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Master Degree Program in

Statistics and Information Management

MONETARY POLICY SHOCKS IN THE EURO AREA: A NEW MEASURE USING EONIA AND ESTER

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Master Thesis

presented as partial requirement for obtaining a Master's Degree in Statistics and Information Management

NOVA Information Management School
Instituto Superior de Estatística e Gestão de Informação
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Dissertation presented as partial requirement for obtaining the Master’s degree in Statistics and Information Management, with a specialization in Information Analysis and Management

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July, 2025

STATEMENT OF INTEGRITY

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Monetary Policy Shocks in the Euro Area: A New measure using EONIA and ESTER

This document was created with the (pdf/Xe/Lua)LaTeX processor and the NOVAthesis template (v7.3.1) (Lourenço, 2021).

To my mother, who always believed in my capabilities.

Acknowledgements

Amidst the many personal and professional challenges that I faced during the two years it took to complete this academic journey, I am grateful for the warm reception of my research topic and for the support of my supervisor, Professor Bruno Damásio, as well as the initial and precise guidance given to me by Professor Afshin Ashofteh, both members of the first academic institution where I was happy to continue my studies after arriving in Portugal. I am thankful to all members of the institution for their commitment to producing high-quality research, fostering excellent professional connections, and providing a rich learning experience, always with a focus on creating a positive impact across various spheres of society.

I am grateful for the inspiration of my grandfather, Carlos, who passed away in 2018 and whose memory helped me keep my head high when my patience was tested and life's challenges seemed insurmountable. I thank my mother, Paola, who gave me the opportunity to begin my journey into adulthood at the age of nineteen and trusted me with autonomy, and also my father, Jullianno, who taught me much and listened to me when I needed him. Finally, I am grateful to my great friend, Luiz Alexandre, because our shared journey since childhood has shown me that it is possible to build a better and more contributive version of oneself through willpower, time, and dedication.

"I have never thought, for my part, that man's freedom consists in his being able to do whatever he wills, but that he should not, by any human power, be forced to do what is against his will."

— Jean-Jacques Rousseau, Reveries of the Solitary Walker (Philosopher)

Abstract

This study investigates the macroeconomic effects of monetary policy surprises in the Euro Area 20 (EA20), a topic studied less extensively than in the United States. We construct a measure of monetary policy surprises via a high-frequency identification strategy adapted for daily EONIA/ESTER data surrounding European Central Bank (ECB) policy announcements. To isolate exogenous policy innovations, these surprises are subsequently orthogonalized using preannouncement macroeconomic and financial information. The dynamic responses of EA20 GDP and HICP inflation to these orthogonalized shocks are then estimated using Local Projections. Our findings indicate that monetary policy surprises do not have a statistically significant effect on EA20 GDP growth. However, we find that a contractionary surprise leads to a statistically significant decrease in HICP inflation, an effect that materializes after approximately 20 months.

Keywords: Monetary Policy Surprises, Monetary Policy Shocks, Euro Area, High Frequency Identification, Local Projections, Impulse Response Functions, ECB (European Central Bank)

Sustainable Development Goals (SDG):

8 DECENT WORK AND ECONOMIC GROWTH

16 PEACE, JUSTICE AND STRONG INSTITUTIONS

Resumo

Este trabalho analisa os efeitos macroeconômicos das surpresas de política monetária na Área do Euro 20 (AE20), um tópico com menor volume de pesquisa em comparação com os Estados Unidos. É construída uma medida de surpresas de política monetária por meio de uma estratégia de identificação de alta frequência, adaptada a dados diários da EONIA/ESTER em torno dos anúncios do Banco Central Europeu (BCE). Com o objetivo de isolar inovações de política exógenas, estas surpresas são ortogonalizadas com base em informação macroeconómica e financeira disponível antes do anúncio. As respostas dinâmicas do PIB e da inflação (IHPC) da AE20 a estes choques ortogonalizados são, em seguida, estimadas usando Projeções Locais. As nossas conclusões indicam que as surpresas de política monetária não exercem um efeito estatisticamente significativo sobre o crescimento do PIB da AE20. Contudo, constatamos que uma surpresa contracionista resulta numa redução estatisticamente significativa da inflação do IHPC, sendo que este efeito se manifesta após cerca de 20 meses.

