset purchases, as their economies are the largest in the EZ. However, the size of the economy is not the sole factor that influences asset purchase volumes. Other factors that can affect purchases include public finance, the development of capital markets, public debt, and the severity of external shocks. Between 2015 and 2018, asset purchases were the most intensive, indicating the ECB's aggressive unconventional approach. To control the injected liquidity in the financial system, a period of passive decline in asset purchases became evident. Fundamentally, the fear of elevated prices with negative effects on GDP was the key factor in the rapid decline in volumes. After the COVID-19 pandemic crisis, APP was revived in the form of the Pandemic Emergency Purchase Programme (PEPP), which covered private and public sector securities. Cautionary volumes of purchases were undertaken in this period, which are lower for all EZ countries relative to the period before COVID-19. Germany and France are countries with moderate purchases, while the rest of the EZ experience slower returns to their previous levels.

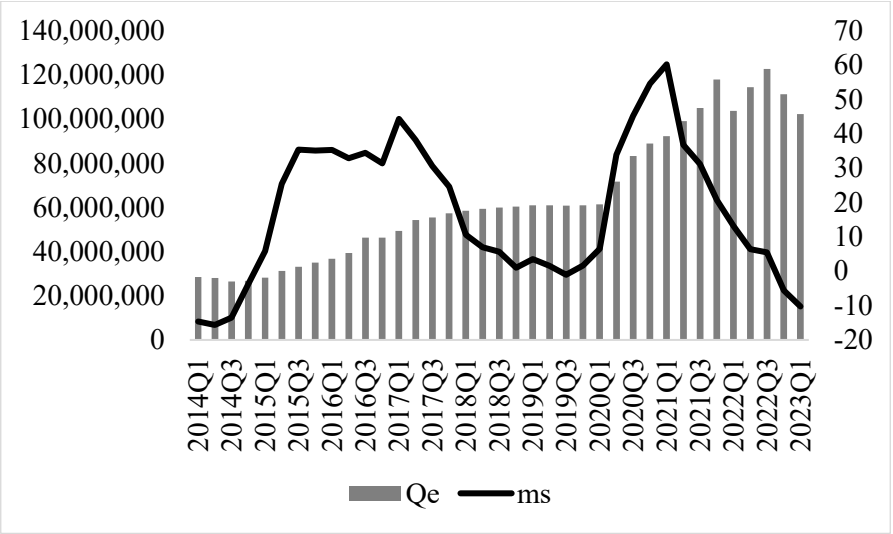

Figure 2. Fluctuation of money supply growth and ECB's balance sheet expansion for the EZ member states during 2014Q1-2023Q1 period

Source: Authors according the quarterly data of IMF and FRED.

Analysing the dynamics between the ECB's balance sheet policy and MS growth, Figure 2 illustrates a stable relationship. The primary axis represents the ECB balance sheet values, while the secondary axis depicts the percentage of MS growth. The ECB balance sheet exhibits an upward trajectory, reflecting the dominant unconventional approach during the presented time horizon. Conversely, the MS experienced robust growth until 2017, after which it underwent a significant contraction. This pattern suggests a liquidity withdrawal from the ECB, as the reduction in growth coincided with a decrease in asset purchase volumes. The disciplined ECB approach can be reflected in appropriate monetary transmission due to the robust institutional framework, developed capital markets, and the banking sector. Since conventional monetary tools exhibit time lag effects, unconventional measures necessitate prompt and short-term reactions in terms of increased liquidity. However, controlling for inflation and addressing the potential negative effects on the real economy are fundamental concerns. Consequently, reducing MS growth is essential. The pandemic crisis required additional monetary stimulus, resulting in an expansion of the balance sheet and high MS growth until the beginning of 2022. In the long-run, liquidity and MS are reduced until the end of the observed period.

