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The Effect of Changes in Exchange Rates, Oil Prices and Interest Rates on Inflation in the Euro Area: An Empirical Study using ARDL Approach

أثر تغيرات أسعار الصرف، أسعار النفط وأسعار الفائدة على التضخم في منطقة اليورو: دراسة قياسية باستخدام مقاربة ARDL

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Abstract:

The paper re-examines the effect of changes in both exchange rates, oil prices, and interest rates on inflation in the euro area over the period 1999(Q1)-2019(Q4) using autoregressive distributed Lag (ARDL) bounds testing. The main findings of this paper are as follows: (i) The results of the bound cointegration test give evidence in support of long-run relationship among the variables (ii) The results support the existence of the exchange rate pass-through to inflation on the long term (iii) On the contrary, the results suggest the existence of the oil price pass-through into euro area inflation in the short term (iv) The results of this study also provide sufficient evidence for the effectiveness of the interest rate channel - specifically short-term interest rates in curbing inflation in the euro area. However, the findings of the study show that the euro area is suffering from cost - push inflation.

Keywords: Exchange Rates; Oil Prices; Interest Rates; Euro Area Inflation; ARDL Model

JEL Classification Codes: E31, E43, E52, E58, E60

ملخص:

عيد الورقة النظر في تأثير التغيرات في أسعار الصرف وأسعار النفط وأسعار الفائدة على التضخم في منطقة اليورو خلال الفترة 1999(Q1)-2019(Q4) باستخدام اختبارا الحدود لنموذج الانحدار الذاتي للفجوات الموزعة المتباطئة ($ARDL$). الاستنتاجات الرئيسية لهذه الورقة هي كما يلي: (1) نتائج اختبار التكامل المشترك تظهر علاقة طويلة الأمد بين المتغيرات (2) النتائج تدعم وجود تأثير سعر الصرف على التضخم على المدى الطويل (3) على العكس من ذلك، تشير النتائج إلى وجود تاثير لأسعار النفط على التضخم في منطقة اليورو على المدى القصير (4) كما توفر نتائج هذه الدراسة أدلة كافية على فعالية قناة سعر الفائدة – خاصة أسعار الفائدة قصيرة الأجل في كبح التضخم في منطقة اليورو. ومع ذلك، تظهر نتائج الدراسة أن منطقة اليورو تعاني من تضخم دفع بالتكلفة.

كلمات مفتاحية: أسعار الصرف. أسعار النفط ، أسعار الفائدة؛ التضخم في منطقة اليورو؛ نموذج ARDL

تصنيفاتJEL : E31, E43, E52, E58, E60

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Introduction

Inflation is simply defined as the rate of increase in prices over a certain period. Whatever the context, inflation represents how much more expensive the relevant set of goods and/or services has become over a given time period (usually measured over a year). According to Milton Friedman, "inflation is always and everywhere a monetary phenomenon". Therefore, inflation is usually seen as a monetary dilemma that all economies suffer from (whether they are developing, emerging or even advanced). Inflation poses a real challenge for policymakers in these countries, especially for monetary authorities. Accordingly, the monetary policy of most of the major central banks around the world (especially in the major industrialized countries) places price stability as its primary objective, in addition to the goal of sustainable economic growth and full employment.

Given the important role it plays in the domestic economy, inflation is receiving special attention from a wide segment of society, ranging from policymakers, academic researchers, economists, investors, companies and even households. All of them are closely monitoring developments that occur at the price levels, and everyone seeks to understand the dynamics of inflation, determine its causes and predict its behavior in the future. Accurate knowledge of these key points would serve the various goals and interests of these parties, or at least reduce the undesirable and potential effects of inflation on the economic decisions of economic agents and this would affect economic growth, in the end

On the part of policymakers, price stability creates the appropriate conditions that would facilitate monetary policy practice and implementation with high efficiency. Moreover, the sustainable price stability signifies credibility and high relative independence of the monetary authority. On the part of economic agents (households and investors), price stability provides an environment conducive to economic decision making, which is not the case when prices change. In other words, price stability for a certain period of time means that the purchasing power of individuals and families will not change and that their available personal incomes will not be affected during this period, and this would increase consumption and savings' rates. Likewise, price stability in the long run instills confidence in the souls of investors and provides them with adequate insurance regarding the availability of financing and real investment costs, and this would increase the rates of investment spending. Hence, long-term price stability guarantees effective allocation of resources and eliminates all potential barriers to sustainable growth and full employment that policymakers and governments aspire to achieve, as final goals of macroeconomic policy.

Returning to monetary policy, the issue of price stability is a permanent concern for the Central Bank. If it is possible to reach the goal of price stability for a period of time, then maintaining this position for a long period of time is difficult to achieve and it represents a great and real challenge for the monetary authority. This is mainly due to two important factors: (i) The multiplicity and complexity of domestic and global drivers of inflation (ii) Inflation has wide-ranging extensions linked to all economic sectors. Inflation is usually seen as a cause and a consequence, at the same time, for a set of interactions and interrelationships between real, monetary, financial economy variables and even some social variables. For this reason, it is not possible in any way to control these variables combined at the same time, and its future paths cannot be accurately predicted. The matter becomes more complicated when it comes to more open economies, such as the euro area economy.

The relationship between macroeconomic variables has always been the subject of concern for macroeconomists, and is always subject to empirical treatment in order to validate the theoretical assumptions based on it. In the context of macroeconomic analysis, attention and focus in this paper is on assessing and discussing the effect of three fundamental macroeconomic variables on inflation in the euro area. More precisely, the study is interested in assessing the potential effects of changes in both exchange rates, oil prices and interest rates on inflation in the euro area. These variables are specifically chosen, as three fundamental macroeconomic variables for a country's economy. Taken together, they play a central role not only in determining the real and nominal economy, but they also have an important and effective role in influencing them as well. This role is clearly evident when we address the issue of inflation or price stability, given the extreme sensitivity between these factors and price stability, at least in theory, and based on experimental experience gained from previous studies. The study seeks to answer the following main question: To what extent can changes in the exchange rate, oil price and interest rate affect inflation in the Euro area, and what are the various possible channels for transmitting these effects? For this purpose, this paper is organized as follows: The first and second sections respectively provide a theoretical and empirical review on the concept of exchange rate pass-through, oil price pass-through and interest rate pass-through to inflation, the third section introduces the research methodology and data used and the last section presents and discusses the results of the standard study.

1. Theoretical Review

1.1 The effect of exchange rates changes on inflation:

It is extremely important for the monetary authorities to discuss the relationship between inflation and exchange rate, especially for managing monetary policy, where the exchange rate channel is one of the most important transmission channels through which monetary policy decisions are transferred to the real economy and price stability in the medium term. Besides, the fear that exchange rate fluctuations can be an important source of macroeconomic instability (such as instability of domestic prices) is among the reasons that the sources of fluctuations in the real exchange rate have attracted the attention of researchers and policy makers. More open economies (such as the Euro Area) are generally seen as highly vulnerable to the effects of exchange rates on domestic prices.

The degree to which exchange rate changes are transmitted to import prices and subsequently to final consumer prices is commonly referred to as exchange rate pass-through (ERPT) (ECB, 2000, p. 54). Exchange rate changes are transmitted to inflation via a number of channels, both direct and indirect. For the direct effects, changes in the exchange rate have a direct effect on consumer price inflation through their effect on import prices. Following an exchange rate depreciation, imported final consumer goods become more expensive, pushing up inflation (first stage pass-through). Through the direct channel, import prices are directly linked to consumer prices. In general, the sensitivity of inflation in the Euro area to changes in the local currency exchange rate depends on the pricing decisions of foreign producers exporting to the economy concerned. As for the indirect effects, which can take longer to trickle through the economy, they work via production costs and real channels. The decrease

in the value of the local currency translates into higher production costs due to more expensive imported inputs, and these feed through the different stages of domestic intermediate and final goods production, with an inflationary impact on domestic consumer prices (second stage pass-through). Through this channel, import prices are linked to product prices and then consumer prices. Finally, the magnitude of the indirect effects of the change in the value of the local currency on inflation depends on the pricing behavior of domestic firms.

