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The Dynamics of Inflation and Output in the Euro Area 20

A Hybrid New Keynesian Phillips Curve Approach

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Católica Porto Business School
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A Hybrid New Keynesian Phillips Curve Approach

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Resumo

No rescaldo da crise financeira global de 2008, agravada pela pandemia da Covid-19 e, principalmente, pelo escalonamento do conflito entre a Rússia e a Ucrânia, a inflação regressou à Área Euro 20. O objetivo principal desta dissertação é compreender a dinâmica da inflação e do produto subjacentes. Para atingir este objetivo, após filtrar os dados utilizando o filtro de Hodrick-Prescott e recorrendo ao método dos Mínimos Quadrados em Duas Etapas, foi estimada uma Curva de Phillips Nova Keynesiana Híbrida para o período de 2015 a 2023. Os resultados indicam que a inflação observada é significativamente influenciada tanto por elementos retrospectivos – ou seja, a inflação passada – como por elementos prospectivos – as expectativas atuais dos agentes econômicos em relação à inflação futura. Curiosamente, o efeito do hiato do produto na inflação observada não é significativo. Além disso, os resultados revelam que as expectativas correntes sobre a inflação futura têm mais peso do que a inflação passada. Adicionalmente, o conflito Rússia-Ucrânia, as medidas de política monetária adotadas pelo Banco Central Europeu e as atividades especulativas por parte dos fundos de investimento têm tido um impacto significativo nessas expectativas.

Palavras-chave: Inflação, Área Euro 29, Curva de Phillips Nova Keynesiana Híbrida, COVID-19, guerra Rússia-Ucrânia

Abstract

In the aftermath of the global financial crisis of 2008, compounded by the COVID-19 pandemic and, most notably, the escalation of the Russia-Ukraine conflict, inflation has returned to the Euro Area 20. The primary objective of this dissertation is to understand the dynamics of inflation and output associated. To achieve this goal, after filtering the data using the Hodrick-Prescott filter and employing the Two-Stage Least Squares method, a Hybrid New Keynesian Phillips Curve was estimated for the period of 2015-2023. The results indicate that observed inflation is significantly influenced by both retrospective elements – past inflation – and prospective elements – the current expectations of economic agents regarding future inflation. Interestingly, the effect of the output gap on observed inflation is not significant. Furthermore, the findings reveal that current expectations about future inflation carry more weight than past inflation. Additionally, the Russia-Ukraine conflict, the monetary polict measures adopted by the European Central Bank, and speculative activities by investment funds have all had a significant impact on these expectations.

Keywords: Inflation, Euro Area 20, Hybrid New Keynesian Phillips Curve, COVID-19, Russia-Ukraine war

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1 Introduction

The main objective of this dissertation is to analyze the dynamics of inflation and output in the Euro Area 20 (EA-20). To achieve this, we estimate a Hybrid New Keynesian Phillips Curve (HNKPC) for the EA-20. The HNKPC recognizes that both retrospective elements – past inflation – and prospective elements – expected future inflation – influence current inflation levels. Furthermore, it acknowledges that economic agents adjust their expectations regarding future inflation based on currently available information.

Over the past few years, since the outbreak of COVID-19 pandemic and particularly after Russia's invasion of Ukraine and subsequent war, the EA-20 economy has faced high levels of inflation. In March 2020, the European Central Bank (ECB) announced a set of policy measures to support the economy in the face of exceptional shocks that contributed to inflation levels far above the established medium-term target of 2%. These initial measures primarily focused on stabilizing the market and providing ample central bank liquidity to support credit provision to the real economy (European Central Bank, 2020a).

As the ECB's main role is to ensure price stability, it monitors and assesses the inflation outlook in light of incoming information and sets monetary policies accordingly. ECB's primary monetary policy instrument is the set of its key interest rates, namely the main refinancing operations rate, deposit facility, and marginal lending facility. The first ECB rate hike since 2011 can be traced back to July 26th, 2022, when the three key interest rates increased by 0,5 percentage points, being the first out of nine subsequent rate hikes up to the present date (ECB, 2023, 2024a).

Given the contemporary relevance of inflation and inherent economic uncertainty on a global scale, the motivation behind this research lies in the attempt to deepen our understanding of the dynamics of inflation within the EA-20. Particularly, we intend to focus on the consequences of the COVID-19 pandemic and the ongoing conflict between Russia and Ukraine.

This dissertation unfolds as follows: After this introductory chapter, chapter 2 examines the HNKPC and the information the literature suggests individuals may consider when forming their expectations regarding future inflation. This is followed by chapter 3, which comprises the empirical analysis. In this chapter, we describe the selected econometric model, the collected data, its treatment, the estimation results, and discuss the findings. Finally, chapter 4 presents the conclusion, fundamentally summarizing the main findings of the dissertation.

2 Literature Review

2.1 The Hybrid New Keynesian Phillips Curve

Phillips (1958) documented statistical evidence in the United Kingdom from 1861 to 1957, demonstrating a clear tendency for wage inflation to be high when unemployment is low, and low – or even negative – when unemployment is high. In the years that followed, Phillips' (1958) seminal work was replicated by Samuelson & Solow (1960) in the United States from 1900 to 1960. Despite analyzing the behavior of price inflation instead of wage inflation, the conclusions remained consistent with Phillips' (1958) findings, suggesting a short-run trade-off between inflation and unemployment, which the authors named the Phillips Curve. This trade-off rapidly became a paramount topic in macroeconomics, providing the groundwork for numerous models developed afterward (Blanchard *et al.*, 2017).

However, the natural rate hypothesis, developed by Friedman (1968) and Phelps (1968), questioned the long-term stability of the trade-off supported by the Phillips Curve. These two authors introduced the concept of a natural rate of unemployment, which is not driven by monetary forces, but rather determined by real forces. In light of this natural rate hypothesis, the actual unemployment rate cannot be systematically sustained below its natural level. While previous research considered expectations to be anchored, this theory perceives expectations to be adaptive, meaning that economic agents continuously adapt their expectations of current inflation based on past inflation (Birol, 2013).

In this manner, in order to systematically achieve lower levels of unemployment, the ECB will need to accelerate the inflation rate, which is not sustainable. Given that economic agents will adjust their expectations based on the previous inflation levels observed, systematic expansionary policies will eventually alter the way prices and wages are set, and unemployment will inevitably return to its natural level. Therefore, monetary policies cannot sustain lower unemployment rates at the expense of higher inflation (Romer, 2019). Thus, there is no permanent or long-run trade-off, merely a temporary or short-run trade-off between inflation and unemployment. These assumptions gave rise to a new formulation of the Phillips curve, which Phelps (1968) named as the augmented Phillips curve, that relates current inflation to expected inflation, unemployment, and its natural rate (Friedman, 1968; Phelps, 1968).

In the 1970s, the oil shocks empirically supported Friedman's (1968) and Phelps' (1968) assertions. These shocks challenged the long-term stability of a trade-off between inflation and unemployment. The oil price increases of 1973-74 and 1978-79 resulted in simultaneous high levels of both inflation and unemployment during sustained periods – a scenario referred to as "stagflation" (Blanchard *et al.*, 2017).

Throughout this decade, annual inflation rates often surpassed levels of 10% across the OECD countries (ECB, 2010). As inflation became more persistent, economic agents adjusted the way expectations of inflation were formed, thereby transforming the nature of the relationship between inflation and output. This way, the oil shocks eventually contributed to the demise of the traditional Phillips Curve (Blanchard *et al.*, 2017).

Moreover, it is crucial to understand that persistence is one of the main characteristics of inflation and it is defined by the rate at which inflation reaches equilibrium after a certain macroeconomic shock (Vyrostková & Mirdala, 2022). In other words, inflation is considered persistent if it converges to equilibrium at a slow rate. With reduced persistence, inflation can be stabilized more quickly after a shock. Therefore, the degree of inflation persistence becomes an important parameter influencing the conduct of monetary policy (Marques, 2004).

Furthermore, Muth (1961) introduced the pivotal concept that expectations in financial markets are rationally formed. However, it was Lucas (1972), often regarded as the founding father of the neoclassical New Classical macroeconomics approach, who asserted that short-run fluctuations in the aggregate economy – the business cycle – could be comprehended within a general equilibrium framework of rational, forward-looking agents (Birol, 2013). Lucas (1972) emphasized that these agents base their decisions on rational expectations, anticipating future events based on all relevant available information: "[…] all agents behave optimally in light of their objectives and expectations, and expectations are formed optimally […]" (Lucas, 1972). Therefore, according to Lucas' theory, economic agents take into account all relevant available information when shaping their expectations concerning current inflation. This includes information related to government policies. Moreover, this theory aligns with the findings of Friedman (1968) and Phelps (1968), suggesting that the pace at which economic agents adjust their expectations of inflation directly influences how quickly the short-run trade-off disappears (Mankiw, 2012). In contrast to adaptive expectations, rational expectations allow agents to swiftly incorporate all relevant information, resulting in more rapid adjustments to their predictions.

The Lucas critique, published in subsequent years, additionally argues that "any change in policy will systematically alter the structure of econometric models" (Lucas, 1976), emphasizing the crucial role expectations play in the economy given their influence on the behavioral patterns of economic agents. Monetary policy should, therefore, be conducted in such a way that anticipates how individuals are likely to respond to changes in policy, specifically regarding their process of expectation formation (Mankiw, 2009).