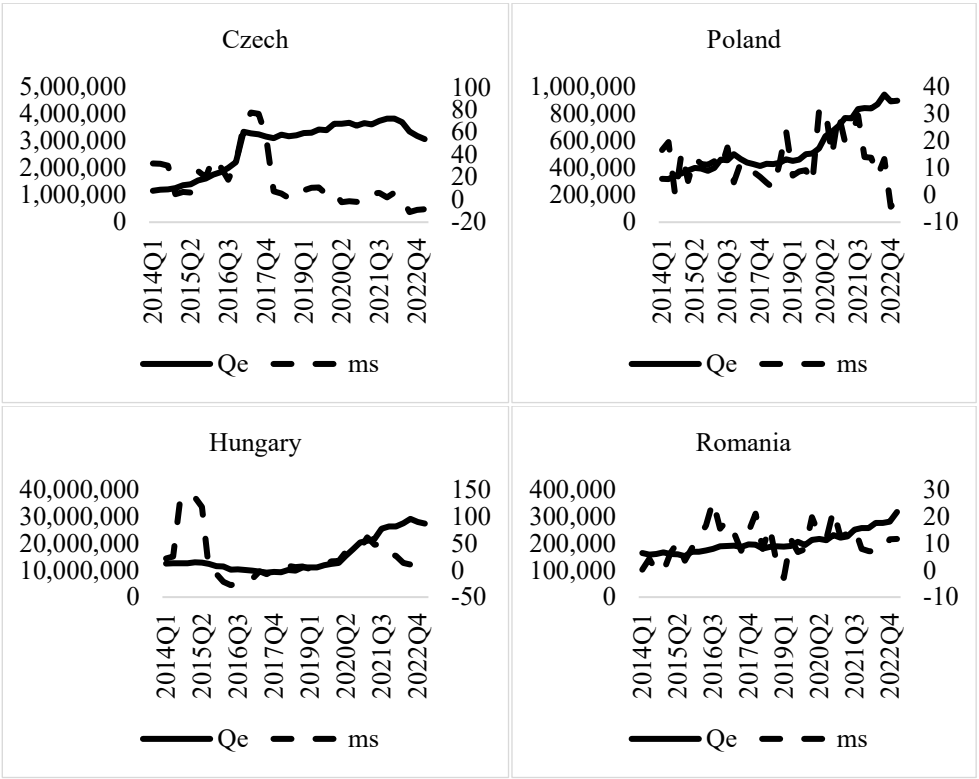

Figure 3. Fluctuation of money supply growth and central bank's balance sheet expansion for monetary autonomous EU countries in the period 2014Q1-2023Q1
Source: Authors according the quarterly data of IMF and FRED.

Based on Figure 3, analysing the relationship between QE and changes in the MS in the Czech Republic, Poland, Hungary, and Romania provides insights into the impact of the central bank's balance sheet expansion on liquidity dynamics in these countries. In general, there is a positive correlation between balance sheet expansion and MS growth, implying that QE led to increased market liquidity. Specifically, since emerging economies do not have developed capital markets, banking sectors, and institutional frameworks, the transmission of QE will be more volatile and uncertain. Considering the high level of European integration among the selected countries, any negative repercussions of balance sheet expansion (such as higher inflation) could potentially slow down real economic indicators. Throughout the selected time horizon, Hungary experienced the highest increase in MS, registering approximately 140% at the beginning of the balance sheet expansion. The Czech Republic achieved an increase of around 80%, while Romania and Poland saw a 30% increase in their MS.

As presented above, there is substantial literature investigating the implications of QE policy on various macroeconomic phenomena, particularly in the context of complex dynamics between QE, liquidity, and GDP. Providing a comprehensive contribution to the literature requires additional confirmation of QE policy

effectiveness on the real economic variables through the liquidity channel of monetary transmission within the presented conceptual framework.

