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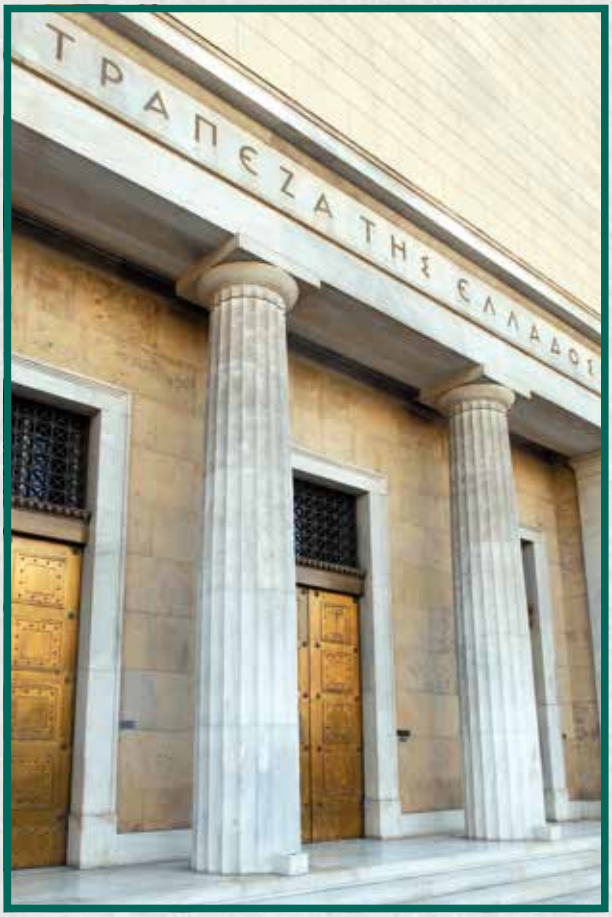

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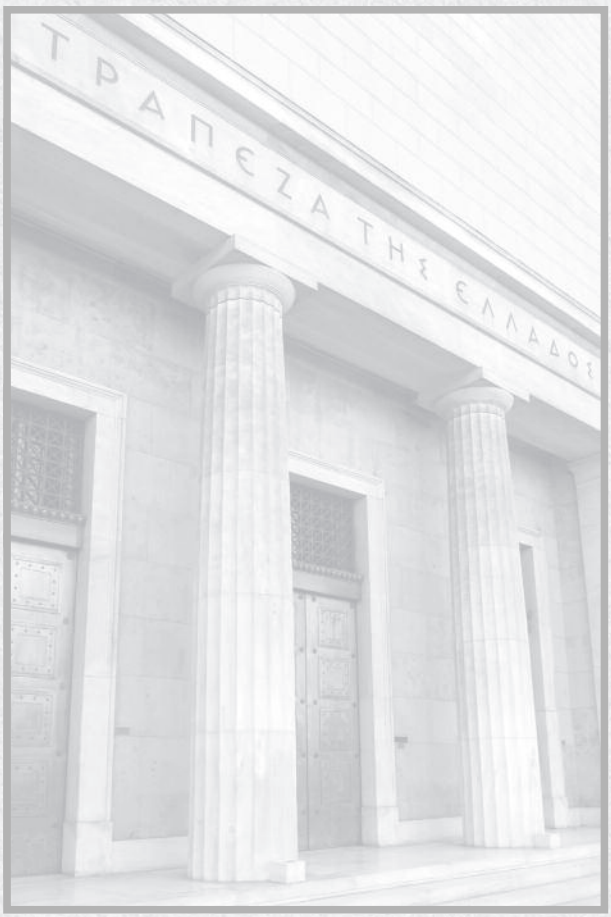

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BANK OF GREECE
21, E. Venizelos Avenue
GR-102 50 Athens

www.bankofgreece.gr

Economic Analysis and Research Department – Secretariat
Tel. +30 210 320 2393

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AN ASSESSMENT OF THE IMPACTS OF INFLATION ON GREEK PUBLIC FINANCES: MACROECONOMIC EFFECTS AND POLICY IMPLICATIONS

Sophia Lazaretou
Bank of Greece, Economic Analysis and Research Department

George Palaiodimos
Bank of Greece, Economic Analysis and Research Department

ABSTRACT

In 2022, the global cost of living surged, pushing already rising global inflation to multi-decade highs. Our empirical analysis assesses the impact of high inflation on Greece's public finances (in terms of flows), considering the extraordinary economic circumstances arising from the pandemic crisis and the initial phase of the recent energy crisis. To this end, we use a small-scale Bayesian vector autoregressive model for the Greek economy to quantify the effects of an adverse price shock on the primary balance, tax revenue and primary spending (all normalised by nominal GDP), as well as on real output, distinguishing between the effects of a demand- and an external supply-driven shock to inflation. We find that the nature of an inflation shock, i.e. whether it is demand- or supply-driven, is important for correctly identifying the short-to-medium-term effects of inflation shocks on fiscal outcomes.

Keywords: price inflation; public finances; COVID-19 pandemic; energy crisis; Greece; Bayesian Structural VAR

JEL classification: H5; H6; E3; C11

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ΕΚΤΙΜΗΣΗ ΤΩΝ ΕΠΙΠΤΩΣΕΩΝ ΤΟΥ ΠΛΗΘΩΡΙΣΜΟΥ ΣΤΑ ΔΗΜΟΣΙΑ ΟΙΚΟΝΟΜΙΚΑ ΤΗΣ ΕΛΛΑΔΟΣ: ΜΑΚΡΟΟΙΚΟΝΟΜΙΚΕΣ ΣΥΝΕΠΕΙΕΣ ΚΑΙ ΠΡΟΤΑΣΕΙΣ ΠΟΛΙΤΙΚΗΣ

Σοφία Λαζαρέτου
Τράπεζα της Ελλάδος, Διεύθυνση Οικονομικής Ανάλυσης και Μελετών

Γιώργος Παλαιοδήμος
Τράπεζα της Ελλάδος, Διεύθυνση Οικονομικής Ανάλυσης και Μελετών

ΠΕΡΙΛΗΨΗ

Το 2022 το κόστος ζωής σε παγκόσμια κλίμακα αυξήθηκε, ωθώντας τον ήδη αυξανόμενο πληθωρισμό τιμών σε επίπεδα που δεν είχαν παρατηρηθεί επί δεκαετίες. Κύριο ερώτημα της εμπειρικής ανάλυσης είναι η αξιολόγηση του αντικτύπου του υψηλού πληθωρισμού στα δημόσια οικονομικά της Ελλάδος (σε όρους ροών), εξετάζοντας την επίπτωση των έκτακτων οικονομικών συνθηκών λόγω της πανδημικής κρίσης και της πρόσφατης ενεργειακής κρίσης, τουλάχιστον στην αρχική της φάση. Για το σκοπό αυτό, χρησιμοποιούμε ένα μικρής κλίμακας διανυσματικό αυτοπαλίνδρομο σχήμα κατά Bayes για την ελληνική οικονομία που μας επιτρέπει να ποσοτικοποιήσουμε τις επιπτώσεις της ανόδου του πληθωρισμού στο πρωτογενές δημοσιονομικό αποτέλεσμα, στα φορολογικά έσοδα και στις πρωτογενείς δημόσιες δαπάνες (όλα τα μεγέθη εκφράζονται ως ποσοστό του ονομαστικού ΑΕΠ), καθώς και στην πραγματική οικονομική δραστηριότητα. Κρίσιμης σημασίας για την αξιολόγηση των επιπτώσεων του πληθωρισμού είναι η προέλευση της πληθωριστικής διαταραχής. Διαπιστώνουμε ότι το είδος της πληθωριστικής διαταραχής, δηλαδή το αν οφείλεται σε διαταραχές στη συνολική ενεργό ζήτηση ή σε διαταραχές στη συνολική προσφορά, είναι σημαντικός παράγοντας για τον εντοπισμό των βραχυπρόθεσμων και μεσοπρόθεσμων επιπτώσεων στα δημοσιονομικά μεγέθη.

AN ASSESSMENT OF THE IMPACTS OF INFLATION ON GREEK PUBLIC FINANCES: MACROECONOMIC EFFECTS AND POLICY IMPLICATIONS*

Sophia Lazaretou
Bank of Greece, Economic Analysis and Research Department

George Palaiodimos
Bank of Greece, Economic Analysis and Research Department

I INTRODUCTION

In 2022, the global cost of living surged, pushing already rising global inflation to multi-decade highs. The world economy is now experiencing a radical shift towards greater vulnerability and higher uncertainty. This shift maps the changing contours the world economy faces today. Geopolitical confrontations, a health crisis, a long-term demographic decline and more frequent and more destructive climate-related natural disasters are unprecedented supply-driven shocks that increase economic and financial vulnerability and hold back potential global economic growth (IMF 2022c). Prominent international economic organisations are pointing to an imminent risk of the global economy slipping into a near-term recession. This risk stems from persistently high inflation and stagnating growth, as central banks across the world simultaneously raised interest rates and, therefore, borrowing costs to fight inflation and prevent inflation expectations from becoming unanchored (see Georgieva and Malpass 2022; Rogoff 2022; IMF 2023).

The global economic recovery from the COVID-19 pandemic was accompanied by an energy crisis and a resurgence of inflationary pressures affecting the real disposable income of households and business profits. In an environment already burdened by rising inflation, Russia's war of aggression against Ukraine and the ongoing hostilities have brought about renewed price increases for energy, food and industrial commodities, which feed into headline inflation. Inflation expectations are also soaring amid continued supply-chain and trade disruptions, and weaker confidence in the economy. Eventually, heightened inflationary pressures seem to be quite persistent. In response to rising energy prices and the higher cost of living, governments have taken emergency measures to support the most vulnerable. However, the increasing burden of these measures on national budgets entails significant fiscal costs, leading to an upending of fiscal plans.

The theoretical and empirical literature on the overall impact of high inflation on public finances is abundant. We take as a starting point the well-known Phelps effect (see Phelps 1973). Its key idea is that, in order to alleviate the burden of distortionary taxation, governments have the option to rely on monetary financing. Following the build-up of large stocks of debt in the aftermath of the global financial crisis of 2007-08, there was a renewed interest of economists in reconsidering the role of inflation in facilitating debt reductions. For example, Rogoff (2010), Blanchard et al. (2010), Aizenman and Marion (2011) and di Bartolomeo et al. (2015), *inter alia*, examine whether a positive non-negligible inflation rate might be an optimal public finance tool to deflate nominal public debt and limit debt accumulation in the long run. More recently, Wickens (2022) and Heer et al. (2020) also examine the effectiveness of policy in influencing public finances by producing a positive inflation rate.

The key purpose of this paper is to analyse the potential impact of high inflation on Greek public finances. Four key factors underpin our

* This paper elaborates upon an initial idea briefly presented in Box 3 entitled "Impact of high inflation on public finances", *Monetary Policy 2021-2022: Executive Summary and Boxes*, 29-32, Bank of Greece, June 2022, available at https://www.bankofgreece.gr/Publications/NomPol20212022_en_Summary_Boxes.pdf. An early version was presented at the Bank of Greece seminars held on 4 July 2022. We are most grateful to all participants in the seminar for their comments, as well as to Pablo Burriel Llombart, Ivan Kataryniuk di Costanzo and Stephan Haroutunian for fruitful discussions and insights on the issue. The views expressed in this article are of the authors and do not necessarily reflect those of the Bank of Greece. The authors are responsible for any errors or omissions.

decision to choose Greece as the reference point of our analysis. First, accelerating nominal GDP growth in 2022 led to a reversal of the so-called snowball effect. Nominal GDP growth is the combined effect of real GDP growth and, broadly speaking, price inflation. If this trend continues, it will be a key factor in rapidly reducing the high debt-to-GDP ratio. Second, public debt remains elevated relative to the country's nominal output, thus making debt sustainability sensitive to increases in borrowing rates. Third, the Greek government has embarked on an exceptionally bold package of financial support measures to shield households and businesses from the energy crisis.[1] However, if the initial inflationary shock persists, this support may intensify budgetary pressures by increasing primary spending, which may fuel inflation. Fourth, before entering the euro area, Greece traditionally faced long-lasting demand-driven inflationary pressures and strong inflation expectations.[2]

Our analysis examines the impact of high inflation on Greece's public finances[3] (with a focus on the primary balance), considering the extraordinary economic circumstances arising from the pandemic crisis and the first phases of the Russian war of aggression in Ukraine, and the ensuing energy crisis.

By means of a standard small-scale Bayesian vector autoregressive model for the Greek economy, we quantify the effects of inflation shocks on government spending, tax revenue and the primary balance, all expressed as percentages of GDP. Our counterfactual analysis, by means of sign restrictions, considers the effects of an external supply-side and a demand-side shock to inflation on both fiscal variables and real growth, in the presence of a responsive monetary policy. We find that in the case of the Greek economy, the proper identification of the nature of the inflation shock, i.e. whether it is demand- or supply-driven, is important in order to correctly identify the medium-term effects on fiscal outcomes, when expressed as percentages of GDP. More specifically, a supply-side shock to inflation, despite its insignificant short-term impact on the ratio of primary balance to GDP, leads to a medium-term deterioration as a result of a decline in the ratio of total tax revenue to GDP, stemming from the estimated adverse effect on real growth. In the case of a demand-side shock to inflation, no significant effect is found either in the short or in the medium run. The key driver behind this type of inflation shock is the sizeable denominator effect that leads to parallel declines in tax revenue and primary spending, also when normalised by nominal GDP.

The rest of the paper is organised as follows: Section 2 describes briefly the evolution of the inflationary phenomenon; it explains both the short-term transitory factors and the structural dynamic factors that give rise to the inflation process. The latter are responsible for triggering a long-term upward inflation trajectory. Section 3 sets the framework for discussing the impacts of inflation on public finances, including the effect of inflation on the ratio of public debt to GDP. It presents the key policy dilemmas facing fiscal authorities: on the one hand, mitigating the negative effects of high inflation and, on the other hand, maintaining a credible fiscal balance. Section 4 sets the econometric framework used to quantify the effects and presents the empirical findings. Finally, Section 5 concludes.

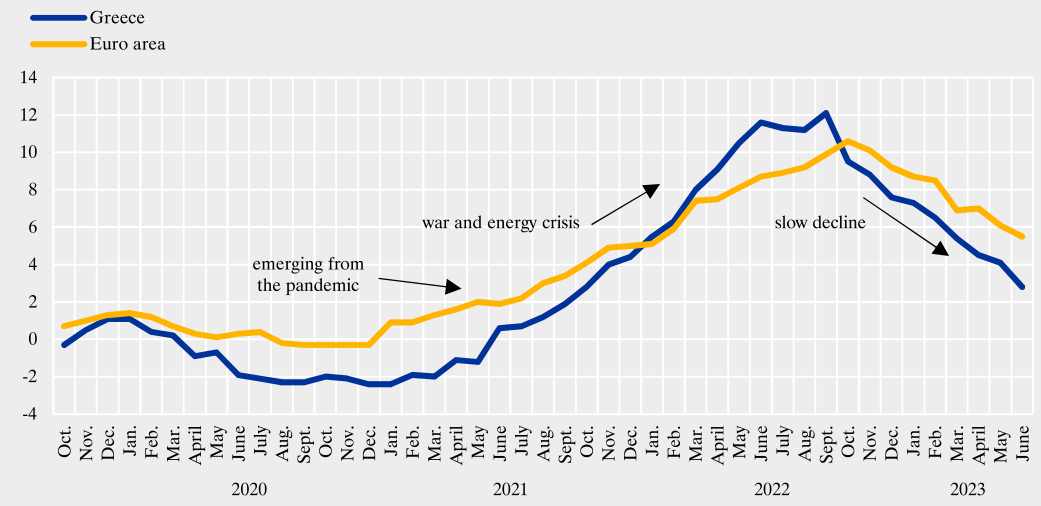
2 PANDEMIC, WAR AND INFLATION: UNCOVERING THE RESURGENCE OF INFLATIONARY PRESSURES

Before the war in Ukraine, as EU countries were emerging from the pandemic altogether, headline inflation, despite being on the rise, remained muted (see Chart 1). Inflationary pressures were thought to be temporary, as they resulted from supply-demand mis-

1 From September 2021 to January 2023, the Greek government allocated €9.5 billion or 5.2% of GDP. See Sgaravatti et al. (2023).
2 For the process of inflation in Greece in the pre-euro era, see Gibson and Lazaretou (2001) and Hondroyiannis and Lazaretou (2007).
3 Abstracting from the stock of public debt and ensuing issues of debt sustainability.

Chart 1 Inflation in the euro area and Greece (October 2019-June 2023)

(annual percentage changes)



Source: Eurostat.
Note: HICP, monthly data.

matches caused by pandemic-related supply shortages, temporary global trade disruptions and pent-up demand, especially for services (see Ha et al. 2021; European Parliament 2022). It was expected that the impact of resurging inflation would fade over time, as countries began to recover. Once global supply chains and production units returned to pre-pandemic normal, aggregate supply would adjust to the temporarily increased aggregate demand and, thus, inflation would return to its medium-term target.