However, these formulations faced widespread criticism and were swiftly challenged by the emergence of neoclassical New Keynesian theories. This innovative macroeconomic approach sought to establish microeconomic foundations that could account for the short-run impacts of monetary policy, all while integrating rational expectations. Keynes (1936) introduced the concept of "sticky prices", which is central to this macroeconomic rationale as it denotes the existence of a certain degree of price rigidity. According to Romer (2019), there must exist a certain degree of price rigidity in order for monetary changes to have real effects. The most common way of introducing such rigidities is to restrict the adjustment of prices, preventing firms from instantaneously altering their prices after macroeconomic changes (Romer, 2019).

In line with Romer's (2001) framework, nominal price rigidities were generally introduced by assuming random intervals between price changes (Calvo, 1983). In Calvo's (1983) price-setting model, only a random fraction of firms is able to reset prices for fixed periods of time. Thus, the remaining firms that keep prices unchanged provide a measure of the degree of price rigidity (Galí *et al.*, 2001). In the Calvo model, firms are forward-looking, meaning that optimal prices are equal to a weighted average of expected future prices, in the absence of price rigidities. Consequently, firms' optimal price-setting strategy entails setting prices as a fixed markup over the marginal cost, since, according to Calvo (1983), real marginal cost is the driving force for inflation. Therefore, this particular formulation – widely recognized as the New Keynesian Phillips curve (NKPC) – proposes current inflation as a function of two factors: expected future inflation and a measure of real marginal cost Romer (2019).

Although the NKPC overlooks a structural relationship between current inflation and past inflation, Galí & Gertler (1999) have suggested otherwise. In their research, in addition to forward-looking firms, Galí & Gertler (1999) incorporate a subset of backward-looking firms into Calvo's pricing model. The price-setting strategy of backward-looking firms is based on the recent history of aggregate prices explain (Galí & Gertler, 1999). Thus, giving rise to a Hybrid NKPC (HNKPC) where current inflation is a function of three factors: expected future inflation, a measure of real marginal cost, and past inflation (Nason & Smith, 2008). The addition of the latter term intends to capture inflation persistence, which the traditional NKPC is unable to explain (Galí & Gertler, 1999).

Notwithstanding, the impossibility to accurately measure the real marginal costs creates a significant challenge in terms of estimating the HNKPC. Thus, many economists recognize the output gap as a theoretically consistent proxy of real marginal costs (Lanne & Luoto, 2013; Medel, 2015). Jašová *et al.* (2020) indicate that both global and domestic output gaps are significant drivers for inflation in a NKPC framework. According to Galí (2002), the output gap is defined as the deviation of the actual output from its natural level in the absence of nominal rigidities. However, computing the output gap is demanding as the natural level of output is not observable. Therefore, natural output must be estimated, which can be done through several distinct methods, namely filtering the data using the Hodrick-Prescott (HP) filter (Razzak & Dennis, 1999). Similarly, Basistha & Nelson (2007) recognize the output gap as the driving force for inflation, suggesting that it must be estimated using statistical detrending procedures, such as the HP filter (Basistha & Nelson, 2007).

The HP filter, proposed by Hodrick & Prescott (1997), is a standard method for detrending data series, that is, for removing trend movements (Ravn & Uhlig, 2002). In their research regarding the dynamics of business cycles, Hodrick & Prescott (1997) recognize that a given data series is composed of both trend and cyclical components. Considering that the trend component varies smoothly over time, detrending data entails removing a smooth trend from the data series. This way, the cyclical component or output gap is estimated through the obtained residual, that is, the deviation from the trend.

The HP filter requires setting a smoothing parameter λ, which is a positive number that penalizes variability in the trend relative to the cyclical component. In their work, Hodrick & Prescott (1997) proposed a value of $\lambda=1600$ for quarterly data when using the HP filter. Finally, this filter can be employed to detrend variables other than the output variables, allowing us to extract their cyclical components (Hodrick & Prescott, 1997; Ravn & Uhlig, 2002; Razzak & Dennis, 1999).

Nevertheless, literature on the HP filter has pointed out a few of its shortcomings. The properties of HP filter closely depend on the value of the smoothing parameter in relation to sample size. Moreover, the detrended values located in the tails of the data set differ from the values in the middle and applying the HP filter may eliminate relevant information. In addition, the HP should only be applied to seasonally adjusted data, given the filter's limited ability to account for seasonal effects. This way, Hamilton (2017) suggested an alternative to the HP filter, known as the Kalman filter. Additionally, Vlad & Balan (2018) demonstrated that using the Kalman filter leads to better estimates of the output gap (Alba & Gómez, 2012; Hamilton, 2017; Vlad & Balan, 2018).

2.2 Drivers of Inflation Expectations in the EA-20

In order to fully comprehend the dynamics of current inflation and output in the EA-20 through estimating a HNKPC model, it is crucial to understand what determines inflation expectations. Through the observation of available information, economic agents adjust their expectations regarding future inflation. Therefore, we intend to identify which macroeconomic variables are taken into consideration during this process of adjusting expectations and which best explain expected future inflation.

First and foremost, Feldkircher & Siklos (2019) identified three sources of inflationary pressures with strong influences on expected future inflation. Their results suggest that both domestic aggregate demand and supply shocks, as well as a global increase in oil prices, exert positive effects on expected future inflation (Feldkircher & Siklos, 2019). As such, we identify the COVID-19 pandemic and the conflict between Russia and Ukraine as contemporary examples of such shocks with strong effects on expected future inflation. These two events heavily contributed to inflation rates well above the 2% target established by the European Central Bank's (ECB) (Schoeller & Heidebrecht, 2023).

Notably, the outbreak of the COVID-19 pandemic was an unprecedented shock, as were the subsequent public health measures necessary to tackle its propagation (Huber *et al.*, 2023). In the beginning of March 2020, social distancing practices and restrictions to non-essential business led to global supply chain disruptions and to constraints in the demand for most industries, namely tourism, public transportation, and entertainment (Rio-Chanona *et al.*, 2020).

Furthermore, Gomes *et al.* (2021) suggested that, up to 2021, demand-side shocks dominated those associated with supply-side disruptions, causing inflation expectations to decline (Gomes *et al.*, 2021). Additionally, Goldman & Zhang (2021) concluded that, during this period, inflation levels remained low, whereas unemployment rates increased, GDP declined steeply, and all activity sectors faced a threat to their financial stability (Goldman & Zhang, 2021). Consequently, in an initial response to the pandemic, the ECB implemented both monetary and fiscal policy measures designed to support the economy.

These temporary measures included keeping borrowing rates affordable by maintaining its three key ECB interest rates – the rate on the deposit facility, on the main refinancing operations, and on the marginal lending facility –

unchanged. The interest rate on the main refinancing operations (MRO) is the rate at which banks borrow money from the ECB for one week, providing the bulk of liquidity into the banking system. On the other hand, the rate on the deposit facility is used by banks for borrowing money from the ECB overnight, and the rate on the marginal lending facility defines the rate banks receive or pay when depositing money with the ECB overnight. In addition, the ECB has implemented non-conventional monetary policies by expanding its pre-existing both asset purchase and lending programmes, which were designed to control borrowing costs and provide additional liquidity to economic agents in the aftermath of the global financial crisis of 2008 (ECB, 2020c, 2024b; Goldman & Zhang, 2021).

To address the global financial crisis of 2008 within the EA, the ECB implemented several lending programmes, notably the Long-Term Refinancing Operations (LTROs), aimed at providing liquidity to the EA banking system (European Central Bank, 2020b). Thus, by increasing banks' lending capacity, the ECB is able to ensure an extra source of credit to firms and households (ECB, 2024c). In addition, the Pandemic Emergency Purchase Programme (PEPP) is an asset purchase programme, through which the ECB can purchases several private and public securities (ECB, 2020a). This way, the ECB aims to creating funding conditions for firms and households by ensuring lower borrowing costs and increasing money supply in the EA (ECB, 2024c).

Moreover, non-conventional monetary policy asset purchase programmes, commonly known as quantitative easing (QE), are among the numerous tools utilized by the ECB to maintain low interest rates and promote economic stability. These purchases improve banks' lending capacity, facilitate households' and firms' access to credit, help boost economic growth (ECB, 2022). However, adopting QE measures, such as PEPP, for long periods may lead to excessive amounts of liquidity in the banking system. Ideally, banks would be able to completely absorb the additional money supply and, in turn, transform it into broad monetary aggregates, ultimately contributing to a higher aggregate demand. Yet, despite ECB's efforts, the slow growth of broad monetary aggregates indicates that this policy goal has not been fully accomplished (Dabrowski, 2023).

In addition, some economists have suggested that excess liquidity influences expectations regarding future inflation. Although Gertler & Hofmann (2018) stated that the relationship between money growth and inflation have weakened over the years, Jung & Villanova (2020) suggested that M3 poses as an indicator for future inflation, considering a time span of 1 to 2 years. In this regard, to understand the impacts of the COVID-19 pandemic on economic agents' expectations of future inflation, we must account for changes in the key ECB interest rates – particularly the MRO rate –, short-term interest rates, long-term interest rates, broad monetary aggregate M3, and borrowing costs for both households and corporations.

In a post-pandemic period, inflationary pressures associated with supply-side disruptions dominated over shocks stemming from the demand side (Gomes *et al.*, 2021). In mid-2021, the lockdowns were lifted, and the economy began to open and recover. This way, the release of pent-up demand along with supply chain bottlenecks resulted in a rapid rise in inflation and, subsequently, in inflation expectations (Acharya *et al.*, 2024). According to the Santis (2021), certain firms were not able to adequately respond to such rapid recovery on the demand side. Supply-chain bottlenecks in material and equipment resulted in a fall in inventories across all sectors (Santis, 2021). Additionally, the increasing tensions between Russia and Ukraine, and reduced supply of fuels magnified the impacts of these supply-side disruptions, with the EA-20 facing sharp price increases in gas, electricity, oil, and other fuels (Bolton, 2024).