Palavras-chave: Surpresas de Política Monetária, Choques de Política Monetária, Área do Euro, Identificação de Alta Frequência, Projeções Locais, Funções de Impulso-Resposta, BCE (Banco Central Europeu)

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Introduction

The effects of monetary policy have gained importance since the institutionalization of monetary authorities, as they have adopted a system of rules to make decisions and a more transparent way of communicating them to the public. Established in January 1999 with 11 member countries and now comprising 20 participants, the Euro Area 20 (EA20) monetary policy is governed by the European Central Bank, an institution created in May 1999 with the mission of maintaining price stability in the Euro Area.

Every 45 days, on average, the Governing Council of the ECB has a meeting to set three key interest rates for the euro area, these are the deposit facility, the main refinancing operations and marginal lending facility. The decision regarding these rates has direct and indirect impacts on the economic activity, inflation, other interest rates (such as the Euro Short-Term Rate (€STR) and the Euro Interbank Offered Rate (Euribor)).

With the institutional adoption of rules to guide policymakers' decisions in central banks, it became possible to predict monetary authority decisions based on publicly available data, because the market builds a consensus on what the monetary policy decision will be in the next announcement based on past, current, and predicted future state of the economy, along with the historical knowledge about the central bank's reaction function. According to the literature, in order to correctly identify the shock, we have to distinguish the predicted from the not-predicted part of each decision. As pointed out by Ramey (2016), in this rule-based framework on which monetary authorities now function, it is essential to distinguish between systematic and non-systematic effects of monetary policy.

Therefore, econometric identification of monetary surprises and understanding of their effects on macroeconomic outcomes are crucial to helping policymakers make better decisions for economic guidance.

Most of the literature on this topic examines the effects of monetary policy shocks on macroeconomic variables in the United States, as shown in Ramey (2016), with only a few studies analyzing their impact on the Euro Area (Afonso et al., 2023; Jarociński & Karadi, 2020; Peersman, 2011; Peersman & Smets, 2001). To address this gap, we will estimate the effects of monetary policy shocks in the Euro Area for GDP and HICP in terms of both magnitude and time, considering the EA20.

In order to find the effects of monetary policy surprises in the GDP and HICP for the EA20, this work follows an adapted version of the high frequency shock identification literature (Gertler & Karadi, 2015; Nakamura & Steinsson, 2018b, e.g.), using Local Projections by Jordà (2005) to estimate impulse response functions in order to find the monetary policy shock effect on GDP and HICP in magnitude and time.

2

Literature Review

The literature review examines the current development of research on monetary policy shocks. We highlighting key refinements in methodological approaches for shock identification and impulse-response functions estimation. The development of these methods was mainly based on the United States, with just a few applications in Europe.

2.1 Identification

According to Ramey (2016), macroeconomic shocks must satisfy the following criteria: (1) they must be exogenous to all current and lagged endogenous variables in the model, meaning that the impact of the shock can be attributed to external factors rather than the model's internal dynamics; (2) they should be uncorrelated with other exogenous shocks to avoid confounding effects; and (3) they should represent unanticipated events or news about future movements in exogenous variables. This ensures that shocks introduce new information that economic agents were previously unaware of. In general, shocks can be interpreted as deviations from the established rules that guide central bank actions, such as changes in the weight assigned to employment in a Taylor rule framework or shifts in the institution's political composition and influence. These examples represent exogenous changes in a given macroeconomic state. Therefore, private or public agents, relying solely on publicly available data, could not anticipate or offset these shifts through rational expectations.