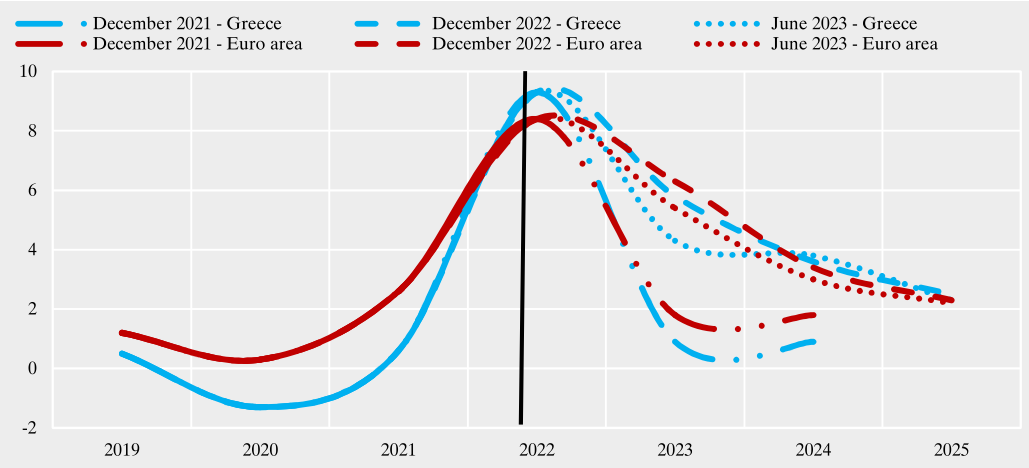
Meanwhile, with a zero lower bound on interest rates and positive output growth rates, conditions were favourable for financing government spending by creating debt without an increase in taxes later (see Blanchard 2019; Hall and Sargent 2021, 2022). In other words, it was expected that a combination of robust growth and temporary inflation would bring down the public debt-to-GDP ratio, even in cases where the fiscal balance remained in deficit.

However, as the war escalates and general geopolitical instability prevails, price inflation is strengthening and becomes persistent. As seen in Chart 1, inflation appears to gain momentum. Currently, supply-side disruptions, particularly distortions in the world energy and food markets resulting from the war and the subsequent sanctions, are adding to inflation. After peaking in September 2022, inflation followed a slow downward trend towards the end of the year and beyond. However, taming inflation will take some time, as shown by the successive upward revisions of the forecast average rate of headline inflation in both the euro area and Greece (see Chart 2). According to the latest forecasts, inflation is expected to moderate further on the back of falling energy prices; however, food price inflation and core inflation are expected to prove more persistent, chiefly due to the lagged pass-through effect of falling energy prices. Thus, inflation is now seen as the most serious threat to stable and sustainable global economic growth. On this ground, fiscal tightening can ease the task of monetary policy in reducing inflation, while mitigating risks to financial stability.

Nonetheless, apart from the temporary factors that shape a short-term upward trend, there are also structural and dynamic factors behind a long-term upward inflation trend. *Structural factors* particularly affecting the supply side

Chart 2 Inflation in the euro area and Greece, projections 2023-2025

(annual percentage changes)



Sources: Eurostat and ECB staff macroeconomic projections.
Note: HICP, monthly data. 2019-2022: historical data; 2023-2025: projections.

include: (i) a reversal of or retreat from economic integration and a fragmentation of global economy into distinct economic blocs with different ideologies, political and economic systems, technology standards, cross-border payment and trade systems and currency reserves that would heighten economic instability and raise enormous difficulties in international trade (Gourinchas 2022); (ii) an accelerated green transition, which would increase transition costs; and (iii) the climate crisis, entailing an increase in the frequency of extreme weather events and very high economic losses from natural disasters.

Dynamic factors refer to the role of central banks' credibility in anchoring inflation expectations and the possibility of de-anchoring of long-term inflation expectations, which would shift the expectations-augmented Phillips curve upwards and lead to higher unemployment and higher inflation (Carstens 2022). Also, trends like the ongoing Great Resignation that do not turn out to be driven by pandemic-related short-term factors, but rather reflect a more profound change, initiate structural changes in the labour market by raising the share of mismatched workers. Hence, competition among employers to hire or retain employees may keep wage inflation and, therefore, price inflation high (see Faccini et al. 2022).

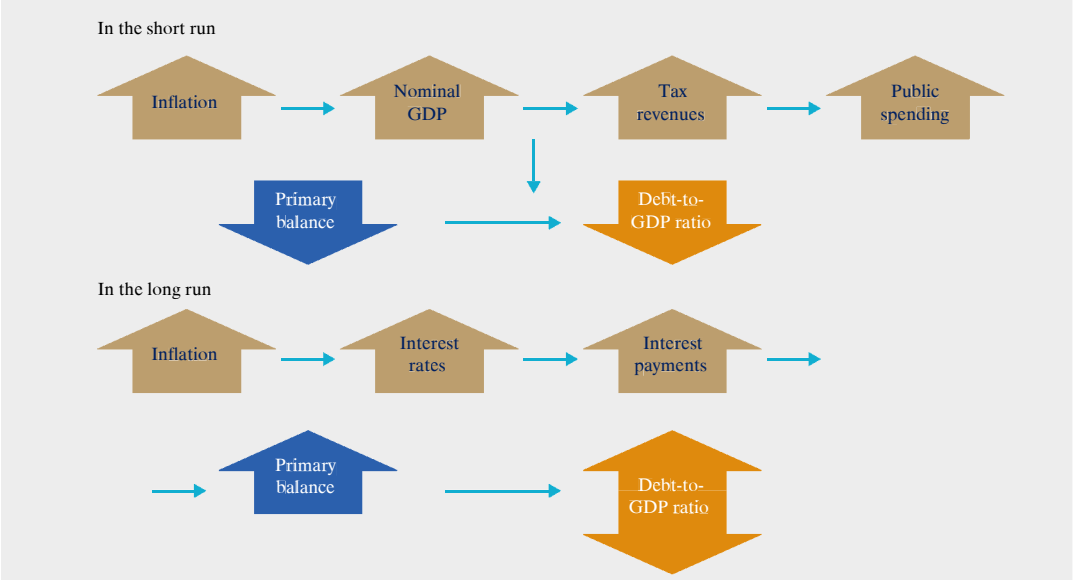
Beyond the aforementioned determinants, the wider effects of inflation *per se* are also directly related to its persistence. In particular, a low inflation rate causes changes in sectoral prices without spillover effects to other sectors. Conversely, high inflation activates inflationary expectations and thus causes spillover effects, which give inflation momentum and duration.[4]

3 MACROECONOMIC EFFECTS AND FISCAL POLICY DILEMMAS

It is often said that inflation is favourable for public finances. The main argument in this regard is that inflation raises nominal tax revenue mechanically and, by raising nominal GDP, it makes it easier, other things being equal, to repay a debt that has not changed (see Attinasi et al. 2016; End et al. 2015). Generally speaking, direct effects include the effects of

4 This happens when agents are not rational and forward-looking. See, for example, IMF (2022c).

Main channels through which inflation affects public finances (in levels)



indexing the parameters of the taxation system and the impact on nominal tax bases (see, for example, Beer et al. 2023). Indirect effects include the deterioration of economic and financial conditions. Nonetheless, the overall impact depends on the origin of inflation. In this section, we try to set out the various impacts of rising inflation on public finances.

Specifically, inflation has two main effects on the government budget and on the economy (see Figure above).

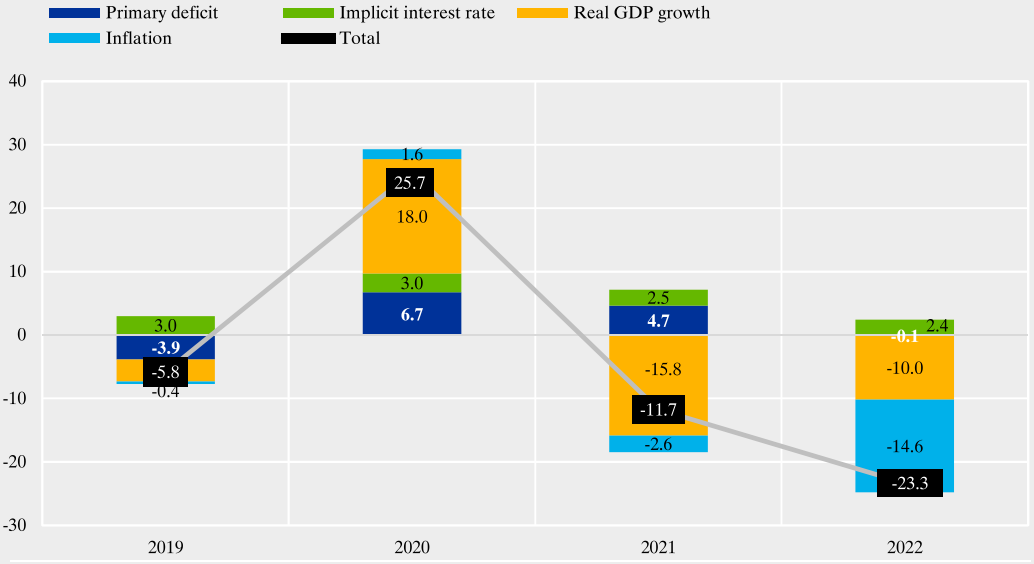
First, unexpectedly high inflation or an upside inflation surprise works as a current government debt reduction, since the real value of debt is repriced under new inflation expectations. This reduction in real debt drives down capital crowd-out and increases investment. Second, inflation directly affects government revenue from indexation. Higher inflation would push up tax allowances and nominal thresholds for income tax and social security contributions, which would reduce revenues. However, a higher indexation of excise duties and other indirect taxes, as well as a higher business tax rate multiplier would raise revenues. Additionally, as nominal incomes rise with inflation, nominal thresholds apply at lower real levels and increase the effective tax liability of taxpayers. The same also applies to capital income, since capital tax generally applies to nominal, not real, returns on investment. This means that not only nominal, but also real tax revenue would rise with inflation, which would generate an adverse effect on macroeconomic aggregates, as the real after-tax return on investment would fall. Summing up, the overall impact on government receipts would be small, especially when expressed as a percentage of nominal GDP.

Debt devaluation

An upside inflation surprise is a form of sovereign default. It works through two channels: by reducing the real value of government debt as well as the debt-to-GDP ratio, as nominal GDP increases with inflation. Inflation reduces the real wealth of savers and investors who hold fixed nominal return assets, such as non-indexed government bonds. If price inflation is expected, the real return on assets whose price accounts for inflation is maintained. An inflation surprise, however, produces an unexpected

Chart 3 Decomposition of annual changes in the debt-to-GDP ratio

(percentage points of GDP)



Source: Bank of Greece calculations.

loss in the real value of assets, since the income received by the holder of non-indexed assets has lost real purchasing power.[5] Thus, unexpected inflation effectively transfers wealth from non-inflation-linked government bond holders to the government. Taking into account that the speed of public debt accumulation depends on two factors, namely (i) the primary balance and (ii) the difference between the interest rate and the growth rate, multiplied by the debt level, there is an immediate effect on debt servicing costs for the inflation-indexed percentage of debt, as any increase in the price level directly translates into higher principal values.[6] For non-indexed debt, there is a progressive effect linked to the rise in market interest rates, as debt is refinanced.

In both cases, the debt burden increases. If nominal GDP increases by the same or even a higher amount, the debt-to-GDP ratio either remains constant or declines. At the current juncture, however, if real GDP is adversely affected by the energy-driven inflation shock, debt accumulates faster. Furthermore, if market interest rates rise much faster than inflation, the favourable effect of inflation on debt reduction through nominal GDP is moderated or even reversed. It becomes apparent that the sensitivity of the public debt-to-GDP ratio to inflation changes depends on the pass-through from inflation to expected nominal sovereign interest rates, which effectively captures the monetary policy response to the inflation shock.

To explicitly examine the effect of inflation on public debt dynamics, we use the standard decomposition of public debt change into its fundamental drivers, i.e. the primary balance, the implicit interest rate, the real GDP growth rate and the deficit-debt adjustment (see Hall and Sargent 2010), that is:

$$d_t = \frac{(1+r)}{(1+g)(1+\pi)} d_{t\text{-}1} + p_t + dda_t \qquad (1)$$

where d_t is the ratio of nominal debt to nomi-

5 The longer the duration of the debt, the more it is affected by a permanent increase in inflation.

6 Inflation-linked bonds can help investors to hedge against inflation risk on the basis of the bond contract, since they increase in value during inflationary periods. They link the bonds' principal and interest payments to inflation and thus soften the real impact of inflation on bond holders.

nal GDP at time t, r is the implicit nominal interest rate calculated as interest payments divided by the amount of debt in the previous year, π is the inflation rate, g is the growth rate of real GDP, p_t is the net-of-interest budget deficit as a percentage of nominal GDP and dda_t is the deficit-debt adjustment as a percentage of nominal GDP.

With this decomposition, it is possible to analyse the sizeable impact that inflation exerts on public debt dynamics. Specifically, if the numerator in (1), i.e. the annual cost of debt servicing, increases faster than the nominal rate of GDP growth, then the debt-to-GDP ratio increases and a primary surplus is required for debt sustainability. But if the numerator grows at a slower rate than the denominator, then the debt ratio falls, even if the primary balance is in deficit. In other words, if inflation is moderate and temporary, fiscal policy does not react by increasing spending, and nominal interest rates rise at a much slower pace than inflation, then deficit countries will be offered the necessary time for a gradual fiscal adjustment.

In line with the above, Chart 3 assesses these effects as well as the contribution of all determinants described in equation (1) in the case of Greece. As can be seen, in 2022 inflation had the largest positive contribution to the fall in the public debt-to-GDP ratio (exceeding 14 percentage points of GDP).[7]

Tax and expenditure effects

Inflation causes tax distortions, given that tax bases and tax rates are typically defined in nominal terms. Tax is levied on nominal tax bases, such as wages and salaries, savings, profits and consumer spending. If there are no automatic indexation mechanisms, that is when non-indexed tax bracket thresholds are in place in a progressive tax system, then high inflation pushes nominal incomes into higher tax brackets. Known as "bracket creep" effect, this can create an inflationary fiscal drag, as taxpayers pay more money on taxes without any increase in their take-home income. This effect is mainly associated with a progressive income tax system. Similarly, taxation of nominal returns on savings means that higher inflation leads to higher tax payments and, thus, lower real after-tax rates of return. On the other hand, fixed allowances, particularly on expenses and tax credits, are less influenced by high inflation rates. However, with increasing price levels, the present value of depreciation, which is fixed in nominal terms, falls short of the real capital cost, thereby depressing investment despite the increase in nominal revenues. Moreover, with fixed nominal interest rate charges on overdue payments, real rates are decreasing as inflation rises, thus making payment delays less costly. Conversely, higher inflation raises nominal interest payments on debt, allowing greater deductibility from taxable income.

Overall, given that wages remain subdued and are subject to higher effective tax rates, while any upward effect of price increases on the nominal value of sales for firms and, therefore, on their profits depends on the extent to which profit margins are squeezed by rapid cost increases, the positive effect on nominal income/revenue would be small. Furthermore, higher consumer prices push up nominal consumer spending and VAT revenue increases mechanically for a given volume of consumption.

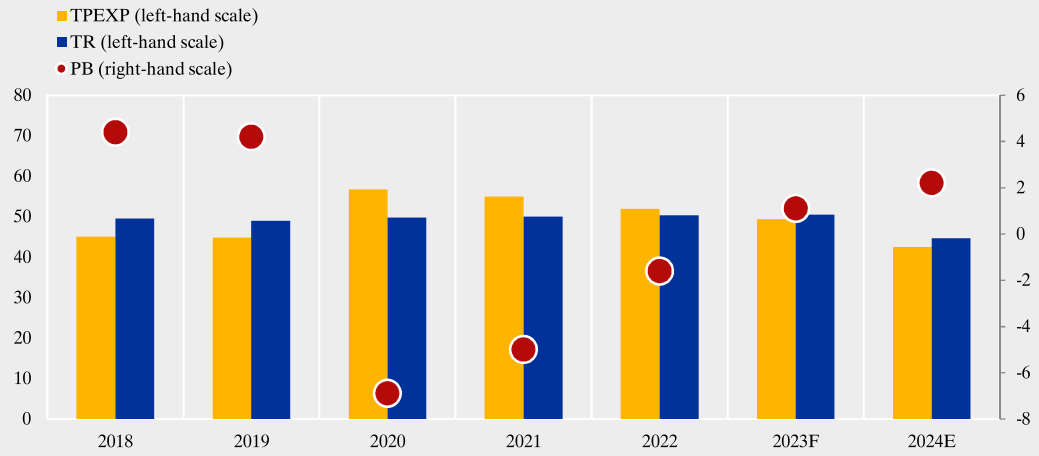
However, tax bases in real terms move in a direction that depends on the origin of inflation. In particular, if inflation is linked to a rapid recovery in aggregate demand, tax bases increase not only nominally, but also in real terms, and public finances improve. Conversely, if inflation is linked to a supply shock, as is the case in the current energy crisis, then prices and nominal incomes rise, while real GDP, real disposable income and consumption decrease. Hence, public finances deteriorate substantially due to a decrease in tax bases.

The same also holds when inflationary pressures prove more persistent than expected.

7 For a similar accounting exercise for Spain, see de Cos et al. (2016).

Chart 4 Evolution of total tax revenue (TR), primary government spending (TPEXP) and primary balance (PB) since 2018

(% of GDP)



Source: AMECO database (European Commission, Winter 2023 Economic Forecast).
Note: E and F denote estimates and forecasts, respectively.