Furthermore, as previously mentioned, Russia's invasion of Ukraine and subsequent war negatively influenced expected future inflation. On February 24, 2022, Russia launched war on Ukraine and deliberately withdrew part of its gas supplies to Europe. This weaponization of gas caused oil prices in the EA to hit all-time highs. Consequently, Russia's war with Ukraine and the sanctions imposed by the European Union (EU) have led to a tremendous energy crisis, significantly increasing economic uncertainty (European Union, 2022).

Energy is a multidimensional resource capable of reflecting the political-economic system of international ties across the globe (LaBelle, 2023). For decades, there has been an evident value chain of oil, coal, and gas beginning in Russia and extending all the way through Europe (Balmaceda, 2021). The oil crisis of the 1970s fostered global oil interdependence between European countries and Russia. This strategy was designed to prevent a new oil crisis with the help of a stable energy supply from the former Soviet Union. However, such interdependence negatively contributed to the use of gas as a weapon between Russia and Europe. More recently, Russia's restriction of gas flows to Europe made it clear the EA-20 required measures to overcome its dependence on Russian energy. Additionally, LaBelle (2023) stated that "Governments need to determine the limits to energy interdependence and dependence to improve energy security". As recently observed, in September 2022, energy prices were 40% higher in the EA-20 (Eurostat, 2023). We can thus conclude that European energy dependence is a significant component fueling inflation levels and that no European country can avoid these price increases caused by the withdrawal of Russian energy sources (LaBelle, 2023).

Moreover, as Ukraine is a significant global exporter of agricultural commodities, its production and supply capacities were severely compromised. The ongoing conflict between Russia and Ukraine prompted trade disruptions and intensified price pressures on food commodities across many economies. In addition, higher oil prices contribute to higher production costs, higher fertilizer prices, as well as higher transportation costs, ultimately increasing food prices. According to the ECB, food inflation in the EA-20 reached peak levels in May 2022 (Bodnár & Schuler, 2022; Emediegwu, 2024).

Thus, with economies facing inflation levels higher than expected, the ECB adopted monetary policy measures to ensure a return of inflation to the target level of 2% over the medium-term. According to Luís de Guindos, Vice-President of the ECB, "The surge in inflation to unprecedented levels in 2022 prompted the ECB to normalize and tighten monetary policy.". To achieve this goal, the ECB reduced their portfolio of purchased assets and increased the key interest rates for the first time since 2011 (Guindos, 2024). As noted by English *et al.* (2024), given that the key ECB interest rates had remained unchanged until September 2022, such a slow response culminated in rate hikes, with ECB's key interest rates increasing much faster and in larger increments. This sudden and tight monetary policy contributed to new risks concerning the EA-02's financial stability, giving rise to financial adversities for households and firms, which were unprepared for such a sharp increase in borrowing costs.

In this manner, both oil prices and the degree of energy dependence are relevant to understand the impacts of the war on expected future inflation. It is, therefore, crucial to account for changes in EA-20's imports of energy. Similarly, we may consider assessing wholesale agricultural commodities prices, and the degree of economic openness regarding the flow of goods and services in the EA-20. Economic openness is generally understood as the degree to which external factors – such as imports and exports – take part in a certain economy. Hence, we can measure this economic openness, commonly referred to as trade openness, by computing the ratio of total imports and exports on gross domestic product (Gräbner *et al.*, 2018). As stated by Kose *et al.* (2019), in advanced economies, higher trade openness has a small positive influence over inflation expectations.

Moreover, Ghosh (2022) recognizes corporate profits and financial speculation in commodities markets as overlooked, yet relevant, drivers of inflation. The author argues that in industries such as energy and food, firms were able to increase profits. In June 2023, Christine Lagarde, President of the ECB, stated that "unit profits contributed around two-thirds to domestic inflation in 2022, whereas in the previous 20 years their average contribution had been around one-third." (Lagarde, 2023). Due to the conflict between Russia and Ukraine, firms saw an opportunity to raise their markups, given that the aforementioned supply disruptions "became convenient excuses for disproportionate price increases."(Ghosh, 2022). According to Acharya *et al.* (2024), as households expected future inflation to reflect the higher prices in their overall consumption basket, certain firms managed to maintain, or even increase, their profits regardless of supply-side bottlenecks. That is, given that households adjusted their expectations in the face of higher inflation levels, firms with higher market power were able to keep on increasing their profits, even after supply-chain disruptions eased (Acharya *et al.*, 2024).

Additionally, Ghosh (2022) draws attention to speculative activity and its impact on spot markets' inflation. Despite consumer's perception of food inflation being a consequence of war-related supply disruptions, growing corporate profits and financial speculation have proved to be of utmost relevance. This way, Ghosh (2022) claims that reducing excess demand through higher interest rates will not correctly counteract inflation (Ghosh, 2022).

Remarkably, financial speculation entails trading financial instruments, namely commodities such as wheat, through the spot market in order to profit from price increases in such commodities. For instance, a study by Agarwal *et al.* (2022) concluded that investment institutions, particularly investment funds, have increased their shares in agricultural commodities markets. In the Parisian wheat market – a benchmark for Europe – investment funds and other financial institutions increased their shares from 35% in May 2018 to 67% in April 2022. This excessive speculative activity contributed to high levels of inflation in agricultural commodities, influencing households' purchasing power (Agarwal *et al.*, 2022). Therefore, it is pertinent to assess to what extent changes in corporate profits, as well as in shares issued by investment funds influence expected future inflation.

In conclusion, the preceding analysis is centered on the relevance of several variables pertaining to inflation expectations in the EA-20. Specifically, multiple studies have focused on the relevance of the key ECB interest rates, both short-term and long-term interest rates, broad monetary aggregates – namely M3 –, borrowing costs for both households and for corporations, corporate profits, financial speculation activities conducted by investment funds, the degree of energy dependence, oil prices, prices of agricultural commodities, and the degree of trade openness as drivers for expected future inflation.

3 Empirical Analysis

3.1 The regression model adopted

For the purpose of analyzing the recent dynamics of inflation and output in the EA-20, we have undertaken the estimation of the HNKPC.

As previously mentioned, the HNKPC recognizes that current inflation results from a combination of three factors: expected future inflation, a measure of real marginal cost of labor – proxied by the output gap –, and past inflation (Nason & Smith, 2008). Additionally, the HNKPC acknowledges that forward-looking individuals adjust their expectations regarding future inflation based on available information. The HNKPC equation to be estimated is the following:

$$\pi_t = \alpha_0 + \alpha_1\pi_{t-1} + \alpha_2 E_t\pi_{t+1} + \alpha_3(y_t - \overline{y}_t) \quad (1)$$

Where current inflation is denoted by π_t, past inflation by π_{t-1}, expected future inflation by $E_t\pi_{t+1}$, and the output gap by $(y_t - \overline{y}_t)$, with actual and natural or potential output represented by y_t and $\overline{y}_t$, respectively.

In equation (1), expected future inflation remains unobserved. However, substituting it with observed future inflation as a proxy creates an endogeneity issue. Endogeneity occurs when at least one of the explanatory variables used in the model is correlated with the error term, potentially causing biased and inconsistent estimates. The solution is to introduce a second equation that replaces future inflation with a set of currently observed exogenous instruments, which is assumed to be used by economic agents to form expectations regarding future inflation.

The two most commonly employed methods to address endogeneity are the Instrumental Variables (IV) and the Two-Stage Least Squares (2SLS). Both methods mitigate the endogeneity problem by introducing exogenous instrumental variables, often referred to as instruments. However, the most fitting choice for our analysis is the 2SLS method, as it allows the model to incorporate multiple instruments to estimate the endogenous explanatory variable (Wooldridge, 2012).

Accordingly, we must find valid instruments that satisfy certain properties, namely that they must be uncorrelated with the error term yet correlated with the endogenous explanatory variable, which is observed future inflation. Subsequently, we must consider two distinct equations to estimate the HNKPC model. Firstly, the 2SLS method computes a first-stage regression, which recognizes the endogenous explanatory variable – future inflation – as a dependent variable explained by the selected instruments (Wooldridge, 2012). This first-stage regression is represented by the following equation:

$$\pi_{t+1} = \beta_0 + \beta_1 z_{1t} + \beta_2 z_{2t} + \cdots + \beta_n z_{nt} + \varepsilon_t \qquad (2)$$

Where each z represents an instrumental variable, and ε_t is the error term associated to quarter t.

Secondly, the method estimates an OLS regression where current inflation is the dependent variable explained by past inflation, expected future inflation – coming from the first-stage estimation –, and a measure of the output gap (Wooldridge, 2012). This second-stage regression is given by the following equation:

$$\pi_t = \delta_0 + \delta_1 \pi_{t-1} + \delta_2 \widehat{\pi_{t+1}} + \delta_3 cgdp_t + \mu_t \qquad (3)$$

Where $\widehat{\pi_{t+1}}$ is estimated future inflation coming from the first-stage regression in (2) and take as expected future inflation, $cgdp_t$ denotes the cyclical component of real GDP as a measure of the output gap, and μ_t is the error term associated with quarter t.

