Inflation Running Hot: A Panel Data analysis of Inflation and its Determinants

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Abstract

In May 2022, year-on-year inflation in the OECD reached 9.6%, its highest level in over three decades (OECD, 2022). The adverse consequences of inflation such as deteriorated growth and lower living standards make inflation a paramount indicator to monitor. To better understand its dynamics, this paper studies panel data of 21 OECD countries ranging from 1987 to 2021. The baseline specification tests a set of nine macroeconomic variables predominantly used in academic literature to determine inflation. This paper uses Fixed Effects model to control for individual heterogeneities across countries. Our results suggest Real GDP and Brent oil price are the two main drivers of inflation. Both variables are positively related to inflation and are economically substantial. Those findings are in line with most of the literature and fit well in the current world scenario of (post-Covid-19) restarting economies and 8-years high oil price levels. The unemployment rate on the other hand is inversely related to inflation and suggests a Phillips Curve relationship in our dataset. Additionally, the Quantity Theory of Money is evidenced in our model, with interest rates playing a persistent role in explaining inflation's fluctuations. However, we find a positive relationship between inflation and interest rates which conflicts with practitioners' consensus. Finally, controlling for time to account for macroeconomic shocks improves the model and can be explained by increased financial integration. On the flip side, exports and imports, real effective exchange rate and real unit labour costs do not consistently produce significant estimates. This study contributes to the literature by presenting a new combination of explanatory variables for inflation while covering the first year of the COVID-19 crisis which remains scarcely studied. The findings of this paper should serve as a basis for decisionmakers when defining inflation targeting policies.

Keywords: Inflation, Inflation determinants, Panel Data, Dynamic Panel Data, Fixed Effects model, First Differences, OECD, Macro-econometrics.

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List of abbreviations

AB	Arellano Bond
CPI	Consumer Price Index
GFC	Great Financial Crisis
GMM	Generalised Method of Moments
LSDV	Least Square Dummy Variables
NAIRU	Non-Accelerating Inflation Rate of Unemployment
NKPC	New Keynesian Phillips curve
PC	Phillips curve
QE	Quantitative Easing
TPC	Traditional Phillips curve

Introduction

The COVID-19 pandemic led to the largest global economic recessions since World War II (World Bank, 2022). The world is now under a new threat that may persist for years. In June 2022, the World Bank raised the alarm against the risk of a global recession amid the threat of stagflation in its monthly *Global Economic Prospects*. Indeed, inflation reached a multidecade high in OECD economies and averaged 9.6% year-on-year in May 2022 (OECD, 2022). Concurrently, the surge in global demand following the sanitary crisis resulted in persisting supply-chain bottlenecks. This drawback compounded with the war in Ukraine and the rising interest rates, possibly bringing economic growth to a halt and maintaining inflation high. World Bank (2022) consequently revised its growth forecasts. In advanced economies, growth is expected to shrink from 5.1 per cent in 2021, to 2.6 per cent in 2022 – one-third below January's estimated figure of 3.8 per cent growth (Refer to Appendix for full forecasts).

To build on the above, since February 24th, 2022, the war in Ukraine added its share of uncertainty to the world's outlook. Aside from its monumental human costs in terms of lives lost and people displaced, Ukraine's invasion by the Russian Federation degraded already disrupted supply chains, led to soaring commodity prices, brought instability to the region and the world, and increased poverty and food insecurity (World Bank, 2022). Those major downturns contributed to the high inflation and reduced economic growth observed in most developed economies.

A low-growth, high-inflation scenario is referred to as stagflation and has not been observed in advanced economies since the 1970s in the United States. Some Central Bankers and policymakers currently evaluate the risk of such an event to be quite plausible. That is, economic growth is forecasted to slow down by twice as much between 2021 and 2024 as during the 1976-1979 period (World Bank, 2022). This stall in growth should be persistent as investments will subsequently decline. Similarly, looming disrupted supply chains and high inflation might lead to a persistence of high inflation for a longer time than currently forecasted. We leave it to further research to determine if indeed, the world's economy will indeed face stagflation as no consensus can be reached yet. World Bank (2022) claims that there will be stagflation; while Christine Lagarde, European Central Bank President, believes otherwise.

Our study attempts to determine what are the main drivers of inflation in 21 OECD economies from 1986 to 2021. We choose OECD countries due to their prevalence in the world's economy. Indeed, 80% of the world's trades and investments originate from the OECD and its main partners (OECD website). This paper challenges the view of the early 2000s stipulating that inflation would remain low in OECD economies (*e.g.*, Levin and Piger, 2004) and attempts to provide insights into today's scenario. Academic literature well documented the adverse impact of inflation on economies including lower growth and investment levels (*e.g.*, Barro, 1996). Therefore, we believe that a better understanding of the sources of inflation, its behaviour and persistence would have significant policy implications for decision-makers when defining inflation targeting and hedging policies.

Inflation is defined as an increase in the general level of prices (Frisch, 1977). It is usually calculated by taking the annual change in the Consumer Price Index (CPI). The CPI represents a weighted average of prices for a representative basket of goods and services (*e.g.*, U.S. consumer spending). We categorize four intensities of inflation: Creeping, Walking, Galloping and Hyperinflation. Creeping is an increase

in the general level of prices up to 3%, Walking an increase between 3% and 10%, Galloping an increase between 10% and 50% and finally, Hyperinflation, the rarest, describes an increase in the prices of more than 50%. As of July 2022, we are experiencing a Walking to Galloping inflation scenario, which is unprecedented in recent years (OECD, 2022).

Further, three main sources of inflation have been identified in the literature: "Demand-pull" inflation, "Cost-pull" inflation, and "Built-in" inflation. The first category, Demand-pull inflation, occurs when there is a higher demand than supply for goods and services. Jain *et al.* (2022) suggest that such a condition stems from an imbalance between total aggregate demand and total aggregate supply. There, the consumers' demand pressures the production ability of suppliers, resulting in inflationary forces. Kalemli-Özcan *et al.* (2022) argue that part of the inflation faced by the Eurozone is induced by "pent-up demand" amid the recovery from the sanitary crisis.

The second category, Cost-pull inflation, lies on the supply side and is considered a "real" shock. Cost-pull inflation characterizes an increase in the general level of prices, following a rise in the cost of the factors of production. One such example is the pass-through between oil shocks and inflation. In the Appendix, we include graphs of the co-movements between oil price and inflation[1]. The visual results are unequivocal and point toward a high correlation between inflation and oil prices. Thus, it is not surprising to see - in this context of high inflation - BRENT price exceeding 100$ per barrel from March 2022 onwards. Oil price reached an 8-year high on June 8th, 2022, soaring to 123$ per barrel. Moreover, wage-push inflation and exchange rate-driven inflation represent other serious cost-pull inflation threats to today's economy.

The third source, Built-in inflation, relates to inflation persistence. A rise in prices in the year before the current one should result, *e.g.*, in higher wages to compensate for the increased cost of living. Therefore, production becomes more expensive which in turn reflects on prices and leads to even more inflation. Built-in inflation is a dynamic process that has consequential implications for policymakers as inflationary shocks propagate across years.

Having identified the three main sources of inflation, we aim to understand which macroeconomic factors drive changes in inflation. We now review the current standings of academic literature on the determinants of inflation. Then we address the methodology and data used. After that, we discuss the results and then conclude.

[1] We take both variables in logarithms to facilitate visual interpretation.

Literature review

The following section will serve as a non-exhaustive academic review of some of inflation's main determinants. We first list the main takeaways from the literature on the consequences of globalisation and global determinants of inflation. We start by briefly addressing inflation expectations, inflation volatility, and inflation persistence. Then, we focus on the Phillips curve. Later, we analyse the domestic and foreign output gaps - which are components of the Phillips curve and key determinants of inflation. There, we bridge the Phillips curve and the Output Gap, another crucial factor in explaining inflation. The next global drivers of inflation we address are Oil prices, Exchange rates, and Exports and Imports. After that, we will list and confront current academic research with other more domestic determinants of inflation, such as Credit Growth to the private sector, Unemployment Rate, Real GDP, GDP growth, GDP per capita, and Unit Labour Costs. In the third and final part, we list historical crises and study inflation and its determinants' behaviours.

The distinction between domestic and foreign factors influencing inflation has been largely studied in academic research, as it has heavy implications for policymakers when tackling inflation. We distinguish global factors and local ones in a purely arbitrary way, to help structure our analysis. This literature review attempts to determine the drivers of inflation in a wider sense, not solely to oppose domestic to global factors.

I) Inflation is Globally defined

In this section, we study the role of globalisation (more largely of global factors) on inflationary processes, mainly building on the works of Borio and Filardo (2007), and Pehnelt (2007). They find that globalisation is in great part responsible for the disinflation observed in industrialized economies in the last decades (Pehnelt, 2007).

Pehnelt (2007) – using empirical panel data – observes that globalisation and economic freedom played a major part in the disinflation trend observed since the 1980s in OECD countries. Globalisation was measured by the KOF index from the Swiss Institute for Business Cycle Research, and economic freedom with the index for Economic Freedom from the Fraser Institute. He lists several outcomes of globalisation as a determinant of inflation processes. We will address a selection of them in the following segment.

Borio and Filardo (2007) use a Phillips curve specification to deep dive into the relationship between globalisation and inflation. Their model distinguishes a country-specific and a globe-centric approach. They extend a traditional backwards-looking Philips curve to include various measures of global economic slack (which they use as a proxy for inflation), controlling for foreign influences, such as import prices and oil prices. Their unequivocal conclusion is that domestic factors have lost importance at the expense of global factors in determining inflation.

A) Inflation expectation – the case of Central Banks

1) Central Banks improved transparency and independence

Pehnelt (2007) explains that inflation expectations, volatility and persistence have gone down due to economic integration. He partly attributes this phenomenon to Central Banks. He claims that Central Banks have become increasingly independent in many countries, adopted sounder monetary policies and improved inflation targeting policies. Baumann *et al.* (2020) add that not only did they become more independent, but Reserve Banks also became more transparent. That is, Banks now more openly disclose their forecasts, objectives, and decisions. Dincer and Eichengreen (2014) also recognise that more transparent Central Banks are associated with lower inflation rates.

2) Financial stability and inflation

Hodgetts (2006) contributes to Pehnelt's argument showing that increased financial stability results in lower inflation expectations. Lower expectations tend to be self-realizing, ultimately contributing to a lower inflation rate. For the 1990-2006 period, Hodgetts concludes that the decline in inflation expectation is the main change observed in inflation's dynamics. Moreover, Pehnelt (2007) argues that this more disciplined environment is responsible for inflation expectation being less correlated to lagged inflations and inflation shocks. This would again contribute toward a lower inflation expectation environment, which would lead to more stable inflation levels in our studied countries.

B) Inflation volatility and persistence

1) Inflation volatility

Pehnelt (2007) then continues with inflation volatility. The drop in inflation volatility observed in the U.S. (by two-thirds from the 1980s to the mid-2000s) and in most OECD countries, is another by-product of economic integration (Blanchard and Simon, 2001). The decline in volatility is a remarkable positive consequence of globalisation, as it has been observed that higher inflation volatility is associated with lower mean growth and lower productivity of investment (Al-Marhubi 1998, Byrne and Davis 2004). Similarly, Bowdler and Malik (2005) establish a clear link between how fast a country opens (internationally), and how much inflation volatility declines in this country.

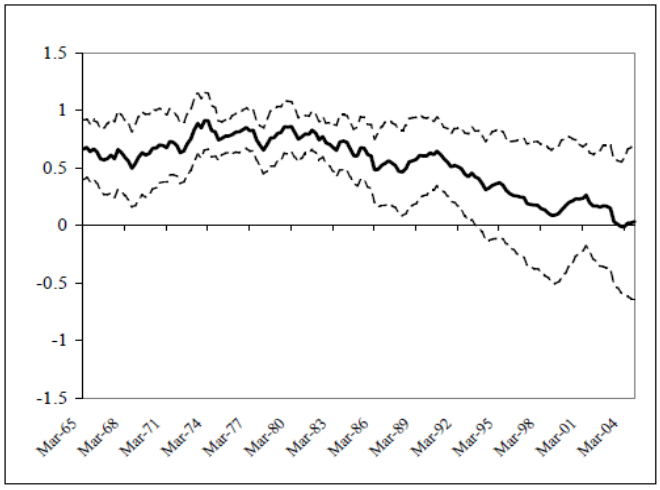
Aisen and Veiga (2006) use a panel of over 100 countries from 1975 to 1999. They bring more evidence that inflation volatility increases when economies are less open and when they suffer more political instability. Interestingly, Karras (2017), in a study of the U.S. inflation behaviour from 1801 to 2016, finds that a lower level of inflation was not always related to less volatility. That is, below a certain threshold, inflation and its volatility become negatively correlated. These findings challenge a broad consensus that a lower inflation rate would mean more stable inflation.

2) Inflation persistence

Finally, inflation persistence is high and significant in Pehnelt (2007) until the beginning of the 1990s; after which the importance of lagged inflation[2] declined. Lagged inflation can be interpreted as adaptive inflation expectations (Calza, 2008).

[2] Lagged inflation represents inflation persistence.

Figure 5: Persistence of Global inflation



Source : Ciccarelli, M., & Mojon, B. (2010). Global inflation. The Review of Economics and Statistics

C) Inflation and the Phillips curve

1) Historic and definition of the Phillips curve

The Phillips curve is a central element of macroeconomic theory. We start by giving a general definition of the Phillips curve and proceed with a discussion about its slope.