There is a risk of negative indirect or second-round effects in real terms, as economic agents pass through price rises to wage-price setting in an effort to maintain real wages, potentially leading to a price-wage spiral. To avoid the impact this may have on private agents' inflation expectations, which are a key driver of nominal wages, monetary policy tightening acts to reduce demand-driven inflation. Consequently, interest rates are raised to stop inflation expectations and wage claims from increasing. In this case, however, borrowing costs are rising for the public and the private sector alike, bringing about a worsening in economic and financial conditions.

Primary balance

Broadly speaking, inflation increases tax revenue, government spending and nominal GDP in parallel. However, in the short run, as government spending is only partially indexed and tax revenue increases faster than government expenditure, rising prices would improve the overall primary balance expressed in levels. In other words, for a given quantity of a tax base (e.g. income, consumption), if consumer prices rise, VAT revenue will also rise; if nominal wages and profits rise, personal and corporate income tax revenue as well as social security contributions will also rise.[8] Nevertheless, this positive effect will quickly dissipate if there are some public expenditures that are indexed to prices (pensions, family benefits, house allowances and minimum income). More importantly, government spending will rise as other expenditure items are gradually indexed, such as civil service salaries, procurement contracts and support measures that governments take to protect the purchasing power of households and limit cost increases for companies.

However, when expressed as a percentage of nominal GDP[9] (see Chart 4), the effect of the denominator can lead to a deterioration in the respective ratios of the primary balance, tax revenue or primary expenditures. In the case of the Greek economy, starting from 2018 and over a 6-year horizon, despite the significant windfall collected in 2022 and part of 2023, expressed as a percentage of GDP, total tax revenue remains almost the same, while primary expenditures decline, which, aside from

8 This should hold true in the case where income tax brackets are not adjusted for the trend of inflation (fiscal drag).
9 Which is more relevant from a debt sustainability point of view.

the unwinding of measures, admittedly also entails a strong denominator effect.

Fiscal policy dilemmas

The pandemic took a heavy toll on public finances, leaving a legacy of large deficits and high government debt. Currently, however, amid widespread high uncertainty and an inflation explosion, fiscal policy is confronted with two additional challenges: the first is to manage the impact of persistently high inflation on household and business budgets, so as to enable the continuation of post-pandemic recovery. The second is to simultaneously achieve a faster restoration of sound fiscal positions, by demonstrating flexibility and adaptability (see IMF 2022c, 2022a).

Specifically, the fiscal policy response to an inflation shock is closely associated with inflation persistence. In the short run, when inflation is low and temporary, the challenge for fiscal policy is to strike the right balance between tax rates and public spending, so as to, on the one hand, stimulate a stagnant economy, without, however, creating the risk of a rise in demand-driven inflation, and, on the other hand, safeguard fiscal balance in order to avoid the risk of debt becoming unsustainable. In the long run, if inflation indicators are surprisingly to the upside, the economy is probably at risk of overheating and a price-wage spiral could be in process. Then, monetary policy should react by raising interest rates at the cost of rising sovereign debt costs. A primary surplus is, therefore, required to safeguard debt sustainability, as interest rates rise faster than the inflation rate. Otherwise, if fiscal policy remains expansionary, inflation expectations will become de-anchored and fuel wage-price inflation, resulting in higher inflation rates. Going forward, economic adjustment will be painful, as it will require ever larger interest rate hikes as well as larger primary surpluses (see Blanchard and Pisani-Ferry 2022; Blanchard 2022; Leeper et al. 2019).

Summing up, in the short run, an inflationary shock, defined as a positive difference between actual (*ex post*) and forecast (*ex ante*) inflation, exerts a positive impact on public debt dynamics. The reason is that unexpected, yet moderate, inflation can have a benign short-run effect on the primary balance-to-GDP ratio, since tax revenue is usually expressed as a percentage of nominal GDP. Moreover, when such inflationary surprise is due to shocks on the demand side, the pursuit of a countercyclical fiscal policy in order to stabilise the business cycle and prevent the economy from overheating results in a reining-in of government spending. In the case of cost-push inflation, governments usually increase spending (grants and benefits) in an attempt to mitigate the recessionary effects of inflation on real incomes.

However, medium-to-long-term debt and fiscal sustainability depend on price stability, since persistently high inflation has a negative impact on real household and business income, leading to lower consumer and investment spending and, therefore, lower GDP growth. Moreover, persistently high inflation puts pressure on fiscal policy to increase public spending in order to boost domestic demand, thus posing the threat of a price-wage spiral. Monetary policy also comes under strong pressure to control inflation by raising interest rates, which would lead to higher nominal borrowing rates and, thus, higher debt dynamics in the medium term.

4 EMPIRICAL EVIDENCE: THE ECONOMETRIC FRAMEWORK

Our empirical investigation follows the Bayesian adaptation of a standard VAR model[10] based on quarterly data for Greece covering the period 2000 Q1-2022 Q2. The chosen period captures the impact of three milestones on the course of the domestic economy, namely, Greece's entry to the EMU in

10 We make use of the BEAR toolbox (Dieppe et al. 2016). The employed model does not consider the case of a non-linear Phillips curve, as the one recently developed by Harding, Lindé and Trabandt (2022) to explain post-COVID inflation dynamics.

2001; the sovereign debt crisis of 2010 and the subsequent long-lasting economic crisis; the pandemic and, to a smaller extent, the initial effects of the recent Russian war of aggression in Ukraine. The general specification is as follows:

$$Y_t = A_0 + \Sigma_{i=1}^{p} A_i Y_{t-i} + e_t \quad (2)$$

where Y_t denotes the vector of endogenous variables of the BVAR[11] model and p denotes lag structure (5 lags utilised). In our analysis, we assume $Y_t=(\pi_t, y_t, r_t, pb_t)$, where π_t denotes the quarterly average of HICP inflation (y-o-y), y_t is the annualised quarterly real growth rate of the Greek economy, r_t is the quarterly average of the 3-month Euribor and pb_t is the primary fiscal balance (expressed as a percentage of quarterly GDP). In the above simplified BVAR specification, we do not consider dynamics related to GDP deflators and debt, abstracting from feedback loops between deficit and debt in line with Bohn's (1998) literature.

We consider two different identification schemes with respect to structural shocks. The first one is the standard Cholesky decomposition of the variance-covariance matrix of the VAR residuals[12] and is used to provide an answer about the general effects of inflation on public finances (Model A).

To address the extent to which supply- and/or demand-driven inflation shocks also have important implications for fiscal policy in the Greek economy, we employ a second identification scheme by means of a sign restrictions version of the Bayesian VAR following the identification strategy of Fry and Pagan (2011), Shapiro (2022) and Jump and Kohler (2022). This identification scheme is used to assess the direct effects of high inflation on the primary balance by distinguishing between demand- and supply-driven shocks to inflation and real growth. In particular, external supply-side shocks related to disruptions in global supply chains and changes in spending patterns due to the COVID-19 pandemic pushed up inflation globally. At the same time, following the lockdowns during the pandemic, demand-side shocks related to pent-up demand[13] and increased savings were also present and pushed up price inflation. Overall, countries experiencing high inflation immediately after the pandemic and during the war in Ukraine benefited from positive effects in the form of windfall tax revenue that enabled the adoption of measures to support households' income and firms' profits in a high inflation environment.

More specifically, under the second identification strategy (SVAR), we disentangle supply- and demand-driven shocks to inflation, considering the external supply-side shock as a purely cost-push shock that affects inflation and output. To do so, we extend our set of endogenous variables by including crude oil prices denoted by cop_t and denominated in euros (Model B).

Our adopted formation of demand- and supply-side shocks follows an identification strategy based on a standard textbook view.[14] A demand shock moves both prices and real output (i.e. quantities) in the same direction along an upward-sloping aggregate supply curve, while supply shocks move prices and real output in opposite directions along a downward-sloping aggregate demand curve. In the latter case, and to better capture the effects of an external sup-

11 Regarding the prior distributions for our BVAR model, we follow its simplest form and employ the Minnesota (or Litterman 1986) prior. In this framework, it is assumed that the VAR residual variance-covariance matrix is known. Moreover, we use optimal hyperparameter values from a grid search based on the seminal paper by Giannone et al. (2012), who propose a procedure that allows selection of hyperparameters that maximise the value of the marginal likelihood for the model. For details, see the BEAR toolbox technical guide.

12 As assumed in Box 3, *Monetary Policy 2021-2022: Executive Summary and Boxes*, Bank of Greece, 2022.

13 At the heart of the New Keynesian theory lies the Phillips curve, which posits that inflation deviates from its expected path due to aggregate demand and supply factors. More recently, researchers have pointed to both supply and demand factors to explain the recent post-COVID inflation surge. For example, according to Jordà et al. (2022), strong demand shocks stemming from unemployment assistance, direct household transfers, child support, business loans and other pandemic assistance programmes had sizeable spillovers to inflation dynamics in 2022 in the case of the US economy. On a similar note, Ball et al. (2022) also attribute US inflation dynamics in the post-COVID-19 era to labour market demand shortages and supply-driven energy price increases, as well as to supply chain disruptions.

14 See Jump and Kohler (2022) and Shapiro (2022).

Sign restrictions for macro model shocks (Model B)

Variable/shock	Supply-side shock (cop_t)	Demand-side shock (π_t)
π_t	+	+
r_t	+	+
y_t	–	+

ply-side shock, we impose block exogeneity[15] between the domestic variables π_t, y_t, pb_t and cop_t that effectively denotes price-setting at the global level. This assumption can be seen as capturing the relatively small size of the Greek economy compared to other economies that directly affect global supply shocks (e.g. China, the United States, etc.).

The table provides a summary of the sign restrictions imposed to decouple the two types of assumed shocks following Faust (1998), Uhlig (2005) and, more recently, Shapiro (2022). The first column captures an external supply shock in the form of a cost-push shock that negatively affects real growth, while the demand-side inflation shock operates in the opposite way, affecting output positively. Given the current context of monetary policy tightening in the euro area, we also assume a responsive monetary policy that increases interest rates when both types of shocks materialise.[16]

5 IMPULSE RESPONSE ANALYSIS

Cholesky decomposition (Model A)

Under the first identification scheme, the typology of structural shocks follows the ordering of the variables in vector Y_t. More specifically, an inflationary shock (sized by one standard deviation) sequentially passes on to real output growth (y_t), nominal interest rates (r_t) and, lastly, fiscal variables (i.e. the primary balance and its split into total tax revenue and primary spending, expressed as percentages of GDP). Under this assumption, relationships are defined between reduced shocks in the first period, while every shock can be affected by any other shock in subsequent periods.

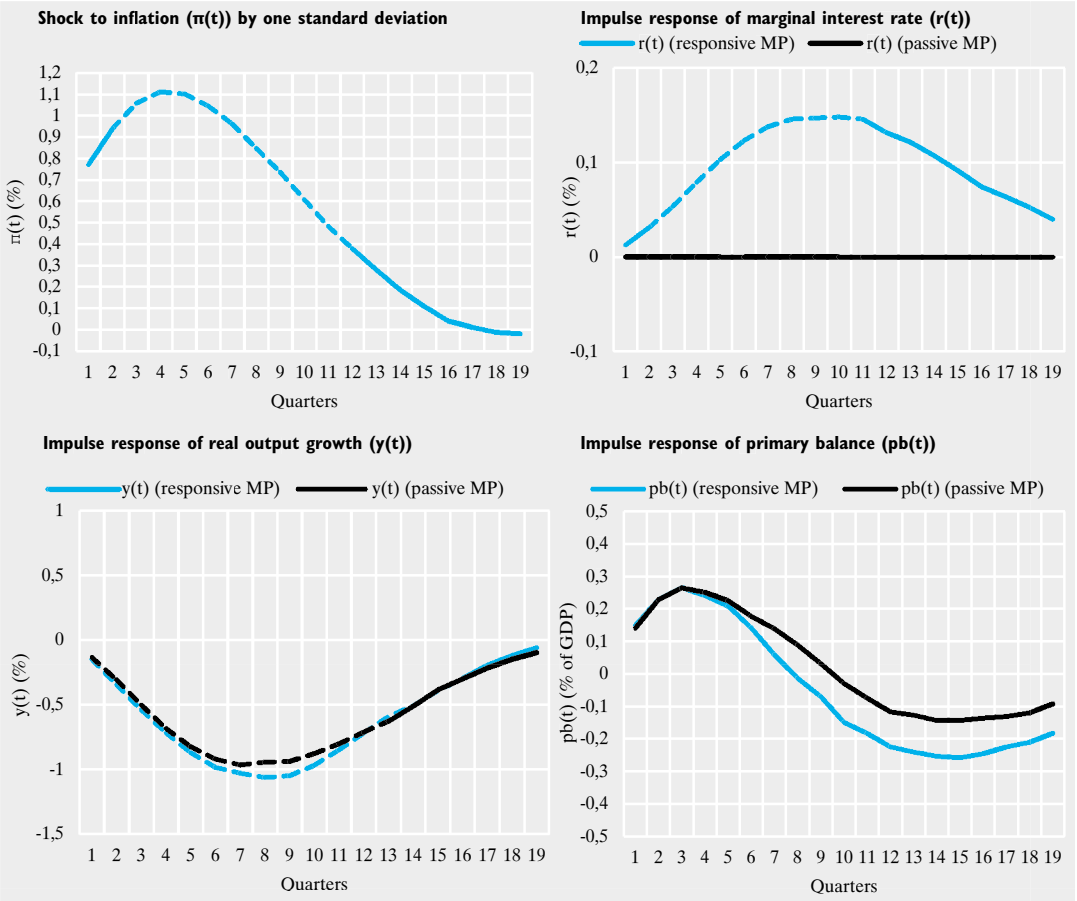
We also present scenarios for a differential monetary policy stance, by means of block exogeneity of variable r_t. In more detail, we present the case of an idiosyncratic inflationary shock, where r_t does not react to changes in π_t, y_t, and pb_t (denoted as passive monetary policy (MP) scenario) and compare it to a counterfactual where r_t increases, describing more clearly the case of a homogeneous horizontal shock across the euro area (denoted as responsive MP scenario).

Chart 5 shows the impulse responses to a positive shock to inflation based on our simplified four-variable BVAR model. It follows that the response of monetary policy is instrumental to the impact of inflation (top-right panel) on the macro and the fiscal side. A responsive MP scenario is estimated to be more detrimental to real activity (bottom-left panel), as well as to the primary balance as a percentage of GDP (bottom-right panel). Yet, in the latter case, some visible improvement in the response of the primary balance in the short run is not statistically significant and the same also holds over the medium term, despite some adverse effects resulting from the impact of inflation on real disposable income.

Chart 6 plots the response of total tax revenue and primary spending (both expressed as percentages of GDP) to an inflationary shock, assuming again a responsive monetary policy.[17] The short-run inflexibility of primary spending in levels[18] and the sizeable "denominator effect" yield the estimated adverse impulse

15 On the formation of block exogeneity and the construction of external supply shocks, see the BEAR toolbox (Dieppe et al. 2016).
16 We make this assumption as we try to formulate a global supply-side shock where the ECB's monetary policy stance reacts to avoid a de-anchoring of inflation expectations. In the same context, we also abstract from the implied dynamics of GDP deflators.
17 Actually, we assume no block exogeneity. The case of passive monetary policy conveys similar dynamics to both total tax revenue and primary spending.
18 Inflexibility basically reflects persistency of budgetary appropriations during a fiscal year and lower indexation of various spending items as well.

Chart 5 Shock to inflation (π(t)) by one standard deviation: impulse responses under passive vs responsive monetary policy (MP) scenarios



Source: Authors' own estimations.
Note: Dashed lines denote statistical significance at the 68% level.

response, when primary spending is expressed as a percentage of nominal GDP.[19] The relatively milder and lagged adverse effects on revenues, observed in the short to medium term, reflect the relatively cyclical nature of tax revenue due to the large share of indirect taxes[20] in total tax revenue and their direct link to private consumption and inflation.

Distinguishing inflation shocks into external supply and demand shocks: the sign restriction approach (Model B)

We proceed with the implementation of the assumed sign restrictions in our BVAR context. Chart 7 presents the obtained quarterly series of the demand- and supply-driven inflation shocks. It turns out that the series accord[21] with the standard narrative concerning the

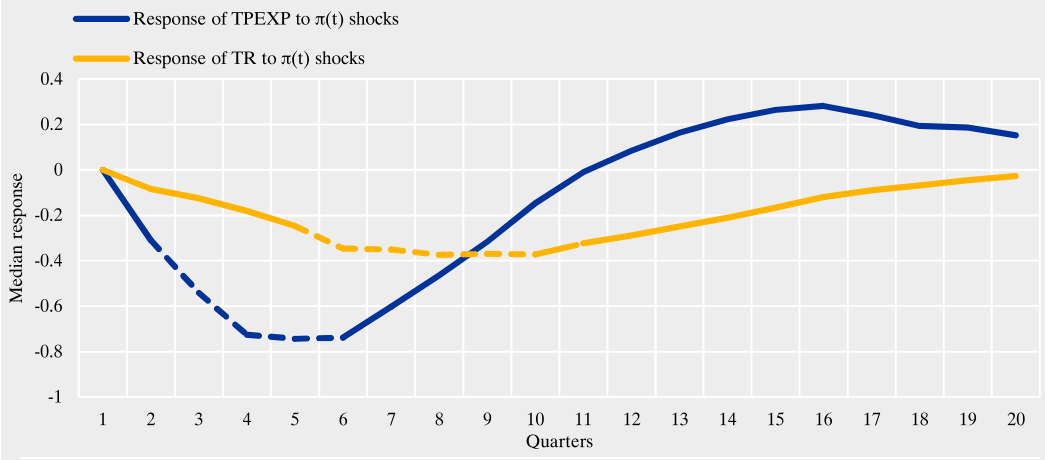
19 According to Bankowski et al. (2023), "...at the euro area aggregate level, the share of automatically indexed expenditure in 2022 is on average one-third of total government expenditure", which effectively leaves the rest of the primary spending items considered relatively less flexible to inflation shocks. In the case of Greece, the spending side indexation remains relatively limited, given the nominal wage freeze in the public sector for almost a decade now and the fact that the pass-through of higher borrowing rates to cash interest payments is very limited due to the virtually 100% share of fixed rate debt and the limited rollover needs.