After estimating the HNKPC model using 2SLS in Stata, the significance of the results obtained through the 2SLS method is tested. In the first place, we run an F-test that assesses the correlation between the selected instruments and the endogenous variable. The null hypothesis states that the instruments are not correlated with the endogenous variable. Thus, if the p-value is smaller than 0,01, we reject this null hypothesis at a significance level of 1%, suggesting that the instruments are indeed correlated with the endogenous variable. Subsequently, we run a chi-square test that accounts for the validity of the selected instruments. The null hypothesis states that the instruments are not correlated with the error term. Therefore, a p-value greater than 0,01 indicates that we do not reject the null hypothesis at a significance level of 1%, implying that the instruments may be valid.

3.2 Data and its treatment

Economic agents adjust their expectations of future inflation in response to new information, which may arise from the observation of numerous macroeconomic variables. To identify the key drivers of expected future inflation in the 2SLS model of the HNKPC, we have collected data on a wide range of macroeconomic variables. These variables potentially serve as instruments for the endogenous observed variable – future inflation.

As discussed in chapter 2, literature on expected future inflation emphasizes the key ECB interest rates, both short-term and long-term interest rates, broad monetary aggregate M3, borrowing costs for both households and corporations, corporate profits, financial speculation activities conducted by investment funds, the degree of energy dependence, oil prices, prices of agricultural commodities, and the degree of trade openness. Therefore, these variables are considered relevant drivers of expected future inflation, that is, they are believed to influence economic agents' process of expectation formation.

Consequently, the pertinent data to conduct this research has been sourced from several statistical outlets, namely ECB's Data Portal and OECD. This analysis is focused on quarterly data spanning from the first quarter of 2015 to the third quarter of 2023, as data on the last quarter of 2023 is not yet available regarding certain variables.

Notably, to ensure that all the variables under consideration are directly comparable and contribute proportionately to this analysis, we must normalize the data. The process of normalizing the data entails multiplying each variable by a suitable multiplication factor so that they fall within the range of 0 to 1. Additionally, in order to convert monthly data into quarterly data, we have computed averages for every set of three months. Similarly, we have calculated averages to transform daily business week data into monthly and, subsequently, into quarterly data.

First and foremost, considering that the Harmonized Index of Consumer Prices (HICP) is the primary measure of price dynamics in the EA-20, inflation rates are determined by the quarter-on-quarter variation of the HICP. Data on the overall HICP was collected from ECB's Data Portal and is working day and seasonally adjusted. In addition, past inflation is determined by the quarter-on-quarter variation of the HICP computed in the previous quarter. Similarly, future inflation is determined by the quarter-on-quarter variation of the HICP computed in the subsequent quarter. In order to compute the variation of the HICP observed in the first quarter of 2015, we have collected data from the HICP of last quarter of 2014. In addition, we consider the variation of the HICP observed in the last quarter of 2014 to correspond to the past inflation value observed in the first quarter of 2015. This way, we have collected data from the third quarter of 2014, to enable the computation of the quarter-on-quarter variation of the HICP observed in the last quarter of 2014. Likewise, to ensure usable data regarding the values of future inflation for the third quarter of 2023, we have gathered data on the HICP observed in the last quarter of 2023.

Moreover, data on one of the three key ECB interest rates, particularly the MRO rate, was also collected from ECB's Data Portal. There is no available information regarding the adjustment of the data, therefore, we consider these values to not be seasonally nor working day adjusted. Additionally, long-term interest rates – referring to yield curve spot rates for government bonds with a maturity of 10 years whose rating is triple A – were also collected from ECB's Data Portal. These low-risk long-term interest rates are determined by the prices at which government bonds are traded on financial markets. From the OECD, we have gathered data on short-term interest rates, which refer to the short-term rates at which financial institutions borrow money either from each other or from the Government. There is no available information regarding the adjustment of these two variables, therefore, we consider these values to not be neither seasonally nor working day adjusted.

Regarding broad monetary aggregates, we have collected data on M3 from the OECD. According to the OECD, the M3 is a seasonally adjusted index which includes currency, deposits, money market fund shares and debt securities up to two years. In addition, we have gathered from ECB's Data Portal both the cost of borrowing for households – specifically for house purchase – and the cost of borrowing for corporations – particularly non-financial corporations. There is no available information regarding the adjustment of the data, therefore, we consider these values to not be seasonally nor working day adjusted.

With regard to corporate profits, we have collected data on the profit shares of non-financial corporations from ECB's Data Portal. These profit shares, determined by the gross operating surplus and mixed income of non-financial corporations as a ratio to gross value added, are working day and seasonally adjusted. Additionally, to account for the effects of financial speculation, we will be considering investment fund shares/units issued by investment funds. This variable has also been collected from ECB's Data Portal and is neither seasonally nor working day adjusted.

Furthermore, to assess EA-20's degree of energy dependence, we have gathered data on energy imports and exports, as well as on the Gross Domestic Product (GDP) at market prices from ECB's Data Portal. Thus, by computing the ratio of imports minus exports on the real GDP, we obtain the degree of EA-20's energy dependence. These variables are working day and seasonally adjusted. In addition, data on Brent crude oil prices, as well as on farm-gate and wholesale market prices of cereal were collected from ECB's Data Portal. Both variables are not working day nor seasonally adjusted.

Regarding the degree of trade openness, we have collected data on both imports and exports of goods and services in the EA-20. The degree of trade openness is obtained by computing the ratio of total imports and exports on real GDP. These three variables are working day and seasonally adjusted.

Moreover, we have gathered data on both the output gap and inflation. The output gap is given by the deviation of the actual output from its natural or potential level. However, as previously mentioned, computing the output gap is demanding as the natural level of output is not observable. Therefore, we will use the collected data on real GDP to estimate the output gap using the HP filter. The output gap is considered to be equivalent to the cyclical component of real GDP.

Upon collecting data on the aforementioned macroeconomic variables and compiling a database in Excel, which is displayed in **Appendix A**, we proceed to import this data into Stata. Initially, we generate a time series amounting to 35 observations, considering a time span from the first quarter of 2015 until the third quarter of 2023. Secondly, we apply the HP filter with a smooth parameter of λ=1600 to detrend all the collected variables. The HP filter, as previously mentioned, decomposes data series into trend and cyclical components. Therefore, after filtering the database using the HP filter on Stata, we then have access to the raw data on both the cyclical component and the trend of each variable. Subsequently, in estimating the HNKPC model, we will exclusively focus on the interrelation between the cyclical components of each macroeconomic variable.

3.3 Instrumental variable choice

Among the detrended variables, it becomes imperative to determine which of these will serve as valid instrumental variables. Thus, it is essential to ascertain which of these potential instruments exhibit stronger correlations with the endogenous explanatory variable – future inflation. To achieve this, we employ the "corr" command in Stata and generate **Table 1**, which displays the correlations between the cyclical components of each of the potential instrumental variables at the present time and the cyclical component of future inflation. We define strong correlations as those exceeding 0,3 in absolute value.

In **Table 1**, we observe that the cyclical components of these 12 potential instruments exhibit a strong correlation with the cyclical component of future inflation.

Present instruments	**Future inflation**
Oil price	0,4713
Corporate profits	0,5230
Energy dependence	0,5284
Monetary aggregate M3	0,6718
Short-term interest rate	-0,6653

Long-term interest rate	-0,3157
Shares/units issued by investment funds	0,6448
Trade openness	0,3878
Cost of borrowing for households for house purchase	-0,5455
Cost of borrowing for corporations	-0,6417
MRO rate	-0,6554
Wholesale price of cereals	0,6098

Table 1: Correlations between the cyclical components of the endogenous variable and potential instruments.
Source: Own work

Consequently, in order to identify which of these 12 variables best explain future inflation, an OLS linear regression is conducted using Stata. In this linear regression, we recognize future inflation as the dependent variable explained by the 12 potential instruments. Given that higher p-values indicate lower levels of statistical significance, a systematic elimination process is undertaken for explanatory variables exhibiting the highest p-values. This iterative process persists until the adjusted R-squared attains its maximal potential value, and the root mean square error (RMSE) reaches its minimal possible value.

Table 2 displays the outcomes of the first OLS linear regression, encompassing the 12 potential instruments as explanatory variables. Incorporating these potential instruments as a measure of expected future inflation leads to an adjusted R-squared of 0,7769 and a RMSE 0,00284. Notably, the farm-gate and wholesale price of cereal is the least significance in explaining expected future inflation, evident by a p-value of 0,972. Consequently, we proceed to eliminate the wholesale price of cereals and run a linear regression with the remaining potential instruments. Subsequently, we eliminate the monetary aggregate M3 with a p-value of 0,842, followed by corporate profits with a p-value of 0,825, then we eliminate the cost of borrowing for non-financial corporations, as it exhibits a p-value of 0,414. The results of this iterative elimination process are displayed in **Appendix B**.

n = 35	Coefficient	Standard error	t	P-value
Oil price	-0,2586826	0,1471723	-1,76	0,092
Corporate profit	-0,040863	0,159514	-0,26	0,800
Energy dependence	0,3348834	0,1211276	2,76	0,011
M3	0,1101162	0,6062587	0,18	0,857
Short-term interest rates	-0,4236142	0,113449	-3,73	0,001
Long-term interest rates	-0,0301362	0,0333051	-0,90	0,375
Shares/units issued by investment funds	0,4709363	0,14743	3,19	0,004
Trade openness	-0,4090581	0,409313	-1,00	0,328
Cost of borrowing for households for house purchase	0,165893	0,098881	1,68	0,107
Cost of borrowing for corporations	0,0639008	0,109294	0,58	0,564
MRO rate	0,3018905	0,1130904	2,67	0,014
Wholesale price of cereals	-0,0037435	0,1052429	-0,04	0,972
Adjusted R-squared	0,7769			
RMSE	0,00284			