3. Methodological framework

3.1 The variables, the sample, and the period

Examining perils and consequences of balance sheet expansion policy, four key variables are used in two separate models: money supply growth (*ms*); central bank's balance sheet assets (measured as logarithmic function of central bank's assets (*lnqe*)); real interest rate (*rir*) and nominal gross domestic product (*ngdp*). Essentially, potential repercussions of the QE approach include increasing the MS enough to generate inflationary pressures. The relationship becomes even more complex when GDP is taken into consideration. The empirical analysis includes a balanced panel dataset consisting of 11 EU countries observed between 2014Q1 and 2023Q1. The defined time horizon is selected based on the beginning of QE programs in 2014Q1 and concluded with 2023Q1 to include two relevant external shocks (COVID-19 pandemic and geopolitical crisis). Research is limited to selected countries to account for fundamental differences in monetary autonomy. A group of countries represents EZ members (Austria, Belgium, France, Germany, Netherlands, Italy, and Spain) with a fixed exchange rate regime, high levels of economic and capital integration, as well as similar institutional patterns. In addition to European integration, the common denominator for the selected group is that monetary policy is led by the supranational entity (ECB). The selection of representatives is based on asset purchase volumes by the ECB during this period, where countries with the highest asset purchases are included in the sample. Monetary autonomous EU countries (Czech Republic, Hungary, Poland, and Romania) are selected based on their exchange rate regime; other countries in the EU that are not in EZ during this time frame, mostly conducted fixed exchange rate to euro hence are not truly monetary autonomous. The dataset is constructed using different sources, mainly from FRED (*rir*), IMF (*ms*, *qe*), and OECD (*ngdp*).

3.2 Panel ARDL model: PMG vs MG estimators

Since one of the central issues of the research is to determine dynamics between QE, MS and GDP, but also to differentiate adjustment mechanisms between two groups of countries, authors apply techniques introduced by Pesaran & Smith, (1995) and Pesaran et al. (1999) based on non-stationary heterogeneous dynamic panels. Since the time dimension in the sample is T=37 for both models in 11 EU economies (N=11); consequently, heterogeneous, non-stationary panels with cross-sectional dependence were used. The econometric technique implemented for the analysis is the Pooled Mean Group (PMG) estimator, which is based on pooling and averaging coefficients resulting in one homogeneous long-run equilibrium relationship for all countries in the panel along with short-run coefficients estimates with an error-

correction term for each country individually. The error-correction term represents the speed of adjustment toward determined long-run equilibrium. On the other hand, the Mean Group (MG) estimator can similarly provide heterogeneous short-run coefficients, but unlike the PMG estimator, it also suggests a heterogeneous long-run relationship. Deciding which of the models is more appropriate can be determined by the Hausman specification test (Hausman, 1978), which distinguishes if the long-run equilibrium restrictions are true in the PMG model. For the null hypothesis, the homogeneous long-run relationship is true, PMG is more efficient. The unrestricted specification for the Autoregressive Distributed Lag (ARDL) (p1, q2, ..., qk) dynamic specification form, for t=1, 2, ..., T time periods, i=1, 2, ..., N countries, for the dependent variable Y (Blackburne & Frank, 2007) is:

$$y_{it} = \sum_{j=1}^{p} \lambda_{ij}^{*} y_{i,t-j} + \sum_{j=0}^{q} \delta_{ij}^{*} X_{i,t-j} + \mu_i + \varepsilon_{it} \qquad (1)$$

where $X_{i,t-j}$ is the (k × 1) vector of explanatory variables for the group i; δ_{ij} are the k-1 coefficient vectors; λ_{ij} are scalars; and μ_i is the group-specific effect. If the variables are, for example, I(1) and cointegrated, then the error term is an I(0) process for all i. A principal feature of cointegrated variables is their responsiveness to any deviation from long-run equilibrium. This feature implies an error correction model in which the short-run dynamics of the variables in the system is influenced by the deviation from equilibrium. Since these methods belong to the panel error correction group, the baseline model can be determined as:

$$\Delta y_{it} = \phi_i (y_{it-1} - \theta_i X_{it}) + \sum_{j=1}^{p-1} \lambda_{ij} \Delta y_{it-1} + \sum_{j=0}^{q-1} \delta_{ij} \Delta X_{it-j} + \mu_i + u_i \qquad (2)$$