Bauer and Swanson (2023) propose a simple model to clarify the identification problem:

They represent the output gap as a scalar variable x_t, assumed to be procyclical. Assuming that x_t follows a simple backward-looking linear process:

$$x_t = \rho x_{t-1} - \theta i_{t-1} + \eta_t, \tag{2.1}$$

where time t is discrete, $|\rho| < 1$ and $\theta \geq 0$ are parameters, i_t denotes the interest rate, and η_t is an exogenous i.i.d. Gaussian process with mean zero and variance

σ_η^2. This corresponds to the standard intuition that higher interest rates reduce future economic activity.

Each period t is divided into two subperiods: x_t is realized in the first subperiod, and i_t is set by the monetary authority in the second subperiod, according to the monetary policy rule:

$$i_t = \alpha_t x_t + \varepsilon_t, \tag{2.2}$$

where α_t denotes the monetary authority's responsiveness to x_t, and ε_t is the monetary policy shock, an exogenous i.i.d. Gaussian process with mean zero and variance σ_ε^2. For simplicity, the authors assume α_t follows a random walk:

$$\alpha_t = \alpha_{t-1} + u_t, \tag{2.3}$$

The authors assume that the monetary authority has perfect information about all the parameters of the model. The private sector knows the parameters ρ, θ, σ_η^2, σ_ε^2, and σ_u^2, and observes x_t and i_t each period, but does not observe α_t, ε_t, or u_t. Therefore, it must form beliefs about α_t based on the observed history of x_t and i_t.

They assume that the private sector forms beliefs rationally using fully Bayesian updating. Let the history of observed variables up to time t be denoted by:

$$\mathcal{H}_t \equiv \{i_t, x_t, i_{t-1}, x_{t-1}, \ldots\}$$

At the beginning of period t, before x_t and i_t are realized, the private sector's prior beliefs about α_t are Gaussian, with:

$$a_t = \mathbb{E}[\alpha_t \mid \mathcal{H}_{t-1}], \quad \sigma_t^2 = \mathrm{Var}[\alpha_t \mid \mathcal{H}_{t-1}]$$

Once the private sector observes x_t, it forms the expected interest rate as:

$$\mathbb{E}[i_t \mid x_t, \mathcal{H}_{t-1}] = a_t x_t$$

The actual interest rate decision by the monetary authority leads to a monetary policy surprise:

$$\mathrm{mps}_t \equiv i_t - \mathbb{E}[i_t \mid x_t, \mathcal{H}_{t-1}] = (\alpha_t - a_t)x_t + \varepsilon_t \tag{2.4}$$

Equation (4) shows that monetary policy surprises can arise either from an exogenous policy shock ε_t, or from imperfect information about the true monetary policy coefficient α_t (i.e., $\alpha_t \neq a_t$).

The related literature for monetary shock identification consists on two main methods: The narrative method and the high-frequency method.

Romer and Romer (2004) narrative method consists on regressing the change in the federal funds rate against current and past data about economic activity and inflation provided by the FED's Greenbook. The method is so called because the identification relies solely on the past data about the economic state and the regressand is the change made by each authority's decision.

The high frequency identification method (e.g., Gertler & Karadi, 2015; Gürkaynak et al., 2005; Nakamura & Steinsson, 2018a) relies on data collected around monetary authority decisions regarding relevant financial assets (eg. FED futures fund rates). Their approach considers market price adjustments following a policy decision as an instrument to identify the shock. This literature is a critic of the narrative method. It points out that solely the changes in a policy rate (e.g. deposit rate in the case of EA20) is not sufficient for the shock identification. The high frequency literature argues that watching for the market reaction around the meeting would be sufficient to capture the effect of the decision, considering also variables of the economic state to control for the agents' previous expectations about the authority's decision.

Both frameworks may face endogeneity issues, once both market participants and the monetary authority continuously adjust their expectations based on the current and predicted state of the economy. As pointed out by Bauer and Swanson (2023), the market agents don't know the monetary authority's reaction function for each decision stance. Instead, market agents estimate this reaction function, which can be a theoretical source for shocks.