Table 2: OLS linear regression with 12 instruments.
Source: Own work

Moreover, the OLS linear regression after removing the potential instruments with the highest p-values, yields an adjusted R-squared of 0,8042 and a RMSE of 0,00266 as represented in **Table 3**. Therefore, we conclude that the following variables may serve as valid instruments for estimating future inflation and predicting expected future inflation: oil price, the degree of energy dependence, both short-term and long-term interest rates, shares/units issued by investment funds, the degree of trade openness, cost of borrowing for households – specifically for house purchase –, and the MRO rate

n = 35	Coefficient	Standard error	t	P-value
Oil price	-0,2389978	0,095845	-2,49	0,019
Energy dependence	0,3236983	0,0857734	3,77	0,001
Short-term interest rates	-0,390393	0,0954197	-4,09	0,000
Long-term interest rates	-0,0329387	0,0264955	-1,24	0,224
Shares/units issued by investment funds	0,483595	0,101345	4,77	0,000
Trade openness	-0,429993	0,3287609	-1,31	0,202
Cost of borrowing for households for house purchase	0,1787545	0,083152	2,15	0,041
MRO rate	0,3144522	0,0919185	3,42	0,002
Adjusted R-squared	0,8042			
RMSE	0,00266			

Table 3: OLS linear regression with 8 instruments.
Source: Own work

3.3 Results and discussion: 2SLS estimation for the HNKPC

Our next step involves estimating the HNKPC model using the 2SLS method in Stata. As previously mentioned, the 2SLS method entails conducting a first-stage regression – as described in equation (2) –, where the 8 selected instrumental variables serve as explanatory variables of future inflation. The results of this first-stage regression are demonstrated in **Table 4**.

The estimated coefficients associated with each explanatory variable represent the expected change in future inflation. For instance, with a coefficient of -0,2198826, it is possible to infer that when there is a one-unit increase in crude oil prices, future inflation decreases 0,2198826 percentage points, holding all other variables constant. Notably, over the analyzed period from 2015 to 2023, crude oil prices, both short-term and long-term interest rates, and the degree of trade openness negatively influence future inflation. Conversely, the degree of energy dependence, shares/units issued by investment funds, cost of borrowing for households for house purchase, and the MRO rate contribute positively to future inflation.

Remarkably, with a coefficient of -0, 339385, it is noticeable that long-term interest rates show a low explanatory power regarding future inflation. On the other hand, the instruments with the highest explanatory power are the shares/units issued by investment funds, as well as short-term interest rates, with coefficients of 0,4836472 and -0,412326, respectively. The former positively impacts future inflation, whereas the latter contributes negatively. For instance, we can infer that as short-term interest rates increase, future inflation is expected to decrease in the following quarter, and, if there is an increase in shares/units issued by investment funds, future inflation is expected to increase as well.

n = 35	Coefficient	Standard error	t	P-value
Past inflation	-0,020081	0,1921089	-0,10	0,918
Output gap	-0,0597539	0,1484903	-0,40	0,691
Oil prices	-0,2198826	0,1145768	-1,92	0,067
Energy dependence	0,304022	0,1032229	2,95	0,007
Short-term interest rates	-0,412326	0,1147235	-3,59	0,001
Long-term interest rates	-0,0339385	0,0331307	-1,02	0,316
Shares/units issued by investment funds	0,4836472	0,1071529	4,51	0,000
Trade openness	-0,3036551	0,4839769	-0,63	0,536
Cost of borrowing for households	0,191206	0,0981415	1,95	0,063
MRO rate	0,3291565	0,1038145	3,17	0,004
Constant	-1,04e-10	0,0004756	-0,00	1,000
Adjusted R-squared	0,7874			
RMSE	0,0028			

	P-value	Null hypothesis
F-test	0,0000	Rejected
Sargan chi-square test	0,0170	Not rejected

Table 4: 2SLS first-stage regression and the F-test and chi-square test.
Source: Own work

The adverse impact of crude oil prices on future inflation does not align with our initial expectations, given its positive correlation of 0,4713 as seen in **Table 1**. Nevertheless, **Figure 1** graphically the relationship between the cyclical components of crude oil prices and future inflation. A mostly positive relationship is observed from the first quarter of 2021 until the first quarter of 2023. Therefore, we can conclude that, during this period, crude oil prices increases were often associated with increases in future inflation.

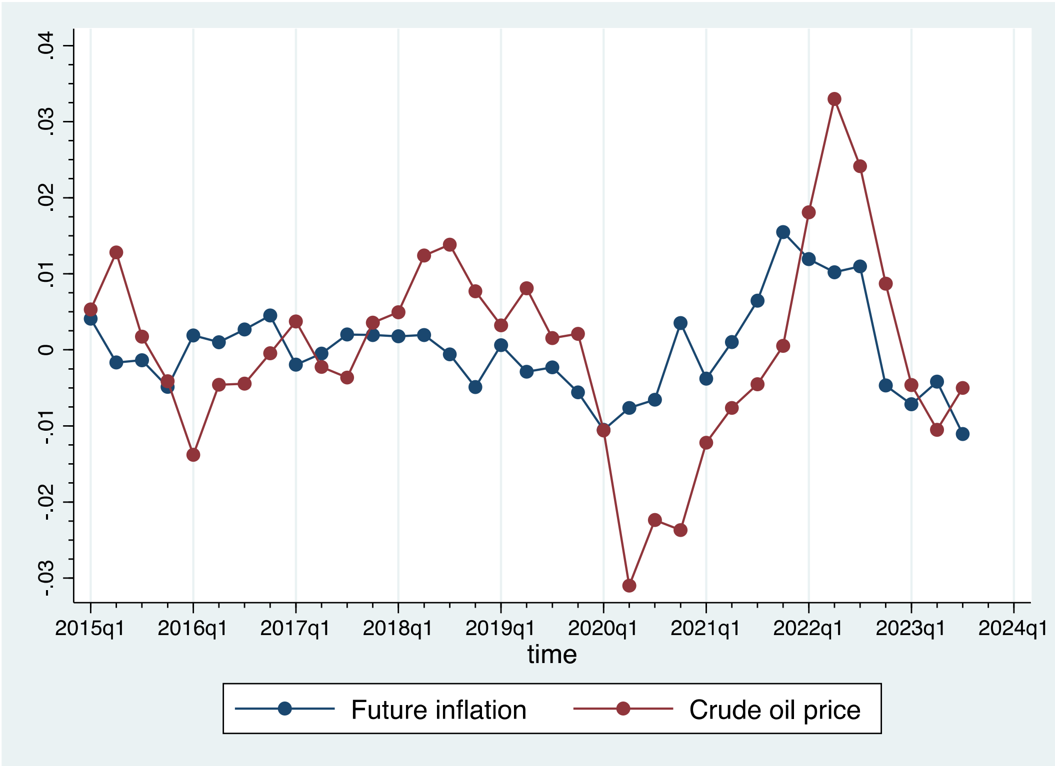

Figure 1: The relationship between crude oil prices and future inflation from 2015 to 2023.
Source: Own work

Additionally, in **Table 4** we note that the degree of trade openness negatively influences future inflation, with a coefficient of -0,3036551. However, as previously seen in **Table 1**, the degree of trade openness appears to be positively correlated with future inflation. **Figure 2** demonstrates that the relationship between the degree of trade openness and future inflation has been mostly positive from the last quarter of 2019 onward, with few exceptions. For instance, from the last quarter of 2020 to the first quarter of 2021, as well as from the first to the second quarters of 2023, an increase in the degree of trade openness did not translate into increasing inflation.

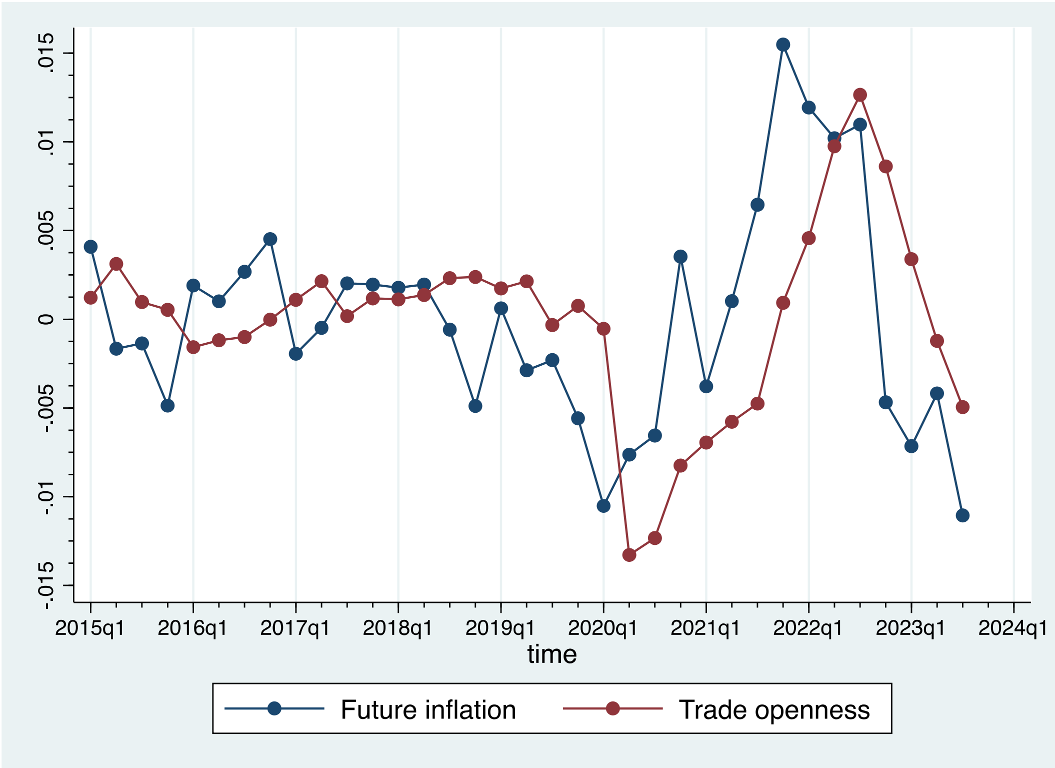

Figure 2: The relationship between trade openness and future inflation from 2015 to 2023.
Source: Own work