where cross-section units are represented by $i = 1, 2, \ldots, N$; the number of periods $t = 1, 2, \ldots, T$; X_{it} is a $k \times 1$ vector of explanatory variables; ϕ_i is the error-correction parameter, which presents adjustment mechanism toward long-run equilibrium relationship for each monetary autonomous and nonautonomous EU economy; the error-correction parameter is expected to be negative under the assumption that long-run relationship exists and variables converge to long-run equilibrium; in contrast, $\phi_i = 0$ means that there is no long-run equilibrium; θ_i is the long-run equilibrium relationship between variables; λ_{ij} is the coefficient of the lagged dependent variable; δ_{ij} is the short-run coefficient for each panel unit (EU economy); μ_i represents the individual effects; and u_{it} is the stochastic disturbance term. In this research, money supply (*ms*) represents the dependent variable investigated in relation to the impact of central bank balance sheet expansion policy (*lnqe*) and real interest rate (*rir*). Specification can be now transformed as follows:

$$\Delta ms_{it} = \phi_i(ms_{it-1} - \theta_i lnqe_{it} - \theta_i rir_{it}) + \sum_{j=1}^{p-1} \lambda_{ij} \Delta ms_{it-1} + \sum_{j=0}^{q-1} \delta_{ij} \Delta lnqe_{it-j} + \sum_{j=0}^{q-1} \delta_{ij} \Delta rir_{it-j} + u_i + u_{it} \quad (3)$$

In our second model, we investigate the effects of balance sheet expansion on the real economy where GDP is taken as a proxy, the dependent variable is the nominal gross domestic product (*ngdp*) while the independent variable is the central bank's balance sheet policy (*lnqe*). We can estimate the following model:

$$\Delta ngdp_{it} = \phi_i(ngdp_{it-1} - \theta_i lnqe_{it}) + \sum_{j=1}^{p-1} \lambda_{ij} \Delta ngdp_{it-1} + \sum_{j=0}^{q-1} \delta_{ij} \Delta lnqe_{it-j} + u_i + u_{it} \quad (4)$$

4. Results and discussion

4.1 Pre-estimation procedure

The initial econometric steps are to investigate the preestimation framework necessary for robust results such as cross-sectional (in)dependence using the Pesaran cross-sectional dependence (CD) test (H0: cross-sectional independence). The null hypothesis of cross-sectional independence must be rejected for all analysed variables, which is anticipated due to the robust institutional framework and high level of integration in the EU (Table 1). The presence of CSD implies the necessity for second-generation panel unit root tests, hence the Pesaran PURT test which accounts for CSD. The results suggest the acceptance of the null hypothesis, as the analysed variables exhibit non-stationarity at the level of the specified model with two lags. The proceeding step is stationarity testing at the first difference, where results show acceptance of H1 implying stationarity of analysed variables. Therefore, the variables *ms*, *lnqe*, and *rir* are integrated in the first order, which is the basis for the further cointegration relationship in the 2014Q1–2023Q1 period. Estimation of the long-run equilibrium relationship between non-stationary variables using the Westerlund test is the next step in the analysis. The results imply that the *p*-value is below 0.05 which rejects the null hypothesis of no cointegration, meaning that *ms*, *lnqe*, and *rir* are cointegrated.

Table 1. Pesaran CD test, Pesaran CIPS test and Westerlund cointegration test

Sample: 11 EU economies; period 2014Q1-2023Q1									
	(a)		(b)					(c)	
Variables	Pesaran CD test	*p*	Lags	Pesaran (PURT) panel unit	*p*	Pesaran (PURT) test at the first	*p*	Westerlund cointegration	*p*

Sample: 11 EU economies; period 2014Q1-2023Q1									
	(a)		(b)					(c)	
				root test in the level		differences		test	
ms	22.45	0.000	0	-2.209	0.014	-12.453	0.000	-2.1437	0.0160
			1	-1.447	0.074	-9.902	0.000		
			2	-3.522	0.000	-4.823	0.000		
lnqe	40.74	0.000	0	3.433	1.000	-12.512	0.000		
			1	3.844	1.000	-6.209	0.000		
			2	3.534	1.000	-1.554	0.060		
rir	37.75	0.000	0	-1.638	0.679	-3.988	0.000		
			1	-1.809	0.446	-3.195	0.000		
			2	-1.616	0.707	-2.262	0.041		

Source: Author's estimations.