20 According to the OECD (2023), the Greek taxation system traditionally relies heavily on indirect taxes and more specifically on taxes on production and sales.

21 Following Känzig (2021), we consider the correlation between the two shocks as a diagnostic control test. We found an admittedly low correlation (+0.18) between the demand and supply shocks, which implies a weak linear dependence between the two.

Chart 6 Shock to inflation (π(t)) by one standard deviation: impulse responses of total tax revenue (TR) and primary government spending (TPEXP)

(% of GDP)

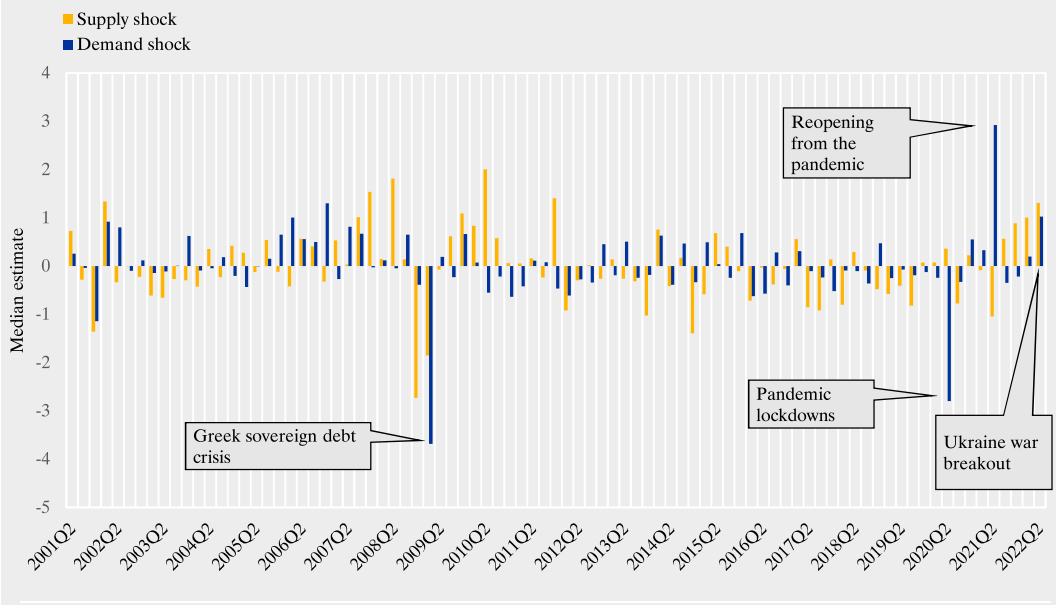


Source: Authors' own estimations.
Notes: Assuming a responsive monetary policy. Dashed lines denote statistical significance at the 68% level.

Greek economy not only during the sovereign crisis in early 2010 but also during the pandemic, when the necessary lockdowns had a negative impact on aggregate demand as well as on aggregate supply, given the global trade disruptions and supply chain bottlenecks. As shown in the chart, the impact of the war in Ukraine has a relatively limited weight, given that our sample period ends in the second quarter of 2022.

Chart 7 Illustration of demand- and supply-side shocks to price inflation

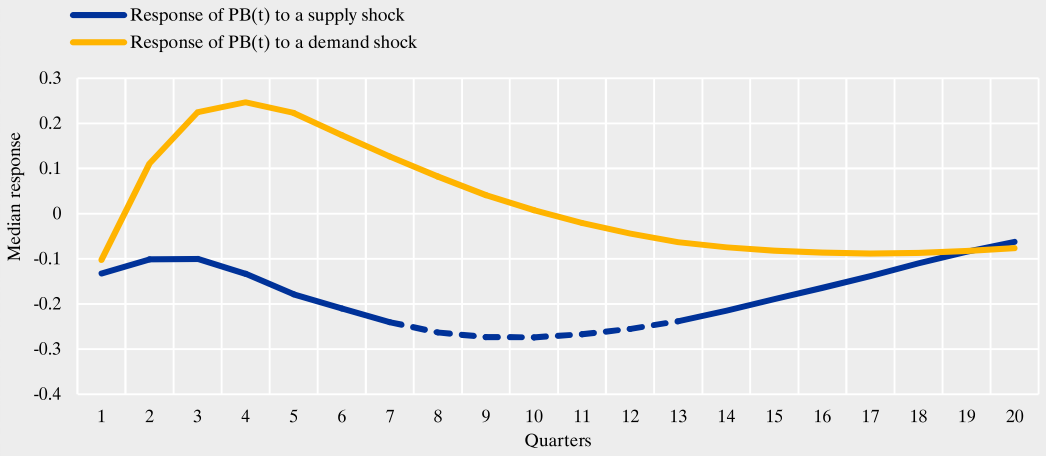
(%)



Source: Authors' own estimations.

Chart 8 Impulse response functions of primary balance (PB) in the case of a demand-side and an external supply-side shock to price inflation

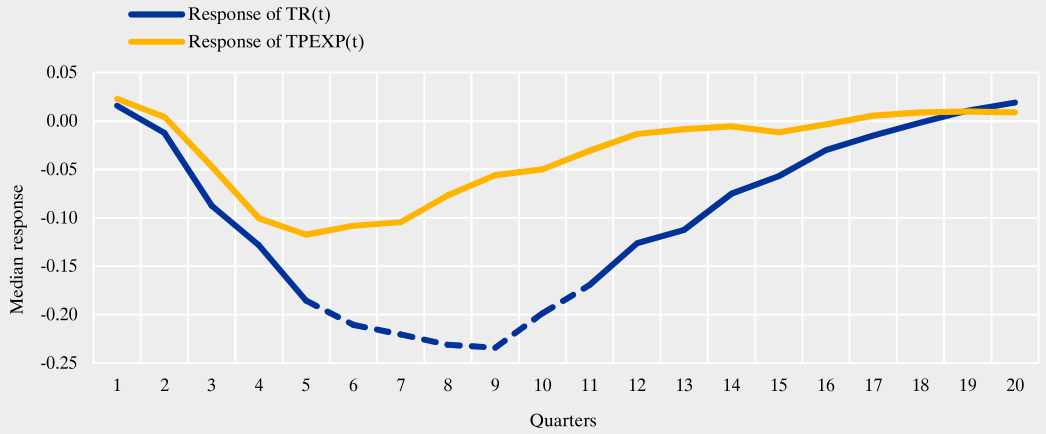
(% of GDP)



Source: Authors' own estimations.
Note: Dashed lines denote statistical significance at the 68% level.

Chart 9 Impulse response functions of total tax revenue (TR) and primary government spending (TPEXP) in the case of an external supply-side shock

(% of GDP)

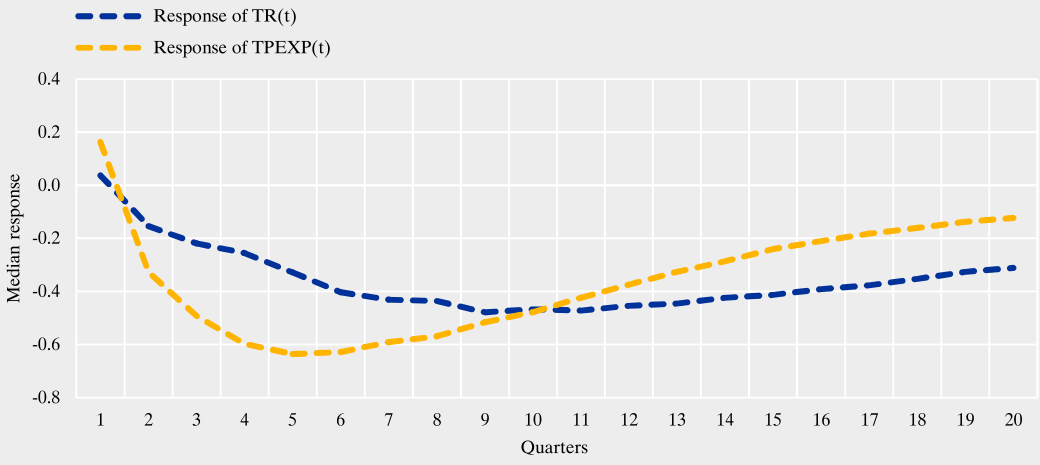


Source: Authors' own estimations.
Note: Dashed lines denote statistical significance at the 68% level.

Chart 8 illustrates a comparison of the impulse response of the primary balance (as a percentage of nominal GDP) in the case of a demand and a supply shock to inflation. More specifically, in the short run, despite opposite median estimates (positive in the case of a demand shock and negative in the case of a supply shock), both shocks appear to have an overall insignificant effect on the primary balance-to-nominal GDP ratio. However, in the medium term, our model estimates a statistically significant negative impact in the case of a supply shock (cost-push inflation), which reflects the adverse effects of supply disrup-

Chart 10 Impulse response functions of total tax revenue (TR) and primary government spending (TPEXP) in the case of a demand-side shock

(% of GDP)



Source: Authors' own estimations.
Note: Dashed lines denote statistical significance at the 68% level.

tions on real growth and disposable income. Indeed, during the same period, demand-driven inflation shocks have an insignificant effect on the primary balance, despite positive median estimates.

Charts 9 and 10 plot fiscal responses when replacing the primary balance with its main components, i.e. total tax revenue (TR) and primary spending (TPEXP),[22] in the case of a supply- and a demand-driven shock.[23] The analysis provides no evidence of a significant short-run effect on either primary spending or tax revenue[24] (as a percentage of nominal GDP) from an external supply shock (see Chart 9). In the medium term, however, a negative impact should be expected on the revenue side, followed by an insignificant impact on total primary spending. These effects mainly capture the adverse first-round effects of a supply-driven inflation shock on households' real disposable income and real output growth.[25]

In the case of a demand-side shock to price inflation (see Chart 10), the insignificant effect on the primary balance (as a percentage of GDP) is broadly in line with the significant effects on primary spending and total tax revenue that overall cancel each other out in the short to medium run. These effects reverse right after, confirming the previously estimated response of the primary balance in Model A (see Chart 4). Same as before, the estimated short-run decline in primary spending compared to total tax revenue captures the inherent inflexibility of primary spending expressed in levels. At the same time, tax revenue includes both regular tax revenue and tax resources accrued from high energy prices, as the recent energy price hikes generated a considerable increase in government resources.[26] Lastly, comparing supply- and demand-driven shocks to inflation, the magnitude of the effects on total tax revenue (TR) follows a ratio of around 1:3. The same also holds in the

22 In doing so, we have also considered a reactive monetary policy followed by block exogeneity on the crude oil price variable (cop_t).
23 The historical decompositions of inflation and real growth with respect to supply- and demand-driven shocks are presented in Chart A1 of the Annex, while Charts A2 and A3 present the impulse response functions derived from Model B.
24 This implies that in the short run the estimated elasticity of nominal GDP and revenues (in levels) should be close to one.
25 Negative through the assumed sign restrictions.
26 The Energy Transition Fund is responsible for collecting revenues from the auctions of CO_2 rights. This additional source of revenues significantly contributed to the build-up of windfall revenues during the recent Russian war in Ukraine and helped the financing of fiscal measures during the energy crisis.

case of primary spending (TPEXP) (see Charts 9 and 10). This is suggestive of a more sizeable denominator effect in the case of a demand-driven compared to a supply-driven shock to price inflation.

6 CONCLUSIONS

This paper assesses the impact of an inflation shock on public finances in the case of the Greek economy. By means of a Bayesian vector autoregressive model, we quantify the effects of an inflation shock on primary spending, taxes and the primary balance, as well as on real output, by disentangling demand- from supply-driven shocks to inflation. Specifically, our empirical analysis compares a demand-driven inflation shock, which is found to have a significant denominator effect, and a supply-driven inflation shock with a significant negative effect on real growth. While in the short run (up to 4 quarters) one can safely expect tax revenue and primary spending to remain broadly stable when expressed as percentages of nominal GDP, their medium-term profile is also associated with the nature of the shocks driving inflation hikes.

In particular, in the case of a demand-driven inflation shock, there is a positive, yet insignificant, impact on the ratio of primary balance to GDP, while in the case of a supply-driven inflation shock a clear deteriorating impact is estimated in the medium term (after 4-5 quarters). Lastly, demand-side shocks appear to have a negative impact on both tax revenue and primary spending (expressed in percentage points of GDP), though the two effects cancel each other out, resulting in an insignificant effect on the primary balance, whereas, in the case of an external cost-push inflation shock an adverse impact should be expected on tax revenue and the primary balance (expressed in percentage points of GDP) in the medium term. In conclusion, from a policy point of view, an evidence-based and informed view on the typology of inflation shocks is important for properly assessing the medium-term effects of inflation on fiscal outcomes and debt sustainability *per se*.

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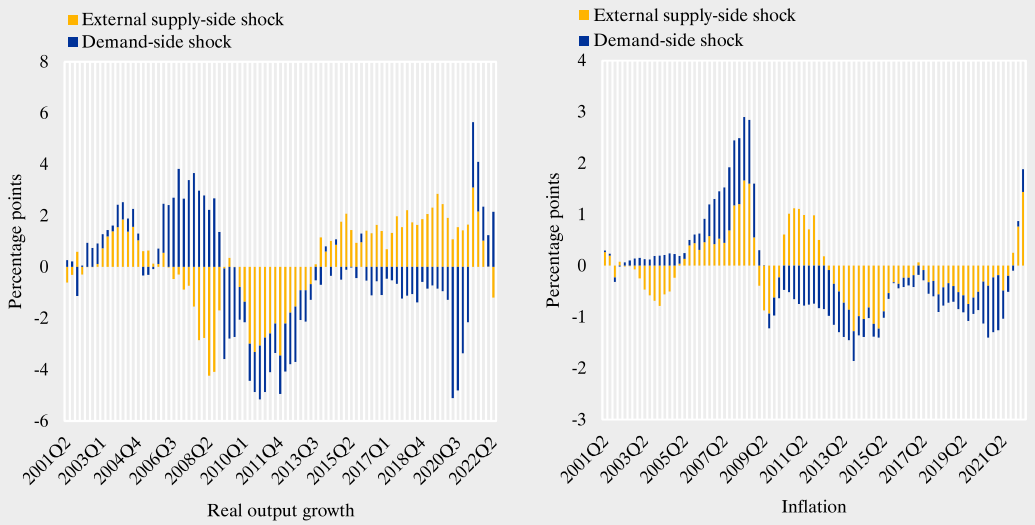
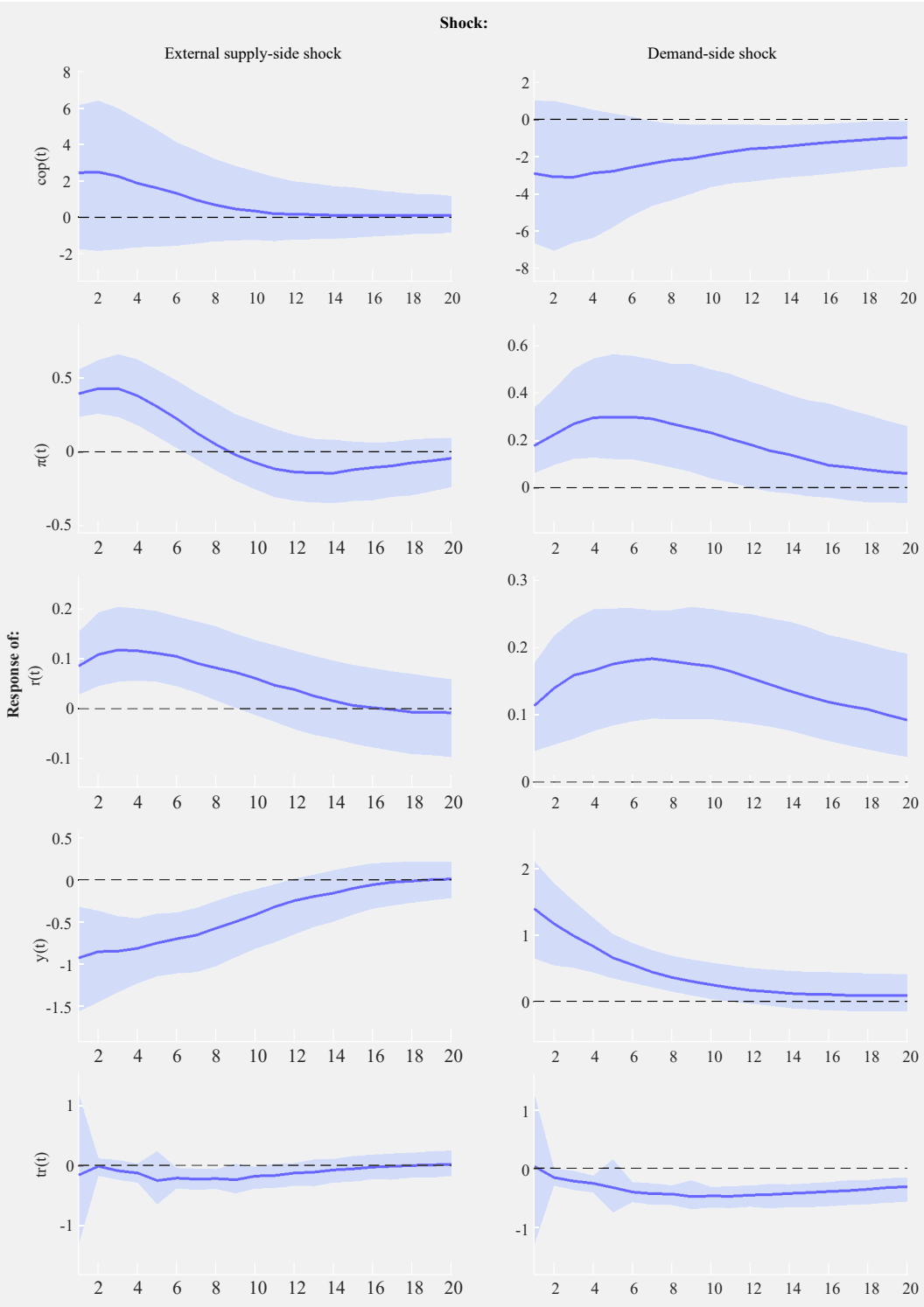
ANNEX