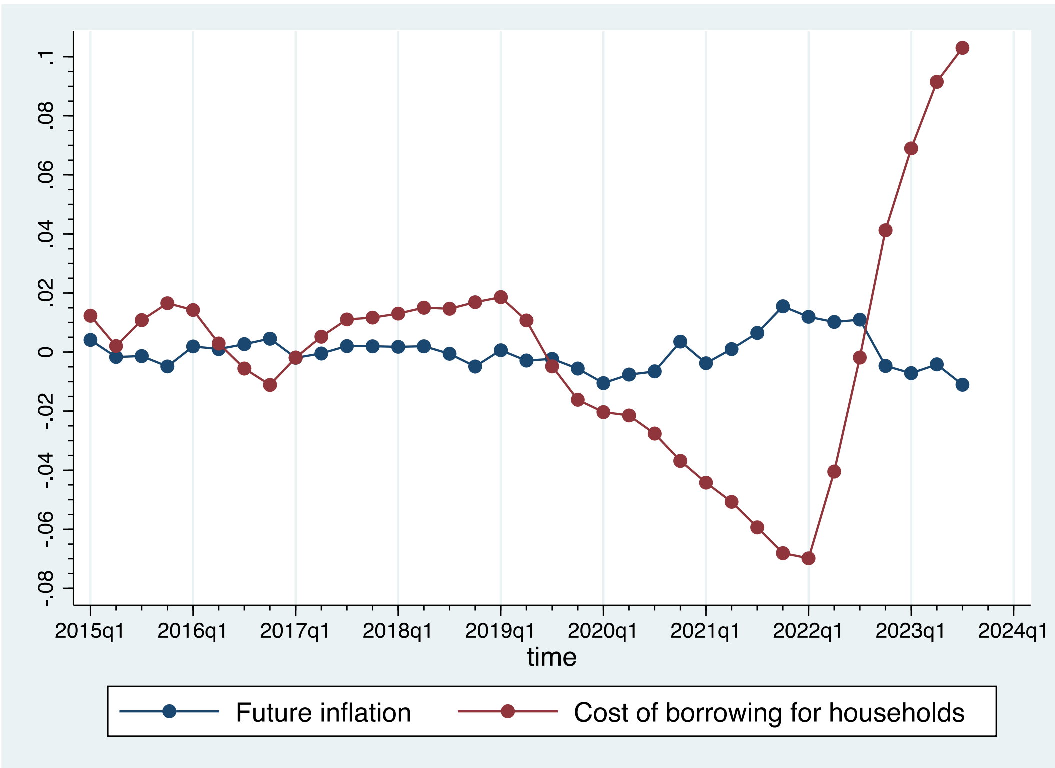

Figure 3: The relationship between cost of borrowing for households for house purchase and future inflation from 2015 to 2023.
Source: Own work

In addition, **Table 4** indicates that the cost of borrowing for households positively influences future inflation, with a coefficient of 0,191206. Nevertheless, **Table 1** demonstrates that these two variables are negatively correlated. As seen in **Figure 3**, from the first quarter of 2020 onward, the relationship between the cost of borrowing for households – specifically for house purchase –, and future inflation is negative.

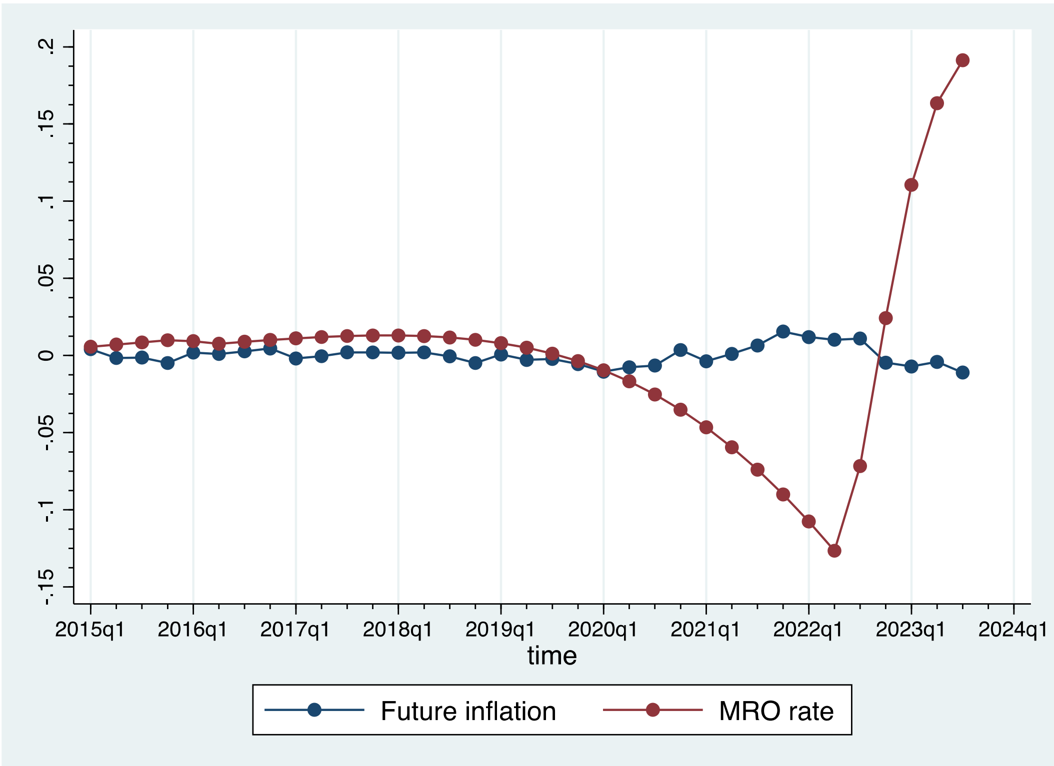

Figure 4: The relationship between the MRO rate and future inflation from 2015 to 2023.
Source: Own work

As previously discussed, due to its primary objective of maintaining price stability, the ECB uses its key interest rates as the primary monetary policy instrument to control EA-20's inflation. As demonstrated in **Table 1**, the MRO is negatively correlated with future inflation. Contrary to what was expected, a coefficient of 0,3291565 indicates that any increase in the MRO rate leads to inflationary pressures. As illustrated in **Erro! A origem da referência não foi**

encontrada., from the second quarter of 2023 onward, as the cyclical component of the MRO rate increases, the cyclical component of future inflation begins to gradually decrease. This is more noticeable from the second quarter of 2023 onward. The graphs displayed in **Figure 1**, **Figure 2**, **Figure 3**, and **Erro! A origem da referência não foi encontrada.** were obtained from Stata by employing the command “tsline”.

Moreover, this first-stage regression leads to an adjusted R-squared of 0,7874 and a RMSE of 0,0028. The F-test, which assesses the correlation between the endogenous variable and the selected instruments, yields a p-value of 0,000. Since this p-value is smaller than 0,01, we reject the null hypothesis at a significance level of 0,01%. Consequently, as illustrated in **Table 4**, we conclude that the instruments are indeed correlated with the endogenous variable. Additionally, the Sargan chi-square tests results in a p-value of 0,0170. As depicted in **Table 4**, given that this p-value exceeds 0,01, we do not reject the null hypothesis at a significance level of 1%. This suggests that the instruments may be valid.

Finally, the 2SLS method estimates a final instrumental variables regression – as depicted in equation (3) –, in which current inflation is the dependent variable explained by past inflation, estimated future inflation (coming from the first-stage regression and taken as expected future inflation), and a measure of the output gap. **Table 5** indicates the results of estimating a HNKPC model through the 2SLS method. Incorporating the aforementioned instrumental variables as a measure of expected future inflation leads to an R-squared of 0,5631 and RMSE of 0,00373. Notably, expected future inflation and past inflation are significant in terms of explaining current inflation. With coefficients of 0,5251244 and 0,3273561, and p-values of 0,000 and 0,015, respectively. Conversely, the output gap has a lower explanatory power, with a coefficient of 0,1141428 and a p-value of 0,228. The results obtained from estimating the HNKPC using a 2SLS regression in Stata, as well as the test statistics employed, are displayed in **Appendix C**.

In addition, expected future inflation exhibits a higher explanatory power relative to past inflation, regarding the estimation of current inflation. Therefore, we can conclude that economic agents tend to demonstrate a forward-looking behavior – focusing on their current expectations on future inflation –, rather than being backward-looking – focusing on past inflation.

n = 37	**Coefficient**	**Standard error**	**z**	**P-value**
Expected future inflation	0,5251244	0,1297139	4,05	0,000
Past inflation	0,3273561	0,1351098	2,42	0,015
Output gap	0,1141428	0,0947351	1,20	0,228
Constant	2,33e-11	0,0006306	-0,00	1,000
R-squared	0,5631			
RMSE	0,00373			

Table 5: 2SLS second-stage regression.
Source: Own work

4 Conclusion

The main objective of this dissertation was to analyze the dynamics of inflation and output in the EA-20. To achieve this, a HNKPC model was estimated using the 2SLS regression method in Stata.