The relationship between exchange rates and inflation is one of the most important research issues, which have been extensively discussed in economic studies. Numerous valuable contributions were made in this field, e.g. *Barro & Gordon (1983), Woo (1984), Dornbusch & Fischer (1984), Sachs (1985), Dornbusch (1985,1986, 1987), Giavazzi & Giovannini (1989), Velasco (1996)* and *Dornbusch (2001)*. Regardless of the temporal and spatial limits, and the methodology used in the analysis, these studies in general agree on the importance of the role that exchange rates play in influencing import and domestic prices. While some studies have confirmed that the exchange rate works through the direct impact of import prices on local prices (e.g. see *Woo, 1983*). Others argue that there are additional effects (indirect effects) of exchange rate changes on import prices and then inflation through the wages and production costs channels (e.g. see *Dornbush & Fisher, 1984* and *Sachs, 1985*). However, all these studies emphasize a fundamental point that a stable exchange rate regime not only provides price stability, but also increases the efficiency of monetary policy.

1.2 The effect of oil prices changes on inflation:

The mechanism through which the effects of shocks in world oil prices are converted to the domestic inflation is usually referred to as oil price pass-through. In general, It is expected that the increase in oil prices will lead to higher inflation. This positive relationship between them can be translated through at least three interrelated mechanisms. These mechanisms include two types of effects, direct and indirect effects. For the direct effects, oil prices' shocks are passed on directly to consumer prices via their impact on consumer energy prices (such as heating oil and fuels for transport) that are directly included in the Consumer Price Index (CPI) (ECB, 2015, p. 87). This is because energy is already an essential part of the households' consumer basket. As for the indirect effects, the rise in oil prices necessarily leads to higher producer prices (as a result of higher production costs), and then an increase in consumer prices (L'oeillet & Licheron, 2009, p. 5). These effects are clearly evident in transportation services, where fuels are a major cost factor, and in the case of consumer goods and services that are produced with relatively high oil and, more generally, energy intensity, such as some pharmaceutical products and some materials used for household maintenance and repair. And because imports are important inputs to domestic production processes or as final consumption goods, changes in oil prices are likely to have indirect effects on inflation, if they trigger changes in output prices in the economies of the trading partners (ECB, 2014, p. 54). According to ECB illustrate, both producer prices of the trading partners of the Euro area, which shape Euro area import prices, and producer prices of euro area producers for the domestic economy tend to follow oil price developments with some lag. On the other hand, higher oil prices may lead to higher expectations for inflation, wages and producer prices (Misati, Nyamongo, & Mwangi, 2013, p. 130). Workers and producers may resist declines in their real wages and profits margins, putting upward pressure on unit labor costs and the prices of finished goods and services (Hunt, Isard, & Laxton, 2001, p. 10). Hence, positive

movements in oil prices may lead to additional upward inflationary pressures in the medium and long term. In the event of a shock in the oil price, the indirect impact of oil prices on inflation depends on three important factors: (i) producer pricing policy, (ii) price adjustments and their speed, (iii) the future outlook of producers regarding profit (negative or positive) and costs for risk.

Oil prices and levels of inflation are often seen as being connected in a cause-and-effect relationship. As oil prices move up, inflation follows in the same direction higher. On the other hand, as the price of oil falls, inflationary pressures start to ease. History shows that the two are indeed correlated, but the relationship has deteriorated since the oil spike of the 1970s. When reviewing the history of the relationship between oil prices and inflation, we find that this relationship has witnessed continuous changes, at least since the early 1970s. Most studies indicate that this relationship was strong during the period of oil shocks in the 1970s and to a lesser extent during the 1990s of the last century, and even during the first ten years of this century (Hooker, 2002, p. 1). On the other hand, historical evidence indicates that this relationship witnessed a clear deterioration during the period of the 19980s and the period after the last financial crisis in 2008 (Seka, Teoa, & Wonga, 2015, p. 631).

Therefore, when reviewing economic literature, several studies can be found that have focused on the relationship between oil prices and inflation. In this context, many of the studies focused on the relationship between oil prices and inflation concluded that the price of oil has a positive impact on inflation, with a difference in the degree of importance of influence across countries and times. While some studies indicate that oil prices have a significant impact on determining consumer price inflation [see, e.g. *Chou & Tseng (2011)* and *Misati et al. (2013)*], some other studies indicate that oil prices have a modest and limited impact on consumer price inflation [see, e.g. *Hooker (2002)* and *Gregorio et al (2007)*], while others provide strong evidence that oil prices are not important on influencing consumer price inflation [see, e.g. *Chen & Wen (2011)* and *Evans & Fisher (2011)*].

Therefore, the relationship between oil prices and inflation is inconclusive and it is constantly being tested. It is important for monetary authorities across the world to discuss the determinants of this relationship with a view to increasing its effectiveness in achieving its primary goal of maintaining price stability.

1.3 The effect of interest rates changes on inflation:

The means by which the official interest rates adjustments influence inflation is commonly referred to as the monetary policy transmission mechanism or interest rate pass-through into inflation. On the monetary policy front, the interest rate is one of the most important tools of quantitative monetary policy used by the central bank to influence the size of the money supply (quantitative effect) and direct it according to the existing macroeconomic policy in the country (qualitative effect).More precisely, the main objective of monetary policy is to maintain and stabilize the value of the local currency, reflected among others in low and stable inflation. To this end, the central bank periodically changes official interest rates. This serves as the primary instrument for influencing economic activity with the overriding objective of achieving the desired level of inflation.

The monetary transmission mechanism operates through interaction between the central bank, the banking system, financial sector and the real sector. This mechanism reflects the various actions that the central bank takes through adjustments in monetary instruments and operational target with effect on a range of economic and financial variables before ultimately influencing inflation as the final objective. In general, most views on the cash transfer mechanism agree around five main channels: interest rate channel, money channel, exchange rate channel, asset price and wealth channel and expectations channel.

1.3.1 Interest rate channel: Medium and long-term interest rates depend, among other factors, on expectations for short-term interest rates in the future. According to the traditional Keynesian interest rate channel, a policy-induced changes in the short term nominal interest rate affect the entire interest rate curve (Ireland, 2005, p. 3). Nominal interest rates for different time horizons also depend on expectations for those time periods (higher inflation expectations lead to higher nominal interest rates). In general terms, real interest rate increases act as a disincentive to expenditure in an economy. On the one hand, when the cost of capital to finance projects increases, investment decreases. On the other hand, when real interest rates increase, the opportunity cost of consumption also increases. Therefore, consumption tends to slow. Both elements affect aggregate demand and, eventually, inflation..

1.3.2 Money channel: When interest rates increase, the credit available for investment and consumption decreases. On the one hand, interest rate increases also raise the cost of credit, and the demand for credit diminishes. On the other, the supply of credit can decline, because higher real interest rates may increase the risk of portfolio recovery, and financial intermediaries typically react to this risk by tightening credit. The decline in consumption and investment leads to a decline in aggregate demand and, consequently, to lower inflation.

1.3.3 Exchange rate channel: It links monetary policy to inflation via two ways. The first is via total demand and works through the uncovered interest rate parity condition. In open economies, when the domestic nominal interest rate rises above its foreign counterpart, the domestic currency will tend to be appreciated towards foreign exchange rates, due to its increased attractiveness as an investment currency. When prices are slow to adjust, this makes domestically produced goods more expensive than foreign produced goods. Net exports fall, as do domestic output and employment, while inflation decreases (Beyer, et al., 2017, p. 14). The second way works through import prices. Changes in the exchange rate affect import prices directly, and these influence the inflation rate (Arestis & Sawyer, 2002, p. 7).