According to Miranda-Agrippino and Ricco (2017), the appropriate shock identification procedure must account for the assymmetrical information held by market participants and the monetary authority regarding the true structural state of the economy. These authors propose capturing the shifts to the policy rates that were unpredicted by market participants and were not generated by a shift in Central Bank's preferences. They propose regressing the price revisions in interest rate futures following Federal Open Market Committee (FOMC) announcements onto their lags to remove the autocorrelation and onto Greenbook forecasts and forecast revisions for real output growth, inflation and the unemployment rate, to control for the central bank's private information at the decision time.

Nakamura and Steinsson (2018b) argue that information captured on a 30-minute window around the FOMC decision is sufficcient to allow for a discontiuity-based identification scheme, since all information that is public at the beginning of this window is already incorporated into the financial market, and any changes in such a narrow period would be considered caused by the decision.

Bauer and Swanson (2023) argue that high-frequency identified shocks are autocorrelated and predictable using public available information, which brings endogeneity to the impulse-response effects. They propose that it is possible to orthogonalize the component of monetary shocks by using public economic and financial data available before each policy decision in order to use it on Vector Autoregressions (VARs) or Local Projections (LPs), by considering the shock as the unpredicted part of the price changes detected in the high-frequency scheme.

2.2 Impulse Response Functions

2.2.1 Local Projections

While VARs have traditionally been the preferred method for estimating IRFs by modeling the entire dynamic system (e.g., Sims, 1980), an alternative approach is the Local Projections (LPs) proposed by Jordà (2005). LPs offer a flexible, semi-parametric way to estimate IRFs directly at each horizon, without needing to specify and estimate the complete dynamic system. This approach is robust to misspecification for the estimation of non-linear or state-dependent effects (Jordà, 2023; Jordà & Taylor, 2024).

The fundamental idea of LPs, as shown in Jordà (2005), is to estimate a series of regressions, one for each impulse response horizon h. For a shock ϵ_t (in this work's case, $mps_t^{\perp}$) and an outcome variable y_t, the IRF at horizon h is the coefficient β_h in the regression:

$$y_{t+h} = \alpha_h + \beta_h \epsilon_t + \sum_{k=1}^{p} \phi_{h,k} y_{t-k} + \Gamma_h' \mathbf{X}_t + u_{t+h} \tag{2.5}$$

where y_{t+h} is the outcome variable h periods ahead, ϵ_t is the identified shock at time t, y_{t-k} are lags of the dependent variable, and $\mathbf{X}_t$ is a vector of other control variables (which could include lags of the shock or other relevant contemporaneous variables not part of the shock identification itself). A separate regression is run for each horizon $h = 0, 1, \ldots, H$.

2.2.2 Comparison with VARs and Advantages

Jordà (2023) provides a comprehensive overview of LPs and their relationship with VARs. While Plagborg-Møller and Wolf (2021) show that LPs and VARs estimate the same impulse responses in population under certain conditions (specifically, if the data generating process is a correctly specified finite-order VAR), LPs offer several advantages, particularly when the true data generating process might be more complex or unknown, which is the case for monetary policy shock effects. VAR-based IRFs are derived from a system-wide, often linear, approximation. If this approximation is poor, the errors can compound across horizons. LPs, by estimating the response at each horizon separately, can be more robust to such misspecifications (Jordà, 2005; Jordà & Taylor, 2024). Jordà et al. (2024) and Plagborg-Møller et al. (2024) further show that LPs can have lower bias and provide correct coverage even with misspecification. LPs are estimated equation by equation, this makes it considerably simpler to introduce non-linearities or state-dependencies (e.g., interacting the shock ϵ_t with a state variable, or estimating separate LPs for different regimes) compared to the complexities of non-linear VARs (Auerbach & Gorodnichenko, 2012; Jordà, 2023).

Despite these advantages, LPs can be less efficient than correctly specified VARs because they do not impose the cross-equation restrictions implied by a VAR structure (Jordà, 2023; Plagborg-Møller & Wolf, 2021). The choice between LPs and VARs often involves a bias-efficiency trade-off, with LPs typically favored when robustness to potential misspecification is a primary concern (Jordà & Taylor, 2024), Section 3).