Chart A1 Historical decomposition of real output growth and inflation into supply and demand components



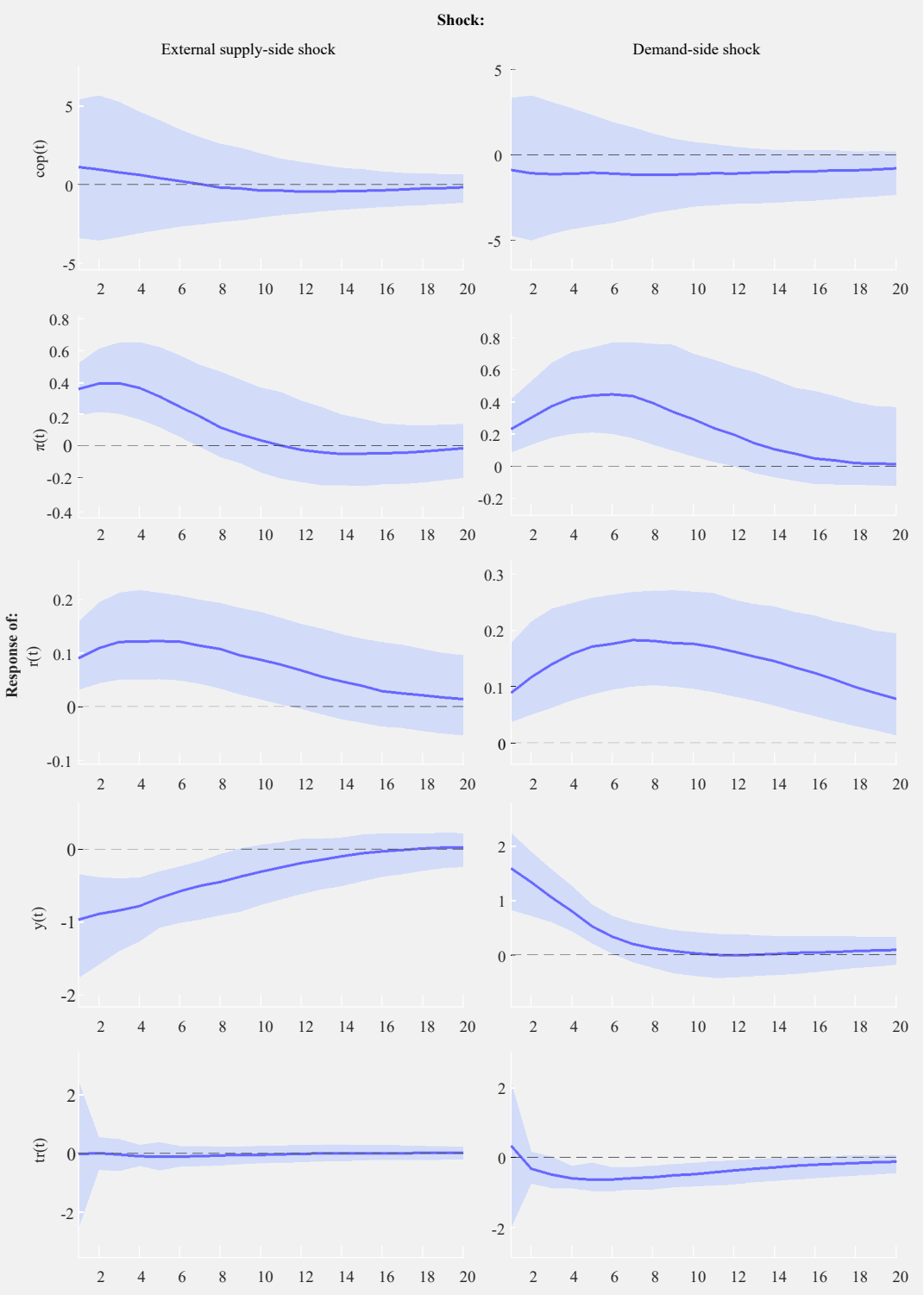
Source: Authors' own estimations.

Chart A2 Impulse response functions from a Bayesian SVAR in the case of a demand- and a supply-driven inflation shock. Fiscal variable in SVAR: total tax revenue (TR)



Source: Authors' own estimations.

Chart A3 Impulse response functions from a Bayesian SVAR in the case of a demand- and a supply-driven inflation shock. Fiscal variable in SVAR: total primary government spending (TPEXP)



Source: Authors' own estimations.

DRIVERS OF INFLATION IN THE GREEK ECONOMY

Iro Kofina
Athens University of Economics and Business

Filippos Petroulakis
Bank of Greece, Economic Analysis and Research Department

ABSTRACT

One of the hallmark achievements of modern central banking has been to quell high inflation. However, after over two decades of low inflation, a series of shocks, including the pandemic recession, supply bottlenecks, highly accommodative policy, and, perhaps most saliently, the war in Ukraine, have led to multi-decade inflation highs across most advanced economies. Understanding the ultimate causes of this inflation surge is vital for the proper design of policy, yet disentangling the various shocks is hard, particularly when they affect prices in the same direction. In this paper, we apply the novel shock decomposition framework of Shapiro (2022) to Greek data and estimate the contribution of supply and demand shocks to inflation developments over the recent episode, as well as for the 2001-2019 period. For the recent episode, we find that supply forces were slightly more important for headline inflation, but much more important for underlying inflation.

Keywords: inflation; demand; supply; energy shocks

JEL classification: E31; E37; Q02

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ΠΡΟΣΔΙΟΡΙΣΤΙΚΟΙ ΠΑΡΑΓΟΝΤΕΣ ΤΟΥ ΠΛΗΘΩΡΙΣΜΟΥ ΣΤΗΝ ΕΛΛΗΝΙΚΗ ΟΙΚΟΝΟΜΙΑ

Ηρώ Κοφινά
Οικονομικό Πανεπιστήμιο Αθηνών

Φίλιππος Πετρουλάκης
Τράπεζα της Ελλάδος, Διεύθυνση Οικονομικής Ανάλυσης και Μελετών

ΠΕΡΙΛΗΨΗ

Ένα από τα σημαντικότερα επιτεύγματα της σύγχρονης κεντρικής τραπεζικής υπήρξε η καταπολέμηση του υψηλού πληθωρισμού. Ωστόσο, μετά από περισσότερες από δύο δεκαετίες χαμηλού πληθωρισμού, μια σειρά διαταραχών, όπως η πανδημία, τα προβλήματα στις εφοδιαστικές αλυσίδες, η επεκτατική μακροοικονομική πολιτική και, ίσως κυρίως, ο πόλεμος στην Ουκρανία, οδήγησαν τον πληθωρισμό σε υψηλά δεκαετιών στις περισσότερες ανεπτυγμένες οικονομίες. Η κατανόηση των αιτιών αυτής της ραγδαίας ανόδου του πληθωρισμού είναι ζωτικής σημασίας για τον κατάλληλο σχεδιασμό της πολιτικής, αλλά είναι δύσκολο να προσδιοριστούν οι παράγοντες που συνέβαλαν σε αυτή την άνοδο, ιδίως όταν επηρεάζουν τις τιμές προς την ίδια κατεύθυνση. Στην παρούσα μελέτη, εφαρμόζουμε το νέο πλαίσιο ανάλυσης διαταραχών του Shapiro (2022) στα δεδομένα για την Ελλάδα και εκτιμούμε τη συμβολή των διαταραχών προσφοράς και ζήτησης στην εξέλιξη του πληθωρισμού κατά την πρόσφατη περίοδο, καθώς και για την περίοδο 2001-2019. Για την πρόσφατη περίοδο, διαπιστώνουμε ότι οι δυνάμεις της προσφοράς ήταν ελαφρώς πιο σημαντικές για το γενικό πληθωρισμό, αλλά πολύ πιο σημαντικές για τον πυρήνα του πληθωρισμού.

DRIVERS OF INFLATION IN THE GREEK ECONOMY*

Iro Kofina
Athens University of Economics and Business

Filippos Petroulakis
Bank of Greece, Economic Analysis and Research Department

1 INTRODUCTION

One of the greatest achievements of monetary policy in recent decades has been inflation stability. In advanced economies, inflation rates that were in the double digits during the 1980s gradually declined to levels nearing 2% by the 1990s. Although Greece experienced a delayed decline, inflation reached historically low levels after meeting the convergence targets for entry into the Economic and Monetary Union (EMU). Throughout this period, inflation remained below 5% and, during the fiscal adjustment in the middle of the last decade, it even turned negative for a significant duration.

However, starting from the second half of 2021, inflation began to rise notably, reaching decade highs across most developing economies by 2022. The war in Ukraine triggered a big surge in energy costs, primarily for Europe. This surge was noticeable in both headline and core inflation, with inflation levels rising consistently. This shock came at the heels of the global COVID-19 pandemic, which had caused major disruptions in economic activity and supply chains. In addition, the unprecedented monetary and fiscal measures implemented by central banks and governments to mitigate the economic impact of the pandemic have also played a part in inflation developments. The combined effect of these forces had a profound influence on inflation, contributing to its overall trajectory.

The objective of this article is to examine the factors that contributed to inflation in the Greek economy during the recent period. It employs the model of Shapiro (2022), which provides a framework for analysing inflationary pressures arising from supply and demand disruptions. The model has been used extensively in similar exercises by the Federal Reserve and the ECB (Gonçalves and Koester 2022).

The decomposition of inflation into demand and supply drivers is crucial for policymakers and analysts to better understand the underlying causes of inflation and to determine appropriate responses. For instance, if demand-pull inflation is driving up prices, policymakers can respond by raising interest rates. On the other hand, if cost-push inflation is the primary driver, policymakers may focus on addressing the underlying supply-side factors. Overall, decomposing inflation into demand and supply drivers can provide a more accurate insight into the causes of inflation and, thus, make it easier to address them more effectively.

The paper is structured as follows. Section 2 provides a brief literature review, while Section 3 explains in further detail the consensus view on the drivers of inflation. Section 4 provides a detailed explanation of the empirical framework used to identify demand and supply shocks, while Section 5 presents the data, providing a detailed description of the matching between price and quantity data, a central aspect of the empirical exercise. Section 6 shows the results and Section 7 concludes.

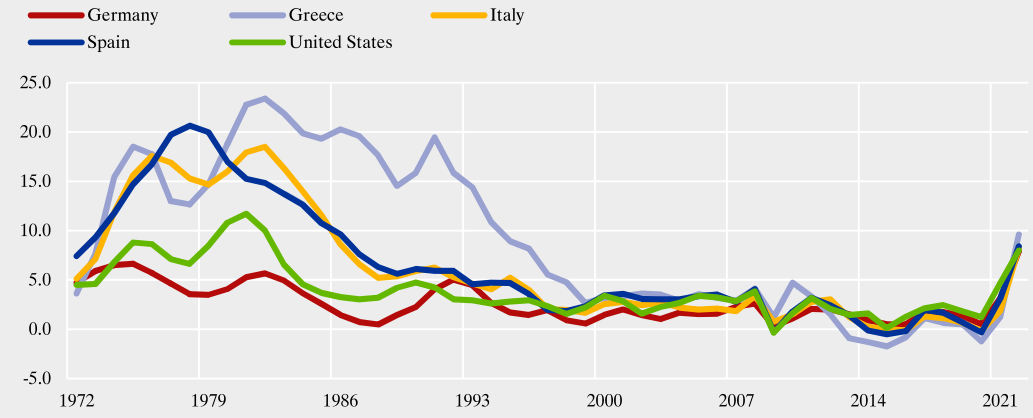
2 LITERATURE REVIEW

In this section, we provide a brief, selective overview of the relevant literature, focusing in particular on what we know about the drivers of inflation, both historically and for the current episode.

* The views expressed in this article are of the authors and do not necessarily reflect those of the Bank of Greece. The authors are responsible for any errors or omissions.

Chart 1 Inflation across selected economies (1970-2022)

(% of GDP)



Source: Ha et al. (2023).
Note: Annual inflation in two-years moving average form.

The nature of inflation dynamics is one of the most contested issues in macroeconomics, because it holds crucial implications for the conduct of policy. A short-run trade-off between inflation and unemployment, as embodied in the Phillips curve, together with a role for expectations, is at the heart of the New Keynesian paradigm (Gali and Gertler 1999). This framework recognises roles for both demand and supply shocks; indeed, allowing for both can help explain the stagflation of the 1970s and 1980s as an inadequate monetary policy (demand) response to severe supply shocks in the global oil markets.

Inflation came down from its 1980s highs to modest levels in the early 1990s, ushering in a roughly 30-year period of a low inflation regime, a period which coincided with inflation targeting and a Taylor rule. The era during and after the global financial crisis was characterised by persistently low (but rarely negative) inflation, seemingly severing the link between real activity and inflation, and led many to question the validity of the Phillips curve. A large literature developed, which tried to provide an explanation why the Phillips curve flattened (Del Negro et al. 2020; McLeay and Tenreyro 2019; Hazell et al. 2022; Bianchi et al. 2023 and references therein).

Reis (2022) investigates the causes behind the surge of inflation in 2021-2022 and evaluates the conduct of monetary policy in this regard across advanced economies, focusing on the misdiagnosis of shocks during this period. Monetary policy must always deal with various aggregate shocks, but correctly diagnosing the sources of these shocks is very difficult in real time. As such, he argues that, given that central banks need to, explicitly or implicitly, trade off between their objectives (price and financial stability, and employment growth), they may inadvertently allow inflation to rise because they misjudged the nature of these shocks. The framework used in this paper cannot directly identify the nature of these shocks, but it can shed light on their sources, i.e. whether they come from the demand or the supply side. Determining whether the supply shocks themselves are temporary (and monetary policy should see through them) or affect potential output is very difficult in real time.

Research on inflation typically focuses on some aggregate inflation measure, but much can be learned from studying its components. Stock and Watson (2016) improve upon measurements of trend inflation by using sectoral inflation data. Stock and Watson (2020) fur-

ther show that some components have a stable and strong correlation with the business cycle, while others do not. They construct an index which weighs components by their cyclical covariance with real activity and find that it provides a real-time indicator of cyclical inflation.

Shapiro (2022) exploits the informational content of disaggregated items for structural estimation and provides a simple framework for a real-time decomposition of inflation into its drivers, based on standard supply and demand arguments. He proposes to classify temporal shocks for each consumption category depending on the relative movements of prices and quantities: if they move together, the demand shock must have been larger. If they change in opposite signs, the opposite must hold. This empirical framework is similar in logic to the more general sign restrictions strategy commonly used in empirical macro models and in structural vector autoregression (SVAR) models (Uhlig 2005; Baumeister and Hamilton 2015, 2018). This framework, which allows only for set identification of parameters, recognises that different shocks are expected to have effects of differing signs on the variables of interest. The approach of Shapiro (2022) is a simplified special case of the more general framework applied to single-equation models, but across different sectors of the economy.[1] The results of this, using a sample from 1990-2022, are consistent with historical intuition; the role of demand is accentuated during booms and falls in downturns. For the COVID-19 episode, he finds an initial large decline, followed by a big rise in demand in 2021, consistent with the large fiscal expansion, with supply surging in 2022, after the Russia-Ukraine war raised energy prices.

Shapiro's framework was inspired by Jump and Kohler (2022), who use such a framework to study the sources of aggregate shocks to the UK economy over a period longer than a century. Using restrictions from the workhorse New Keynesian model, they use a bivariate SVAR model with inflation and unemployment to identify aggregate demand and supply shocks. Their findings align well with contemporaneous narrative accounts and they find a larger role for demand, with 20 out of the 30 largest shocks being accounted for by demand. They find that the 1970s-1980s episode was a sequence of positive demand and negative supply shocks. This is useful since Shapiro (2022) does not include data for large supply shocks other than COVID-19. One insight is that supply shocks are especially problematic if they occur after demand shocks, which makes it harder for policymakers to understand the shocks in real time.