1.3.4 Asset price and wealth channels: Interest rates affect the prices of various assets, e.g. bonds, stocks, and houses (Pétursson, 2014, p. 64). Monetary policy induced increase in the nominal interest rates may, from an investor's point of view, raise the attractiveness of new debt instruments compared to equities and existing debt. After this monetary tightening, the prices of these assets will be negatively affected, which will lead to a decrease in investment spending. On the other hand, low asset prices reduce the real wealth of household, which in turn may discourage borrowing and spending as well. As a result, all economic activity decreases and price levels decline

1.3.5 Expectations channel: The last channel is the effect of changes in interest rates on people's expectations of future interest rates, growth, and inflation. Expectations of future official interest-rate changes affect medium and long-term interest rates, as longer-term interest rates depend in part on market expectations about the future course of short-term

rates. These expectations often affect decisions of firms and households about current saving and investment choices. They also affect wages, the prices of goods and services and asset prices, eventually translating into a price level change. If, for example, official interest rates were expected to rise in the future, longer term interest rates and inflation would typically rise to reflect this expectation. However, monetary policy can also guide economic agents' expectations of future inflation and thus influence price developments. A central bank with a high degree of credibility can firmly anchor expectations of price stability. In this case, economic agents do not have to increase their prices for fear of higher inflation or reduce them for fear of deflation.

It is worth noting that the effect of the policy rate on price levels through the previous channels depends heavily on savings, investment and consumption decisions of households and firms, and their expectations for inflation in the future, in addition to the credibility of the central bank and the degree of economic agents' confidence in monetary policy decisions.

The origin of the debate over the influence of the rate of interest on inflation is usually attributed to the studies of the Swedish economist Knut *Wicksell (1907, 1936)*. According to *Wicksell (1907)* - with other things remaining the same - if the central bank reduces the interest rate by 1 percentbelow its ordinary level, and keeps it so for several years, then the prices of all commodities will rise and rise without any limit whatever. Conversely, if the central bank raises the interest rate by 1 percent above its normal level, and maintains it for several years, then all prices would fall and fall without any limit except Zero.

Wicksell assumes that any deviation in the market price - that is, the interest rate that appears in the capital market- from the neutral interest rate, results in changes in the prices through the Wicksell's cumulative process which explains how the difference between natural interest rate and market rate results in increases in prices. Accordingly, suppose that the market interest rate is lower than the natural one, in such case, the level of economic activity will enhance and thus a rise in prices will occur. And then, increases in prices will put further pressure on the real interest rate, resulting in a further rise in the level of economic activity and therefore at prices.

2. Empirical Background

The different relationships between inflation and previous variables of interest have been investigated in an extensive number of studies, which differ in methodology, economies under study, time period covered, data used in the analysis, the main objectives of the study and even in results. Because of the large number of studies, in the following paragraphs we will focus on research that has discussed these relationships in the European economy (the euro area) or relatively similar economies, and even some studies that we find useful and valuable, at least from our point of view. These studies will be arranged in chronological order from oldest to newest, according to the following classification:

2.1 Empirical literature on the relationship between exchange rate and inflation

McCarthy (1999) investigated the impact of exchange rates and import prices on the domestic producer price index (PPI) and consumer price index (CPI) in selected industrialized economies (United States, Japan, Germany, France, the United Kingdom, Belgium, the Netherlands, Sweden, and Switzerland) for the period from 1976 (Q1) to1998 (Q4) for most

countries. By using vector autoregression model (VAR) and impulse responses, the results have shown that exchange rates have a modest effect on domestic price inflation while import prices have a stronger effect. The results also indicated that the pass-through is larger in countries with a larger import share and more persistent exchange rates and import prices.

Hahn (2003) investigated the pass-through of external shocks, i.e. oil price shocks, exchange rate shocks, and non-oil import price shocks to the Euro area inflation at different stages of distribution (import prices, producer prices and consumer prices). The analysis in this study is based on quarterly data covering the time period 1970 (Q2) -2002 (Q2). Based on a VAR model, the study found that the pass-through is largest and fastest for non-oil import price shocks, followed by exchange rate shocks and oil price shocks, and that the size and the speed of the pass-through of these shocks decline along the distribution chain. The results have shown also that the External shocks explain a large fraction of the variance in all price indices. This means that oil price shocks, exchange rate shocks and non-oil import price shocks have contributed significantly to shaping Euro-area inflation.

Campa and Goldberg (2002) argue that the exchange rate regime optimality, as well as monetary policy effectiveness depends on the tightness of the link between exchange rate movements and import prices. In this context, *Campa et al (2005)* re-checked the extent of exchange rate pass-through into the import prices, across countries and product categories, in 23 OECD countries using monthly data over the period of 1989-2004. The empirical results confirmed the existence of a long-run relationship between the exchange rate, import prices and inflation. The results suggest that the transmission of exchange rate changes to import prices in the short run is high, although incomplete, and that it differs across industries and countries. While, in the long run, exchange rate pass-through is higher and close to one. They also found that industries producing differentiated goods were more likely to experience reduced rates of exchange rate pass-through to import prices since the launch of the euro.

Ben Cheikh (2011) examined the exchange rate pass-through (ERPT) into import prices using recent panel data techniques for a sample of 27 OECD countries. The researcher employed both FM-OLS and DOLS approaches to estimate long-run ERPT. The results indicated a regime dependence of ERPT. As the countries with higher inflation regime and more exchange rate volatility would experience higher degree of pass-through. Currencies with relatively low variability are preferred for transaction invoicing and local-currency pricing would reduce ERPT. The author also argues that the literature on ERPT generally finds that lower currency volatility tends to be accompanied by lower ERPT.

Ben Cheikh & Rault (2015) investigated whether exchange rate pass-through (ERPT) into import prices is a nonlinear phenomenon for five heavily indebted Euro area countries, namely the so-called GIIPS group (Greece, Ireland, Italy, Portugal, and Spain). Using logistic smooth transition models, they found that the extent of ERPT is higher in periods of macroeconomic distress, i.e. when sovereign bond yield spreads exceed a given threshold, which indicates that the increase in macroeconomic instability and the loss of confidence during the sovereign debt crisis have led to a higher sensitivity to import prices for exchange rate movements. In the case of Greece, for example, they found that the rate of pass through is equal to 0.66% when the yield differential is below 2.13%, but beyond this threshold level, the sensitivity of import prices becomes higher and reaches full ERPT.

Miyajima (2019) employed a standard estimation technique of exchange rate pass-through (ERPT) to inflation, extended to incorporate exchange rate volatility using quarterly data for March 2005–June 2018. The main estimated results suggest that higher exchange rate volatility tends to increase core inflation but to a relatively limited extent in South Africa. The researcher believes that this result strongly supports the policy of allowing the Rand to float freely and work as a shock absorber, consistent with the nation's successful inflation targeting regime.

Colavecchio & Rubene (2020) examined possible non-linearities in the transmission of exchange rate movements to import and consumer prices in all 19 Euro area countries as well as the euro area as a whole from 1997 to 2019(Q1). To measure the transfer of exchange rate changes to local prices over time, the analysis in this study relies on a time series model of one equation similar to the Philips dynamic curve. In addition to estimating the dynamic impulse responses to the exchange rate shift using local expectations (LP), developed by *Gordon A (2005)*. The empirical study found out the following results (i) Euro Area consumer and import prices respond significantly to exchange rate movements after one year, responding more when the exchange rate change is relatively large (ii) Euro appreciations and depreciations affect the level of Euro area exchange rate pass-through in a symmetric fashion (iii) Euro area countries' results differ for import and consumer prices and across countries.

2.2 Empirical literature on the oil price pass-through into inflation

Using a version of the IMF's MULTIMOD model, *Hunt et al (2001)* analyzed the macroeconomic effects of oil price shocks in major industrial countries (United states, Euro area, Japan, United Kingdom, Canada and other industrial countries) with a distinction between temporary, more persistent and permanent shocks, with particular attention being paid to the channels through which oil price increases can pass through into CPI inflation and core inflation. The results showed, in general, that there is a positive relationship between inflation and changes in oil prices, and that the direct contemporaneous effects of an increase in oil prices by a 50% lead to an increase in CPI inflation – through gasoline and other direct energy costs – by 1.3% in both USA and Euro area, 0.6% in both Japan and UK, 0.8% in Canada and 0.7% in the block of other industrial countries.