The main innovation of LPs is the shift from system-based estimation of IRFs to a more direct, horizon-specific regression approach. This provides greater flexibility, particularly for handling non-linearities and complex processes where VAR assumptions might be too restrictive. Recent advancements have significantly improved inferential procedures, making LPs a robust and versatile tool for applied macroeconomic research (Jordà, 2023; Jordà & Taylor, 2024).

Having established the key methodological advancements in shock identification and impulse response estimation, we now turn to how these approaches have been applied to the Euro Area.

2.3 Summary of Euro Area Studies

Early studies using Vector Autoregression (VAR) models found that policy had clear effects. For example, both Peersman and Smets (2001) (looking at the pre-euro period) and Peersman (2011) (analyzing the ECB's first decade) used VARs to show that a contractionary shock lowered output and prices after a lag of several months to a year. This general agreement was challenged when researchers began using high-frequency identification (HFI).

Jarociński and Karadi (2020) found that when policy surprises were measured in a tight window around ECB announcements, they had no statistically significant impact on GDP or prices. They argued this was because the policy signal was mixed with "information shocks"—new data about the economy released by the ECB at the same time. This raised a puzzle: were the effects seen in earlier studies simply a result of less precise methods?

More recent work tries to solve this problem by combining the new identification methods with different estimation techniques. Afonso et al. (2023) took the HFI shocks from Jarociński and Karadi (2020) and analyzed them with a Panel Local Projection model. In this setup, the negative effects on GDP and inflation reappeared. Their work suggests that finding the true impact of monetary policy depends not only on accurately measuring the shock, but also on the model used to estimate the response—a model that should account for differences across countries and other factors, such as the government's fiscal policy.

3

Methodology and Data

The proposed work is divided into three phases: (i) Identification of monetary shocks using Nakamura and Steinsson (2018b) high frequency strategy adapted to the Euro Area for daily data, (ii) orthogonalization of shocks based on Bauer and Swanson (2023) and (iii) estimation of impulse response functions using i and ii based on the LPs by Jordà (2005)).

3.1 Data

The data selection follows Bauer and Swanson (2023), that, for the US study, used a set of financial data (based on Bauer & Chernov, 2021; Cieslak, 2018) that were available to financial markets before the monetary authority decisions. The authors selected nonfarm payroll surprises, employment growth, S&P 500 and the yield curve slope. In the adaptation for EA20, only data from December 2005 is available for the data selected. The following datasets were included in the study:

- The log change in total employment from one year earlier to the most recent release before the ECB announcement.
- The log change in the Eurostoxx 50 index from three months before the ECB announcement to the day before the ECB announcement.
- The change in the slope of the yield curve from three months before the ECB announcement to the day before the ECB announcement, measured as the second principal component of one- to ten-year zero-coupon Treasury yields from Gürkaynak et al. (2007). In the European case, we are using Euro Yield Curves provided by the ECB for the EA20 on AAA-rated bonds. These changes are linked to expectations about future short-term rates and monetary policy tightening or easing.
- The log change in the Commodity Price Index from three months to the day before the ECB announcement.

- EA20 GDP Volume on a quarterly frequency.
- EA20 Industrial Production Index excluding construction, on a monthly frequency.
- EA20 Harmonized Price Index, on a monthly frequency.
- ECB Monetary Policy Decisions: From all the press releases publicly available, the date of the decision and the date of effect for the three key ECB interest rates. This database was built by the author and contains all the announced decisions and time of decision publication from March 4th 1999 to Mar 6th 2025. We cover 309 meetings in this period.
- Daily closing of EONIA/ESTER rates.

The EA20 GDP Quarterly Volume was interpolated at a monthly frequency using the Chow-Lin method with monthly industrial production as an indicator. This approach assumes that the residuals follow an AR(1) process. For detailed model statistics and results, see the annex.

$$Y_t = \sum_{s \in \text{quarter } t} y_s \tag{3.1}$$

$$\text{with} \quad y_s = \beta X_s + u_s, \quad u_s \sim \mathcal{N}(0, \sigma^2) \tag{3.2}$$

Where Y_t is the observed quarterly aggregate value at quarter t (e.g., quarterly GDP), y_s is the unobserved monthly value for month s within quarter t, X_s is a higher-frequency indicator observed at month s, closely related to the variable of interest, β is a vector of parameters linking the indicator X_s to the monthly variable y_s, u_s is the error term at month s, assumed to be normally distributed with mean zero and variance σ^2, i.e., $u_s \sim \mathcal{N}(0, \sigma^2)$.