Phillips (1958) initiated the conversation on the trade-off between unemployment and the change in the nominal wage rate. Samuelson and Solow (1960) found it more appropriate to use inflation instead of the change wage rates.

The Phillips curve (PC) relates the real and nominal sides of the economy. Inflationary pressures would reveal the true level of economic activity and inflation expectations. The PC helps understand the relationship between inflation and the domestic supply and/or demand parameters. For instance, an excessive labour demand puts pressure on wages which contributes to higher inflation. Ceteris paribus, finding employment would be easier in this context. On the contrary, when labour supply exceeds demand, wages tend to go down which tempers inflation, but the unemployment level rises.

2) Traditional Phillips curve and New Keynesian Phillips curve

Nowadays, two Phillips curves are prevalent in the academic world: the New Classical or Traditional Phillips curve (TPC) and the New Keynesian Phillips curve (NPKC).

On the one hand, the TPC is of the backwards-looking kind. Inflation is determined by lagged inflation expectation and by a measure of slack, such as the output gap. The output gap is calculated such that:

$$Output\ gap = Actual\ output - potential\ output$$

We come back to this measure in the following sub-section.

On the other hand, the NKPC is a forward-looking, micro-funded relation, where inflation is determined as a function of economic slack and inflation's anticipation from firms. It serves today as the main workhorse when studying PC (Coibion *et al.*,2018).

3) The slope of the curve

In recent years, several authors found that globalisation had a major impact on the flattening of the Phillips curve (Debelle and Wilkinson 2002; Temple 2002; Benati 2005; Bean 2006; IMF 2006). A flatter Phillips curve means that inflation, and the domestic output gap, are less sensitive to domestic economic conditions such as the unemployment rate. This, again, supports the prevalence of international drivers. Concurrently, Duca and VanHoose (2000) find that globalisation is key in determining inflation, as increased competition in the goods market leads to lower inflation levels, a flatter Phillips curve and even a mild decrease in the NAIRU. However, this conclusion is not unanimous.

While some authors find mixed or inconclusive evidence of the flattening of the curve; some even argue that globalisation led to a steeper Phillips curve (Romer 1993; Rogoff 2003b; Bowdler 2004). They claim that if an open economy tries to stimulate its short-term output level by increasing the money supply, this economy will suffer a deterioration in its term of trade and a higher fluctuation of the exchange rate. Less friction in price-setting coupled with pricier inflation results in a steeper Phillips curve. It is interesting to note that both strands of literature on the Phillips curve conclude that globalisation led to lower inflation levels.

4) Limitations and criticisms

Coibion *et al.* (2018), list some of Phillips' curve's major shortcomings, using a Neo Keynesian Phillips New Keynesian Phillips curve (NKPC) specification. They explain that the Phillips' curve lack of persistence has called for ad-hoc lags, that the Great Recession should have shown disinflationary processes which were not observed, that the PC forecasting power is lower than naïve alternatives and finally that the PC is sensitive to the slack measures employed. All these puzzles and limitations contribute to Hall (2013) and many others calling the Phillips curve "dead".

D) From the Phillips curve to the Output Gap

1) Output Gap overview and evolution

Previously mentioned Borio and Filardo (2007) theorise that inflation is nowadays less influenced by domestic factors than it used to be. Consequently, global parameters like the output gap of the main trading partners have become increasingly prevalent in determining domestic inflation rates.

To reach their conclusion, both Borio and Filardo (2007) and Pehnelt (2007) use domestic and foreign output gaps in their PC model. The output gap is widely used as a measure of excess demand or slack and is positively related to inflation (Baumann *et al.*, 2020). The aforementioned studies observe a decline in the significance of the domestic output gap, replaced by a stronger foreign output gap. This can be understood as global factors playing an increasingly key role in explaining inflation. Additionally, Baumaan et. al (2021) find that the output gap is positively and non-linearly related to inflation before and after the Great Financial Crisis.

2) Deep dive on Borio and Filardo (2007)

We now quickly summarize the work of Borio and Filardo (2007), who greatly influenced this paper and who focused their attention on output gaps. The authors extend a backwards-looking TPC specification and include different measures of slack. They control for a set of external influences, such as oil and import prices:

$$\pi_t - \pi_t^U = c + \beta Gap_{t-1}^D + \emptyset Gap_{t-1}^{G_i} + \eta \boldsymbol{X}_{t-1} + \varepsilon_t$$

With π, the inflation rate; π^U, the underlying inflation rate trend (proxy for slowly changing inflation expectations). They use a Hodrick-Prescott filter to evaluate core inflation trend. π^U isolates the effects of slack at cyclical frequencies from sluggish inflation expectations. Gap^D is the domestic output gap, $\boldsymbol{X}$ is a vector capturing variables present in most empirical PC (oil, import, unit labour costs) and ε is a stochastic error term. Gap^G is a globe-centric output gap. The authors investigate five weight measures (4 domestic, 1 global). The weight specifications on the output gap look as follows:

$$Gap_j^{G_i} = \sum_{k \in K} w_{j,k}^i \, Gap_k^D, G_i \in \{W1, W2, W", W4, WG\}$$

Where w is the respective weights and Gap^D is the domestic output gap for country j. The different measures are a trade (exports and imports)-weighted gap; an import-weighted gap; an exchange rate-weighted gap; a mix of the trade- and exchange rate-weighted gap and a GDP-weighted gap. The first four weights are country-specific, meaning that they depend on trade and exchange rate linkages. By contrast, the global GDP-weighted gap is not country-specific.

Their confirmed assumption is that global measures of economic slack supplant the relevance of domestic factors to determine inflation. Pehnelt (2007) obtains similar results, stating that inflation became less influenced by domestic parameters, particularly the domestic output gap. Conversely, global factors like foreign output gaps became more important in determining national inflation rates.

E) Oil Price

1) Oil price, a major driver of inflation

It is argued that oil is one of the key drivers of inflation (Cuñado and Pérez de Gracia, 2003; LeBlanc and Chinn, 2004; Catao and Terrones, 2005), inflation expectations (Coibion and Gorodnichenko, 2015), and is usually added to any empirical Phillips curve (Borio and Filardo, 2007). The relevance of oil prices is further demonstrated in (Loungani and Swagel, 2001; Barsky and Kilian, 2004; Hamilton and Herrera, 2004) who all agree that oil improves greatly the goodness of fit of regressions explaining the determinants of inflation.

2) Empirical evidence

In the short term, the variation in the price of globally traded commodities has a systematic effect on the price of inputs used in the production process (raw materials, energy). Those inputs represent a substantial part of the CPI. Thus, if their prices go up, so does inflation (Ciccarelli and Mojon, 2010).

Aastveit et. al. (2021) support existing evidence that expected and actual inflation are sensitive to oil price shocks (Harris *et al.*, 2009; Coibion and Gorodnichenko, 2015; Wong, 2015). Oil price sharp movements usually affect more developed countries than less-advanced economies (Calderón and Schmidt-Hebbel, 2008). Similarly, Ha *et al.* (2019) demonstrate that steep changes in oil prices were largely responsible for the rapid changes in inflation between 1970-2018, based on a large sample of 141 EMDEs[3] and 34 developed economies. LeBlanc and Chinn (2004) find that a ten-percentage point increase in oil's price led to 0,1-0,8 percentage points higher inflation in the U.S. and the E.U. This result is both statistically significant and consequential.

In contrast with the preceding, De Gregorio *et al.* (2007) find that the pass-through between oil price shocks and inflation decreased worldwide over the last thirty years. They attribute this result in part to

[3] Emerging Markets and Developed Economies

the decline in the exchange rate pass-through but also the declining oil stock production. Kilian and Zou (2021) believe on the contrary that the low stocks of oil available are a source of rising oil prices, which in turn increase global prices.

F) Exchange rate

1) Exchange rate – overview and history

In a globalised economy, exchange rate adjustment should prevent inflation shocks from propagating across countries' rates (Ciccarelli and Mojon, 2010). Specifically, inflation differentials between economies should be compensated for by the nominal exchange rate. However, Reinhart and Rogoff (2003) disagree with the idea that exchange rates have been floating since the end of the Bretton Woods agreements. They postulate that effective floating exchange rates would be more "the exception rather than the rule", *i.e.*, exchange rates tend to be sticky. Thus, if the adjustment mechanism which protects an economy from non-domestic shocks to prices is not functioning, inflation is determined internationally – at least to some extent (Ciccarelli and Mojon, 2010).

2) Exchange rate movements

Exchange rate fluctuations lead to currency appreciations and depreciations. Currency depreciation[4] is a prominent source of inflation via direct and indirect channels (Pehnelt, 2007). The direct channel consists of firms from a country whose currency got depreciated, deciding to repercuss it on their prices. The indirect channel consists of imported factors of production like oil or raw materials that become more expensive. These higher prices then get reflected in the general level of prices.

Erdogan *et al.* (2020) use a spatial panel analysis for 28 European countries from January to July 2020 to investigate the determinants of inflation at the beginning of the COVID-19 pandemic. They find that exchange rates followed an upward trend during the early months of the pandemic, especially in developing countries. This was primarily due to foreign capital outflow. Also, investors converted their cash into safer currencies than those of developing countries. Erdogan *et al.* (2020) reaffirm that higher uncertainty in exchange rates is linked to higher production costs and ultimately higher prices. Interestingly, in a study of New Zealand's inflation determinant, Hodgetts (2006) finds that higher CPI is no longer determined by traditional drivers, namely the exchange rate.

G) Exports and Imports

1) Overview

Many authors find exports and imports to be drivers of inflation (Narayan *et al.*, 2021; Pari and Lim, 1997). Dexter *et al.* (2005) in a large study on the US economic prospect, find that foreign trade is highly significant for inflation. They conclude that while exports are correlated with inflation, imports have an inverse relation to inflation. Divergent opinions are shared among scholars regarding the prevalence of imports over exports.

[4] When the exchange rate goes down.

2) Conflicting opinions

On the one hand, Sahoo and Sethi (2018) argue that exports are more consistently correlated with inflation than imports. They use a Johansen Co-integration test, which supports this result in both the short and long term.

By contrast, Pain *et al.* (2006) refer to a prevalent "import price effect". Import prices would be increasingly significant in determining domestic inflation in OECD countries since the mid-1990s. It can be understood by the increased participation of countries outside of the OECD in international trade. Pain *et al.* (2006) suggest that foreign competition with lower-priced countries has pressured domestic producers to reduce the price they charge to domestic customers. This translates into lower inflation rates.

3) Empirical evidence and Phillips curve

Several academic research has been conducted on the influence of imports and exports on inflation, we now list a few empirical findings. For example, Gylfason (1997) finds that high inflation is linked with a low level of exports. Lim and Sek (2015) postulate that imports of goods and services have a long-lasting impact on the CPI in low-inflation countries. They however do not find a similar relationship for high inflation countries. Likewise, Pehnelt (2007) contributes to the idea that cheaper imports are indirectly linked to a lower level of inflation. Durgutti et al (2021) add up to that, suggesting that higher prices of imported intermediate inputs result in higher levels of inflation.

Finally, imports are commonly included in traditional Phillips curves. Alone, import prices are not sufficient to capture foreign influences on inflation (Borio and Filardo, 2007). Nonetheless, together with the exchange rate, import prices represent satisfactory international influences on a PC.

Conclusion globalisation part

A large strand of the literature agrees that national inflation has increasingly been determined on an international level, especially for OECD countries from the 1980s to the GFC at least. This was empirically supported by the co-movement in domestic inflation rates across OECD countries. This joint movement in the national inflation rate represented a large part of the variability in country-specific inflations (Ciccarelli and Mojon 2005).

II) Domestic determinants of inflation

In contrast with the first part, we now focus on more locally defined drivers of inflation. Not only does it give us a full picture of the determinants of inflation, but domestic factors might become increasingly relevant in the future. The reason for that is what The Economist and recent literature have called a growing "slowbalisation" phenomenon. This process is characterized by indicators of globalisation (such as trade over GDP, and FDI) declining over the last decade (Kandil *et al.*, 2020).

A) Money Supply

The quantity theory of money is one of the main macroeconomic axioms. Money supply represents all the cash and liquid assets currently in circulation in an economy. Its growth rate is widely believed to have a proportional relationship with inflation. From the quantity theory, Milton Friedman and other monetarist economists held the monetarist theory of inflation. The demand-pull inflation theory is consistent with the monetarist theory of inflation. Nonetheless, it brings more emphasis to the idea that

an excessive money supply leads to excessive aggregate demand. Friedman and Schwartz (1963) support the claim that if an economy's money supply doubles, prices will do so as well.

Bikai *et al.* (2016), in a panel VAR model on CEMAC[5] countries from 1990 to 2014, find that inflation is primarily determined by money supply and imported inflation. However, they note that those two factors only represent 30% of the variation of inflation, while 64% is attributed to inflation (persistence) itself. Pehnelt (2007) states that price rigidities have gone down in large part due to international competition. Thus, globalisation should have dramatically limited the effect of money supply on employment and real output. Indeed, it would reduce the incentive from policymakers to suddenly increase the money supply to obtain a higher real output in the short run or to tackle unemployment. Increasing the money supply in such a way would lead to inflation (Cavelaars, 2003). Money supply is further addressed in empirical examples in the third part of our literature review.