LeBlanc & Chinn (2004) estimated the effects of oil price changes on inflation for the G-5 countries (United States, United Kingdom, France, Germany, and Japan) using an augmented Phillips curve on the period 1980(Q1) to 2001(Q4). The results indicated that a 10 percent increase in oil price leads to direct inflationary increases of about 0.1-0.8 percentage points in these countries and there is no significant difference in the pass-through between U.S. and the E.U.

Zoli (2009) assessed the role of international commodity prices (Including oil prices), cyclical fluctuations and convergence in driving inflation in 18 European emerging economies. Country specific Vector Autoregressions (VARs) and panel estimates indicated that international commodity price shocks have a significant impact on domestic inflation, but the inflation response is asymmetric for positive and negative shocks. Cyclical fluctuations explain a relative small share of inflation variability, and the inflation response is asymmetric during upturns and downturns. Price convergence is estimated to add nearly 3 percentage

points to headline inflation, for the average country whose price level is about 50 percent relative to the EU-15 average. These findings imply that the responses of domestic inflation to global oil price shocks in developing economies can be influenced by region-specific factors.

Karimli et al (2016) evaluated different channels of oil price pass through into inflation for Azerbaijan, Kazakhstan and Russia using quarterly time series data for the period 2000 - 2014.In this study, the researchers employed the VAR approach drawing on variables on world oil (Brent) prices, domestic oil production, trade partners' CPI, real fiscal expenditures and domestic CPI. The main findings of this study indicate that the level of inflation in these oil exporting countries responds significantly to oil price shocks. The fiscal and cost channels are major amplifiers of the effects of oil price shocks on inflation.

Lacheheb & Sirag (2016), examined the relationship between oil price changes and inflation rate in Algeria from 1970–2014. Using a method known as nonlinear autoregressive distributed lags (NARDL). The results of the estimated model revealed the existence of nonlinear effect of oil price on inflation. Specifically, they found a significant relation between oil price increases and inflation rate, whereas, a significant relation between oil price reduction and inflation was absent.

Choi et al (2017) studied the impact of fluctuations in global oil prices on domestic inflation using an unbalanced panel of 72 advanced and developing economies over the period from 1970 to 2015. They found that a 10 percent increase in global oil inflation increases, on average, domestic inflation by about 0.4 percentage point on impact, with the effect vanishing after two years and being similar between advanced and developing economies. They also found that the effect is asymmetric, with positive oil price shocks having a larger effect than negative ones. The impact of oil price shocks, however, has declined over time. The researchers claimed that, this was due in a large part to a better conduct of monetary policy. Further, they examined the transmission channels of oil price shocks on domestic inflation during the recent decades, by making use of a monthly dataset from 2000 to 2015. The results suggested that the share of transport in the CPI basket and energy subsidies are the most robust factors in explaining cross-country variations in the effects of oil price shocks during this period.

Bala & Chen (2018) examined the asymmetric effects of changes in oil prices on inflation in Algeria, Angola, Libya, and Nigeria using different kinds of oil price data (the actual spot oil price of individual countries, the OPEC reference basket oil price, and an average of the Brent, WTI, and Dubai oil price). Using annual data for the period 1995-2014, and by applying the autoregressive distributed lag (ARDL) dynamic panels, the study concluded that the positive and negative changes in oil prices have positively affected inflation in these countries, and they found that the effects became more severe when oil prices fell. Because the model used in this study includes the exchange rate as an interpreted variable, the results indicated a positive relationship between exchange rate movements and inflation in these countries. Finally, researchers advise using a deflationary monetary policy and stimulating domestic food production, in terms of quantity and quality, to reduce inflation.

2.3 Empirical literature on the relationship between interest rate and inflation

Using different co-integration techniques, several studies have been conducted to examine the relationship between interest rate and inflation, e.g. *Fama (1975)*, *MacDonald & Murphy (1989)*, *Wallace & Warner (1993)*, *Mishkin (1992)*, *Crowder & Hoffman (1996)*, *Booth &*

Ciner (2001), *Junttila (2001)*, *Muse & Alimi (2012)* and *Sen et al (2019)*. Regardless of the economy under study, the period of time covered, the aim of the study and the nature of the relationship, previous studies in their entirety concluded that there is a long-run equilibrium relationship between the interest rate and inflation. While other studies, for example, *Bouham (1991)*, *Wu & Zhang (1996)*, *Culver & Papell (1997)*, *Koustas & Serletis (1999)*, *Lee & Wu (2001)*, *Wu & Chen (2001)*, *Ghazal & Ramlee (2003)*, *Basher & Westerlund (2006)* and *Hjalmarsson & Österholm (2007)* found no evidence of cointegration between nominal interest rates and inflation.

Asgharpur et al (2007) investigated the interactions between interest rates and inflation in developing countries (40 Islamic countries) using new causality approach and applying panel data methodology over the 2002-2005 periods. After estimating the model using the Seemingly Unrelated Regression (SUR) method, the results revealed a negative relationship between the interest rate and the rate of inflation, and that an increase in the interest rate by one percent leads to a decrease in inflation of about 0.13 percent. Likewise, for the Hsiao causality test, the results indicated a unidirectional causal relationship from interest rate to inflation rate.

Employing pooled probit analysis to estimate the contribution of the key factors to inflation starts, *Vansteenkiste (2009)* empirically assessed which factors trigger prolonged periods of inflation for a sample of 91 countries, of which 63 developing countries and 28 advanced economies over the period 1960-2006. The empirical results suggest that for all countries with more fixed exchange rate regime and lower real policy rates, the probability of an inflation start increases. This means that policy interest rates negatively affect inflation in these countries. The results also indicated that oil prices and M2 growth were never statistically significant.

In the context of analyzing the macroeconomic policies of the United States, *Brayton et al (2014)* examined the effect of the federal funds rate on both output and inflation, using the FRB/US model. The results of the estimated model showed a positive relationship between the target interest rate and output, and a negative relationship between the interest rate and inflation in the United States. More precisely, in the Fed's model of economy, a one percentage point increase in the federal funds rate would increase the output gap by 0.2-0.5 percentage points and decrease inflation by 0.2-0.8 percentage points at its peak (after about two years).

Based on the results of the estimated DSGE model for a small open economy, *Wesołowski (2016)* showed that the long-term interest rate that includes a time-varying term premium stabilizes GDP, but does not significantly affect the volatility of inflation in Poland.

Meyer et al (2018) investigated the effectiveness of the use of the repo rate (interest rate) as an instrument to facilitate price stability and GDP in South Africa using quarterly time series data for the period 2000-2016. In order to analyze the long-term, short-term, and casual relationships between interest rates, inflation, and GDP, the VECM model and the Granger causality tests were employed in this study. The results showed a significant and negative long-run relationship between the repo rate and the inflation rate. However, in the short term there is no relationship between them.

In order to determine the macroeconomic effects of the ECB's unconventional monetary policies, *Mouabbi & Sahuc (2019)* estimated a medium-scale DSGE model in which the shadow rate was used as a proxy for the policy rate, with perform counterfactual analyses. In general, the results of the empirical study indicated that without unconventional measures, the Euro area would have suffered (i) a substantial loss of output since the Great Recession (ii) a period of deflation from mid-2015 to early 2017. This translates into year-on-year inflation and GDP growth differentials of 0.61% and 1.09%, respectively, over the period 2014 (Q1)-2017(Q2). These results implicitly indicate significant interest rate effectiveness - in the context of unconventional monetary policy - in controlling euro zone inflation as a single bloc.

Alekseievska et al (2019) researched the impact of the unconventional monetary policy of the central banks of the developed countries on national economies. The study included central banks that use both traditional and unconventional methods of monetary policy (The Fed, the ECB, the BOE and the BOJ). For this purpose, a model was designed based on the consumer price index, as a dependent variable, and a set of explanatory variables that include many types of interest rates (a mixture of short and long-term interest rates). Using the least squares method, the researchers found that the highest impact is observed for the variable yield of ten-year government bonds. The results indicated that an increase in the yield on 10-year euro bonds by 1%, leads to a decrease in the consumer price index by 4 points.