4.2 The discussion of the final results

Since long-run relationship is confirmed in the model, the estimated homogeneous long-run coefficients using the PMG and MG estimators are presented in Table 2. The Hausman test serves as the foundation for selecting the more efficient estimator among two heterogeneous, non-stationary, and dynamic macro-panel estimators (MG vs. PMG). Consequently, we employ the Hausman specification test to investigate the impact of heterogeneity on the coefficients. If the null hypothesis of parameter homogeneity cannot be rejected, the PMG estimator is more efficient. Conversely, if the alternative hypothesis is accepted, the efficient estimator is MG (*p*-value below 0.05). The presented results suggest that the *p*-value is 0.15, meaning that the null hypothesis cannot be rejected. We can conclude that the efficient estimator is PMG. Looking at the short-run dynamics, the presence of monetary time lag effects is confirmed, since interest rates are not statistically significant in the short-run. This suggests that a prompt reaction to stimulate the economy in crisis conditions cannot be found in conventional monetary policy. On the other hand, QE policy is showing a strong positive and significant effect in the short-run on MS. Long-run dynamics further confirm the lagged effects of conventional policy, since interest rates are negative and significant this time. However, in order to understand the negative and significant (at the 10% level) relationship between QE and MS in the long-run, the investigated sample must be divided into two groups of countries based on monetary autonomy. The error-correction term helps to analyse the sustainability of the long-run relationship by indicating the speed of adjustment toward equilibrium. The coefficient of the error-correction term is significantly negative (-0.31), implying that market liquidity adjusts at 31% speed of adjustment each quarter. A previously determined cointegrated relationship is as expected confirmed with estimated long-run coefficients as well as with error-correction term.

Table 2. PMG and MG estimator results for 11 European economies in the period 2014Q1-2023Q1 (homogeneous coefficients)

Sample: 11 EU economies; period 2014Q1-2023Q1							
Dependent variable: *ms*		**Long-run Equilibrium (θ)**		**Short-run relationship**		**Error-Correction (Φ_i)**	
		Coef.	***p***	**Coef.**	***p***	**Coef.**	***p***
MG	*lnqe*	-14.981	0.007	67.661	0.000	-0.364	0.000
	rir	-9.595	0.000	2.3875	0.122		
PMG	*lnqe*	-7.467	0.065	78.026	0.000	-0.310	0.000
	rir	-3.089	0.002	-0.725	0.439		
Hausman test statistic		3.78	0.1511	PMG estimator, the efficient estimator under the null hypothesis, is preferred.			

Source: Author's estimations.

Understanding the negative repercussions of QE as a result of unstable transmission, underdeveloped capital markets, and institutional governance of this policy requires dividing the sample into two groups of countries based on their monetary regime (supranationalits vs. autonomy). Table 3, as anticipated, confirms short-run coordination of monetary tools for the EZ members. The results show a strong positive and significant QE effect on the MS, which is accompanied by positive real interest rates. Conventional time lag effects are confirmed since in the long-run interest rates have an inverse relationship. However, the ECB maintains a disciplined QE approach with appropriate interest rate manoeuvres to prevent inflationary pressures in the long-run. The findings are confirmed looking at the long-run, where QE has a negative and significant (at 1% level) effect on the MS, meaning that excess liquidity is withdrawn from circulation in the long-run. Error-correction term is significantly negative (-0.25), which confirms robust adjustment toward a long-run relationship.