The effective change in the ECB's Deposit Rate is made a few days after its announcement by a Press Release. Here, we use the Press Release Date as the moment to identify any shock, once this is the channel that brings new information to the economic agents.

To ensure a consistent time series of overnight rates, we follow the transition from EONIA to ESTER as implemented by the ECB. Until 30 September 2019, EONIA was published on the same day (T). From 1 October 2019 to 3 January 2022, EONIA was recalibrated as ESTER plus 8.5 basis points and published on T+1, aligning with the new ESTER methodology. From 1 October 2019 onward, we adopt the published ESTER, which reflects transactions from day T and is released at 08:00 CET on T+1. Prior to this date, we approximate ESTER by adjusting EONIA downward by 8.5 basis points, allowing for a continuous and methodologically consistent series.

3.2 Estimation

The identification of the monetary surprise will follow the high frequency identification proposed by Nakamura and Steinsson (2018b), backed up by the theoretical foundation proposed by Bauer and Swanson (2023) regarding endogeneity issues, with adaptations due to data availability. The first adaptation is due to the lack of access to intraday data for the German Bund or EONIA/ESTER Futures. To address this problem, we are using daily changes in the EONIA/ESTER that are publicly available on the ECB website. The impulse response function will be estimated using the Local Projections proposed by Jordà (2005). We divide the estimation process into three steps:

- (i) Being T the meeting date, the monetary policy shocks will be identified as the delta in EONIA/ESTER from T - 1 to T.
- (ii) The orthogonalized shocks are the residuals of the following equation:

$$mps_t = \alpha + \beta X_{t-} + \epsilon_t \tag{3.3}$$

- (iii) We use orthogonalized shock to estimate LPs for GDP and HICP:

$$Y_{t+h} = \omega_h + \phi_h(L)Y_{t-1} + \theta_h mps_t^{\perp} + \beta_h X_t + \mu_h \tag{3.4}$$

4

Results

Figure 1 shows the comparison between orthogonalized and non-orthogonalized shocks. The main difference here is that, in the orthogonalized case, we just have data available for 2005 onward, once the ECB Yield curves are not available for precedent periods.

The differences in variance for different periods of EONIA and ESTER can be interpreted as the consolidation and improvement of the Euro and the ECB's increase in communication efficiency and institutional maturity, which would normally imply a smoother monetary policy conduction with less perceived shocks. The advantage of using data from 2005 is that it reflect a more stabilized scenario for the Euro Area.