3. Research Methodology

In empirical studies that use time series data, and in order to achieve the desired goals of this study, it is necessary to adhere to econometric techniques for time series. This is in accordance with the following technical procedures: (i) unit root tests, (ii) ARDL bounds test for cointegration, (iii) estimation of the Short and long-run relationship.

3.1 Model specification

To determine the effect of fluctuations in the interest rate, exchange rate, and crude oil price on the harmonized consumer price index in the euro area, a linear regression model is adopted based on the theoretical approaches that were discussed in the theoretical framework. This regression can be formulated in the following linear equation:

$$\mathrm{INF} = \beta_0 + \beta_1 \mathrm{REER}_t + \beta_2 \mathrm{OIL}_t + \beta_3 \mathrm{INT}_t + \beta_4 \mathrm{IMP}_t + \beta_5 \mathrm{MS}_t + \beta_6 \mathrm{ULC}_t + \beta_7 \mathrm{GDP}_t + \varepsilon_1 \dots\dots (1)$$

Where, HICP expresses the Harmonized Consumer Price Index in Euro area, usually used to measure inflation, or as a proxy for inflation rate in the Euro area (Haan, Hoeberichts, Maas, & Teppa, 2016, p. 16). INT denotes the immediate interest rate in Euro area, REER denotes real effective exchange rate based on CPI (Index, 2015=100), OIL denotes Brent oil price. Other control variables were added in the model. IMP expresses the world import prices index, which was used as a proxy for the euro area import price index, ULC denotes unit labour cost; MS denotes money supply (broad money), GDP denotes real gross domestic product per capita. These variables have been added due to the importance of their role in explaining the dynamics of inflation, at least in theory, and they also greatly help in understanding the nature and channels of transmission of the impact of the main variables in this study on inflation in the euro area.

3.2 Data

The study used Euro area quarterly time series data from 1999 to 2019. The data for Harmonized Consumer Price Index (HCPI), immediate interest rate (INT), Real effective exchange rate (REER) and Money supply (MS) were collected from OECD Statistics. While, unit labor cost (ULC) and Real gross domestic product per capita (GDP) data were obtained from the Eurostat database, and crude oil prices (OIL) were sourced from Federal Reserve Bank of St. Louis. Finally, the Import price index (IMP) data was obtained from the International Monetary Fund Database (IFS).

3.3 Estimation techniques

3.3.1 Unit Test Root

Most macroeconomic time series are trended and therefore in most cases they are nonstationary (Asteriou & Hall, 2007, p. 291). Therefore, when dealing with models that use time series data, it is necessary to check the properties of the data in advance. This is for at least three reasons: First, the regression analysis that includes nonstationary time series may lead to the phenomenon of spurious or nonsense regression (Gujarati D. , 2011, p. 207). In other words, in the presence of nonstationarity, the results obtained from a regression of this kind are totally spurious (Granger & Newbold, 1974, p. 111). Second, the stationarity of a series can strongly influence its behaviour and properties. For a stationary series, 'shocks' to the system will gradually die over time. This can be contrasted with the case of non-stationary data, where the persistence of shocks will always be infinite (Brooks, 2008, p. 319). Third, if a time series is nonstationary, we can study its behavior only for the period under consideration. Each time series will therefore be a particular episode. As a result, it is not possible to generalize it to other time periods (Gujarati D. , 2011, p. 207). Therefore, for the purpose of dynamic models' analysis, forecasting or policy analysis, nonstationary time series will be of little practical value.

Testing for unit root prior to estimation has become conventional. It involves testing the stationarity properties of the variables so as to determine their order of integration. There are several different methods for testing unit roots, e.g. Dickey-Fuller test (DF)1979, Augmented Dickey-Fuller test (ADF) 1981, Philip-Perron (PP) 1988 test, Kwiatkowski–Phillips–Schmidt–Shin test (KPSS)1992, and others. For the purpose of the study, we employ the (ADF) test and the (PP) test. These are two of the most important unit root tests that are widely used in macroeconomic and financial experimental studies. These two tests are sufficient to test the stationarity of the time series under study, and to determine their order of integration. Both the ADF and PP tests, test the null hypotheses of unit root (nonstationary) against the alternative hypothesis of non-existence of unit root (stationarity).

3.3.2 The ARDL Approach for Cointegration

In order to determine the impact of interest rate fluctuations, the exchange rate, and the price of oil on the rate of inflation in the Euro area, and to analyze the long and short relationships between variables of this system, we employ in this study the Autoregressive Distributed Lag (ARDL)/bounds testing cointegration procedure. This approach was developed by Pesaran & Pesaran (1997), Pesaran & Shin (1999) and Pesaran et al. (2001). The ARDL model combines features of the AR model and the finite distributed lag model (Griffiths, 2008, p198). The ARDL approach has several comparative advantages over other

traditional approaches for cointegration, similar to the well-known residual-based approach proposed by Engle & Granger (1987) and the maximum likelihood-based approach proposed by Johansen and Julius (1988) and Johansen (1990).

Perhaps, one of the most important features of this different approach is the following: (i) It does not require unit-root pre-testing, therefore it is applicable irrespective of whether the regressors in the model are purely stationary I(0), purely non stationary I(1) or mixture of I(1) and I(0) (Narayan P. K., 2004, pp. 6-7). However, it may be advisable to first perform unit roots, though not as a necessary condition in order to ensure that none of the variables is I(2) or beyond, before carrying out the bound F-test (Nkoro & Uko, 2016, p. 82). (ii) The ARDL approach provides unbiased estimates of long-term relationship with valid t-statistics if some of the model repressors are endogenous. It is also suitable, and relatively more efficient in small samples or finite sample data size. (iii) The short-and long-run parameters with appropriate asymptotic inferences can be obtained by applying OLS to ARDL with an appropriate lag length. To determine the long run and the short run dynamics and error correction model, Equation (1) can be transformed into:

$$\begin{aligned}\Delta HICP = {} & \beta_0 + \sum_{i=1}^{n} \beta_{1i}\, \Delta HICP_{t-1} + \sum_{i=0}^{n} \beta_{2i}\, \Delta REER_{t-i} + \sum_{i=0}^{n} \beta_{3i}\, \Delta OIL_{t-i} + \sum_{i=0}^{n} \beta_{4i}\, \Delta INT_{t-i} \\ & + \sum_{i=0}^{n} \beta_{5i}\, \Delta IMP_{t-i} + \sum_{i=0}^{n} \beta_{6i}\, \Delta MS_{t-i} + \sum_{i=0}^{n} \beta_{7i}\, \Delta ULCL_{t-i} + \sum_{i=0}^{n} \beta_{8i}\, \Delta GDP_{t-i} \\ & + \delta_1 HICP_{t-1} + \delta_2 REER_{t-1} + \delta_3 INT_{t-1} + \delta_4 OIL_{t-1} + \delta_5 IMP_{t-1} + \delta_6 MS_{t-1} \\ & + \delta_7 ULC_{t-1} + \delta_8 GDP_{t-1} + \varphi ECT_{t-1} + \varepsilon_1 \ldots\ldots\ldots\ldots\ldots\ldots (2)\end{aligned}$$

Where, Δ is the first difference operator, β_0 the drift component, and ε_1 is the usual white noise residuals or error term. The coefficients (δ_1- δ_8) represent the long-run relationship whereas the remaining expressions with summation sign, (β_{1i} -β_{8i}) represent the short-run dynamics of the model, φ denotes the speed of adjustments, and ECT denotes the residual obtained from estimated cointegration in equation.

In theory, a negative relationship is expected between inflation and both the real effective (REER) exchange rate and the short-term interest rate (INT), A positive relationship is also expected between the inflation rate and the rest of the explanatory variables included in the equation (2),which are indicated by the following abbreviations: OIL, IMP, MS, ULC and GDP.