B) Credit growth to the private sector

Another variable related to inflation and money supply is domestic credit creation to the private sector (Schularick and Taylor, 2012). The authors argue for a distinction between credit growth and money supply because both variables decoupled since the mid-1980s in advanced economies.

Two opposite effects are possible: an inflationary and a disinflationary one. On the one hand, credit expansions – usually accompanied by money expansion – may result in an inflation-raising effect. On the other, domestic credit may proxy financial depth and, as such, contain information expected to be negatively related to inflation. (Calder´on and Schmidt-Hebbel, 2010). In addition, a credit expansion that leads to a build-up of investment and an expansion of production capacities puts downward pressure on prices.

C) Unemployment Rate

1) Relevance of unemployment and debates

Many studies including Milenković *et al.* (2020) postulate that inflation is largely determined by unemployment. Berentsen *et al.* (2011) document the relationship between monetary policy (proxied by inflation and exchange rates) and labour market performances (proxied by unemployment). They conclude that unemployment and inflation are positively related. Blanchflower *et al.* (2014), using survey data of European countries between 1975-2013, affirm that inflation and unemployment lower well-being. They strikingly find that unemployment is nearly six times as damaging as inflation to individuals' well-being.

Despite this apparent significance of unemployment in explaining inflation, scholars and policymakers alike have been trying to identify what are the main drivers of unemployment for decades now (*e.g.*, Arpaia, Kiss, & Turrini, 2014; European Central Bank, 2015). Such efforts to determine unemployment's causes can be understood for instance in Esu and Atan (2017), who admit in their panel of twenty-nine Sub-Saharan countries, that the high rates of unemployment observed remain an "enigma".

[5] Central African Economic and Monetary Community (CEMAC): Cameroon, Chad, the Central African Republic, Equatorial Guinea, Gabon, and the Republic of Congo

2) Economic integration and unemployment

Other strands of the literature focus on the interactions between the unemployment rate and globalisation. Labour market effects and globalisation would be a cause for lower inflation rates and even lower NAIRU[6] (Pehnelt, 2007). This is explained by pressure on wages in industrialized nations due to the worldwide competition from lower-income economies. Less-advanced economies usually have unions with less negotiating powers than in the OECD. Thus, they have less bargaining power over salaries. Also, economic integration might offer higher purchasing power and growth in real wages (thanks to cheaper imports), which reduces the necessity for nominal wages to increase (Frankel, 2006). This deters unions to negotiate for higher wages, thus keeping them low which contributes to a lower NAIRU that helped the disinflation process in OECD members. (Pehnelt, 2007).

Pehnelt further explains that globalisation limited the power of negotiation among OECD countries. Therefore, changes in the labour market (*e.g.*, wages) should impact less inflation than they previously used to. Blanchard (2016) concurs, finding that the drop in the unemployment rate in the U.S. has less than a third as much power to raise inflation as it did in the mid-1970s.

3) Defining NAIRU and NAWRU

Around these debates, one critical question remains on the evolution of the NAIRU. It serves as a proxy for structural unemployment and is widely used to evaluate potential output and structural budgets (Heimberger *et al.*, 2017). NAIRU assumes that for a given economy, there exists an unobserved level of unemployment that leaves inflation unchanged. Ball and Mankiw (2002) refer to it as the "natural rate of unemployment". In a scenario without temporary or seasonal fluctuations, the unemployment rate would be NAIRU (Friedman, 1968; Phelps, 1967). NAWRU[7][8] represents a trend, "cyclically adjusted unemployment rate" (Lendvai *et al.*, 2015).

4) Unemployment and the Phillips curve

NAWRU is often considered to stem from the Phillips curve. PC includes trend macroeconomic parameters (unemployment, potential growth) and cyclical variables (output gap) (Lendvai *et al.*, 2015). However, Esu and Atan (2017) find no PC relationship in Sub-Saharan countries, and as such no clear relationship between inflation and unemployment.

From the PC we understand that in the short-run, unemployment and inflation rates are caused either by a negative shock to aggregate supply or by a negative shock to aggregate demand (Esu and Atan, 2017). For example, the oil crises of the 1970s were a major negative supply shock, while the contractionary fiscal and monetary policies of the 1980s in OECD countries led to a negative demand shock (Bhattarai, 2004).

5) Unemployment recession gap

Stock and Watson (2010), in an empirical study of US recessions, developed a new gap measure. They define the unemployment recession gap as the difference between the actual and the natural rate of unemployment over the current and past eleven quarters. Lendvai *et al.* (2015), define it as:

$$Unemployment\ recession\ gap = Actual\ unemployment\ rate - Trend\ unemployment\ rate$$

[6] "non-accelerating inflation rate of unemployment"
[7] "non-accelerating wage unemployment rate"
[8] We use NAWRU and NAIRU interchangeably in this paper.

In other words, inflation increases whenever the natural unemployment rate is higher than the actual inflation rate, and vice-versa. Stock and Watson (2010) demonstrate that most US recessions were accompanied by lower inflation rates. This was due to the deviation of core inflation from its trend (in an unemployment recession gap model).

6) Concluding remarks on unemployment

As we have seen, no clear consensus is reached yet. Some authors claim that unemployment has a lesser impact on inflation, namely due to globalisation. Some like Zaniboni (2011) do not observe any decline in the impact of the national unemployment rate on inflation over the last twenty-five years.

D) Real GDP, GDP growth and GDP per capita

Gross domestic product (GDP), its growth rate and its measurement per capita (GDP pc) are considered by many authors to be key elements of the variation in prices of an economy.

1) GDP growth

While it is widely accepted that GDP growth is relevant when studying the determinants of inflation, there exists a vivid debate around the nature of its impact. No agreement was reached on that question yet (Durgutti *et al.*, 2018). Authors like Mallik and Chowdhury (2001) argue in favour of a positive relationship between GDP growth and inflation. Durguti *et al.* (2018) conclude that economic growth in the Western Balkans is synonym with higher inflation rates too. However, Fischer (1993) exhibits a negative relationship between GDP growth and inflation.

The growth of GDP is further supported by Lim and Sek (2015). With a dynamic panel data approach, they observe that GDP growth is one of the main drivers of inflation, both in low and high inflation countries. Saini and Singhania (2018) also find that real GDP growth is a major determinant of inflation.

2) GDP per capita

Another strand of the literature argues that GDP growth is less relevant than the output gap in explaining inflation (Baumann *et al.*, 2020). Beyond the output gap, the authors find that GDP per capita is the most relevant measure to estimate inflation. They believe GDP per capita is an efficient measure to understand increasing inflation.

GDP per capita is also used as a proxy for the quality of institutions in an economy. Dollar and Kraay (2003) justify this usage, explaining that all cross-country differences in institutions they studied could be mimicked by differences in the levels of GDP pc. Hielscher and Markwardt (2012) also claim that GDP pc can be used to control for structural differences such as differences in technologies, in the financial sector or on the optimal level of inflation.

3) Output gap

Lastly, as addressed in the global determinants part of this literature review, the global output gap would now be more relevant than the domestic one. However, this measure of slack is a domestic factor unique to each country and is indeed related to inflation in several studies (*e.g.*, Ciccarelli, & Mojon, 2010; Pehnelt, 2007).

E) Unit Labour Costs (ULC)

1) ULC – an overview

Labour costs inflation is defined as the "wage inflation-adjusted for productivity developments" (Bobeica *et al.*, 2019). ULC is defined by Eurostat as the measure between the cost of labour in producing output and productivity. Deniz *et al.* (2016) use real wage - which they consider interchangeable with ULC - to evaluate an economy's competitiveness[9].

When a country has high ULC, domestic firms will be incentivized to invest in foreign – cheaper - production facilities. Thus, these relative higher domestic production costs make foreign countries more attractive to investors. That is, globalization also impacted the relevance of ULC.

2) ULC in debate

Labour costs are thought to be another substantial source of inflation, although their role is fiercely debated. On the one hand, some authors claim that ULCs are responsible for the cost-push effect of inflation. That is, inflation, *i.e.*, higher prices, would be mainly driven by higher costs. Banerji (2005) supports this idea, explaining that labour costs alone represent two-thirds of costs endured by US private companies.

On the other hand, Bobeica *et al.* (2019) in their study detail that U.S. evidence has so far, not found any irrevocable proof of a link between higher prices and unit labour costs, especially in the short-term. Peneva and Rudd (2017) argue that this link between inflation and ULC – if existing – has weakened over time. Instead, stronger anchoring of inflation expectations would play a more important role than cost-push effects in impacting global prices. Baumann *et al.* (2020) also mention a potential disinflationary effect. Disinflation is resulting not directly from ULC but from technological progress, which would in turn reduce ULC and inflation.

3) ULC, Phillips curve and parameters' validity

Adam and Padula (2011) use surveys to determine agents' inflations expectations. They show that both output gap and ULC yield the expected signs for the Phillipe curve's slope.

However, Rudd and Whelan (2005) explain that nor real ULC nor detrended real GDP permit obtaining a satisfactory data fit in an NKPC context. Meanwhile, King and Watson (2012) find a missing disinflation puzzle since 1999. They argue real ULC should have led to a fifteen-percentage point disinflation which was not observed. They conclude that traditional ULC is no longer a suitable construction to understand inflation dynamics.

III) Inflation throughout crises

In this final section of our literature review, we briefly come back to three major crises where inflation and some of its determinants played a predominant role: the 1970s oil crisis, the Great Financial Crisis of 2008 and the Covid-19 sanitary crisis that started in 2020.

[9] Under the assumption that real wage equals the marginal productivity of labour.

A) The 1973 and 1978 oil supply shocks

The traditional reason called for the unprecedented stagflation[10] observed in the 1970s is that of an adverse shift in the aggregate supply curve. Political events and wars resulted in a disruption in oil supply which led to its prices soaring substantially. Many researchers believe the oil shocks of 1973 and 1979 to be responsible for most of the Great Inflation (from 2 to more than 10% in the U.S.) observed in the 1970s (Ciccarelli and Mojon, 2010). Indeed, oil shocks put on major inflationary pressures on the economy. Barsky and Killian's (2001) research demonstrates on the contrary that oil shocks, although important, were not the main cause of stagflation. They attribute it to the excessive monetary injection from the FED in the economy to try to curb inflation.

On another note, inflation remained surprisingly stable at the beginning of the 2000s, despite a steep increase in energy and raw materials prices (Pehnelt, 2007). De Gregorio *et al.* (2007) corroborate this finding, arguing that oil's importance in the economy has declined since the oil shocks of the 1970s. This is partly due to economies being more service-oriented, but also more energy-efficient and diverse following the 1970s oil shocks.

B) The 2008 Great Financial Crisis

The GFC led to a global recession. However, unlike the other two crises mentioned, inflation rates stayed in check throughout the crisis. In 2007, the inflation rate in the OECD was 2.5% and rose to its peak at 3.7% in 2008. However, other macroeconomic variables took a blow as a result of the crisis.

This is the case of the unemployment rate, namely in European Countries. In the E.U., unemployment went up from 7.6% at the beginning of the crisis to 12% in 2013 and later decreased to 10.9% in 2015. Following the crisis, unemployment persistence became a major source of concern as almost 10 years after the start of the GFC, the average unemployment rate remained higher than the pre-crisis level (Heimberger, 2017). In parallel, several scholars tried to make sense of the missing disinflation puzzle after the GFC (*e.g.*, Hall 2013, IMF 2013). They defend that given the level of economic slack in the economy; we should have observed disinflation. IMF (2013) explains that one of the two reasons for this missing disinflation puzzle was that the unemployment that resulted from the GFC was structural. That is, the inflation pass-through caused by high levels of unemployment was lower following the GFC than in the other crises.

Money supply was also greatly used in the wake of the 2008 crisis. Liquidity was injected into the economy by the FED and other Central Banks to avoid a credit crunch. Reserve Banks thus played their expe role of "lender of last resort" (Cordemans & Ide, 2012). Quint and Tristani (2018) study the consequences of Central Banks' liquidity injection in the Eurozone. They conclude that the injection of money reduced the adverse impact of the crisis. The authors show it also reduced investment. Essentially, money injection led to a bigger lending spread. This resulted in a stricter lending environment in the private sector and lower economic activity. However, Quint and Tristani's counterfactual model reveals that in the absence of this money injection, investments would have fallen by more than twice what they did. Finally, they conclude that this monetary policy did not lead to inflationary pressures in the Eurozone.

C) The Covid-19 crisis

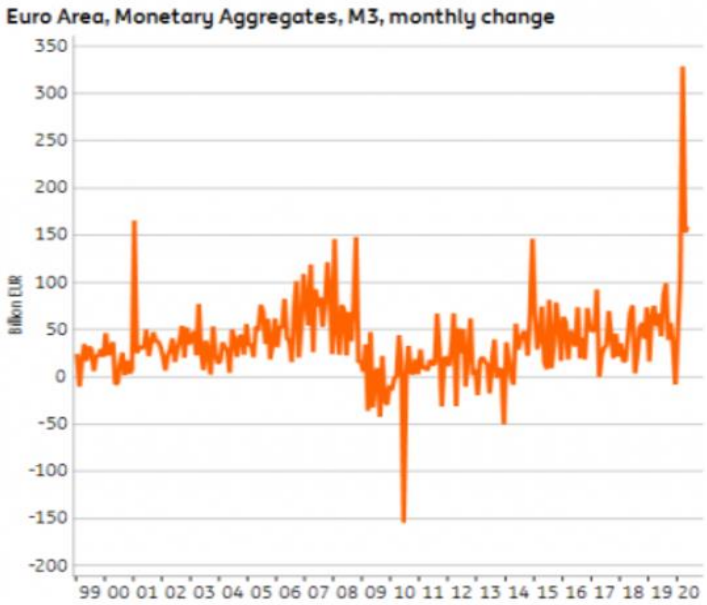
The sanitary crisis contracted economies' growth rates to exceptional negative values. IMF (2020) even qualified the pandemic as "the worst economic downturn since the Great Depression". The impact on inflation in the early days of the pandemic was rather ambiguous. On the one hand, consumption fell

[10] Stagflation is defined as a period of high inflation while economic output stagnates.

because of lockdowns in most OECD countries and oil prices were low which led to downward pressures on inflation. On the other hand, upward pressures on prices originated from supply chain bottlenecks, reduction and halting of production.