Relevant to the current episode is the extensive literature studying the effects of commodity developments on headline inflation. The link was strong up until the 1980s and commodities, especially oil, were, hence, useful in forecasting inflation at the time, but have been less successful since (Stock and Watson 2003). In a highly influential paper, Kilian (2009) argues that the primary driver of oil prices is either aggregate demand or oil-specific demand shocks and that supply shocks have historically been of little importance, as they tend to simply reflect OPEC responses to demand shocks. This implies that oil developments are essentially driven by the global cycle, rather than influencing it, and so output effects are small. More recently, Baumeister and Hamilton (2019) find a larger role for supply shocks in output fluctuations. Regarding inflation, Ha et al. (2023) find that, while global oil shocks explain a quarter of inflation variability in the median country (in a large panel of countries), and more so recently, a small fraction of this is due to either supply or price shocks. Sekine and Tsuruga (2018) find that for a large cross-country panel the effects of commodity price shocks on inflation are transitory on average across countries, although effects are more

1 Brinca et al. (2021) and Petroulakis (2023) also employ the SVAR sign restrictions framework of Baumeister and Hamilton (2015) in a multi-sector setup. Note that the approach of Shapiro (2022), following Jump and Kohler (2022), has the additional benefit that it is only concerned with the sign of the relationship, rather than the identification of structural parameters, in which case further non-sign assumptions have to be made.

persistent for dollar-pegged countries, which constrains monetary policy.

3 DETERMINANTS AND CLASSIFICATION OF INFLATION

3.1 DETERMINANTS

The literature typically groups the causes of inflationary pressures into three sources: demand-pull, cost-push and expectational. This grouping combines standard Phillips curve aspects of inflation together with rational expectations and inertia. While these shocks are conceptually distinct, they can interact in complex ways. This section is purposely pedagogical and uses the formalisation of Gordon's (1988) "triangle model".

Demand-pull

Demand-pull inflation is the result of excess demand for goods and services in an economy, for a given level of productive capacity. Supply is relatively rigid in the short run, as firms need to expand their labour pool and increase their capital through investment in order to respond to increased demand. This is especially the case when the economy is at or near full employment and so any increase in capacity will have to come through investment. In this case, any increase in aggregate demand can lead to inflation, as there are not enough resources available to meet the increased demand without raising prices (Machlup 1960). As such, a shift in demand when supply is inelastic will tend to raise prices, as firms try to balance out the shortage. Several factors may cause aggregate demand to rise, including higher government spending, lower taxes, more accommodative monetary policy or any other shock which increases disposable income, all of which lead to higher consumer spending.

Cost-push

Cost-push inflation, on the other hand, is the result of adverse shocks to supply, which raise the cost of production, such as an increase in wages, raw materials or taxes. When production costs rise, companies raise their prices to cushion the hit to their profit margins. This, in turn, causes the general price level to rise, leading to inflation. Cost-push inflation can occur as a result of supply-side shocks, such as natural disasters or political instability, which disrupt production and increase the cost of goods and services. It can also be caused by external factors, such as tariffs, embargoes or changes in the exchange rate, which increase the cost of imports, and by internal factors, such as price controls, which discourage production and reduce supply. Most notably, cost-push shocks can arise due to shocks in energy markets, especially oil, as in the 1970s, when the economy suffered from two large oil shocks, leading to periods of high unemployment and inflation (stagflation).

It should be noted that, while it is undisputed that cost shocks can lead to higher price levels, whether they can lead to sustained increases in inflation (price changes) is debated. Most famously, Milton Friedman and the monetarists rejected the validity of cost-push inflation, arguing that higher aggregate demand, due to an increase in money supply, is the ultimate factor. The New Keynesian literature has argued that supply shocks may indeed lead to persistent cost-push inflation, as workers and firms continuously bid up the prices for their products (Blanchard 1986; Lorenzoni and Werning 2023a, b), leading to a wage-price spiral.[2]

Expectational

The expectational channel refers to the pricing behaviour of firms and households relating to how they expect inflation to evolve in the future and is due to the well-known stickiness of price and wage formation. If nominal contracts were fully flexible, then expectations would trivially be irrelevant for pricing decisions. In the traditional Phillips curve, expectations were backward-looking, i.e. current inflation was affected by lagged inflation, giving rise to inertial or "built-in" inflation. This can result from adap-

2 Empirical evidence suggests that such episodes rarely lead to sustained wage and price inflation (Alvarez et al. 2022).

tive expectations, as agents slowly adjust their behaviour to new levels of inflation with a lag or naïve rule-of-thumb pricing strategies (Roeger and Herz 2012). The idea is that long periods of high inflation become ingrained in the pricing behaviour (e.g. due to the wage-price spiral mentioned above), which can explain why high inflation in some emerging economies can persist over decades.

The New Keynesian literature (Gali and Gertler 1999) instead emphasises optimising behaviour in the presence of price stickiness, giving rise to a forward-looking term of inflation expectations. In the New Keynesian Phillips curve (NKPC), this forward-looking term in fact encapsulates future marginal shocks and, thus, expectations of cost-push shocks. The logic of the NKPC is that, if people expect prices to rise in the future, and given that prices are generally sticky and only subject to periodic changes, they will adjust their behaviour accordingly, by demanding higher wages or raising the prices of the services they provide.[3] Thus, a self-fulfilling cycle can be established, in which expectations of inflation lead to actual inflation. The conventional wisdom is that such inflation can be difficult to control because it is embedded in the economy and in people's expectations (Reis 2022).[4] Indeed, the literature has centered around the idea that inflation became more persistent, as expectations became better anchored (Watson 2014).

3.2 INFLATION CATEGORIES

Inflation is typically thought to reflect the rate of change in prices in some basket of goods and services consumed by the average household. Relative prices between goods change all the time to reflect different productivity and relative demand and supply trends across different items. Such movements are desirable, as they aid the price discovery mechanism, which is crucial for the efficient allocation of resources in market economies.

Headline inflation, the most commonly used measure of inflation, is the rate of change in the consumer price index (CPI), constructed by a weighted average of all items consumed by the representative household. This is the measure targeted by most central banks engaged in inflation targeting, because it reflects the prices paid by households.[5] It is considered to reflect the overall inflation rate in an economy. For the purposes of conducting policy, however, headline inflation has some drawbacks, most importantly the fact that it can display short-term swings as a result of changes in the prices of its most volatile items, in particular food and energy.

Commodity supply is subject to large short-term fluctuations, which can affect the overall index. As monetary policy affects the real economy only with "long and variable lags" (Friedman 1961), it is imprudent to react forcefully to temporary changes induced by transitory supply shocks. At the same time, since commodity prices also tend to be determined in global markets, monetary policy is unlikely to influence them, which further reduces the usefulness of reactions to these shocks. As such, central banks also consider core inflation, a measure of inflation that excludes food and energy prices (HICPX for the euro area). Such items, which are excluded from core inflation, can be affected by factors like weather conditions and geopolitical events, thus causing temporary price spikes. By excluding them, core inflation proves to be a more stable measure of inflation, less affected by transitory price movements. This is because prices tend to be sticky in the short term and it is typically assumed that transitory shocks in energy and food are less likely to affect pricing policies in other sectors. On the other hand, if high inflation becomes embedded, then core inflation may remain elevated

3 The full-information rational expectations (FIRE) version of the NKPC has had mixed empirical success and the literature has moved to more sophisticated specifications; see Coibion et al. (2018).
4 Interestingly, workhorse models can differ substantially in the pass-through of expectations (Werning 2022).
5 A notable exception is the Federal Reserve, which targets the price index for Personal Consumption Expenditures (PCE). The major difference with CPI is that PCE is measured on the basis of business surveys instead of consumer surveys.

even while headline inflation comes down, after energy or food shocks subside. This is in fact the situation in the Greek economy in the second quarter of 2023, with core inflation higher than headline.

It is important to understand that both headline and core inflation are useful to analysts and policymakers for different purposes. Headline inflation, as mentioned earlier, is the most widely used measure of inflation and has proved useful in assessing the general price level and the purchasing power of households. On the other hand, core inflation is effective in filtering out volatile components and providing a more accurate picture of underlying price trends, which tend to be more persistent. Nevertheless, both core and headline inflation are useful measures that can provide valuable insights into changes in the general price level. Apart from this distinction into core and headline inflation, other groups can be created according to the needs of the analysis being conducted. The remainder of this section proposes the more appropriate inflation groups for the study.

In addition to headline and core inflation, we will consider inflation in services and non-energy industrial goods (NEIG). Each merits attention due to the different informational content that the prices of these goods have for overall inflation. Services inflation is an important indicator of underlying, slow-moving pressures on inflation, as it is strongly influenced by labour costs and much less so by commodities. An uptick in services inflation is often considered evidence of higher wage growth, but also of second-round effects of inflation, since wages tend to comove across sectors.

NEIG inflation, on the other hand, essentially corresponds to the goods portion of core inflation. NEIG markets are internationally contestable and benefit from productivity growth and trade, and, thus, their prices tend to grow more slowly (or, in fact, fall) over time. Industrial goods, whether imported or not, tend to be produced over multiple locations and are the result of energy-intensive production. As such, surges in commodity prices tend to produce so-called "pipeline" pressures, especially in the early stages of production and distribution.[6] An uptick in NEIG inflation after increases in commodity prices is, hence, a useful indicator of the pass-through of such shocks to the rest of the economy.

4 FRAMEWORK

This paper uses the novel framework of Shapiro (2022) to distinguish the sources of the rise in inflation between demand and supply shocks, using the refinement of Gonçalves and Koester (2022) for European data. The model of Shapiro (2022) is based on the observation that although negative supply and positive demand shocks both lead to a price increase, they have opposite effects on consumption: negative supply shocks reduce consumption and positive demand shocks raise it. As such, an unexpected change in prices and quantities in the same direction is due to a demand shock, while an unexpected change in opposite directions is due to a supply shock.

To operationalise this framework, we estimate price and consumption regressions separately for each consumption category. When the estimation errors (deviations of actual prices and quantities from those predicted by the model) of price and consumption have the same sign, the disturbance is assumed to come from demand; if they have a different sign, it is assumed to come from supply. In fact, supply and demand shocks coexist and, thus, the model can identify the relative strength of the shocks. Strictly speaking, it is the net demand and supply shocks that can be identified.

We run ten-year rolling window regressions (40 quarters), with four lags. The model is formally given as follows:

6 See https://www.ecb.europa.eu//pub/economic-bulletin/focus/2021/html/ecb.ebbox202105_07~d799754f4e.en.html.

$$q_{i,t} = \sum_{j=1}^{4} \gamma_j^{qp} p_{i,t-j} + \sum_{j=1}^{4} \gamma_j^{qq} q_{i,t-j} + v_{i,t}^{q}$$

$$p_{i,t} = \sum_{j=1}^{4} \gamma_j^{pp} p_{i,t-j} + \sum_{j=1}^{4} \gamma_j^{pq} q_{i,t-j} + v_{i,t}^{p}$$

In the expressions above, t is time in quarters, i denotes consumption category, q is the log change in quantity and p is the log change in price. We classify each quarter for each consumption category as being driven by a supply or demand disturbance, according to the classification above, if the error is statistically significant; otherwise, the given observation is classified as ambiguous. This flexible procedure can be used to separately analyse the drivers of inflation across a variety of product groups. As such, we aggregate the estimates for each category, using the appropriate weights, to measure demand and supply shocks for headline inflation, as well as for HICPX, NEIG and services inflation.

As has been highlighted in the recent literature, the huge shock of the lockdowns imposed in early 2020 due to the COVID-19 pandemic makes statistical inference problematic in time series analysis. The presence of huge outliers means that ignoring them may lead to inconsistent estimates. A variety of methods has been proposed by the literature to deal with this concern, mostly for vector autoregression models (e.g. Lenza and Primiceri 2022; Ng 2021; Carriero et al., forthcoming). In our simple single-equation setting, we follow the suggestion of Lenza and Primiceri (2022), who argue that, for the purposes of estimating structural parameters, it is sufficient to simply remove the COVID-19 sample from the data. As such, we use a sample up to the fourth quarter of 2019 to estimate the models. At the same time, the choice of four lags means that, in order to avoid using the two quarters that were particularly affected by the pandemic (second and third quarters of 2020), we can measure shocks from the fourth quarter of 2021 onwards.

5 DATA

The analysis in this paper requires data on prices and quantities of goods and services produced in the Greek economy. Price data consist of the price indices for the components of the Harmonised Index of Consumer Prices (HICP), obtained from the European Central Bank (ECB). The classification system according to which the HICP data are organised is the COICOP system, also at the two- and three-digit aggregation level, where appropriate. We use different levels of disaggregation in order to maximise the match between NACE and COICOP. This part of our data is essentially identical with Shapiro (2022).

Quantity data, however, are not readily available for our purposes. Eurostat publishes detailed consumption aggregates at the sectoral level only at annual frequencies, which is not sufficient for our analysis, given that opposing shocks in successive quarters may wash out during the year. Even then, granularity is limited and using production data would conflate local with foreign consumption (for exporting sectors). As such, we follow Gonçalves and Koester (2022) and use sectoral turnover data from Eurostat's Short-Term Business Statistics database, for both retail trade and services. These indices are classified according to the NACE Rev. 2 standard, at the two-digit level of aggregation. The turnover indices for retail trade come from the sts_trtu_q dataset, and for services from sts_setu_q. The original analysis of Shapiro (2022) used four-digit aggregation, which unfortunately is not available for Europe at quarterly frequencies. Retail turnover data are further broken down in several subcategories by type of establishment, allowing us to match turnover indices with price indices at a sufficiently granular level. Note that while Gonçalves and Koester (2022) end up with 45 categories of goods and services for the euro area, Greek data are available in less granular aggregations and our final sample consists of 23 different sectors of goods and services.

The turnover series for both services and retail trade come at quarterly frequency, from the first quarter of 2010 to the third quarter of 2022. The price indices obtained come at monthly frequencies and were converted to quarterly frequencies using period means.

One complication in this analysis was that several of the series used in the exercise were only available in raw format. Seasonal adjustment is crucial in these exercises for horizons different than 12 months. We hence used X13 – Tramo Seats to seasonally and calendar adjust the turnover indices on services and retail trade, as well as the HICP component series.

A final step in the data preparation stage was to deflate the turnover series in order to obtain real consumption measures. The retail trade turnover series collected by Eurostat were already deflated, with the exception of "Sale of motor vehicles", which we instead obtained from the Hellenic Statistical Authority (ELSTAT). The turnover series for services were only available in nominal form and we deflated them using the corresponding HICP component.

5.1 NACE-COICOP MATCHING

In order to implement the framework of Shapiro (2022) on Greek data, we need to link prices and consumption data for each consumption category, which requires consistent measurement of both series. However, a major complication in this study is the fact that the data on prices and quantities are compiled from different sources using different classification systems. Even though both are produced by Eurostat, there exists no official correspondence table between the two datasets. As such, these two sets of data need to be manually matched; given the central role of this aggregation for the results of this paper, in this section we detail the steps taken to achieve this match.

Turnover data are classified according to production, at the sectoral level, using the NACE Rev. 2 classification system. The NACE (Nomenclature of Economic Activities), used by Eurostat to classify economic activities, categorises businesses according to the type of goods and services they produce; this is the most common categorisation of industrial activity in Europe, corresponding to the NAICS classification in the United States and is used in essentially all structural analyses of European economies.

On the other hand, COICOP (Classification of Individual Consumption According to Purpose) is the classification system developed by the United Nations Statistics Division to categorise individual consumption expenditure based on the purpose for which the goods and services were purchased. COICOP is organised on the basis of household expenditure and, hence, consumption; as NACE is organised on the basis of production, matching NACE with COICOP data is not straightforward. The most obvious complication occurs in manufacturing; with few exceptions, final goods are purchased by households through retail establishments and not by the entity that produced the goods. As such, an increase, for instance, in the price index of furniture cannot be easily matched to fluctuations in the consumption of furniture, since our data would only record turnover in retail, and this would need to be sufficiently granular to be useful. On the other hand, production and consumption of services, especially personal services, tend to be close and so this matching is more straightforward.