Table 3. PMG estimator results for EZ member states in the period 2014Q1-2023Q1 (homogeneous coefficients)

Sample: 7 EZ members; period 2014Q1-2023Q1							
Dependent variable: *ms*		**Long-Run Equilibrium (θ)**		**Short-run relationship**		**Error-Correction (Φ_i)**	
		Coef.	***p***	**Coef.**	***p***	**Coef.**	***p***
PMG	*lnqe*	-27.542	0.000	67.801	0.000	-0.251	0.000
	rir	-14.30	0.000	4.733	0.000		

Source: Author's estimations.

The results presented in Table 4, amplify fundamental differences in QE implementation for monetary autonomous EU countries relative to the EZ members. Focusing on monetary autonomous EU countries will try to shed light on how monetary adjustment functions in autonomous exchange rate regime. Looking at the short-run dynamics, the balance sheet expansion policy has a strong and significant

effect on MS. Unlike for EZ members where short-run interest rates counter the QE expansionary effect, for monetary autonomous countries, interest rates are not significant. Furthermore, in the long-run, a positive QE relationship simultaneously with interest rates substantially increases MS. Adjustment to long-run equilibrium is statistically significant and negative (-0.54).

Table 4. PMG estimator results for monetary autonomous EU members in the period 2014Q1-2023Q1 (homogeneous coefficients)

Sample: 4 EU economies; period 2014Q1-2023Q1							
Dependent variable: *ms*		**Long-run Equilibrium (θ)**		**Short-run relationship**		**Error-Correction (Φ_i)**	
		Coef.	***p***	**Coef.**	***p***	**Coef.**	***p***
PMG	*lnqe*	9.621	0.006	64.436	0.000	-0.540	0.010
	rir	-3.233	0.000	-1.704	0.524		

Source: Author's estimations.

Table 5 shows the heterogeneous aspect of the PMG model with error-correction parameters and short-run parameters for each economy in the sample for the effects of *lnqe* and *rir* on *ms*. In each economy, significant adjustment toward long-run relationship is detected, confirming that monetary policy is a fundamental factor in increasing money market liquidity in crisis conditions. Short-run effects are detected only for the balance sheet expansions in nine economies; this again, confirms the limitations of conventional monetary apparatus. Looking at the EZ members, statistically significant long-run and short-run adjustments are also consistent across the group. The adjustment magnitude is lowest in Italy (23%) while highest in Spain (27%); short-run parameters exhibit similar positive patterns, where coefficient estimates are consistent with the lowest in Italy and highest in Spain. Some of the reasons for these results can be related to the robust institutional framework and high level of capital integration in the EZ, which helps with coordinated monetary transmission. Also, QE efficiency can be attributed to the ECB's disciplined and coherent approach, but also suggests that unconventional policy was the primary tool for economic malaise. On the other hand, monetary autonomous countries exhibit more heterogeneous results. Opposite to EZ members, adjustment estimates to the long-run relationship are volatile, with the highest in Romania (64%) and lowest in the Czech Republic (20%). This implies a lower integration with country-specific vulnerabilities, but also a less developed institutional framework leading to less efficient monetary transmission. Short-run dynamics are also heterogeneous and less evident. Interest rates are limited in the short-run restricting conventional policy in crisis conditions, while unconventional balance sheet expansion is statistically significant only in the Czech Republic and Romania. The primary reason for heterogeneity lies in differences within the financial systems. Countries like the Czech Republic and Romania have less rigid systems, resulting in a quicker response to QE transmission. Conversely, Hungary and Poland face regulatory and structural limitations that hinder the transmission process. In Hungary, exchange rate targets are achieved through controlled

interventions, while in Poland, the primary objective is inflation targeting. In general, results correspond to the previous ARDL model, confirming QE relevance and conventional (interest rates) policy insignificance in the short-run.