Monetary expansion was used at great length to attempt to boost demand and reduce the adverse effects of the economic slowdown. Central Banks indeed resorted to liquidity injections to fight the higher unemployment resulting from the pandemic (and the subsequent economic recession). Erdogan *et al.* (2020) warn however that a sustained injection of money in excess of production will result in a rising inflation level.

Colijn and Brossens (2020) claim that the increase in broad money circulating during the pandemic is bound to be temporary only. Their scenario nuances the more concerning view adopted by the previously mentioned authors. They argue that as economies restart, liquidity injections will be less necessary and thus government will move their focus away from liquidity support. Loans' demand will also decrease, and with time loans contracted during the crisis will be repaid. Therefore, deposits and M3[11] will go down. Colijn and Brossens add that the relationship between inflation and money supply has unravelled over the last years, mainly due to asset purchase (QE) and a declining link with banking loans.



Source: ING Research (2020)

[11] M3, or Broad Money, includes currency, deposits with an agreed maturity of up to two years, deposits redeemable at notice of up to three months and repurchase agreements, money market fund shares/units and debt securities up to two years. Source: OECD.

Methodology

Most of the following methodology is taken from Wooldridge (2013, 2015), Baltagi (2008), and Verbeek (2017).

I) Panel data

In this section, we first briefly define panel data and list a few of its advantages over cross-sectional data and time series. Then, we detail the Fixed Effects methodology we use on our panel.

1) Panel data – an overview

In our study of the main drivers of inflation, we created a panel dataset of 21 OECD economies[12], over the period 1970-2021. Panel data, or longitudinal data, contain observations about different cross-sections (countries) across time (years). They are best suited to study inflation thanks to its two-dimensional format. Cross-sectional data or time series could not provide such an abundant source of information (Baltagi & Kao, 2001).

Economic activity is inherently dynamic (Nerlove, 2002). Fortunately, panel data capture intertemporal changes at the unit level. Dynamic panels account for momentum or inertia. They control for Omitted Variable Bias and are thus useful to observe dynamic relationships. Thus, macroeconomics models tend to use dynamic panel data. This is the case for our analysis, as inflation is not only defined by current iterations, but also by lagged inflation (*i.e.*, our dependent variable) (Bikai *et al.*, 2016). We test lagged inflation as a regressor in a robustness check (Bikai *et al.*, 2016). We come back in a later section on the problems that may arise from including lagged dependent variable in our model.

2) Advantages of panel data

Aside from providing more informative data, panel data are more advantageous and polyvalent than cross-sectional and time-series analysis in many regards. Firstly, panel data coupled with fixed effects enable us to control for individual heterogeneities. Baltagi (2008) explains that time series that fail to control for units' differences, get biased results. Secondly, on top of offering more informative data than time series or cross-sectional data, panels offer more variability, more degrees of freedom, more efficiency, and less collinearity between the variables (Baltagi, 2001). Hsiao *et al.* (1995) find that panel data estimates are more reliable and limit the impact of OVB. Nevertheless, more accurate estimates rely on the assumption that the same relationship holds for every country. We test this assumption later in the paper. Lastly, panel data are best suited to study dynamics of adjustments (*e.g.*, if a country had high unemployment at time t-1, will it still be high at t?). Unlike cross-sectional data which only gives

[12] Australia, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, and the United States.

the proportion of the population unemployed at t, panel data also inform us about the proportion of people that stopped being unemployed at t+1.

3) Limitations of panel data

In terms of limitations, non-stationarity should not be a problem given the size of our sample (not too large T nor N). For those variables that would be non-stationary, we first difference them. We test later the efficiency of such technique. In like manner, the asymptotic argument should hold as our 35 years' time dimension is relatively large. However, cross-country dependency might be a severe issue and lead to misleading inferences if countries are correlated. We also test for error cross-sectional dependence.

II) Fixed Effect model

Fixed Effect – an overview

To estimate the main drivers of inflation, we run a Fixed Effects regression of inflation on a list of explanatory variables taken from the literature. Fixed Effects, or within-group estimators, will be our baseline estimation. Later, we list robustness checks and other specifications.

Fixed Effect models account for individual heterogeneity. This method captures the changes in the determinants of inflation that vary over time only. We assume that countries have specific unobservable characteristics (policies, productivity, resources available) that would bias the predictors, thus we control for them. We remove the effect of those time-invariant characteristics to fully capture the impact of our explanatory variables on inflation. Using Fixed Effect is the same as allowing a different intercept for each cross-sectional unit.

Baseline estimation method

The basic Fixed Effect specification looks like:

$$Y_{it} = \alpha_i + \beta \boldsymbol{X}_{it} + \varepsilon_{it}$$

Where α_i $(i = 1, \dots, n)$ is the individual intercept for each country (n country-specific intercepts). Let $\alpha_i = \beta_{0+} \beta_1 Z_i$, where the Z_i are the unobserved time-invariant heterogeneities across countries; Y_{it} is the dependent variable (inflation), with i = country and t = years; $\boldsymbol{X}_{it}$ represents a vector of the explanatory variables listed above, β their respective coefficient; ε_{it} the error term.

FE models are linear regressions model in which the intercepts varyy over the individual units i. FE are obtained by adding a set of N dummy variables for each unit in the model and by estimating the model with OLS. The estimator for β is the least squares dummy variable (LSDV) estimator. Thus, under dummy variable regression, each country has a different intercept that encompasses all unobserved time-invariant factors.

Dummy variable regressions are similar to within estimators, or simply FE estimators (Verbeek, 2017). Within-group FE has the advantage to be less numerically tedious. Regressions in deviation from individual means produce the same estimator for β as with the LSDV estimator, and also eliminates the individual effects α_i.

Robustness checks

1) Time dummies

We extend the baseline specification to a time and entity fixed effect regression (*e.g.*, to account for crisis).

$$Y_{it} = \alpha_i + \beta \boldsymbol{X}_{it} + \sigma_t + \varepsilon_{it}$$

With α_i, the cross-sectional FE. σ_t is the year-specific factor used as a crisis dummy. We control for those variables that change over time but not across countries. Such unaccounted-for variables would lead to unobserved heterogeneity; heteroskedasticity and autocorrelation within individual units' errors, but not across them.

2) Lagged inflation

We run a second robustness check by including lagged inflation as a regressor. Therefore, our model is now dynamic and presents itself as:

$$Y_{it} = \alpha_i + \beta \boldsymbol{X}_{it} + \sigma_t + \beta Y_{it\text{-}1} + \varepsilon_{it}$$

Other checks are performed and placed in the Appendix, with alternative measures of some variables from the original specification, such that:

- $GDP\ p.c._{i,t}$ as an alternative measure of Real GDP.
- $BRENT$ Crude Oil price as a baseline, and the Refiner Acquisition costs and WTI as alternative measures.

Specification

$$\begin{aligned} Inflation_{i,t} = \ & \alpha_i + \beta_1 RGDP_{i,t} + \beta_2 BRENT_t + \beta_3 Exports_{i,t} + \beta_4\ Imports + \beta_5\ RULC + \beta_6\ Short \\ & - term\ Interest\ Rates_{i,t} + \beta_7 Long - term\ Interest\ Rates_{i,t} + \beta_8 REER_{i,t} \\ & + \beta_9 Unemployment_{i,t} + \varepsilon_{i,t} \end{aligned}$$

Where i refers to the individual (country), t the time (year), α_i the country-specific intercept, and ε the error term. $RGDP$ is the Real Gross Domestic Product, $RULC$ the Real Unit Labour Costs, and $REER$ the Real Effective Exchange Rate.

Assumptions

As mentioned, FE rely on the assumption that each cross-sectional unit have unobservable, relevant characteristics that need to be controlled to avoid omitted variable bias (OVB). Hill *et al.* (2020) explain that these time-invariant are omitted by design. Also, those country-specific – time-invariant – characteristics need not to be correlated with other features, say of a neighbouring country. We assume countries to be different, thus the error term and the constant (that capture country's individual characteristics) should not be correlated with those of other countries. Therefore, variables should be i.i.d. across countries, but can be autocorrelated within entities. The third and fourth assumptions stipulate that large outlier is unlikely and that there is no perfect multicollinearity.

Additionally, if lagged dependent variables are not used as regressors, one needs strict exogeneity to hold (Verbeek, 2017). That is, the idiosyncratic error term must be uncorrelated with the variables of interest such that:

$$E\{\boldsymbol{X}_{it}\varepsilon_{it}\} = 0$$

If conditions of independence, unbiasedness, normality of the error, distribution of β_{FE} and consistency are satisfied, then explanatory variables are strictly exogeneous. Strictly exogeneous variables shall not depend on present, past and future values of the error term. This proves to be restrictive in our model as inflation is known to be persistent and thus depends on its previous iterations. We thus resort to alternative estimation methods such as First Differencing techniques, although Hill *et al.* (2020) question its practical applicability.

Fixed Effect - limitations

Hill *et al.* (2020) define a list of twelve limitations of FE on panel data. They consider that unobserved heterogeneity[13] is the most prevalent limitation to FE in panel data. We use time dummies to try to minimize this concern. From their paper, the other main shortcomings of FE that might impact our analysis are external validity[14], "mysterious undefined variables"[15] and measurement error[16].

Literature (*e.g.*, Pesaran and Smith, 2003) warns against the use of standard pooled estimators such as FE to estimate dynamic panel data models, arguing that these are subject to large biases when the parameters are heterogeneous across countries and the regressors are serially correlated. As mentioned, lagged inflation may be a key determinant of current inflation, and thus lead to bias.

However, the low statistical power observed in some FE panel data, due to their focus on time-varying data only, should not be a concern for our sample given the nature of our variables. Treiman (2009) explains that FE estimators are only reliable if there is sufficient variability in the sample studied, which we assume is true. Similarly, Allisson (2009) mentions that standard errors would be larger with FE models. Low variation over time would be the root cause, nonetheless, we do not believe this to be too impacting given our macroeconomic variables fluctuating over 50 years.

Instrumental Variables and Dynamic panels

Dynamic panel data use lagged dependent variables as regressors. Thus, if T is too small, explanatory variables will be correlated with the error term which violates the assumption of strict exogeneity of the FE estimator. This biased estimator is called Nickell's bias. Nickell (1981) demonstrates that FE estimators in dynamic panel models are inconsistent and biased. Judson and Owen (1999) confirm that

[13] Unobserved heterogeneity here refers to time-varying unobserved or miss-measured drivers of inflation that lead to biased coefficients.

[14] Hill *et al.* (2020) and Alisson (2009) warn against FE that omit by design time-invariant variables, as they alter samples. Indeed, if one model only includes varying units, findings will apply only to a "selected subgroup". Intuitively, they theorise that an individual who is changing over time will be different from another who is not. Thus, we question how much our results (from a restricted sample) can be extended and generalized to a broader population.

[15] Some variables we consider fixed by design in FE models might still change over time (*e.g.*, resources endowment, culture).

[16] If the data on which we base our analysis is systematically misreported, miscomputed, or misused, they will compound over time. Given the high number of variables, sources, and manual computations in our dataset, we cannot rule out this threat. Angrist and Pischke (2009) warn that these measurement errors lead to attenuation bias.

the size of the T is critical: a panel with a T of 30 results in a bias of "20% of the true value of the coefficient of interest".

A way to tackle both the inconsistency and biasness issues is to use Instrumental Variables (IV). IV provides unconditional population moment conditions. We explore one Instrumental Variable: First Differences estimator.

First Differences

First differences subtract from each variable its value for one period before then estimating the model. Regressions are run not on levels but on changes between 2 years.

$$Y_{i(t-1)} = \beta_0 + \beta_1 X_{1i(t-1)} + \cdots + \alpha_i + \sigma_{(t-1)} + u_{i(t-1)}$$

$$(Y_{it} - Y_{i(t-1)}) = \beta_1 (X_{2it} - X_{2i(t-1)}) + \cdots + (\sigma_t - \sigma_{(t-1)}) + (u_{it} - u_{i(t-1)})$$

Here again, the time-invariant factors cancel out. This technique fits well with time series such as ours. We use a combination of fixed effect regression on first-differenced variables in our model.

Additional tests

We run a set of additional tests on our baseline estimation unless otherwise specified.

- Testing Fixed Effects versus Random Effects and Pooled OLS: Hausman test, Breusch-Pagan Lagrange Multiplier
- Test for heteroskedasticity: Wald test
- Testing for time dummy
- Tests for serial autocorrelation: Woolridge test
- Testing for cross-sectional errors independence: Pesaran test
- Testing for stationarity: Fisher-type unit-root test based on Augmented Dickey-Fuller (ADF) test

Data

Most of the following data were obtained from the OECD database; the Annual Macroeconomic database of the European Commission (AMECO); the IMF Monetary and Financial Statistics database (MFS); the ECB database; the FRED economic database and the World Bank database.