Our findings indicate that current inflation is significantly influenced by both retrospective – past inflation – and prospective – expected future inflation – elements, while the impact of the output gap is not significant. Nevertheless, it appears that economic agents place greater emphasis on their current expectations of future inflation than on past inflation.

Moreover, our results show that crude oil prices, the degree of EA-20's dependence on energy, short-term interest rates, shares/units issued by investment funds, the degree of trade openness, cost of borrowing for households – specifically for house purchase –, and the key ECB interest rate on the MRO are the most significant macroeconomic variables in terms of explaining future inflation. Among the multitude of possible variables that agents with rational expectations may consider in the present to form expectations about future inflation, these are the most significant. Therefore, we conclude that the ongoing conflict between Russia and Ukraine, the monetary policy measures adopted by the ECB, as well as the activities of investment funds have had a significant impact on economic agents' expectations of future inflation.

Finally, this dissertation has some limitations. First, the HP filter used: i) has a limited ability to account for seasonal effects, and a few of the variables considered in the database were not seasonally adjusted; ii) it is sensitive to the choice of the smoothing parameter; iii) it might eliminate relevant information in the process of smoothing the data; iv) it has a problem in dealing with the tails of the data set. The Kalman filter offers a potential solution for addressing the limitations highlighted by the literature in relation to the HP filter in future research.

Additionally, although this dissertation has contributed to our understanding of the dynamics of inflation in the EA-20 as a whole, future research could delve deeper into analyzing the heterogenous inflation rates across EA-20 countries. Understanding the country-specific drivers of inflation could offer valuable insights into economic and policy disparities among Member-States within the EA-20. This knowledge would empower policymakers to better design and adjust monetary and fiscal policy measures. Not only does this help achieving the EA-20's inflation target of 2% over the medium-term, but it also mitigates the hysteresis effects of recessions.

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Appendix

Appendix A: Unfiltered data base in Excel

n = 36	Inflation	Past inflation	Future inflatior	GDP at market prices	Oil price	Profit	Energy dependence	M3	Short-term	Long-term	IF shares	Trade openness	Household borrowin	Corporations borrowin	MRO	Cereal price
2015q1	-6E-04	-0,0017	0,00485	0,262263048	0,0479	0,4	0,065631171	0,098	0,005	0,04101	0,0947031	0,08657	0,235	0,239	0,01	0,10609
2015q2	0,0049	-0,0006	-0,0007	0,263520707	0,0558	0,4	0,071046045	0,1	-0,001	0,06192	0,0938397	0,08904	0,22	0,228	0,01	0,09896
2015q3	-7E-04	0,00485	-0,0002	0,264538227	0,0452	0,4	0,063530005	0,101	-0,003	0,08009	0,090204	0,08745	0,224	0,218	0,01	0,098507
2015q4	-2E-04	-0,0007	-0,0035	0,265740041	0,0398	0,4	0,055112688	0,102	-0,009	0,06716	0,0938116	0,08758	0,225	0,213	0,01	0,09644
2016q1	-0,004	-0,0002	0,00348	0,267296719	0,0306	0,4	0,044452903	0,103	-0,019	0,04256	0,0925803	0,08605	0,218	0,205	0	0,088473
2016q2	0,0035	-0,0035	0,0028	0,267882194	0,0403	0,4	0,047126779	0,104	-0,026	0,01706	0,0949619	0,08702	0,202	0,194	0	0,086043
2016q3	0,0028	0,00348	0,00468	0,269162313	0,041	0,4	0,048645636	0,106	-0,03	-0,0098	0,0984155	0,0878	0,189	0,185	0	0,08368
2016q4	0,0047	0,0028	0,00674	0,271264909	0,0456	0,41	0,055821765	0,107	-0,031	0,02062	0,1007887	0,08939	0,179	0,182	0	0,088297
2017q1	0,0067	0,00468	0,00049	0,273163205	0,0504	0,4	0,064219297	0,108	-0,033	0,03962	0,1051032	0,09114	0,184	0,179	0	0,09747
2017q2	0,0005	0,00674	0,00217	0,275336266	0,0451	0,41	0,057210742	0,11	-0,033	0,03747	0,1068239	0,09283	0,187	0,178	0	0,09041
2017q3	0,0022	0,00049	0,00491	0,277396102	0,0444	0,41	0,051590047	0,111	-0,033	0,04946	0,1095707	0,09153	0,189	0,172	0	0,092223
2017q4	0,0049	0,00217	0,00508	0,279591213	0,0523	0,41	0,061182731	0,112	-0,033	0,04452	0,1125928	0,09322	0,186	0,189	0	0,091967
2018q1	0,0051	0,00491	0,00516	0,279606045	0,0544	0,4	0,066465326	0,112	-0,033	0,06718	0,1124901	0,09388	0,184	0,169	0	0,091727
2018q2	0,0052	0,00508	0,00561	0,281190225	0,0625	0,4	0,071000473	0,114	-0,033	0,05511	0,1145849	0,09487	0,183	0,166	0	0,092793
2018q3	0,0056	0,00516	0,00337	0,281120042	0,0647	0,4	0,076030563	0,115	-0,032	0,04181	0,1169487	0,0966	0,18	0,163	0	0,10116
2018q4	0,0034	0,00561	-0,0006	0,283027726	0,0593	0,4	0,074421299	0,116	-0,032	0,04239	0,1110545	0,09749	0,18	0,164	0	0,10482
2019q1	-6E-04	0,00337	0,00528	0,284762097	0,0556	0,4	0,070490189	0,117	-0,031	0,01768	0,1192811	0,09771	0,18	0,164	0	0,10614
2019q2	0,0053	-0,0006	0,0022	0,285769437	0,0613	0,4	0,069796502	0,119	-0,032	-0,0058	0,1220336	0,09904	0,171	0,157	0	0,10171
2019q3	0,0022	0,00528	0,00324	0,28623093	0,0557	0,4	0,060506407	0,121	-0,04	-0,047	0,1265296	0,09757	0,155	0,153	0	0,09618
2019q4	0,0032	0,0022	0,00047	0,286339608	0,0573	0,4	0,062419447	0,122	-0,04	-0,03	0,1309234	0,09972	0,144	0,155	0	0,10051
2020q1	0,0005	0,00324	-0,0039	0,276587314	0,0457	0,38	0,058591469	0,124	-0,041	-0,0364	0,1158612	0,09959	0,141	0,151	0	0,10551
2020q2	-0,004	0,00047	-0,0004	0,245401327	0,0266	0,39	0,033843175	0,129	-0,03	-0,0365	0,1261834	0,0881	0,142	0,147	0	0,10706
2020q3	-4E-04	-0,0039	0,00133	0,274917129	0,0368	0,4	0,036901808	0,132	-0,047	-0,0446	0,1299876	0,09042	0,139	0,151	0	0,10275
2020q4	0,0013	-0,0004	0,01209	0,274825966	0,0371	0,41	0,03787677	0,135	-0,052	-0,0552	0,1391757	0,09599	0,134	0,152	0	0,11149
2021q1	0,0121	0,00133	0,00546	0,276112378	0,0505	0,42	0,050740735	0,138	-0,054	-0,0405	0,1464969	0,09888	0,132	0,146	0	0,12196
2021q2	0,0055	0,01209	0,01094	0,281865135	0,0571	0,42	0,06228792	0,14	-0,054	-0,0191	0,1538769	0,10174	0,132	0,149	0	0,12341
2021q3	0,0109	0,00546	0,01703	0,287729257	0,0623	0,41	0,071225482	0,143	-0,055	-0,0366	0,1575907	0,10454	0,131	0,147	0	0,13308
2021q4	0,017	0,01094	0,02666	0,2891659	0,0696	0,41	0,108869106	0,145	-0,057	-0,0226	0,1652924	0,11206	0,131	0,139	0	0,16845
2022q1	0,0267	0,01703	0,02366	0,291073811	0,0894	0,41	0,137029209	0,147	-0,053	0,01793	0,1597725	0,11759	0,139	0,145	0	0,18694
2022q2	0,0237	0,02666	0,02242	0,293424199	0,1066	0,41	0,170816719	0,149	-0,036	0,11539	0,1495686	0,12468	0,179	0,163	0	0,22108
2022q3	0,0224	0,02366	0,02362	0,294783453	0,1	0,42	0,200694871	0,152	0,048	0,14203	0,1463101	0,12949	0,229	0,202	0,08	0,19951
2022q4	0,0236	0,02242	0,00835	0,294519791	0,0868	0,42	0,157917578	0,152	0,177	0,22119	0,1457644	0,12737	0,284	0,308	0,19	0,19758
2023q1	0,0084	0,02362	0,00623	0,294796035	0,0757	0,41	0,115222388	0,152	0,263	0,23952	0,1499844	0,12404	0,324	0,39	0,3	0,17307
2023q2	0,0062	0,00835	0,00954	0,295186997	0,0719	0,41	0,099828107	0,151	0,336	0,24677	0,152995	0,12133	0,359	0,458	0,38	0,14415
2023q3	0,0095	0,00623	0,00299	0,294823385	0,0796	0,4	0,089498532	0,151	0,378	0,26553	0,1520717	0,11949	0,383	0,5	0,43	0,14193