According to Pesaran et al (2001), the ARDL approach involves two steps for estimating the long-run relationship. The first step is to reveal the existence of long-run relationship among all variables in an equation. In other words, the first procedure uses a F-test to determine the joint significance of the lagged-level variables. Where the null hypothesis indicates the non-existence of a long-term relation as (H_0:δ_1=δ_2……..=δ_8=0) versus the alternative hypothesis (H_1: δ_1≠δ_2……≠δ_8=0). Pesaran et al (2001) find lower and upper critical bounds in the F-test. If the computed F statistic is higher than the upper bound of the critical values, then the null hypothesis of no cointegration is rejected (Narayan P. K., 2005, p. 1981). Conversely, if the F-statistic is less than the lower bound, then the null hypothesis is accepted. Whereas, if the statistic falls between these two sets of critical values, the result is inconclusive. The second step is to estimate the long-run and short-run coefficients of the

same equation by using the ECM. We run the second step only if we find a cointegration relationship in the first step. This step determines the appropriate lag lengths for the independent variables. Finally, To ensure the convergence to the long-run equilibrium, the sign for the coefficient of the lagged error correction term (ECT_{t-1}) must be negative and statistically significant.

3.3.3 Diagnostic test and stability tests

The study runs diagnostic tests to verify if the results of the model are reliable and efficient. The time series models have to satisfy the assumption of classical linear regression model (Gujarati & Porter, 2009, p. 208). The tests of serial correlation (Breusch– Godfrey serial correlation LM test), normality test (Jarque-Bera), misspecification (Ramsey RESET Test) and heteroskedasticity test (ARCH test) are done. The diagnostic tests are performed in order to determine if the assumptions are not violated.

4. Empirical results and discussion

4.1 Description of study variables

Table (1): Descriptive summary of data

	HICP	REER	OIL	INT	IMP	MS	ULC	GDP
Mean	90.9	106.9	62.4	1.8	113.6	8605.7	92.5	7110.2
Median	91.9	105.9	60.6	1.5	115.2	9316.9	93.5	7230.0
Maximum	105.3	118.0	122.2	5.0	189.5	12997.2	110.2	9000.0
Minimum	73.6	94.0	11.1	-0.4	42.9	4459.59	75.8	5280.0
Std. Dev.	9.6	6.3	30.8	1.8	42.1	2449.6	8.6	880.2
Skewness	-0.2	0.2	0.35	0.4	0.1	-0.1	-0.1	-0.08
Kurtosis	1.7	1.9	2.03	1.9	1.9	1.9	1.9	2.32
Observation	**84**	**84**	**84**	**84**	**84**	**84**	**84**	**84**

Source: Authors estimations using Eviews 9

4.2 Simple correlation matrix between variables

Furthermore, Table 2 shows the correlation matrix which describes the nature and strength of the correlation between variables under study, as shown in the following table:

Table (2): Simple correlation matrix between variables

	HICP	REER	OIL	INT	IMP	MS	ULC	GDP
HICP	**1**	-	-	-	-	-	-	-
REER	-0.14	**1**	-	-	-	-	-	-
OIL	0.63	0.12	**1**	-	-	-	-	-
INT	-0.82	0.20	-0.32	**1**	-	-	-	-
IMP	0.71	0.12	0.98	-0.38	**1**	-	-	-
MS	0.98	-0.10	0.56	-0.78	0.65	**1**	-	-
ULC	0.94	-0.13	0.55	-0.79	0.63	0.93	**1**	-
GDP	0.95	-0.07	0.54	-0.71	0.62	0.97	0.94	**1**

Source: Authors estimations using Eviews 9

The correlations based on quarterly data in Table 2 strongly support the nature of the expected relationships between the harmonized consumer price index and all selected explanatory variables in the Euro area. All the signs were consistent with the previously discussed theoretical proposition. Regardless of the nature of the relationship, the results

indicate that all variables have a strong correlation with HICP, except for the real effective exchange rate.

4.3 Unit root test results

Table (3): Augmented dickey fuller test (ADF) and Phillips-Perron (PP) test for unit

	(ADF) Test		(PP) Test	
	Intercept	**Intercept-trend**	**Intercept**	**Intercept-trend**
HICP (I_0)	-1.6488(0.4531)	-1.3483(0.8681)	-2.0125(0.2811)	-1.6368(0.7698)
HICP(I_1)	-3.3392(0.0004)***	-3.6655(0.0007)***	-14.296(0.0001)***	-14.299(0.0000)***
REER(I_0)	-1.9455(0.5803)	-2.0224(0.5803)	-2.1076(0.2423)	-2.1220(0.5259)
REER(I_1)	-7.4998(0.0000)***	-7.4520(0.0000)***	-7.5258(0.0000)***	-7.4745(0.0000)***
OIL(I_0)	-2.3222(0.4227)	-2.3118(0.4227)	-2.0917(0.2486)	-1.9120(0.6394)
OIL(I_1)	-7.2166(0.0000)***	-7.2485(0.0000)***	-6.7135(0.0000)***	-6.7279(0.0000)***
INT(I_0)	-1.5033(0.0218)**	-3.7938(0.0218)**	-1.2294(0.6584)	-2.6862(0.2450)
INT(I_1)	-4.9487(0.0001)***	-4.9435(0.0006)***	-5.0566(0.0001)***	-5.0538(0.0004)***
IMP(I_0)	-1.8169(0.8203)	-1.5042(0.8203)	-1.9165(0.3233)	-1.6426(0.7674)
IMP(I_1)	-6.7289(0.0000)***	-6.8039(0.0000)***	-5.6093(0.0000)***	-5.6131(0.0001)***
MS(I_0)	-0.4025(0.2539)	-2.6647(0.2539)	0.1009(0.9640)	-1.5707(0.7962)
MS(I_1)	-2.6966(0.0090)***	-2.6725(0.0407)**	-6.8753(0.0000)***	-6.8642(0.0000)***
ULC(I_0)	-0.8142(0.1006)	-3.1579(0.1006)	-3.7086(0.3756)	-12.998(0.0723)*
ULC(I_1)	-4.6162(0.0003)***	-4.6236(0.0019)***	-68.490(0.0001)***	-69.093(0.0001)***
GDP(I_0)	-0.1764(0.6536)	-1.8835(0.6536)	-0.8547(0.7977)	-5.6324(0.6421)
GDP(I_1)	-3.8195(0.0041)***	-3.7906(0.0222)**	-39.686(0.0001)***	-39.318(0.0001)***

Notes: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant

Source: Computed by authors

According to table 3, results of (ADF) test and (PP) test show that all variables are non-stationary (accept the null hypothesis) at the 1% level of significance. But after the transformation to first difference I(I) they become stationary (reject the null hypothesis). Depending on the results of the unit root tests for (ADF), (PP), we can say that all variables are integrated to the same order I(1), this makes ARDL the preferred approach to this empirical study.

4.4 Cointegration test of Pesaran et al. (2001)

As a reminder, there are two steps to follow to apply the Pesaran cointegration test: (i) Determine the optimal lag selection model before all (AIC, SIC), (ii) Use the Fisher test to test cointegration between series (bounds test).

4.4.1 Choosing the Appropriate Lag Length for the ARDL Model

In order to determine the optimal Lag Length for the ARDL model, the information standard (Akaike) which is the most common standard, as well as Schwarz and Hannan-Quinn standards were used. The estimation results of the optimal ARDL model selected are represented below..

Table (4):The lag order selection by Akaike criteria

Model	LogL	AIC*	BIC	HQ	Adj. R-sq	Specification
53776	42.960661	-0.249017	0.733569	0.144930	0.999586	**ARDL(4, 1, 2, 3, 4, 3, 4, 4)**
Note: * = Akaike Information Criterion						

Source: Computed by authors

As can be seen in table 4 , the best executing ARDL model selected is the Akaike Information Criterion, is most preferred in relation to the other model specification presented in Table 3, because it produces the least values of -0.249017, 0.733569, and 0.144930 among Schwarz criterion and Hannan–Quinn criterion respectively. The AIC lag specification for the model is presented with the optimal lag for each variable, as shown in Table 3. So, the ARDL model (2,3,1,4,3,4,4) is the most optimal model in this case.