The results for impulse-response functions using the orthogonalized shocks show

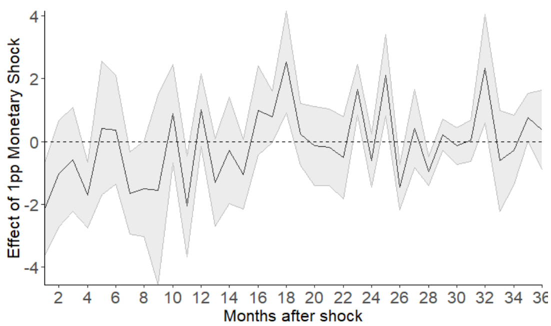

Figure 4.1: *Monetary policy shock IRF on Real GDP growth.*

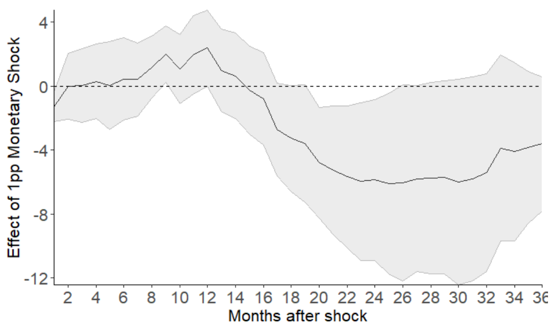

Figure 4.2: *Monetary policy shock IRF on HICP change.*

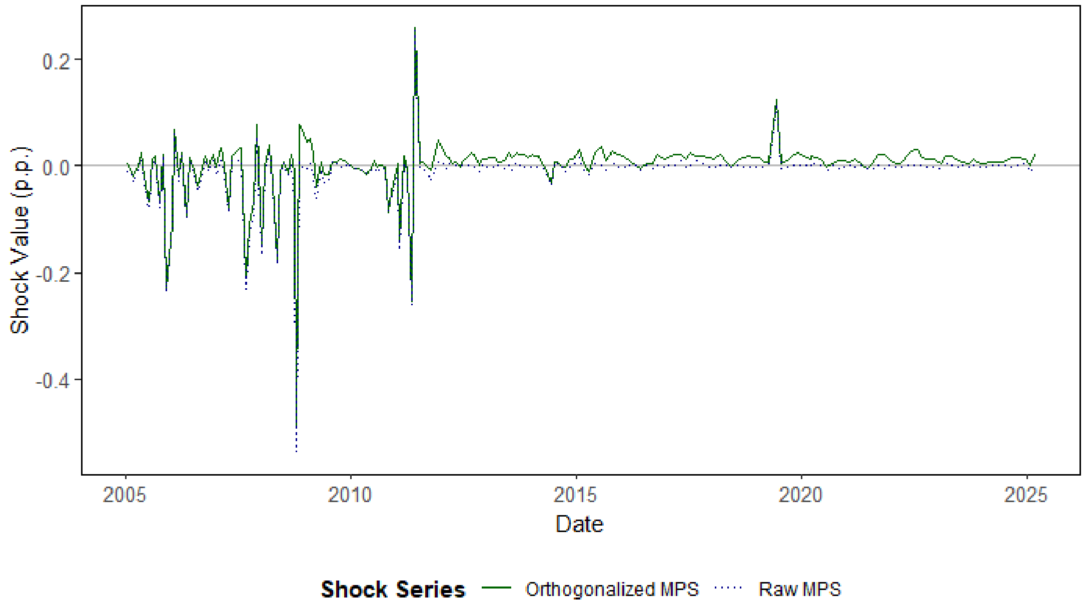

Figure 4.3: *Comparison of raw and orthogonalized monetary policy shocks.*

that there is not a statistically significant effect in GDP (Figure 2). The form of impulse response is not in line with Jarociński and Karadi (2020), but the neutrality of shocks regarding GDP is consistent. These results are not aligned with the other European studies reviewed, since they find significant effects for GDP in 6 to 12 months horizons after the shock. We find puzzling results for the HICP, since a contractionary shock can lead to an increase in price level iif we consider point estimates. The puzzle is not statistically significant, though. A contractionary shock of 1 percentage point will lead to statistically significant decrease in HICP after the 20th month, with the bounds returning to zero after the 26th month. This means, consistently with current economic theory, that the effects of monetary decisions can be far delayed in time.

5

Conclusion

This study identifies monetary policy surprises in the Euro Area 20 and estimates their impulse-response effects on GDP and HICP. Adopting a high-frequency identification strategy using daily changes in EONIA/ESTER rates around ECB announcements, and subsequently making one of the first applications to the surprises orthogonalization with pre-announcement macroeconomic and financial data following Bauer and Swanson (2023), we aimed to isolate exogenous policy shocks. The impulse-response of these shocks was measured using Local Projections by Jordà (2005).

Our empirical results present a distinct picture of monetary policy transmission in the EA20. For real economic activity, we find no clear, statistically significant effect of orthogonalized monetary policy surprises on GDP growth across the analyzed horizons. This outcome of GDP neutrality, while contrasting with earlier studies like Peersman and Smets (2001) and Peersman (2011) who found negative output responses using VAR methodologies, is consistent with the findings of Jarociński and Karadi (2020).