The creation of the subsequent dataset was performed by the author of this paper. It is thus an ambitious gathering of data. It makes it prone, however, to computational issues.

To obtain a balanced panel dataset, we restrict our analysis to 21 OECD countries – covering the period from 1986 to 2021. Some variables from the Literature Review are also dropped (due to data limitations).

VARIABLES		***EXPECTED SIGN***	***FORM***	***SOURCES***
Dependent Variable:	**Inflation**: *CPI*		***Changes in CPI including all items:*** *(Pehnelt, 2007):* ***Lagged Inflation*** *(Borio and Filardo, 2007; Pehnelt, 2007),* ***Annual inflation growth rate*** *(Sek and Lim, 2015, Ciccarelli and Mojon,* 2010*)*	International Financial Statistics (IFS), European Commission database AMECO, OECD main economic indicator
Independent Variables:	**Oil** *Oil prices: BRENT, WTI, Refiner Acquisition Costs*	+	***Real oil price in $, level and log:*** *(Blanchard and Gali, 2007)*	Bloomberg terminal, FRED, and the Energy Information Association.
	GDP *Real GDP* *GDP per capita*	+ +	***Log level****: Dollar and Kraay (2003)* ***Real GDP per capita (level):*** *(Baumann et al., 2020),*	International Financial Statistics (IFS), European Commission database AMECO
	Effective Exchange Rate Unit of national currency per USD	-	***Real effective Dollar-denominated exchange rate*** *(Wagner, 2000; Erdogan et al., 2020)*	OECD main economic indicator, European Commission database AMECO
	Interest Rates (proxy Money Supply) Annual growth in (%)	-	***Short-term and Long-term interest rates*** *(Arrif et al., 2012)*	OECD database
	Unit Labour Costs	+	***Real ULC: (****King and Warson, 2012)*	OECD main economic indicator
	Trade Balance *Exports* *Imports*	± ±	***Exports****: (*Gylfason, 1997 ; Durguti et al., 2021) ***Imports****: (Narayan et al., 2011; Dexter et al., 2005; Papi and Lim, 1997)*	European Commission database AMECO
	Unemployment *Unemployment rate*	±	***Actual unemployment rate*** (Lendvai et al., 2015)	European Commission database AMECO
	Output Gap (not included) *Domestic output gap*	+	***Domestic output gap (level):*** *(Borio and Filardo, 2007; Pehnelt, 2007)*	European Commission database AMECO
	Credit (not included) Domestic Credit to the private sector	±	***Credit as % of GDP:*** *(Baumann et al., 2020)*	World Bank database, European Commission database AMECO

Transformations

We bring some of our dependent variables into a logarithmic form. We "log-transform" explanatory variables whenever it makes sense and helps interpretation. In the literature, most variables that represent a price, have non-negative values or that have a scale substantially greater than the rest of the regressions are log-transformed. A great advantage of such a transformation is that it helps us to perform the normality assumption. Logarithms are also used with macroeconomic data to reduce the heteroskedasticity of the data (Nau, 2019). We log the following variable: Real GDP, BRENT, Exports and Imports, and Real Unit Labour Costs.

Data - limitations

The Literature Review of this paper presents the ideal data we hoped to compile to explain the movements in inflations. However, the lack of availability of some data forces us to proxy those variables or to drop them altogether. This is the case for the Output Gap that is too scarcely available. Thus, we drop it and use an alternative measure of output such as Real GDP or GDP p.c. We recognise the non-inclusion of the output gap as a shortcoming of our analysis given its importance in the literature. Similarly, Domestic Credit to the private sector data is too incomplete to be kept in our final regressions. Further, NAWRU due to data unavailability and absence of consensus on its measurements is dropped. Rather, we use the unemployment rate (Eurostat definition) to observe labour's market behaviour.

Money Supply data could only be found for countries outside of the Eurozone, as such data are not directly available within a monetary union. Therefore, we use the Short- and Long-Term Interest rates[17] instead. The linkage between Money Supply and Interest Rates as Monetary policy tools is evidenced in many papers (see Ariff *et al.*, 2012; Alvarez *et al.*, 2001). Alvarez *et al.* consider that monetary policy actions are interchangeable between "a change in the money supply or as a change in interest rates". That is, both money supply and interest rates are tools used to reach inflation targeting objectives. Furthermore, interest rates are one of the components of money's demand.

[17] Short-term interest rates are defined as the rates at which short-term government paper is issued or traded in the market. They are the average daily rates measured in percentages. Long-term interest rates are also the average daily rates taken in percentages. They represent the price at which government bonds maturing in ten years are traded in the market.

Descriptive statistics

The following summary statistics, correlation matrices and graphs are computed by the author in the statistical software STATA

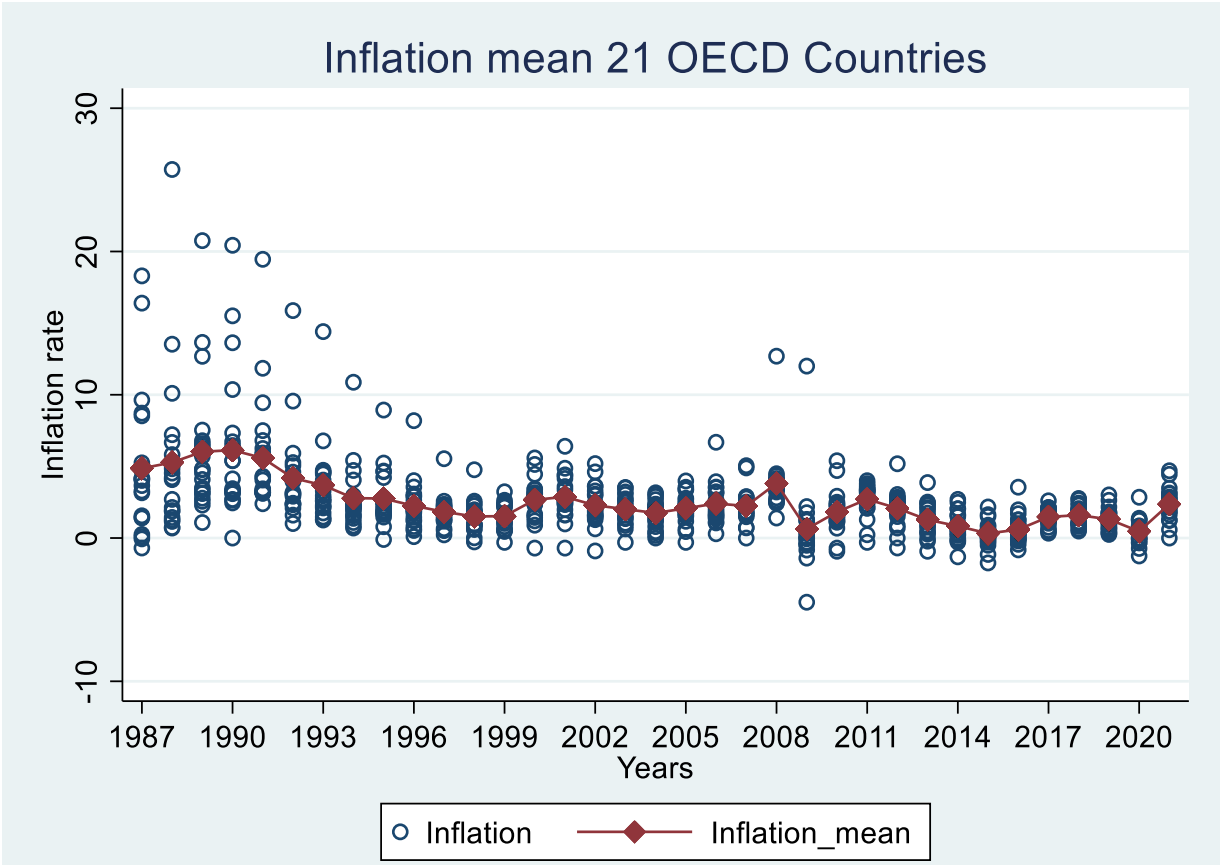
VARIABLES	N	mean	sd	min	max
Years	735	2004	10.11	1987	2021
CPI annual growth rate (%)	735	2.516	2.748	-4.478	25.73
WTI	735	44.75	27.23	12.14	98.83
BRENT	735	46.85	31.13	12.76	111.6
Real GDP	735	25,011	104,354	18.12	555,748
GDP per capita	717	35,263	16,908	8,775	117,721
Unemployment rate	730	7.219	4.197	0.509	27.50
Refiner Acquisition Costs	735	43.26	28.25	12.04	102.6
Real Unit Labour Costs	729	103.7	9.782	84.29	167.4
Imports	735	2,714	11,469	7.369	82,459
Exports	735	2,427	10,358	5.275	86,177
Real Effective Exchange Rate	735	101.7	12.71	67.57	157.0
Long-Term Interest Rate	688	4.707	3.293	-0.524	22.50
Short-Term Interest Rate	681	3.993	4.303	-0.819	31.02
Lagged CPI (%)	714	2.519	2.781	-4.478	25.73
Number of countries	21	21	21	21	21

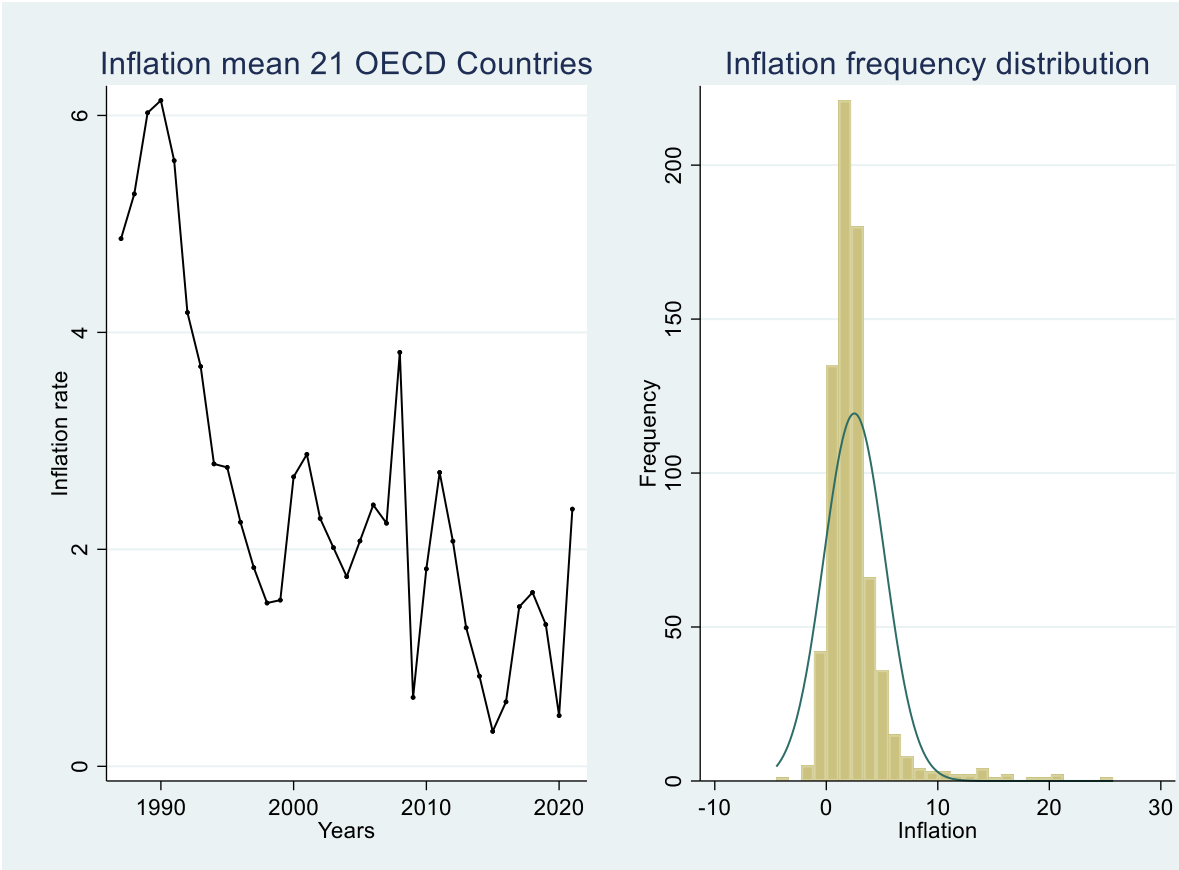
Matrix of correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Inflation	1.000											
(2) BRENT	-0.176	1.000										
(3) Real GDP	-0.188	0.111	1.000									
(4) GDP per capita	-0.307	0.507	0.011	1.000								
(5) Unemployment rate	-0.114	0.017	-0.157	-0.322	1.000							
(6) Real Unit Labour Costs	0.176	-0.148	0.018	-0.223	0.160	1.000						
(7) Imports	-0.185	0.117	0.989	0.023	-0.162	0.012	1.000					
(8) Exports	-0.180	0.111	0.968	0.029	-0.163	0.008	0.993	1.000				
(9) REER	0.215	-0.100	-0.199	-0.111	-0.167	0.021	-0.215	-0.227	1.000			
(10) Short-term Interest Rate	0.698	-0.519	-0.160	-0.578	-0.007	0.251	-0.165	-0.163	0.337	1.000		
(11) Long-term Interest Rate	0.595	-0.452	-0.213	-0.673	0.259	0.269	-0.221	-0.222	0.293	0.853	1.000	
(12) Lagged Inflation	0.687	-0.231	-0.196	-0.328	-0.022	0.181	-0.192	-0.186	0.224	0.661	0.592	1.000

From the matrix of correlation above, we observe a rather low and mostly negative correlation between our explanatory variables and inflation. As expected, lagged inflation strongly correlates with inflation in our dataset. This is also the case for the two measures of Interest Rate. Also, some correlations displayed are quite intuitive such as Imports with Exports or Long and Short-term Interest rates.