Table 5. PMG estimator results for 11 European economies in the period 2014Q1-2023Q1 (heterogeneous coefficients)

Sample: 11 EU economies; period 2014Q1-2023Q1						
Dependent variable: *ms*						
PMG Estimator	**Error-correction (Φ_i)**		**Δ*lnqe***		**Δ*rir***	
EZ members	**Coef.**	**p**	**Coef.**	**p**	**Coef.**	**p**
Austria	-0.242	0.000	67.468	0.000	4.469	0.320
Germany	-0.247	0.000	69.961	0.000	4.534	0.384
France	-0.257	0.000	69.813	0.000	6.022	0.175
Belgium	-0.254	0.000	68.113	0.000	4.928	0.256
Netherlands	-0.254	0.000	68.113	0.000	4.928	0.256
Italy	-0.234	0.000	60.608	0.002	2.484	0.389
Spain	-0.271	0.000	70.529	0.000	5.765	0.122
Monetary autonomous EU countries						
Czech	-0.206	0.008	95.603	0.008	2.455	0.547
Poland	-1.091	0.000	30.715	0.178	0.096	0.962
Hungary	-0.223	0.025	90.395	0.184	-9.556	0.148
Romania	-0.641	0.000	41.029	0.029	0.185	0.906

Source: Author's estimations.

Further examining the repercussions on the real economy of unconventional monetary policy in Table 6, panel ARDL confirms expected results between *ngdp* and *lnqe*. Since the Hausman specification test suggests that the null hypothesis of homogeneity cannot be rejected, the results support the PMG estimator as being more efficient. Analysing short-run dynamics, the relationship between presented variables is significant and negative. We need to be careful when interpreting the estimate of the short-run sign. As previously confirmed, QE has a short-run effect that increases MS promptly. Asset purchases will increase the demand for financial assets injecting liquidity. Accordingly, higher market liquidity will increase aggregate consumption, but also prices which in the short-run can negatively affect GDP. Finally, after lagged effects and a period of adjustment, in the long-run, QE policy has a significantly positive effect on GDP. Results confirm that unconventional monetary policy is an effective measure in crisis conditions characterised by a prompt and substantial increase in the MS. However, it also highlights the necessity of a time lag effect in the transmission of this policy to the real economy.

Table 6. PMG and MG estimator results for 11 European economies in the period 2014Q1-2023Q1 (homogeneous coefficients)

Sample: 11 EU economies; period 2014Q1-2023Q1						
Dependent variable: *ngdp*	**Long-run equilibrium (θ)**		**Error-correction (Φ_i)**		***Δlnqe***	
	Coef.	***p***	**Coef.**	***p***	**Coef.**	***p***
MG	68540.63	0.000	-0.240	0.000	-43312.87	0.000
PMG	28035.99	0.000	-0.093	0.031	-21398.99	0.000
Hausman test statistic	4.15	0.245	PMG estimator, the efficient estimator under the null hypothesis, is preferred.			

Source: Author's estimations.

Table 7 presents heterogeneous coefficients that indicate a divergence between two groups of countries during the 2014Q1-2023Q1 time horizon. Adjustment toward long-run equilibrium relationship is detected in six economies, while short-run estimates are significant for two countries in the sample. Analysing EZ members, adjustment to long-run relationship is confirmed, except in Austria and Germany. Reasons for the absence of long-run adjustment in these countries can be found in lower exposure to monetary shocks. Germany is a core EZ member and a key factor in EZ economic policy, hence the lower necessity to adjust to exogenous shocks. On the other hand, Austria's close ties with Germany and lower foreign capital reliance indicate stable domestic policy without a higher need for adjustment during this period. Short-run dynamics reveal significance for only two EZ member states, France and the Netherlands. Both countries are characterised by robust banking sectors, particularly the Netherlands, which serves as a pivotal foreign capital centre within the EU. The advanced banking sector implies a prompt response to macroeconomic policies, hence efficient monetary transmission. On the other hand, among monetary autonomous EU countries, only Hungary has a statistically significant (10% level) adjustment to the long-run relationship. The reasons behind this is a centralised banking sector coordinated with domestic policies, which helps with the adjustment process. Poland is the only country with a significant short-run QE dynamic next to Hungary. The fundamental reason behind it is the structure of their aggregate consumption, where significant aspects represent small and medium enterprises. This sector is more volatile to the macroeconomic framework, which implies quicker responses to policy changes. In general, results suggest a higher adjustment to the long-run relationship for EZ members, which can be attributed to disciplined asset purchases. On the other hand, the absence of adjustment for monetary autonomous EU countries implies a macroeconomic slowdown caused by overestimated balance sheet expansion.