Jarociński and Karadi (2020) also reported statistically zero effects on GDP for the Euro Area using a high-frequency identification approach with sign restrictions. Our findings also differ from Afonso et al. (2023), who, using quarterly panel local projections, found a negative GDP response within the first five quarters. Potential reasons for this divergence include the use of orthogonalized high-frequency shocks, a focus on daily rather than quarterly data, and the shorter sample window for orthogonalized shocks (starting in 2005).

Regarding inflation, the impact of monetary policy surprises appears with a considerable lag. While initial point estimates for the HICP response were inconclusive, our analysis reveals that a contractionary monetary policy surprise of one standard deviation leads to a statistically significant decrease in the HICP. This effect becomes apparent approximately 20 months post-shock, with the impact dissipating after the 26th month. This delayed reaction of prices is consistent with economic theory and underscores the protracted nature of the monetary transmission mechanism to inflation in the EA20. For instance, Peersman and Smets (2001) found price level responses with a delay of 12 months, while Afonso et al. (2023) noted negative price effects beyond the 10th quarter (30 months). Our finding of a significant effect around 20-26 months fits within this broader range of delayed price responses.

The main contribution of this work lies in the application of a contemporary high-frequency identification and orthogonalization framework to the EA20, using readily available daily data. The use of data from 2005 onwards for the orthogonalized shocks reflects a period of greater maturity for the Euro and the ECB. However, the orthogonalization procedure itself (Table I.2) showed that the selected pre-announcement variables explained a relatively small fraction of the raw shock variance, suggesting that either daily EONIA/ESTER changes on announcement days already capture a substantial surprise component, or that further refinement of conditioning variables could be beneficial.

Several limitations are pertinent. The reliance on daily, rather than intraday, data for shock identification is an adaptation to data availability. The interpolation of quarterly GDP to a monthly frequency, while a standard technique, introduces its own set of assumptions. Furthermore, the dataset for orthogonalized shocks begins in 2005, restricting the historical depth of the primary impulse response analysis.

Future research could explore the robustness of these findings by incorporating alternative or expanded sets of pre-announcement control variables. Given the flexibility of Local Projections, investigating potential non-linearities or state-dependent effects of monetary policy in the EA20 could also provide deeper insights. Moreover, a disaggregated analysis at the member-state level might uncover heterogeneities in the transmission mechanism that are averaged out in the aggregate EA20 data.

In conclusion, this study provides updated evidence on the effects of monetary policy surprises in the EA20. The results suggest a limited impact on real output and a significantly lagged, though eventually discernible, effect on inflation.

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Annex 1

Table I.1: Regression Results of Chow-Lin Temporal Disaggregation

Variable	Estimate	Std. Error	t value	Pr(> $\|t\|$)	Significance
Intercept	343,630.5	109,817.4	3.129	0.00221	**
Indicator (IP Index)	6,191.5	284.1	21.797	< 2e-16	***
Adjusted R-squared: 0.798					
Number of low-frequency obs.: 121, converted to 411 high-frequency obs.					
AR(1) Parameter: 0.999					

Significance codes: *** $p < 0.001$, ** $p < 0.01$

Table I.2: Regression Results for Orthogonalization of Monetary Policy Shocks

Variable	Estimate	Std. Error	t value	Pr(> $\|t\|$)	Significance
Intercept	-0.014721	0.004189	-3.514	0.000547	***
d_PC2	-0.027699	0.019667	-1.408	0.160582	
d_uwie	0.087314	0.051568	1.693	0.091997	.
emp_change	0.139117	0.149430	0.931	0.352999	
d_e50	-0.031010	0.053665	-0.578	0.564033	
Residual standard error: 0.05933 on 197 degrees of freedom					
Multiple R-squared: 0.03226, Adjusted R-squared: 0.01261					
F-statistic: 1.642 on 4 and 197 DF, p-value: 0.1652					

Significance codes: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, . $p < 0.1$

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