Below, we graph the mean of inflation in our dataset. Visually, we observe a decline in it the volatility and the magnitude of inflation prior to the COVID-19 crisis (at the exception maybe of the 2008 crisis).


Inflation mean 21 OECD Countries
Inflation rate
30
20
10
0
-10
1987
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
2020
Years
Inflation
Inflation_mean


Inflation mean 21 OECD Countries
Inflation rate
6
4
2
0
1990
2000
2010
2020
Years
Inflation frequency distribution
Frequency
200
150
100
50
0
-10
0
10
20
30
Inflation

Results

We first run our baseline estimation of the determinants of inflation. We have one endogenous variable (inflation) in the main specification, and nine sets of exogenous variables (Real GDP, Brent, ST & LT Interest Rates, Real Effective Exchange Rate, Real Unit Labour costs, Imports, Exports, and Unemployment). We then extend our model by adding two robustness checks. The first one adds a time dummy ("i.years"). The second adds another endogenous variable by including lagged inflation into our regression.

Every specification is run twice. The first regression takes the variables in levels, and the second first-differences both our dependent and independent variables. Differencing stabilises the mean of our variables by taking the changes in the levels out. Thus, it helps reduce seasonality and trends. We test for stationarity later in the paper.

We conduct additional checks, *e.g.*, for oil, we run our FE with the WTI index, the BRENT index, and the Refiner Acquisition Costs. Among those three oil prices in our dataset, we decide to use BRENT. All measures of oil are statistically significant and show the same positive sign. Further, we choose Real GDP over GDP pc. In this case, however, both measures share the same positive sign but only Real GDP is significant.

Below, we exhibit the result of our six main specifications (three in levels, three first-differenced) and discuss their implication.

Table 1 captures the results from our baseline specification, using Fixed Effects on levels and first differences. Our baseline estimation shows that inflation is positively impacted by BRENT oil price and Real GDP at levels. However, when we first difference our variables, the estimated effect of GDP is less precise and becomes statistically insignificant.

Column (1) reports that log GDP, log BRENT, Short and Long-term Interest rates, REER and Unemployment are strongly statistically significant. In Column (1), the logarithm of GDP is the main determinant of inflation. That is, holding everything else constant[18], if Real GDP goes up by 1%, inflation is expected to increase by 1.983 percentage points (*i.e.*, inflation increases by 0.019 points). This estimate is consistent with the literature and gives the expected positive sign. In column (2), we first-difference both our dependent and independent variables. The first difference of the log of GDP is not statistically different from zero. In other words, the growth rate of GDP would not be a key driver of inflation which challenges most previous literature.

[18] We use this assumption for the rest of our interpretations.

1) Baseline Specification

Table 1: Inflation and its determinants (FE)

	Fixed Effects Levels (1)	**Fixed Effects First Differences** (2)
Inflation		
Log GDP	1.983***	0.652
	(0.557)	(0.432)
Log BRENT	0.765***	1.667***
	(0.108)	(0.163)
Log Exports	-0.792*	0.612
	(0.416)	(0.834)
Log Imports	0.201	-0.773
	(0.373)	(0.839)
Log RULC	2.078**	1.686
	(0.915)	(1.892)
Short-Term Interest rate	0.289***	0.270***
	(0.0282)	(0.0407)
Long-Term Interest rate	0.171***	0.110**
	(0.0331)	(0.0442)
REER	-0.0348***	-0.0705***
	(0.00549)	(0.0101)
Unemployment	-0.166***	-0.184***
	(0.0211)	(0.0376)
Constant	-17.93***	-0.0273
	(6.414)	(0.0477)
Observations	649	636
R-squared	0.586	0.365
Number of countries	21	21
Country FE	YES	YES

Notes: Standard errors in parentheses. All the values in the 2nd column are first-differenced, including the dependent variable which leads to the second regression having fewer observations. Inflation is the dependent variable and is measured by the annual growth rate (%) of the CPI. The analysis dataset covers the years 1987 to 2021 for 21 OECD countries.

*** p<0.01, ** p<0.05, * p<0.1

The results in Table 1 corroborate the view that energy is a major determinant of inflation. Indeed, the log of BRENT is the second main driver of inflation in our regression. It is significant and strongly positive both at levels and in growth rates[19][20]. From column (2), a 1% increase in BRENT growth rate increases first-differenced inflation by 1.667 percentage points. Our study contributes to the cost-push inflation theory supported by Ciccarelli and Mojon (2010), who find that oil's increased price causes higher input costs. The high significance of oil in OECD countries also concurs with Calderón and Schmidt-Hebbel (2008) who explain that oil fluctuations affect severely developed economies However, this study is limited in its scope, as we do not research its impact on less-advanced countries.

The Monetary Theory of Inflation is supported in our model. Indeed, interest rates[21] are relevant to determining inflation, particularly in the short term. The prevalence of the short-term interest rate as a

[19] The co-movement between the two measures is included in the Appendix.

[20] The first difference of the logarithm of x is the growth rate of x.

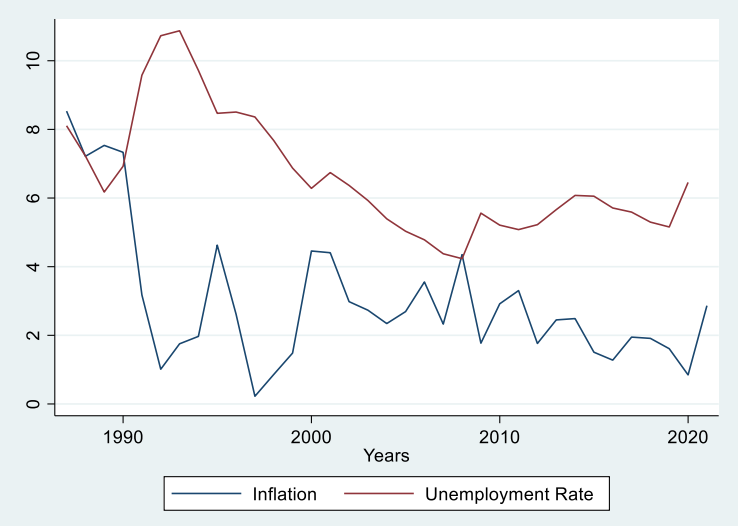
[21] As mentioned, we use interest rates on behalf of money supply due to data limitations.

monetary policy instrument follows the consensus reached by economists in Alvarez *et al.* (2001). However, Table 1 suggests that inflation and interest rates are positively related, not negatively as in Alvarez *et al*. The authors reject the quantity theory of money, which we do not (given the interdependence between interest rate and money supply). As such, Column (1) tells us that a one-unit increase in the short-term interest rate results in a 0.289 percentage points higher inflation. Our findings go against a wide consensus that increasing interest rates makes it more expensive to borrow money, which in turn slowdowns the economy and reduces inflation (De Nederlandsche Bank, 2022). The linkage between inflation and interest rates is therefore supported in our model, although its magnitude is not predominant, and its sign is "counter-intuitive".

Further, Log RULC is the estimate with the highest economic significance (2.07 in Column (1)), however, its statistical significance drops when taking its change over time (Column (2)). That is, labour market forces in our model only lead to a general increase in the level of prices when studying the 1% increase in the level of unit labour costs, but not when taking its growth rate. Notably, Table 1 goes against Baumann *et al.* (2020) who mention a potential disinflationary effect. It does, however, contribute to the ongoing debates regarding unit labour costs relevance.

Despite the vast literature identifying imports and exports as key drivers of inflation, we find no such relationship in our data. At best, we find a negative relationship between Log Exports and inflation at the 0.1 significance level. This coefficient's significance vanishes when taking Exports' growth rate and even changes sign. Thus, we conclude an insignificant relation between inflation and the Trade Balance components for the 21 OECD countries over the period studied.

Lastly, Table 1 is in line with the literature on the expected negative signs for the Real Effective Exchange Rate and the Unemployment rate. For the latter, when the first difference of the unemployment rate goes up by 1 unit, the year-on-year (YoY) evolution of inflation declines by 0.184 percentage points. This result has consequential implications, as it would suggest we find a Phillips curve relationship in our dataset. This is further supported when studying the graph of the unemployment rate and inflation. Their inverse relationship is visually captured during some periods, especially around the early 1990s and in 2008.



2) Robustness check: Time Dummy

Table 2: Inflation and its determinants – Controlling for macroeconomic shocks

	Fixed Effects – Levels Time Dummy (1)	**Fixed Effects – First Differences Time Dummy** (2)
Inflation		
Log GDP	2.217***	1.475**
	(0.560)	(0.647)
Log BRENT	2.839***	3.412***
	(0.523)	(0.558)
Log Exports	-1.361***	-0.396
	(0.409)	(0.911)
Log Imports	-0.00719	-0.788
	(0.377)	(0.815)
Log RULC	1.143	1.000
	(0.930)	(1.807)
Short-Term Interest rate	0.323***	0.295***
	(0.0340)	(0.0490)
Long-Term Interest rate	0.191***	0.180***
	(0.0366)	(0.0495)
REER	-0.0305***	-0.0627***
	(0.00536)	(0.00978)
Unemployment	-0.156***	-0.147***
	(0.0213)	(0.0378)
Constant	-18.55***	0.0738
	(6.298)	(0.337)
Observations	649	636
R-squared	0.677	0.522
Number of Countries	21	21
Country FE	YES	YES
Time FE	YES	YES

Notes: Standard errors in parentheses. All the values in the 2nd column are first-differenced, including the dependent variable. Inflation is the dependent variable and is measured by the annual growth rate (%) of the CPI. The analysis dataset covers the years 1987 to 2021 for 21 OECD countries. Time dummies are used to account for shocks such as crises. Dummies are not displayed to facilitate reading. 15 years are strongly statistically significant in Column (1), and only 6 in Column (2).

*** p<0.01, ** p<0.05, * p<0.1

Table 2 is a robustness check to Table 1. It includes time dummies to our FE model[22]. Its main findings are the increase in the explanatory power of both GDP and BRENT which are the main drivers of inflation and the strong negative effect of exports in levels.

Controlling for time-unit fixed effects[23] is a common tool used in applied panel data empirical analyses. Time-fixed effects are often proposed to adjust for macroeconomic shocks and are (nearly) automatically adopted to generate unbiased results (Gösser and Moshgbar, 2020). Indeed, we observe

[22] We perform a test that confirms the necessity to use time dummies in our model in the Appendix.

[23] We call "time-unit fixed effects" "time fixed effects"

that our R-squared improved for both regressions with respect to Table 1. We do not address the risk of overfitting our model and we recognise it as a potential limitation. Short-term and Long-term interest rates, log Imports, REER and Unemployment are consistent with our baseline model. We now address the main differences observed.

Firstly, Table 2 confirms the intuition gained from Table 1 that oil is a prevalent determinant of inflation. In effect, BRENT is statistically significant in both columns at the 0.01 level and has the largest coefficients of both regressions. A 1% increase in the growth rate of BRENT drives the YoY first difference of inflation up by 3.412 percentage points, which is also economically significant. Time-dummy models could better encompass oil shocks, which are one such example of a major economic shock. Similarly, the log of GDP is key in explaining inflation's variations. Its growth rate coefficient became significant at the 0.05 level and still exhibits a positive relationship.

Secondly, log Export is now strongly significant in levels and negatively correlated with inflation. Therefore, accounting for time dummies helps our model fit the literature that argues in favour of a strong effect of exports. For instance, our results are similar to the ones of Gylfason (1997) who finds that high inflation environments are linked to low levels of exports.

Lastly, log RULC's statistical precision drops. Thus, adding more regressors in the regression results in unit labour costs being no longer significant, both in levels and in first differences. We link our results to the one of Bobeica *et al.* (2019), who find no evidence between inflation and unit labour costs in the U.S. (which is part of our dataset).

As a second robustness check, we include Lagged Inflation – which proxies inflation persistence. In Table 3, lagged inflation is strongly significant in our model notwithstanding its changing sign between levels and first differences. This follows the Literature Review of this paper which documents the importance of inflation persistence in explaining inflation. Unsurprisingly, including lagged inflation does not have consequential changes in other coefficient estimates. That is, most independent variables keep the same sign and economic relevance. The explanatory power of our model only slightly increases compared to our baseline model.

Column (1) reports that including inflation in $t-1$ increases inflation in the current year. A one unit increase in the lag of inflation thus drives inflation up by 0.209 percentage points. Column (2) on the other hand finds a negative impact of lagged inflation on global prices level. This finding challenges the Built-In inflation theory that predicts that higher inflation in the past year must lead to higher inflation in the following year as prices and wages need to adjust.

Interestingly, adding a measure of persistence does not decrease the Phillips curve relationship similar to DiNardo and Moore (1999). Thus, inflation remains negatively correlated to the unemployment rate throughout our baseline and robustness checks.