We manually matched NACE and COICOP data using the crosswalk table of Cai and Vandyck (2020). Throughout this process, we matched some NACE turnover indices one-to-one with the corresponding HICP component, whenever possible. For the most part, however, one turnover series was matched to more than one HICP component, using the appropriate HICP weights. For example, turnover in the retail sale of food and beverages (NACE G47_FOOD) corresponds to the COICOP categories of food goods (CP01.1) and non-alcoholic beverages (CP01.2). All in

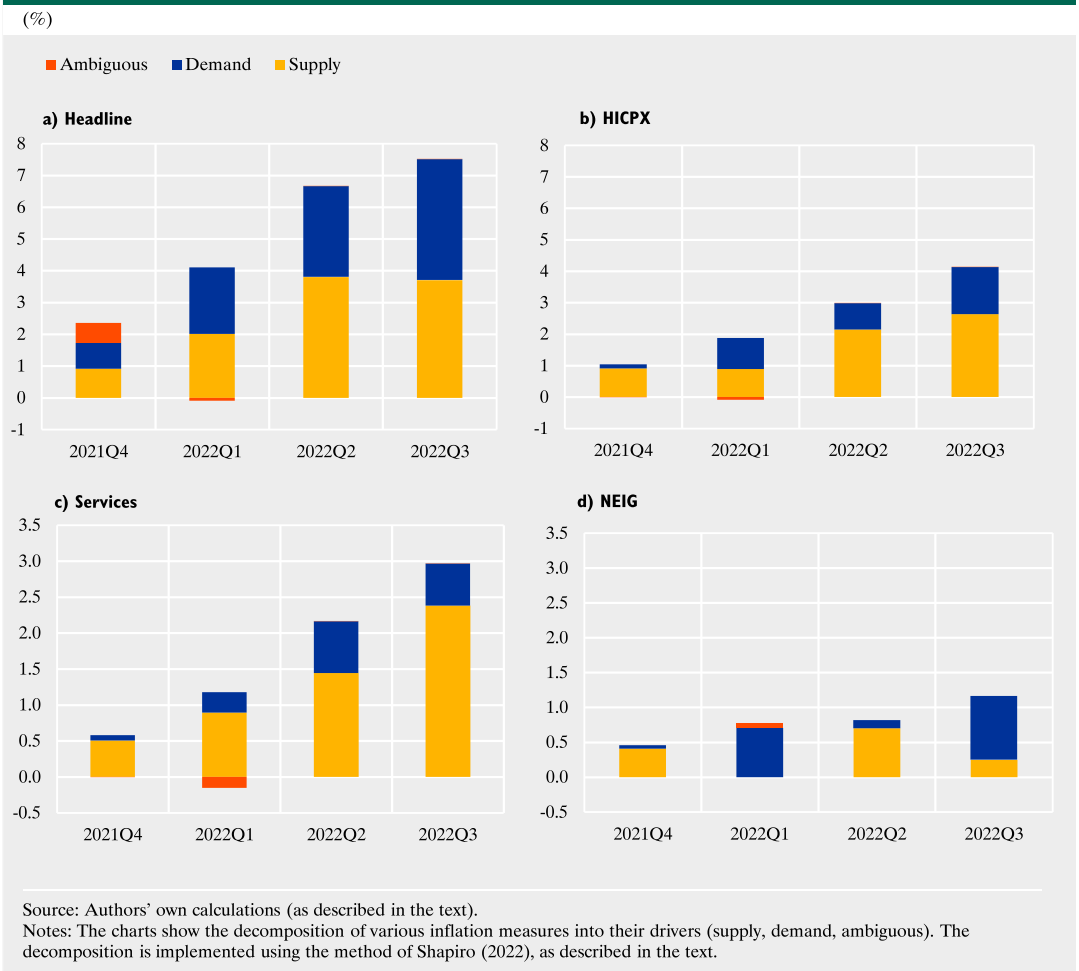
all, we matched fifteen series for services turnover (sts_setu_q) and eight series for retail trade turnover (sts_trtu_q) to forty-one HICP series.

As Gonçalves and Koester (2022) point out, the matching between NACE and COICOP is experimental and unofficial, and, therefore, the results are indicative. This mainly concerns goods, which are usually sold by intermediate retail businesses, and, therefore, production is relatively distant from distribution. The final sample corresponds to about 85% of the total consumer basket, as for some consumption categories there are no turnover indices. These are tobacco, furniture repair, tools and equipment for house and garden, education, health services, some transportation categories, as well as financial services and insurance and social services.

6 RESULTS

We report the results of our decomposition exercises in Chart 2 below. For each quarter, we take all consumption categories classified as having been hit by demand shocks, and calculate the weighted sum of (annual) inflation from these categories. We do the same for those classified as having been hit by supply shocks and those with ambiguous shocks, and plot the contribution of shocks for the given quarter. The sum of these three components

Chart 2 Inflation decomposition (2021-2022)



Source: Authors' own calculations (as described in the text).
Notes: The charts show the decomposition of various inflation measures into their drivers (supply, demand, ambiguous). The decomposition is implemented using the method of Shapiro (2022), as described in the text.

gives the overall annual inflation rate that we can account for (roughly 85% of total, as mentioned above). The yellow part of each bar shows the contribution of supply shocks, the blue part shows the contribution of demand shocks and the red part shows the part that was labeled as ambiguous. We run these exercises for headline, HICPX, services and NEIG inflation.

Beginning with headline inflation, we see that during the early stages of the episode, when inflation was still moderate, individual effects balanced each other out. In the fourth quarter of 2021, there is a notable element of uncertainty. As inflation started to accelerate in 2022, the supply factor became increasingly significant, accounting for 52% of the overall inflation rate. A similar pattern is observed for core inflation, which excludes energy and food items. Supply shocks had an even greater contribution to core inflation, particularly in the second and third quarters of 2022, when inflation reached its highest point in over 20 years. In total, approximately two-thirds of core inflation during these two quarters can be attributed to supply shocks.

We then break down headline inflation into two different categories: services inflation and non-energy industrial goods (NEIG) inflation. Results are shown in Chart 2, panels c) and d). As already discussed, services, in particular, are considered to reflect underlying inflationary pressures, since the main variable cost for services production (other than energy) is labour. Results indicate an even greater role for supply, accounting for around three-fourths of services inflation. On the other hand, results are more mixed and volatile for NEIG inflation, with a large role for demand.

Finally, Chart 3 shows the determinants for the four inflation categories over the period 2001-2019. Consistent with the results of Shapiro (2022) for the United States, the supply shocks dominate over long horizons. During the period leading up to the financial crisis, when the economy is conventionally understood to have been overheated, the role of positive demand shocks in driving inflation, especially for services, was at its largest. This is also consistent with the reduction of real interest rates which accompanied euro accession, a result of the elimination of borrowing spreads within the euro area through the elimination of devaluation and country risk (Alogoskoufis 2019).

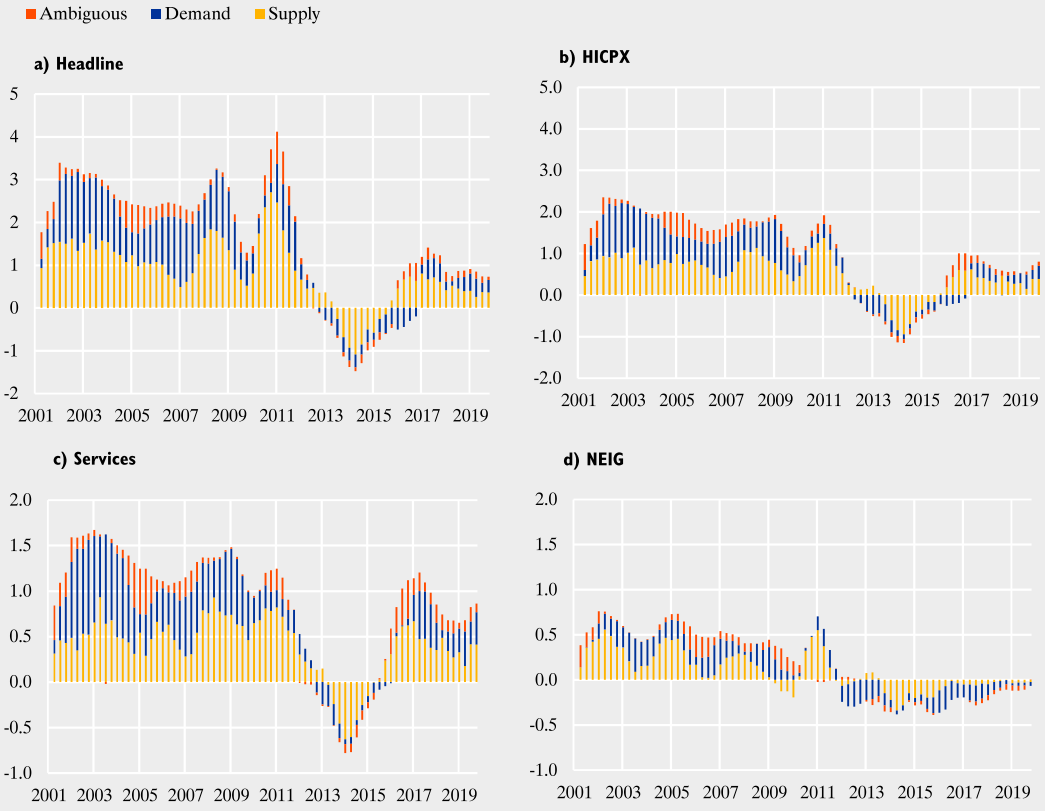
The collapse of inflation started in 2008 and continued with brief interruptions, probably due to a sequence of oil shocks in 2008 and 2010-2011, as can also be surmised by a large and persistent spike of supply shocks. This collapse was also primarily driven by falling demand pressures, which eventually turned negative in 2012 and remained negative until 2016 to rebound once the economy recovered, from 2016 onwards. Supply pressures also turned negative around 2012, possibly as a result of extensive reform programmes undertaken by successive governments. During the interim period, it is interesting that demand shocks are negative for far longer than supply shocks. This may reflect the fact that reform-driven supply shocks are more likely to have level effects on prices.

The most striking difference between longer-term developments and the current episode is in NEIG inflation, which has surged after almost a decade of negative growth. This highlights the exceptional circumstances of this inflation surge.

It is important to note that the model does not take into account shocks to supply and demand in the global economy. This is particularly important for categories of goods with a high import share, such as non-energy industrial goods. Shocks for these goods reflect a combination of domestic demand, domestic distribution costs and international production costs. For example, if there is a global supply shock, but domestic demand is strong, the model is likely to attribute the simultaneous rise in prices and consumption to a demand shock, when in fact domestic demand does not affect prices,

Chart 3 Inflation decomposition (2001-2019)

(%)



Source: Authors' own calculations (as described in the text).
Notes: The charts show the decomposition of various inflation measures into their drivers (supply, demand, ambiguous). The decomposition is implemented using the method of Shapiro (2022), as described in the text.

which are set internationally.[7] Thus, the model has an inherent tendency to overstate the role of demand for imported products.[8]

7 CONCLUSION

The combined pandemic-induced and energy crisis shocks have given rise to intense inflationary pressures, posing a complex challenge for policymakers. A key source of uncertainty stems from the difficulty in distinguishing the relative impacts of demand and supply factors driving this surge in inflation. This paper has used a new framework, based on a simple and transparent identification framework, to dissect Greek inflation and discern the contributions of supply and demand drivers. The results show that both supply and demand shocks have made comparable contributions to headline inflation in the 2021Q4-2022Q4 period, but supply shocks have exerted a notably stronger influence on core inflation, particularly in services. As a result, the primary source of underlying inflationary pressures can be traced back to supply shocks, which unfortunately restricts

7 This is graphically represented by a flat supply curve for the domestic economy, implying that prices depend solely on the supply shock, while consumption depends on both supply and demand shocks.

8 According to the literature, large multinational manufacturing companies apply a similar pricing policy across countries sharing the same currency. See Cavallo et al. (2014).

the effectiveness of monetary policy instruments. Nonetheless, it remains essential for monetary policy to respond promptly to prolonged supply shocks so as to avert the buildup of inflation expectations. The recent interest rate increases implemented by the ECB are a step in the right direction towards addressing this need. The fact that the contribution of supply shocks remains relatively modest is an encouraging indication that disinflation can be achieved without significantly compromising economic activity.

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COVID-19 PANDEMIC: OVERVIEW OF THE FISCAL POLICY RESPONSE AND MACROECONOMIC DEVELOPMENTS IN THE EURO AREA AND THE UNITED STATES

Marianthi Anastasatou
Bank of Greece, Economic Analysis and Research Department

Sofia Anyfantaki
Bank of Greece, Economic Analysis and Research Department

ABSTRACT

The COVID-19 pandemic has had a profound impact on the European Union and the United States, with varying waves of severity and divergent progress in vaccination campaigns across regions. To address the short-term costs and potential long-term effects of the crisis, policymakers adopted support measures, particularly fiscal policies. This paper provides an overview of the fiscal support measures implemented, with a focus on the euro area and the United States. It also examines the impact of the pandemic and of support policies on the economies of both regions, as well as the ongoing economic recovery. By analysing the fiscal responses and the macroeconomic developments, this study aims to contribute to a better understanding of the diverse approaches taken by policymakers in combatting the COVID-19 crisis and mitigating its economic consequences.

Keywords: COVID-19; fiscal support; economic recovery; labour productivity

JEL classification: E62; H12; H25; H51; J38; J68

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ΕΠΙΣΚΟΠΗΣΗ ΔΗΜΟΣΙΟΝΟΜΙΚΩΝ ΜΕΤΡΩΝ ΣΤΗΡΙΞΗΣ ΚΑΙ ΜΑΚΡΟΟΙΚΟΝΟΜΙΚΩΝ ΕΞΕΛΙΞΕΩΝ ΣΤΗ ΖΩΝΗ ΤΟΥ ΕΥΡΩ ΚΑΙ ΣΤΙΣ ΗΠΑ ΤΗΝ ΠΕΡΙΟΔΟ ΤΗΣ ΠΑΝΔΗΜΙΑΣ ΤΟΥ ΚΟΡΩΝΟΪΟΥ (COVID-19)

Μαριάνθη Αναστασάτου
Τράπεζα της Ελλάδος, Διεύθυνση Οικονομικής Ανάλυσης και Μελετών

Σοφία Ανυφαντάκη
Τράπεζα της Ελλάδος, Διεύθυνση Οικονομικής Ανάλυσης και Μελετών

ΠΕΡΙΛΗΨΗ

Η πανδημία του κορωνοϊού (COVID-19) είχε σοβαρές επιπτώσεις στην Ευρωπαϊκή Ένωση και τις Ηνωμένες Πολιτείες, με διαφορές μεταξύ των δύο περιοχών όσον αφορά τις εξάρσεις των κρουσμάτων και την πρόοδο των προγραμμάτων εμβολιασμού. Για να αντιμετωπίσουν το βραχυπρόθεσμο οικονομικό κόστος και τις πιθανές μακροπρόθεσμες επιπτώσεις της κρίσης, οι υπεύθυνοι χάραξης πολιτικής υιοθέτησαν μέτρα οικονομικής στήριξης, ιδίως δημοσιονομικά. Το παρόν άρθρο περιλαμβάνει μια επισκόπηση των μέτρων δημοσιονομικής στήριξης που εφαρμόστηκαν, με έμφαση στη ζώνη του ευρώ και τις Ηνωμένες Πολιτείες. Εξετάζει επίσης τον αντίκτυπο της πανδημίας και των πολιτικών στήριξης στις οικονομίες και των δύο περιοχών, καθώς και τη συνεχιζόμενη οικονομική ανάκαμψη. Αναλύοντας τις δημοσιονομικές πολιτικές που υιοθετήθηκαν και τις μακροοικονομικές εξελίξεις, η παρούσα μελέτη στοχεύει να συμβάλει στην καλύτερη κατανόηση των διαφορετικών προσεγγίσεων που ακολούθησαν οι υπεύθυνοι χάραξης πολιτικής για την καταπολέμηση της πανδημικής κρίσης και το μετριασμό των οικονομικών συνεπειών της.

COVID-19 PANDEMIC: OVERVIEW OF THE FISCAL POLICY RESPONSE AND MACROECONOMIC DEVELOPMENTS IN THE EURO AREA AND THE UNITED STATES*

Marianthi Anastasatou
Bank of Greece, Economic Analysis and Research Department

Sofia Anyfantaki
Bank of Greece, Economic Analysis and Research Department

1 INTRODUCTION

The COVID-19 crisis has profoundly affected both the European Union and the United States. Different countries have been hit by waves of different severity at different times, while progress in vaccination campaigns has also varied across countries. Compared to the European Union, the impact on human health has been larger in the United States, which experienced a higher total number of deaths due to COVID-19 per million people (see Chart 1). As for the euro area, although it reported the highest number of per capita cases in the spring of 2021, vaccine rollouts accelerated in the summer of 2021, with the percentage of fully vaccinated people overtaking that of the United States, an early leader in the share of the population vaccinated.[1]

As the COVID-19 pandemic caused an enormous health crisis, lockdown measures were implemented in order to contain the spread of the virus, resulting in a prolonged suspension of various economic activities. To overcome the short-run costs of the COVID-19 crisis and its possible scarring effects in the long run, policymakers adopted economic (especially fiscal) policy support measures. Each country has been affected differently by the pandemic and, accordingly, responded differently (Dimitropoulou and Theofilakou 2021). The measures encompassed preventive and mitigating health actions, as well as comprehensive macroeconomic policies, such as fiscal and monetary support to assist struggling businesses and households. This paper focuses on the fiscal responses to the COVID-19 crisis.