4.4.2 Bounds cointegration test

To test if there is any long run relationship between inflation and the explanatory variables of interest in this study, we use the bounds test. In order to test the null hypothesis (Ho: there is no long run relationship exists between the variables), the calculated F statistic, will be compared to the critical values (which form bounds) as follows:

- If : Fisher >Upper bounds : Cointegration exists
- If : Fisher <Lower bounds : Cointegration does not exist
- If : Lower bounds < Fisher <Upper bounds : The decision is inconclusive

Table (5): Results of the bound cointegration test of Pesaran et al. (2001)

k	**F -statistic**	**10%**		**5%**		**1%**	
-	-	Lower bounds I**(0)**	Upper bounds **I(1)**	Lower bounds **I(0)**	Upper bounds **I(1)**	Lower bounds I**(0)**	Upper bounds **I(1)**
7	**6.453491**	**1.92**	**2.89**	**2.17**	**3.21**	**2.73**	**3.9**

Source: Computed by authors

The results of the bound cointegration test confirm the existence of a cointegration relationship between the series under study (the value of F-stat= 6.453491, is greater than the upper bounds critical values at 1%), which gives the possibility of estimating the error correction model, for finding the short and long effects of REER,OIL, INT, IMP, MS, ULC, and GDP on HICP inflation..

4.5 Results of estimating short and long-term coefficients

4.5.1 Results of estimated short-term coefficients

The error correction model reflects the measurement of the short-term relationship, on the one hand, and the measurement of adjustment speed to rebalance the dynamic model on the other. As we can see in table 6 below, the adjustment coefficient or restoring force is statistically significant at 1% level, it is negative and it is between 0 and 1 in absolute value, which guarantees an error correction mechanism , and therefore the existence of a long-term relationship (cointegration) between variables.

Table (6): Estimated Coefficients of the Short run Dynamic ECM

Dependent variable: D(HICP)			
Variable	**Coefficient**	**t-value**	**Prob**
D(HICP(-1))	-0.356861***	-3.818578	0.0004
D(HICP(-2))	-0.341687***	-3.720298	0.0005
D(HICP(-3))	-0.286779***	-3.102796	0.0032
D(REER)	-0.007535	-0.784265	0.4368
D(REER(-1))	-0.016098	-1.554158	0.1269
D(OIL)	0.031820***	3.504244	0.0010

D(OIL(-1))	0.032455***	3.412803	0.0013
D(OIL(-2))	0.024861**	2.566060	0.0135
D(INT)	-0.468831***	-4.345419	0.0001
D(IMP)	-0.008457	-0.961634	0.3412
D(IMP(-1))	-0.016312*	-1.724343	0.0912
D(IMP(-2))	-0.013302	-1.439011	0.1568
D(IMP(-3))	0.009834***	3.403850	0.0014
D(MS)	0.000025	0.051554	0.9591
D(MS(-1))	0.001605***	3.172557	0.0027
D(MS(-2))	0.001038*	1.895193	0.0642
D(ULC)	0.268728***	6.198890	0.0000
D(ULC(-1))	0.095662**	2.336782	0.0238
D(ULC(-2))	0.213172***	5.694441	0.0000
D(ULC(-3))	0.225573***	5.984581	0.0000
D(GDP)	0.002740***	6.586616	0.0000
D(GDP(-1))	0.001820***	4.776320	0.0000
D(GDP(-2))	0.001729***	4.507000	0.0000
D(GDP(-3))	0.002484***	6.953842	0.0000
ECT(-1)	**-0.214834*** **	-8.244248	**0.0000**
R^2=99.97%, Adj R^2= 99.95%, S.E= 0.184518, SSR=1.600207, F-stat=5968.178, **Prob (F-stat) =**0.000000, **DW**=1.806187			
Note: (***) significant at% 1, (**) significant at% 5,(*) significant at 10%			

Source: **Authors estimations using Eviews 9**

Looking at the results of table 6, the error correction coefficient (0.2148) indicates that about 21.48% of disequilibrium in the inflation rate in the previous quarter is corrected and adjusted in the current quarter. According to the Fisher test (F-stat=5968.178, Prob (F-stat) =0.000000), the short-run ARDL model is statistically significant at the 1% level of significance. The value of the determination coefficient indicates that a percentage of 99.97% from inflation variation is explained through the ARDL model relative to the Short-term interest rate, real effective exchange rate, oil prices, and other independent variables.

The coefficients of the ARDL short run showed that inflation is negatively and significantly influenced by its own values with 1, 2 and 3 lags. The short run coefficients also suggest that real effective exchange rate (REER) is negative and insignificant at the 1 percent level, meaning that changes in the euro exchange rate have no effect on inflation in the short term. As for oil prices (OIL), the results revealed a positive relationship between inflation and oil prices in the short term, and that the increase in the price of a barrel of oil by one dollar leads to an increase in inflation of about 0.03 percent. While, the short run coefficients suggest that short-term interest rate (INT) has a significant negative impact on inflation at 1% level in the short run, where the results indicated that an increase in interest rate by 1% leads to a decrease in inflation of about 46.88 percentage points in the short term in the Euro area. As for the other independent variables, the results indicated that they positively affected inflation, in which, the increase by one unit (each variable according to its unit) in import price index (IMP), money supply (MS), unit labour cost (ULC) and real gross domestic product per capita (GDP) led to a 0.01% increase, 0.002% increase, 0.27% increase and 0.003% increase in inflation respectively in the short term.

4.5.2 Estimated long-term coefficients

Table (7): Estimated long run Coefficients

Variable	Coefficient	t-value	Prob
REER	-0.119311***	-3.180198	0.0026
OIL	-0.096913	-1.593479	0.1178
INT	-0.751083**	-2.043164	0.0467
IMP	0.133900**	2.534582	0.0146
MS	-0.001662	-1.096678	0.2784
ULC	0.914774**	2.670242	0.0104
GDP	0.003266	1.063714	0.2929
C	1.524994	0.053057	0.9579
Note: (***) significant at% 1, (**) significant at% 5,(*) significant at 10%			

Source: **Authors estimations using Eviews 9**

Table 7 presents the long run coefficients estimated using ARDL approach. The results of the model HICP show that the coefficient of real effective exchange rate (REER)has a statistically significant negative effect on inflation (HICP) in the long-run with coefficient of about -0.12 at 1% level of significance. As in the short term, the results of long-term coefficients showed a high negative elasticity of inflation(amounted to about 0.75) due to changes in the interest rate (INT).This value indicates that the 1 percent increase in the interest rate leads to a decrease in inflation of about 0.75 percentage points in the long-term. While the results indicate that the coefficients of import price index (IMP) and unit labour cost (ULC) have a statistically significant positive effect on inflation (HICP) in the long-run with coefficients of about 0.13 and 0.91, respectively at 5% level of significance. Finally, the coefficient of oil prices (OIL), money supply (MS) and GDP per capita (GDP) have a statistically insignificant relationship with inflation (HICP) at 1%, 5% and 10% levels of significant in the long-term.

Overall, what can be deduced from the previous estimation results is that there is a clear difference between the results of the short and long term coefficients, in terms of level of significance, effect size and sign of the estimated coefficients, as shown in Table 8, which shows the ratio of the effect of short-term coefficients to the effect of long-term parameters.