3) Robustness check: Lagged Inflation

Table 3: Inflation and its determinants – Controlling for inflation persistence

	Fixed Effects – Levels Lagged Inflation (1)	**Fixed Effects – First Differences Lagged Inflation** (2)
Inflation		
Log GDP	1.668***	2.507
	(0.547)	(2.154)
Log BRENT	0.658***	1.515***
	(0.105)	(0.184)
Log Exports	-0.741*	-0.723
	(0.405)	(1.033)
Log Imports	0.254	-0.0591
	(0.369)	(0.883)
Log RULC	1.515*	3.298*
	(0.893)	(1.938)
Short-Term Interest rate	0.236***	0.236***
	(0.0285)	(0.0428)
Long-Term Interest rate	0.136***	0.162***
	(0.0325)	(0.0474)
REER	-0.0300***	-0.0664***
	(0.00535)	(0.0101)
Unemployment	-0.146***	-0.205***
	(0.0207)	(0.0512)
Lagged Inflation	0.209***	-0.224***
	(0.0330)	(0.0342)
Constant	-14.04**	-0.0472
	(6.285)	(0.0746)
Observations	638	615
R-squared	0.602	0.405
Number of Countries	21	21
Country FE	YES	YES
Time FE	YES	YES

Notes: Standard errors in parentheses. All the values in the 2nd column are first-differenced, including the dependent variable. Thus column (2) has fewer observations. Inflation is the dependent variable and is measured by the annual growth rate (%) of the CPI. The analysis dataset covers the years 1987 to 2021 for 21 OECD countries. Lagged Inflation represents inflation persistence and is calculated by taking inflation at t-1.

*** p<0.01, ** p<0.05, * p<0.1

4) Additional Tests

We run a set of additional tests to determine successively the best suited model between the Fixed Effects model, Random Effects (RE) model and Pooled OLS, then we test if our model is Heteroskedastic, if our model needs a time FE dummy, if it exhibits auto-correlation, if its cross-sectional errors are independent and if it is stationary. We run those tests on our baseline estimation in levels only (unless specified otherwise). All those tests are reported in the Appendix. Below, we only discuss their results.

A) Hausman test:

The Hausman test is significant. Thus, we accept the null hypothesis that the difference in coefficient is not systematic. The Fixed Effects model is therefore the most appropriate of the two models (FE and RE) to estimate the determinants of inflation with our dataset.

As a precautionary measure, we also perform the Breusch-Pagan Lagrange Multiplier (LM). Here again, the test is significant which indicates the presence of random effects and therefore rules out the pooled OLS model and confirms our Fixed Effects specification.

B) Test for heteroskedasticity:

The significant result indicates we reject the null hypothesis, of homoskedasticity. Therefore, there is a heteroskedasticity problem issue in our model.

C) Test for panel error term autocorrelation:

This test is significant in levels. Therefore, we reject the null hypothesis and conclude serial autocorrelation of the errors in our panel.

The presence of autocorrelation and heteroskedasticity invalidates the use of regular standard errors. Heteroskedasticity and Autocorrelation-Consistent (HAC) standard errors allow for heteroskedasticity and autocorrelated standard errors within countries but not for correlation across them. Clustered standard errors are of the HAC type. We run our regressions with clustered standard errors (on countries) and add them to the Appendix. A shortcoming of such transformation is that standard errors all increase. Thus, some coefficients such as RULC and Exports become insignificant in the level form, whilst only Long-term interest rates lost significance in the first-differenced specification.

We run the test a second time on first-differenced variables and this time, we fail to reject the null hypothesis. Therefore, first differencing rids us of the problem of error term autocorrelation.

D) Testing for the necessity to include time FE:

We run a joint test to determine if the dummies for all the years in our sample are 0. We reject the null hypothesis. Thus, time-fixed effects are needed in our regression.

E) Testing for independence of the residuals:

Baltagi (2001) warns against the risk of cross-sectional dependence of the residuals in macro panels with long time series. Our panel consists of 35 years of observations; thus, we test the independence of our residuals. We conduct Pesaran's test for cross-sectional dependence from Pesaran (2004). This test follows a standard normal distribution. The null hypothesis is that there is cross-sectional independence. We have strong evidence to reject the null hypothesis both at levels and in first differences. Thus, we have solid ground to believe our cross-sectional residuals are dependent in our FE model.

These results follow the current strand of literature (*e.g.*, De Hoyos and Sarafidis, 2007) that argues that panel data have a large chance to have dependent cross-sectional residuals. De Hoyos and Sarafidis argue that this might be partly due to the financial integration and interdependence of economies, that would absorb common shocks which we then find in the error term.

F) Testing for stationarity:

We test if our series evolves around zero, *i.e.*, if the series is stationary. We use a unit-root test combined with a Dickey-Fuller test. We add to the Appendix the results table. When all four tests' (Inverse chi-squared, Inverse normal Z, Inverse logit t, Modified inv. chi-squared) p-values are less than 0.05, we reject the null hypothesis that panels contain unit roots which in turn suggests stationarity of our series. When series are not stationary, regressions are said to be spurious. We conduct the same test on our first-differenced model. As expected, all of our series are stationary.

Conclusion

In this study, we examine the main determinants of inflation in a panel dataset comprising 21 OECD countries and spanning over 35 years (1986 to 2021). We find that inflation is primarily driven by Real GDP and Brent oil price. Understanding inflation's drivers is of utmost importance in the current scenario of multidecade-high global prices. Inflation's adverse consequences on growth, investment and living standards make it a primary index to regulate when judged unacceptably high.

Panel data coupled with fixed effects control for individual heterogeneities. Undoubtedly, countries have different natural resource endowments, cultures, and other unobservable characteristics that would bias our estimations if not controlled for. Our baseline specification consists of a FE regression in levels and in first differences. We extend our model by adding time dummies to control for shocks. Then, we include lagged inflation to proxy inflation persistence.

Our first main finding is the strong and significant correlation (in levels) observed between inflation and the Gross Domestic Product. A 1% higher Real GDP increases inflation on average by 1.9 percentage points. Adding time dummies follows in a strong statistical significance of GDP both in levels and in growth rates. In this model, a 1% increase in (level) GDP results in a commensurate 2.2 percentage points higher inflation rate. The *Global Economic Prospects* of June 2022 forecasts that global economic growth will stall due to various geopolitical and economic downturns (World Bank, 2022). Whether this lower GDP growth will eventually lead to lower inflation levels should be carefully studied in the coming months. The report predicts that other factors such as persistence in inflation and disrupted supply chains should keep inflation high in the foreseeable future. However, our study is inconclusive regarding inflation persistence (proxied by lagged inflation). Although statistically different from zero in both levels and first differences, its magnitude is relatively small and its sign changes between levels and first differences. Not being able to postulate how lagged inflation influences current inflation is a pivotal drawback of our analysis.

This paper additionally finds a high correlation between oil price and inflation. Our baseline estimation reports that a 1% increase in BRENT's growth rate increases first-differenced inflation by 1.6 percentage points. With time dummies, a 1% increase in the growth rate of BRENT leads to soaring YoY global prices by 3.4 percentage points. Those results are statistically significant and economically sizeable. It is thus not surprising to see that the high inflation currently experienced in most OECD countries coincides with an 8-years high oil price. The surge in oil price is tightly linked to the fear amid the war in Ukraine and Russia's potential embargo on oil supply. Our study and the current geopolitical scene are in line with Kilian and Zou (2021). The authors warn against the turmoil caused by low stocks of oil traded in the market, which leads to higher energy prices and in turn higher global prices.

Further, our model evidences the Monetary Theory of Inflation via statistically significant interest rates (both short-term and long-term). A unit increase in the short-term interest rate results in a 0.29 percentage points higher inflation. This result has direct policy implications. First, it challenges the expected negative correlation between the inflation and interest rates. Second, following the announcements from most Central Banks (including the FED) to raise interest rates high enough to cool the economy down. A major limitation of our analysis is not being able to directly observe the interdependence between inflation and Money Supply due to data limitations. It prevents us from drawing conclusions on the potential inflationary pressures from the consequent liquidity injections in the early days of the COVID-19 pandemic.

Finally, our work is in line with the one from Sahoo and Sethi (2018) who find that exports are more consistently correlated to inflation than imports. We find (in levels) a negative relationship between

inflation and the export level of a country. Moreover, an increase in the unemployment rate is also related to a decrease in inflation. This finding supports a Phillips curve relationship in our dataset. Thus, it suggests an inflation-unemployment trade-off for OECD countries; and defies the critics who call this association “dead”.

Overall, this paper does not conclude on any prevalence of domestic factors over global ones (and conversely). Further study should aim to distinguish between domestic and international drivers of inflation with techniques such as Vector Auto-Regressive models. This study, however, clearly illustrates the need for continuous revision of economic theory and empirical studies when attempting to understand economy’s behaviours. Some variables highly praised in previous study find no significance in our data. On the other hand, we corroborate the prevalence of other determinants like GDP, oil price or the unemployment rate.

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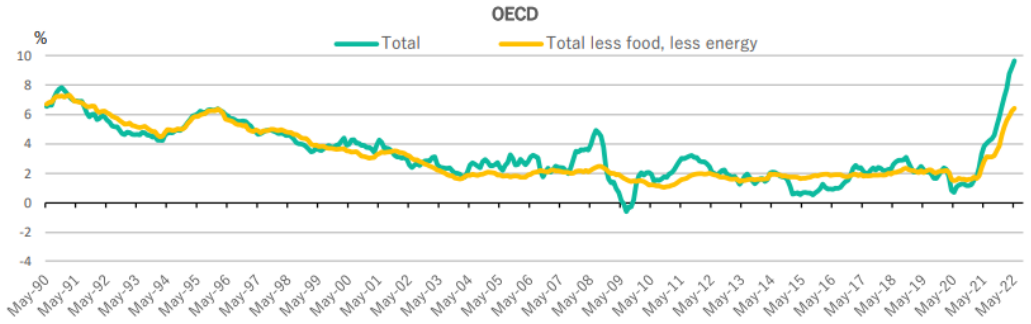
Appendix

Inflation since 1990's

Figure 3 – Inflation since 1990's: All items and all items excluding food and energy
OECD, United States, Japan (CPI) and euro area (HICP), year-on-year inflation rate



Source: OECD (2022)

Economic outlook

TABLE 1.1 Real GDP[1]

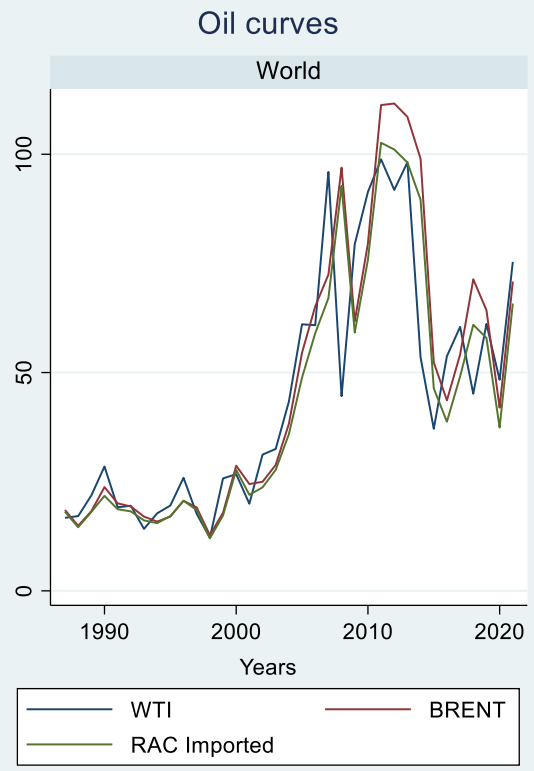
	2019	2020	2021e	2022f	2023f	2024f	Percentage point differences from January 2022 projections 2022f	2023f
World	**2.6**	**-3.3**	**5.7**	**2.9**	**3.0**	**3.0**	**-1.2**	**-0.2**
Advanced economies	**1.7**	**-4.6**	**5.1**	**2.6**	**2.2**	**1.9**	**-1.2**	**-0.1**
United States	2.3	-3.4	5.7	2.5	2.4	2.0	-1.2	-0.2
Euro area	1.6	-6.4	5.4	2.5	1.9	1.9	-1.7	-0.2
Japan	-0.2	-4.6	1.7	1.7	1.3	0.6	-1.2	0.1
Emerging market and developing economies	**3.8**	**-1.6**	**6.6**	**3.4**	**4.2**	**4.4**	**-1.2**	**-0.2**
East Asia and Pacific	5.8	1.2	7.2	4.4	5.2	5.1	-0.7	0.0
China	6.0	2.2	8.1	4.3	5.2	5.1	-0.8	-0.1
Indonesia	5.0	-2.1	3.7	5.1	5.3	5.3	-0.1	0.2
Thailand	2.2	-6.2	1.6	2.9	4.3	3.9	-1.0	0.0
Europe and Central Asia	2.7	-1.9	6.5	-2.9	1.5	3.3	-5.9	-1.4
Russian Federation	2.2	-2.7	4.7	-8.9	-2.0	2.2	-11.3	-3.8
Turkey	0.9	1.8	11.0	2.3	3.2	4.0	0.3	0.2
Poland	4.7	-2.2	5.9	3.9	3.6	3.7	-0.8	0.2
Latin America and the Caribbean	0.8	-6.4	6.7	2.5	1.9	2.4	-0.1	-0.8
Brazil	1.2	-3.9	4.6	1.5	0.8	2.0	0.1	-1.9
Mexico	-0.2	-8.2	4.8	1.7	1.9	2.0	-1.3	-0.3
Argentina	-2.0	-9.9	10.3	4.5	2.5	2.5	1.9	0.4
Middle East and North Africa	0.9	-3.7	3.4	5.3	3.6	3.2	0.9	0.2
Saudi Arabia	0.3	-4.1	3.2	7.0	3.8	3.0	2.1	1.5
Iran, Islamic Rep.[3]	-6.8	3.4	4.1	3.7	2.7	2.3	1.3	0.5
Egypt, Arab Rep.[2]	5.6	3.6	3.3	6.1	4.8	5.0	0.6	-0.7
South Asia	4.1	-4.5	7.6	6.8	5.8	6.5	-0.8	-0.2
India[3]	3.7	-6.6	8.7	7.5	7.1	6.5	-1.2	0.3
Pakistan[2]	3.1	-0.9	5.7	4.3	4.0	4.2	0.9	0.0
Bangladesh[2]	7.9	3.4	6.9	6.4	6.7	6.9	0.0	-0.2
Sub-Saharan Africa	2.6	-2.0	4.2	3.7	3.8	4.0	0.1	0.0
Nigeria	2.2	-1.8	3.6	3.4	3.2	3.2	0.9	0.4
South Africa	0.1	-6.4	4.9	2.1	1.5	1.8	0.0	0.0
Angola	-0.7	-5.2	0.7	3.1	3.3	3.2	0.0	0.5
Memorandum items:								
Real GDP[1]								
High-income countries	1.7	-4.6	5.1	2.7	2.2	2.0	-1.1	-0.2
Middle-income countries	4.0	-1.3	6.8	3.3	4.2	4.5	-1.3	-0.3
Low-income countries	4.8	1.9	3.9	4.1	5.3	5.7	-0.8	-0.6
EMDEs excl. Russian Federation and Ukraine	3.9	-1.5	6.7	4.2	4.5	4.5	-0.5	0.0
EMDEs excl. China	2.5	-4.0	5.6	2.7	3.4	4.0	-1.5	-0.4
Commodity-exporting EMDEs	1.8	-3.8	4.8	1.2	2.6	3.2	-2.1	-0.5
Commodity-exporting EMDEs excl. Russian Federation and Ukraine	1.8	-4.0	4.8	3.7	3.3	3.4	0.3	-0.1
Commodity-importing EMDEs	4.9	-0.4	7.5	4.4	4.9	5.0	-0.8	-0.1
Commodity-importing EMDEs excl. China	3.2	-4.2	6.6	4.6	4.5	4.9	-0.7	-0.1
EM7	4.5	-0.5	7.3	3.3	4.3	4.7	-1.5	-0.4
World (PPP weights)[4]	2.9	-3.0	6.0	3.1	3.4	3.5	-1.3	-0.2
World trade volume[5]	**1.4**	**-8.0**	**10.3**	**4.0**	**4.3**	**3.8**	**-1.8**	**-0.4**
Commodity prices[6]								
Oil price	-9.9	-33.9	66.5	42.0	-8.0	-13.0	35.0	3.8
Non-energy commodity price index	-4.2	3.3	32.7	17.9	-8.1	-3.1	19.9	-4.1