Appendix A: Unfiltered data base in Excel.
Sources: ECB and OECD

Appendix B: The iterative process of eliminating potential instruments with the highest p-values in Stata

```
. regress cfinf coil cprofit cendep cm3 cst clt cifshares cecopen cborhouse cborcorp cmro ccer, noc
> onstant

      Source |       SS       df       MS              Number of obs =      35
-------------+------------------------------           F(12, 23)     =   11.16
       Model |  .001080656    12  .000090055           Prob > F      =  0.0000
    Residual |  .000185642    23  8.0714e-06           R-squared     =  0.8534
-------------+------------------------------           Adj R-squared =  0.7769
       Total |  .001266299    35   .00003618           Root MSE      =  .00284

------------------------------------------------------------------------------
       cfinf |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        coil |  -.2586826   .1471723    -1.76   0.092    -.5631318    .0457666
     cprofit |   -.040863    .159514    -0.26   0.800    -.3708427    .2891168
      cendep |   .3348834   .1211276     2.76   0.011     .0843117     .585455
         cm3 |   .1101162   .6062587     0.18   0.857    -1.144026    1.364258
         cst |  -.4236142    .113449    -3.73   0.001    -.6583013   -.1889271
         clt |  -.0301362   .0333051    -0.90   0.375    -.0990331    .0387606
   cifshares |   .4709363     .14743     3.19   0.004     .1659541    .7759185
     cecopen |  -.4090581    .409313    -1.00   0.328    -1.255787    .4376704
   cborhouse |    .165893    .098881     1.68   0.107    -.0386579    .3704439
    cborcorp |   .0639008    .109294     0.58   0.564    -.1621911    .2899927
        cmro |   .3018905   .1130904     2.67   0.014     .0679452    .5358359
        ccer |  -.0037435   .1052429    -0.04   0.972     -.221455    .2139679
------------------------------------------------------------------------------
```

```
. regress cfinf coil cprofit cendep cm3 cst clt cifshares cecopen cborhouse cborcorp
> cmro, noconstant
```

Source	SS	df	MS
Model	.001080646	11	.000098241
Residual	.000185652	24	7.7355e-06
Total	.001266299	35	.00003618

Number of obs	=	35
F(11, 24)	=	12.70
Prob > F	=	0.0000
R-squared	=	0.8534
Adj R-squared	=	0.7862
Root MSE	=	.00278

cfinf	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
coil	-.2583872	.143848	-1.80	0.085	-.5552748	.0385005
cprofit	-.0377249	.1301024	-0.29	0.774	-.306243	.2307932
cendep	.3346363	.1183855	2.83	0.009	.0903007	.578972
cm3	.0976359	.4840174	0.20	0.842	-.901327	1.096599
cst	-.42353	.1110392	-3.81	0.001	-.6527036	-.1943564
clt	-.0306296	.0296429	-1.03	0.312	-.0918095	.0305503
cifshares	.4700922	.1424481	3.30	0.003	.1760939	.7640906
cecopen	-.4151595	.3638233	-1.14	0.265	-1.166054	.335735
cborhouse	.1657471	.0967185	1.71	0.099	-.03387	.3653643
cborcorp	.0627617	.1022995	0.61	0.545	-.1483741	.2738975
cmro	.3034629	.1019041	2.98	0.007	.0931432	.5137827

```
. regress cfinf coil cprofit cendep cst clt cifshares cecopen cborhouse cborcorp cmro
> , noconstant
```

Source	SS	df	MS
Model	.001080331	10	.000108033
Residual	.000185967	25	7.4387e-06
Total	.001266299	35	.00003618

Number of obs	=	35
F(10, 25)	=	14.52
Prob > F	=	0.0000
R-squared	=	0.8531
Adj R-squared	=	0.7944
Root MSE	=	.00273

cfinf	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
coil	-.276563	.1099591	-2.52	0.019	-.503028	-.0500979
cprofit	-.0248135	.1110742	-0.22	0.825	-.253575	.203948
cendep	.3486455	.0940177	3.71	0.001	.1550124	.5422785
cst	-.4254549	.1084851	-3.92	0.001	-.6488841	-.2020257
clt	-.0300921	.0289509	-1.04	0.309	-.0897177	.0295334
cifshares	.4787655	.133173	3.60	0.001	.2044905	.7530404
cecopen	-.4352235	.3431829	-1.27	0.216	-1.142022	.271575
cborhouse	.1614121	.0924738	1.75	0.093	-.0290412	.3518654
cborcorp	.0721146	.089422	0.81	0.428	-.1120535	.2562827
cmro	.2994569	.0980139	3.06	0.005	.0975936	.5013202

```
. regress cfinf coil cendep cst clt cifshares cecopen cborhouse cborcorp cmro, nocons
> tant
```

Source	SS	df	MS			
Model	.00107996	9	.000119996	Number of obs	=	35
Residual	.000186338	26	7.1669e-06	F(9, 26)	=	16.74
				Prob > F	=	0.0000
Total	.001266299	35	.00003618	R-squared	=	0.8528
				Adj R-squared	=	0.8019
				Root MSE	=	.00268

cfinf	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
coil	-.2692609	.1030524	-2.61	0.015	-.4810883	-.0574336
cendep	.3502697	.0920075	3.81	0.001	.1611455	.5393939
cst	-.4182404	.1016569	-4.11	0.000	-.6271992	-.2092817
clt	-.0323317	.0266589	-1.21	0.236	-.0871299	.0224664
cifshares	.4611816	.1054412	4.37	0.000	.2444441	.6779192
cecopen	-.4489062	.331446	-1.35	0.187	-1.130203	.2323908
cborhouse	.1562644	.0879052	1.78	0.087	-.0244274	.3369561
cborcorp	.072869	.0877104	0.83	0.414	-.1074222	.2531603
cmro	.2960832	.0950575	3.11	0.004	.1006897	.4914768

```
. regress cfinf coil cendep cst clt cifshares cecopen cborhouse cmro, noconstant
```

Source	SS	df	MS			
Model	.001075014	8	.000134377	Number of obs	=	35
Residual	.000191285	27	7.0846e-06	F(8, 27)	=	18.97
				Prob > F	=	0.0000
Total	.001266299	35	.00003618	R-squared	=	0.8489
				Adj R-squared	=	0.8042
				Root MSE	=	.00266

cfinf	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
coil	-.2389978	.095845	-2.49	0.019	-.4356556	-.0423401
cendep	.3236983	.0857734	3.77	0.001	.1477059	.4996907
cst	-.390393	.0954197	-4.09	0.000	-.586178	-.194608
clt	-.0329387	.0264955	-1.24	0.224	-.0873031	.0214256
cifshares	.483595	.101345	4.77	0.000	.2756521	.6915378
cecopen	-.429993	.3287609	-1.31	0.202	-1.104555	.2445686
cborhouse	.1787545	.083152	2.15	0.041	.0081407	.3493683
cmro	.3144522	.0919185	3.42	0.002	.1258511	.5030534

Appendix B: Iterative process of eliminating the potential instruments with the highest p-values.
Source: Own work

Appendix C: 2SLS regression results and statistical tests in Stata

```
. ivregress 2sls cinf cpinf cgdp (cfinf = coil cendep cst clt cifshares cecopen cborh
> ouse cmro), first
```

First-stage regressions

Number of obs	=	35
F(10, 24)	=	13.60
Prob > F	=	0.0000
R-squared	=	0.8500
Adj R-squared	=	0.7874
Root MSE	=	0.0028

cfinf	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
cpinf	-.020081	.1921089	-0.10	0.918	-.4165743	.3764123
cgdp	-.0597539	.1484903	-0.40	0.691	-.3662228	.2467149
coil	-.2198826	.1145768	-1.92	0.067	-.4563576	.0165924
cendep	.304022	.1032229	2.95	0.007	.0909804	.5170637
cst	-.412326	.1147235	-3.59	0.001	-.6491037	-.1755483
clt	-.0339385	.0331307	-1.02	0.316	-.1023169	.0344398
cifshares	.4836472	.1071529	4.51	0.000	.2624945	.7047999
cecopen	-.3036551	.4839769	-0.63	0.536	-1.302534	.6952241
cborhouse	.191206	.0981415	1.95	0.063	-.0113481	.3937602
cmro	.3291565	.1038145	3.17	0.004	.1148939	.5434192
_cons	-1.04e-10	.0004756	-0.00	1.000	-.0009816	.0009816

```
Instrumental variables (2SLS) regression          Number of obs   =         35
                                                  Wald chi2(3)    =      49.94
                                                  Prob > chi2     =     0.0000
                                                  R-squared       =     0.5631
                                                  Root MSE        =     .00373

------------------------------------------------------------------------------
        cinf |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       cfinf |   .5251244   .1297139     4.05   0.000     .2708898     .779359
       cpinf |   .3273561   .1351098     2.42   0.015     .0625457    .5921665
        cgdp |   .1141428   .0947351     1.20   0.228    -.0715347    .2998202
       _cons |  -2.33e-11   .0006306    -0.00   1.000    -.001236     .001236
------------------------------------------------------------------------------
Instrumented:  cfinf
Instruments:   cpinf cgdp coil cendep cst clt cifshares cecopen cborhouse
               cmro

. estat first, all

  First-stage regression summary statistics
  --------------------------------------------------------------------------
               |            Adjusted      Partial
      Variable |   R-sq.       R-sq.        R-sq.      F(8,24)   Prob > F
  -------------+------------------------------------------------------------
         cfinf |  0.8500      0.7874       0.8132      13.0621    0.0000
  --------------------------------------------------------------------------


. estat overid

  Tests of overidentifying restrictions:

  Sargan (score) chi2(7) =  17.0553  (p = 0.0170)
```

Appendix C: 2SLS regression results and statistical tests in Stata.