Table 7. PMG estimator results for 11 European economies in the period 2014Q1-2023Q1 (heterogeneous coefficients)

Sample: 11 EU economies; period 2014Q1-2023Q1 Dependent variable: *ngdp*				
PMG Estimator	**Error-correction (Φ_i)**		***Δlnqe***	
EZ members	**Coeff.**	***p***	**Coeff.**	***p***
Austria	-0.026	0.122	-4982.236	0.465
Germany	-0.043	0.549	-42148.15	0.387
France	-0.456	0.001	-94176.56	0.035
Belgium	-0.042	0.085	-4954.867	0.571
Netherlands	-0.139	0.008	-21890.18	0.046
Italy	-0.270	0.007	-50406.74	0.146
Spain	-0.264	0.007	-49082.01	0.118
Monetary autonomous EU countries				
Czech	0.032	0.289	-15206.39	0.843
Poland	0.043	0.391	-28443.43	0.013
Hungary	-0.053	0.075	-6908.552	0.059
Romania	0.037	0.518	2814.386	0.689

Source: Author's estimations.

5. Conclusions

This paper explores the repercussions of market liquidity dynamics along with heterogeneity in monetary adjustments of key EZ members under the supranational monetary authority (fixed exchange rate regime) against monetary autonomous EU countries. Investigating MS dynamics is achieved using two relevant variables: (i) the central bank's balance sheet asset and (ii) the real interest rate as a proxy for conventional monetary policy. The limitations of primary conventional monetary tools such as interest rates, in supporting an economy during crisis conditions necessitated the introduction of unconventional measures. However, expansionary balance sheet policy requires a robust economic structure to achieve immediate policy effects. Fundamentally, the key challenges that limited the effective transmission of balance sheet policy to GDP in monetary autonomous EU countries were underdeveloped capital markets, a transparent institutional framework, and the absence of monetary discipline. On the other hand, supranationalists with robust monetary frameworks and institutional governance ensured adequate policy responses and appropriate transmission mechanisms.

The authors of this research try to shed more light on understanding how conventional (RIR) and unconventional (QE) monetary policy influence MS dynamics along with relevant repercussions in different monetary regimes. The estimated, heterogeneous, dynamic, and non-stationary macro-panel of 11 EU

economies in the period 2014Q1-2023Q1 help us in analysing short-run and long-run dynamics among the two groups of countries differentiated by monetary autonomy, level of development, as well as with institutional framework. The preestimation procedure includes various tests such as CSD, Pesaran's PURT, and the cointegration test to ensure the robustness of the estimated results. The authors identified inefficiencies in conventional monetary tools in the short run, necessitating a shift toward prompt unconventional measures. The key finding suggests that QE will expand MS in both groups of countries, but relevant differences can be observed in the adjustment mechanisms. For EZ members, higher economic development ensures adequate monetary transmission, while the supranational authority controls MS dynamics to mitigate negative real economic consequences. Conversely, autonomous EU countries possess greater monetary flexibility and lower economic development, which tends to limit the transmission mechanism. The absence of monetary transmission will only eventually increase prices without significant effects on the real economy. These findings underpin essential problems for monetary autonomous EU countries; to ensure clear transmission in governing unconventional policy, higher capital market development, a robust institutional framework along with transparent monetary discipline is required.

For a sustainable EU, it is imperative to minimise heterogeneity and ensure higher policy efficiency for less-developed members. Higher institutional investments in the economic framework of emerging EU economies, along with political and fiscal convergence, can achieve these targets. Furthermore, investments in strengthening emerging capital markets and the banking sector can minimise divergences and reduce vulnerability to macroeconomic shocks.

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