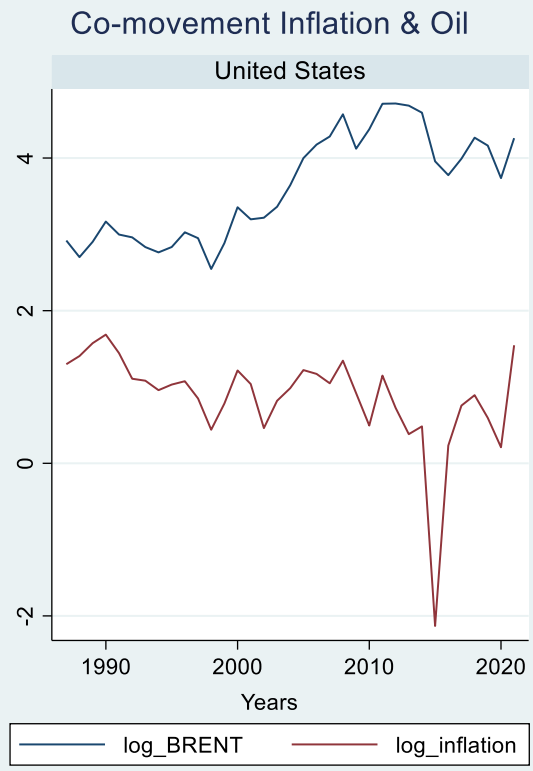
Source: World Bank.

1. Headline aggregate growth rates are calculated using GDP weights at average 2010-19 prices and market exchange rates. The aggregate growth rates may differ from the previously published numbers that were calculated using GDP weights at average 2010 prices and market exchange rates. Data for Afghanistan and Lebanon are excluded.
2. GDP growth rates are on a fiscal year basis. Aggregates that include these countries are calculated using data compiled on a calendar year basis. Pakistan's growth rates are based on GDP at factor cost. The column labeled 2022 refers to FY2021/22.
3. GDP growth rates are on a fiscal year basis. Aggregates that include these countries are calculated using data compiled on a calendar year basis. The column labeled 2022 refers to FY2022/23.
4. World growth rates are calculated using average 2010-19 purchasing power parity (PPP) weights, which attribute a greater share of global GDP to emerging market and developing economies (EMDEs) than market exchange rates.
5. World trade volume of goods and nonfactor services.
6. Oil price refers to the Brent crude oil benchmark. The non-energy index is the weighted average of 39 commodity prices (7 metals, 5 fertilizers, and 27 agricultural commodities). For additional details, please see https://www.worldbank.org/commodities.

Note: e = estimate; f = forecast. World Bank forecasts are frequently updated based on new information. Consequently, projections presented here may differ from those contained in other World Bank documents, even if basic assessments of countries' prospects do not differ at any given date. For the definition of EMDEs, commodity exporters, and commodity importers, please refer to table 1.2. EM7 includes Brazil, China, India, Indonesia, Mexico, the Russian Federation, and Turkey. The World Bank is currently not publishing economic output, income, or growth data for Turkmenistan and República Bolivariana de Venezuela owning to lack of reliable data of adequate quality. Turkmenistan and República Bolivariana de Venezuela are excluded from cross-country macroeconomic aggregates.

Source: OECD (2022)


Oil curves
World
100
50
0
1990
2000
2010
2020
Years
WTI
BRENT
RAC Imported
Graphs by Countries


Co-movement Inflation & Oil
United States
4
2
0
-2
1990
2000
2010
2020
Years
log_BRENT
log_inflation
Graphs by Countries

Robustness check: Different Oil Prices

VARIABLES	(1) Fixed Effects-BRENT	(2) Fixed Effects - WTI	(4) Fixed Effects - RAC
Log GDP	1.983***	2.298***	1.979***
	(0.557)	(0.565)	(0.557)
Log BRENT	0.765***		
	(0.108)		
Log Exports	-0.792*	-0.605	-0.786*
	(0.416)	(0.425)	(0.416)
Log Imports	0.201	0.343	0.231
	(0.373)	(0.380)	(0.373)
Log RULC	2.078**	2.904***	2.116**
	(0.915)	(0.920)	(0.913)
Short-Term Interest rate	0.289***	0.305***	0.292***
	(0.0282)	(0.0290)	(0.0282)
Long-Term Interest rate	0.171***	0.175***	0.167***
	(0.0331)	(0.0339)	(0.0331)
REER	-0.0348***	-0.0362***	-0.0349***
	(0.00549)	(0.00562)	(0.00549)
Unemployment	-0.166***	-0.157***	-0.166***
	(0.0211)	(0.0215)	(0.0211)
Log WTI		0.537***	
		(0.111)	
Log RAC			0.770***
			(0.108)
Constant	-17.93***	-24.90***	-18.23***
	(6.414)	(6.399)	(6.396)
Observations	649	649	649
R-squared	0.586	0.568	0.586
Number of countries	21	21	21
Country FE	YES	YES	YES

Notes: Standard errors in parentheses. BRENT and WTI are commonly used to valuate oil. OPEC countries use the BRENT measure as a pricing benchmark. Refiner Acquisition Cost is also included to proxy a market-free price for oil.

Robustness check: Different GDP measures

VARIABLES	(1) Fixed Effects - Real GDP	(2) Fixed Effects – GDP per capita
Log GDP	1.983***	
	(0.557)	
Log BRENT	0.765***	0.825***
	(0.108)	(0.108)
Log Exports	-0.792*	-0.544
	(0.416)	(0.418)
Log Imports	0.201	0.212
	(0.373)	(0.374)
Log RULC	2.078**	0.959
	(0.915)	(0.869)
Short-Term Interest rate	0.289***	0.280***
	(0.0282)	(0.0280)
Long-Term Interest rate	0.171***	0.186***
	(0.0331)	(0.0338)
REER	-0.0348***	-0.0349***
	(0.00549)	(0.00548)
Unemployment	-0.166***	-0.201***
	(0.0211)	(0.0189)
Log GDP pc		0.426
		(0.328)
Constant	-17.93***	-4.827
	(6.414)	(5.391)
Observations	649	632
R-squared	0.586	0.606
Number of countries	21	21
Country FE	YES	YES

Additional tests

A) Hausman and Breusch-Pagan tests

Hausman test

H0: difference in coefficient not systematic

Hausman (1978) specification test

	Coef.
Chi-square test value	59.976
P-value	0

Breusch-Pagan Lagrange Multiplier (LM)

H0 : CPI[id,t] = Xb + u[id] + e[id,t]

Breusch and Pagan Lagrangian multiplier test for random effects

	Coef.
chibar2(01)	78.47
P-value	0

B) Wald test

H0: sigma(i)^2 = sigma^2 for all i

Modified Wald test for groupwise heteroskedasticity

	Coef.
chibar2(21)	235.4708
P-value	0

C) Wooldridge test

H0: no first-order autocorrelation

Wooldridge test for autocorrelation in panel data

F(1, 20) = 12.928

Prob > F = 0.0018

D) Year Dummy test

H0: coefficient for all years equal to zero
Joint test for time dummies

F(33, 585) = 9.50
Prob > F = 0.0000

E) Pesaran test

H0: cross-sectional dependence
Pesaran's test for cross-sectional dependence across residuals.

Pesaran's test of cross-sectional independence = 19.460, Pr = 0.0000
Average absolute value of the off-diagonal elements = 0.305

F) Augmented Dickey Fuller test

H0: All panels contain unit roots
Fisher-type unit-root test for CPI. Based on augmented Dickey Fuller tests.

H0: All panels contain unit roots — Number of panels = 21

Ha: At least one panel is stationary — Number of periods = 35

AR parameter: Panel-specific — Asymptotics: T -> Infinity

Panel means: Included
Time trend: Not included
Drift term: Not included — ADF regressions: 1 lag

		Statistic	p-value
Inverse chi-squared(42)	P	165.1622	0.0000
Inverse normal	Z	-8.0662	0.0000
Inverse logit t(109)	L*	-9.5615	0.0000
Modified inv. chi-squared	Pm	13.4381	0.0000

P statistic requires number of panels to be finite.
Other statistics are suitable for finite or infinite number of panels.

	Stationary (Levels)	Stationary (First Difference)
Inflation	Yes	Yes
Log GDP	Yes/No	Yes
Log BRENT	No	Yes
Log Exports	No	Yes
Log Imports	No	Yes
Log RULC	No	Yes
ST Interest rate	Yes/No	Yes
LT Interest Rate	Yes/No	Yes
REER	Yes	Yes
Unemployment	Yes	Yes
Lagged Inflation	Yes	Yes

Clustering Standard Errors

VARIABLES	(1) Fixed Effects Levels	(2) Fixed Effects First Differences	(3) Fixed Effects Levels	(4) Fixed Effects First Differences
Log GDP	1.983***	0.652	1.983**	0.652
	(0.557)	(0.432)	(0.832)	(0.804)
Log BRENT	0.765***	1.667***	0.765***	1.667***
	(0.108)	(0.163)	(0.154)	(0.137)
Log Exports	-0.792*	0.612	-0.792	0.612
	(0.416)	(0.834)	(0.556)	(0.964)
Log Imports	0.201	-0.773	0.201	-0.773
	(0.373)	(0.839)	(0.547)	(1.077)
Log RULC	2.078**	1.686	2.078	1.686
	(0.915)	(1.892)	(1.230)	(2.781)
Short-term interest rate	0.289***	0.270***	0.289***	0.270***
	(0.0282)	(0.0407)	(0.0552)	(0.0482)
Long-term interest rate	0.171***	0.110**	0.171***	0.110***
	(0.0331)	(0.0442)	(0.0353)	(0.0353)
REER	-0.0348***	-0.0705***	-0.0348***	-0.0705***
	(0.00549)	(0.0101)	(0.0119)	(0.0198)
Unemployment	-0.166***	-0.184***	-0.166***	-0.184***
	(0.0211)	(0.0376)	(0.0456)	(0.0386)
Constant	-17.93***	-0.0273	-17.93**	-0.0273*
	(6.414)	(0.0477)	(7.854)	(0.0137)
Observations	649	636	649	636
R-squared	0.586	0.365	0.586	0.365
Number of countries	21	21	21	21
Country FE	YES	YES	YES	YES
Cluster SE			YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Note: Variables in columns 2 and 4 are first-differenced.