Table (8):The ratio of the short-term effect to the long-term effect

Variable	REER	OIL	INT	IMP	MS	ULC	GDP
LT coefficient	-0.119	-	-0.751	0.134	-	0.915	-
ST coefficient	-	0.032	-0.469	0.010	0.002	0.269	0.003
The ratio (ST/LT) (%)	-	-	62.45	7.46	-	29.4	-
Impact priority	**4**	**5**	**1**	**3**	**7**	**2**	**6**

Source: Authors calculations based on the results of previous estimates

In general, long-term parameters express the total effects (direct and indirect) of independent variables (internal or external) on the dependent variable, while short-term parameters measure only the direct effect of independent variables on the dependent variable. Therefore, what concerns policymakers is the overall effect of changes in explanatory variables on the dependent variable. On this basis, the following results can be drawn (i) What is directly observed from Table 8 is the high volume of long-term effect of explanatory variables (i.e. parameter values) on inflation compared to short-term parameters. (ii) However, the results of the ratio of short-term parameters to long-term parameters indicate a

low magnitude of the influence of explanatory variables on inflation except for the interest rate (most ratios are less than 50%). (iii) The variable that has an important and significant role in influencing inflation in the Euroarea is the interest rate (The monetary policy transmission channel). Followed directly - in terms of the degree of importance -by the unit cost of labour in the second place (as one of domestic inflation drives that reflect the changes in the labour market). Import prices are ranked third, in terms of their importance in influencing the inflation of the Euro area (as one of the global drivers of inflation that express imported inflation). While the exchange rate channel (as one of the monetary policy channels, and expresses external shocks at the same time) is ranked fourth in terms of the importance of influencing inflation in the Euro area. While in the 5th rank comes the role of shocks in oil prices (which express the external shocks or the secretions of economic globalization) in shaping inflation in the Euro area. Finally; with little importance, the real GDP per capita (a real variable) and money supply (a monetary variable) are in the sixth and seventh ranks, respectively.

Through the results of estimating the parameters of the short and long term relationship, and taking into consideration the results of the import price index, we confirm that there is a partial pass-through of the exchange rate to the euro area inflation in the long term only. On the contrary, the results support the existence of a partial and limited pass-through of oil prices to the Euro area inflation in the short term only. These results can mainly be attributed to the relatively limited share of Euro area imports (including energy imports). More importantly, it is the trend towards enhancing the volume of intra-Euro Area trade exchanges, and reducing dependence on imports from extra-Euro area.

Through the results of the coefficients of short-term interest rate, money supply and real GDP per capita, we emphasize that there is a significant impact and significant effectiveness of the short-term interest rate in curbing inflation in the Euro area, especially in the long term. It can also be seen that the importance of the role that money and economic growth play in influencing the price level has diminished, which can be explained by the shift in the interests of the European Central Bank from focusing on the role of money in influencing economic activity towards the role of interest rates in maintaining a low level of inflation ((I.e. focusing on the inflation target, rather than the goal of economic growth). Several recent studies indicate this shift in the policies of the European Central Bank, and many analysts believe that this excessive monetary tightening and focus on the goal of inflation has become a barrier to economic growth in the Euro area.

Because there is a partial pass-through of both the exchange rate and oil prices, this was reflected in one way or another in the increase in production costs within the Euro area, and then a significant increase in the basket of consumer prices, especially in the long run. This indicates that the Euro area is suffering from cost inflation.

4.6 Diagnostic tests

Table 9 : Result of the diagnostic test for ARDL model

Test	hypothesis	Statistic	Value	Prob
LM Test	Autocorrelation	F-stat [1]:	0.649962	0.4243
		F-stat [2]:	1.131043	0.3317
ARCH Test	Heteroscedasticity	F-stat [1]:	0.031177	0.8603
		F-stat [2]:	0.625175	0.5379
Ramsey RESET Test	Specification	F-stat [1]:	0.866689	0.3567
		F-stat [2]:	1.684879	0.1970
Normality Test	Normally distributed	Jarque-Bera-stat	3.425941	0.18329

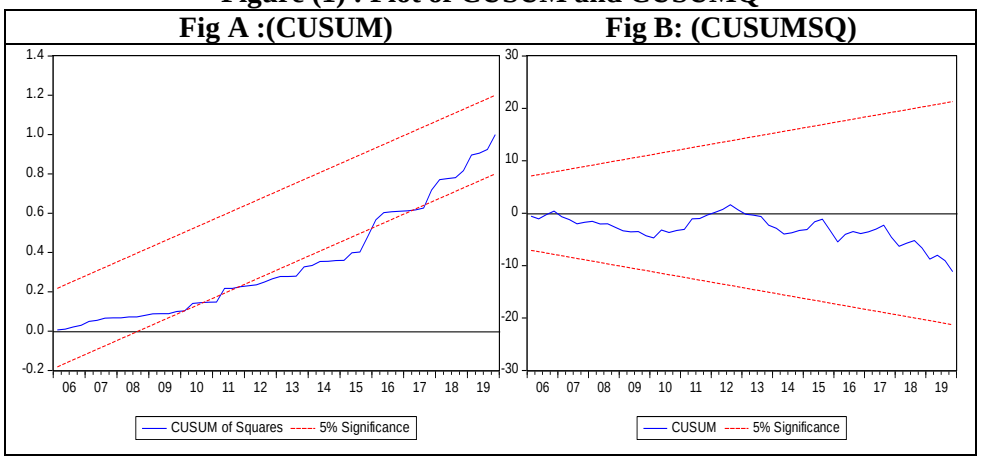
Source: Authors computations using Eviews 9

The null hypothesis is accepted for all tests included in the table above. In other words, the diagnostic tests show that the estimates are free from serial correlation (LM Test), heteroskedasticity (ARCH Test), misspecification (Ramsey RESET Test) and the residuals of the estimated ARDL model are normally distributed (Jarque-Bera test).

4.7 stability test results

In order to examine the stability of the estimated model, we used the cumulative of the recursive residuals (CUSUM) and cumulative sum of squares of recursive residual (CUSUMQ) tests. This technique was developed by Brown, Durbin and Evans (1975).The result of this test is shown in the two figures below.

Figure (1) : Plot of CUSUM and CUSUMQ



Source: Authors computations using Eviews 9

The CUSUM test parameters are within the critical lines of 5% level of significance throughout the sampled period. Therefore, it serves as evidence that our estimated model is stable (Figure A). The line representing the CUSUM of squares is contained in the 5% lines of significant (Figure B). Therefore, it proves that our estimated model is stable for the sampled period. Hence, these results confirm the stability of the long-run coefficient of inflation rate with respect to explanatory variables in the ARDL model.

Conclusion

In this study, we examined the effects of the exchange rate, oil price and interest rate on inflation in the Euro area economy. Using quarterly data ranging from 1999Q1 to 2019Q4. To this end, we used the ARDL bounds test approach developed by Pesaran et al (2001), in order to determine the various effects of the changes in the value of the Euro, the price of Brant oil

and the short-term interest rate on inflation in the Euro area, and then deduce the various possible channels for these effects in the short and long term. In addition, we also engaged the unit root tests (ADF and PP) to determine the order of integration for our variables, to ensure that none is beyond I(1), and to demonstrate the efficiency of the bounds test cointegrating a long-run relationship from other cointegration approaches. The study reached the following results:

First, from the results of the simple correlation matrix, it is clear that the different relationships between the studied variables are fully consistent with theoretical expectations. The results also indicate a strong correlation between all variables of interest and inflation in the euro area, excluding the real effective exchange rate. Second, according to bounds test, our empirical results confirm that there is a long run relationship between exchange rate, oil prices, interest rates and inflation in euro area during the period under study. Third, our results indicate that the positive shock of the euro exchange rate reduces inflation on the long term only, which supports the existence of the exchange rate pass-through to inflation in the euro area on the long term (a partial pass-through). Fourth, on the contrary, our results indicate that the positive shock of oil prices leads to a slight increase in inflation on the short term. which supports the existence of the oil price pass-through into euro area inflation on the short term (a partial pass-through); but not on the long term. Fifth, our results also indicate that increases in short-term interest rates reduce inflation significantly on both the short and long term. These results provide sufficient evidence of the high degree of short-term interest rate pass-through into inflation in the euro area on the short and long term together, which confirms the effectiveness of the interest rate channel in general, and short-term interest rates in particular, in curbing inflation in the euro area. Sixth, on the contrary, the results provide strong evidence that the size of the money supply and GDP per capita are insignificant in causing upward inflationary pressures. Finally, the Euro area however, seems to suffer from cost - push inflation, especially on the long run in addition to the presence of some undesirable effects of import prices on the inflation of the euro area, especially in the long run..

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