During mild economic shocks, automatic stabilisers have proven effective as policy tools for fiscal authorities to stabilise aggregate demand.[2] However, the economic impact caused by the spring 2020 lockdowns was unprecedented in both scale and duration. In essence, a fiscal response was both necessary and timely (Bouabdallah et al. 2020).[3]

In order to assess the short-run economic impact of the COVID-19 crisis on the euro area and the United States, this paper surveys the fiscal responses in the two regions and the macroeconomic developments during the pandemic and until today.[4] The recovery has exhibited notable disparities between these two economies. These differences can be attributed not only to the inherent differences of these economies, but also to the distinct approaches adopted by the respective governments in terms of support measures. Euro area countries primarily empha-

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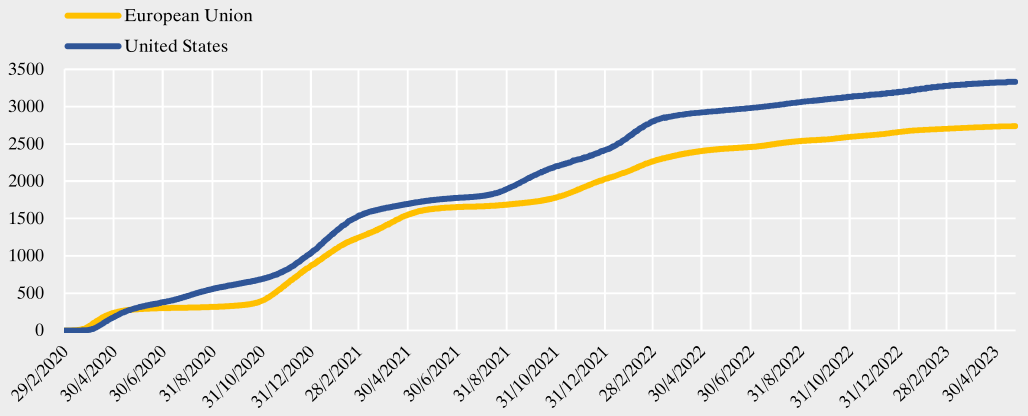
1 https://www.whitehouse.gov/wp-content/uploads/2022/04/Chapter-3-new.pdf.

2 For an analysis of how automatic fiscal stabilisers operated during the pandemic crisis and of their effectiveness, see Bank of Greece (2021), *Annual Report 2020*, Box V.1 (in Greek).

3 Nonetheless, questions arise regarding the extent of fiscal responses in certain countries and their appropriateness. As discussed in Romer and Romer (2022), the sensible approach to policy during a pandemic is to compensate individuals for the losses they would have incurred if they had been able to protect themselves against pandemic-related effects. However, if the pandemic leads to an aggregate demand shortfall and output falls below a level that can be produced safely, implementing broad fiscal stimulus becomes appropriate and desirable (Romer 2021).

4 Using a novel database of daily fiscal policy announcements for 52 countries from 1 January to 31 December 2020, Deb et al. (2021) find that fiscal policy announcements have been effective in stimulating economic activity, boosting confidence and reducing unemployment, but their effect varies by the type of measure and the stage of the pandemic. Jordà and Nechio (2023) find that aggressive fiscal support in the United States added 2.5 percentage points to wage and price inflation, compared to a situation where the extent of fiscal support was calibrated to maintain real disposable income on trend. De Soyres et al. (2022) similarly find that domestic fiscal stimulus added 2.5 percentage points to inflation in the United States. In a recent communication, the European Commission stated that the necessary fiscal response to the COVID-19 pandemic and the contraction in output have resulted in a significant increase in government debt ratios, in particular in some high-debt Member States, though without rising debt servicing costs. See https://ec.europa.eu/commission/presscorner/detail/en/ip_22_1476.

Chart 1 Total confirmed deaths due to COVID-19 per million people



Source: https://ourworldindata.org/grapher/total-covid-cases-deaths-per-million.

sised employment support schemes, while the United States largely focused on measures aimed at bolstering disposable income. Finally, several indicators confirm that the health and economic crisis caused by COVID-19 affected sectors in a heterogeneous way. Some sectors have been hit particularly hard (Battistini and Stoevsky 2021), while the recovery has been also uneven.

The structure of this paper is as follows: Section 2 provides a concise overview of the fiscal support measures implemented, with a focus on the euro area and the United States. Section 3 examines the impact of lockdown and support measures on the economies on both sides of the Atlantic, as well as the economic recovery up to now. Section 4 concludes.

2 FISCAL POLICY RESPONSE TO THE ECONOMIC FALLOUT OF THE CORONAVIRUS PANDEMIC

Discretionary measures aimed at cushioning the economic shock by protecting employment, containing the fall in private consumption and supporting disposable income. The main fiscal support measures adopted can be grouped into two categories. First, directly budget-relevant measures, such as income transfers through benefits or taxes and social security contribution deferrals. Job retention schemes, which provided support to both businesses and households, played a crucial role.[5] Second, measures without a direct budget impact, to support liquidity and solvency, such as loan moratoria, public guarantees and government loans, trade credit insurance and capital injections (e.g. to airline companies).

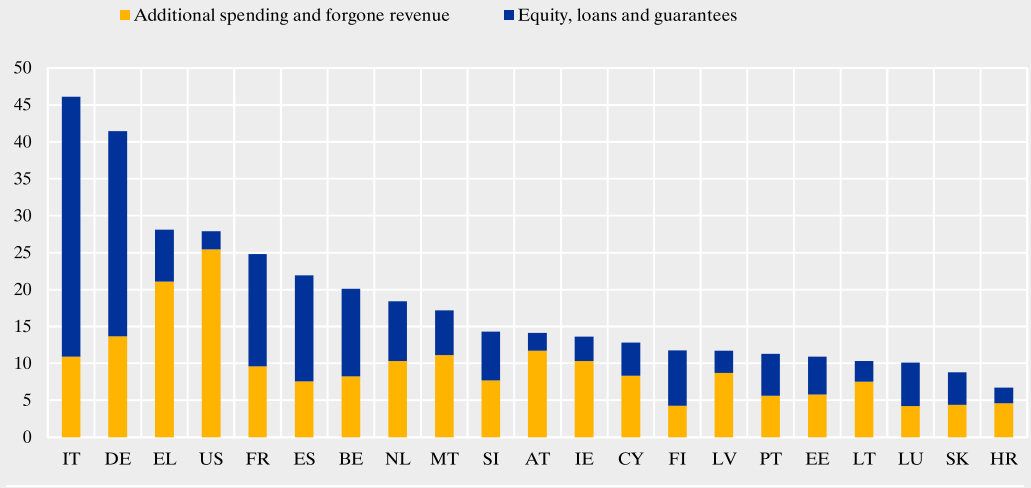
2.1 EURO AREA

In 2020, in order to contain the coronavirus pandemic and minimise its socio-economic impact, euro area governments adopted considerable fiscal and liquidity support measures at the national level.[6] According to the European Commission, the discretionary fiscal measures implemented by euro area governments in 2020 amounted to around 4% of GDP, on average, at the euro area level, while loan guarantees and other liquidity support measures for businesses, which, however, have no direct budgetary impact, reached around 17% of the euro area GDP.[7] An alternative metric of fiscal support is based on the general government primary surplus. The change in the

5 For more details about job retention schemes across countries, see Eichhorst et al. (2022).
6 For the economic measures taken in 2020 to address the consequences of the coronavirus crisis, see Bank of Greece (2020), *Monetary Policy 2019-2020*, Box II.1 (in Greek).
7 See European Commission, *European Economic Forecast: Autumn 2020.*

Chart 2 Discretionary fiscal response to the COVID-19 pandemic in selected economies

(% of GDP)



Source: IMF, Database of Country Fiscal Measures in Response to the COVID-19 Pandemic.
Note: Estimates as of 5 June 2021. Percentages of GDP are based on the July 2021 World Economic Outlook Update.

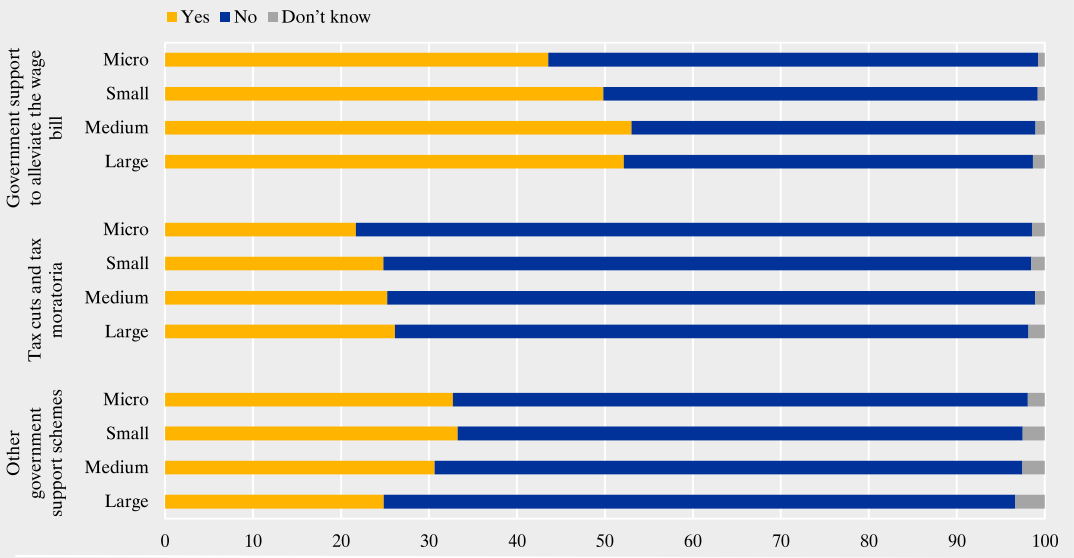
primary surplus captures the impact of the discretionary measures introduced and expired or expected to expire, as well as the impact of automatic stabilisers (excluding liquidity support and guarantee-providing measures that have no direct budgetary impact). In euro area countries, the cumulative change in the primary fiscal balance relative to 2019 is estimated on average at 13.8% of GDP in 2020-21 and 17% of GDP in 2020-22. If inflows of funds from the Recovery and Resilience Facility (RRF) are also taken into account, total support comes to 17.9% of GDP.[8] It should be noted that by the first half of 2022 the pandemic-related support measures introduced over the previous two years had been largely lifted.

Yet, there is significant cross-country heterogeneity within the euro area in terms of both the amount and the composition of such measures (see Chart 2). The International Monetary Fund (IMF), in an overview of policy responses during the pandemic crisis (IMF 2021), classifies discretionary measures into two categories: (i) above-the-line support; and (ii) below-the-line measures and contingent liabilities. The first category includes measures such as higher public spending on the health sector, extension of unemployment benefits, grants, tax and social security contribution moratoria. The second category comprises measures such as state-guaranteed loans, capital injections and government guarantees. On the basis of data on the discretionary fiscal measures announced between January 2020 and June 2021 (with an implementation horizon from 2020 onwards), Italy and Germany stand out, with overall measures surpassing 45% and 40% of their 2020 GDP, respectively, followed by France with about 25% and Spain with 22%. The composition of measures is also very different. Large European economies, such as Germany, France, Italy and Spain, announced government loans and guarantees to a much greater extent than above-the-line support. Consequently, the ranking changes if only above-the-line measures are taken into account: Greece ranks first, with overall measures accounting for 17.5% of 2020 GDP, followed by Germany and Austria (around 15% each), Italy (around 11%), France (9.6%) and Spain (slightly above 8%).

8 See Licchetta, M., G. Mattozzi, R. Raciborski and R. Willis (2022).

Chart 3 Euro area companies that have received government support in response to the pandemic

(% of respondents)



Source: IMF, Database of Country Fiscal Measures in Response to the COVID-19 Pandemic.
Note: Estimates as of 5 June 2021. Percentages of GDP are based on the July 2021 World Economic Outlook Update.

Measures to support businesses

Most euro area governments introduced policies to support businesses, with a focus on small and medium-sized enterprises (SMEs) and households during the implementation period of containment measures. Business support policies mostly included measures to enhance firms' liquidity in order to prevent layoffs and/or bankruptcies.[9] Sizeable measures were adopted to improve access to finance of businesses through public guarantees, government loans on favourable terms or subsidies.

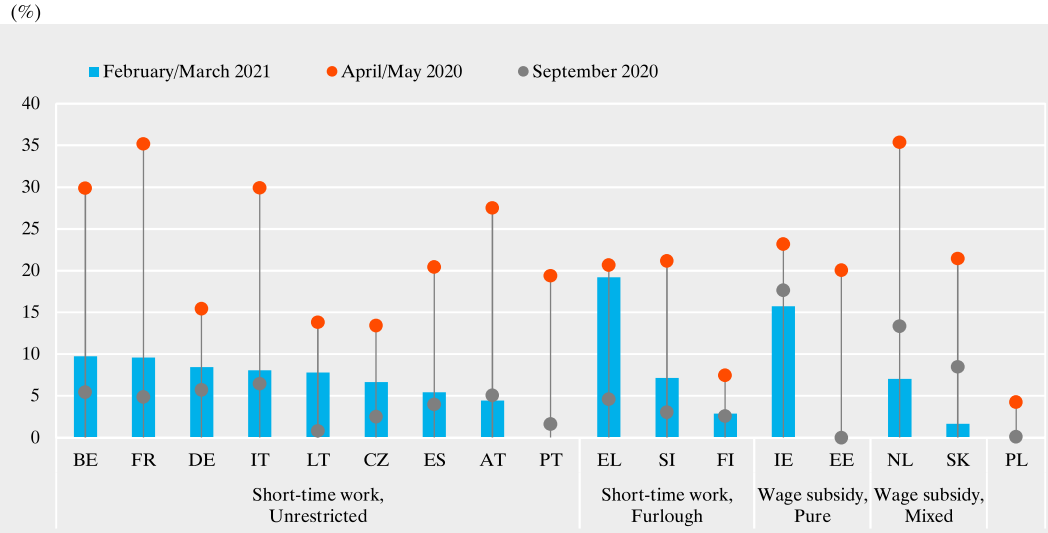
According to the responses to the Survey on the Access to Finance of Enterprises (SAFE) conducted between October 2020 and March 2021 (see Chart 3), 55% of large and medium-sized companies, as well as 49% and 45% of small and micro firms, respectively, reported having received government support aimed at alleviating their wage bills. At the same time, 28% of large firms and more than 25% of SMEs mentioned tax cuts and tax moratoria. Finally, other forms of government support (including loan guarantee schemes, as well as other country-specific policies) were mentioned by more than 33% of micro and small firms and by only 24% of large companies. Of those SMEs that had made use of such government support measures, the vast majority considered them to be extremely important in terms of meeting their immediate and short-term obligations. At the euro area level, almost two-thirds of SMEs stated that such schemes were also important in terms of overcoming the difficulties caused by the pandemic and avoiding bankruptcy, as did 52% of large firms.

Job retention schemes

Most euro area countries used job retention schemes in order to mitigate the labour market impact of the COVID-19 crisis. Employment support programmes took three different forms, as outlined by the OECD (2020). First, short-time work schemes, such as *Kurzarbeit* in Germany, under which businesses facing difficulties because of COVID-19 could, subject

9 See https://www.eca.europa.eu/Lists/ECADocuments/INSR22_28/INSR_SURE_EN.pdf.

Chart 4 Use of job retention schemes as a percentage of dependent employment



Source: OECD Employment Outlook 2021.
Note: Short-time work – unrestricted: no significant limits on the reduction in working time; short-time work – furlough: no partial reductions in working time allowed; wage subsidy – pure: based on wage bill only; wage subsidy – mixed: based on wage bill and reduction in business activity. Take-up rates are calculated as a percentage of all dependent employees in Q1 2020. Italy, Slovenia and Slovakia: latest data refer to December 2020. Portugal: data for December unavailable.

to conditionality, temporarily reduce their employees' working hours instead of laying them off, while ensuring their full-time employment income through government grants. Businesses were only burdened with the cost of actual hours worked by their employees, while employees received a government grant for the hours not worked, thereby securing their full-time employment income. Second, furlough schemes, which provided grants to workers whose employment contracts were suspended, such as the Spanish *ERTE* scheme. Third, wage subsidy schemes, which entailed the subsidisation of businesses for recruiting unemployed persons, such as the Dutch *Noodmatregel Overbrugging Werkgelegenheid (NOW)*. A crucial aspect of all these schemes was that workers kept the contract they had signed with their employer even if their work was suspended (OECD 2020).

Overall, the use of job retention schemes was high, as suggested by the OECD (OECD 2021). The use of these schemes responded to varying lockdown measures and the structure of the economies and, thus, cross-country differences were observed in their design and implementation (see Chart 4). The actual use of these schemes was considerably lower than the initial requests in some countries, but still about ten times as high as during the global financial crisis across the OECD (OECD 2020). The majority of European countries (including the United Kingdom) had already in place relatively generous unemployment benefit schemes and short-time work schemes prior to the pandemic. With the outbreak of the pandemic and the ensuing imposition of restrictions, all euro area countries introduced such schemes or expanded existing ones to protect employment and support incomes. In Germany, for instance, the existing short-time work scheme became temporarily more flexible and broader in scope. It is estimated that almost 10 million people had benefited from the *Kurzarbeit* scheme by mid-May 2020, compared with around 1.4 million people during the global financial crisis.[10]

10 https://www.bundesfinanzministerium.de/Web/EN/Home/home.html.

The use of both new and old job retention schemes was widespread during the first wave of the COVID-19 pandemic (OECD 2022). Take-up as a share of dependent employment peaked at above 20% in most countries in April/May 2020. Take-up rates tended to be considerably high in countries with general short-time work schemes, reaching or exceeding 30% in France, Belgium and Italy. The use of job retention support declined quickly, as most countries relaxed restrictions over the summer of 2020. Take-up fell to below 6% in almost all countries by September 2020, just before several countries began to see a resurgence of the pandemic. Countries that were hit by a new wave of the coronavirus, such as France and Italy, saw increases in take-up in February/March 2021 – although to levels well below the peak of spring 2020. However, in Greece, take-up reached levels very close to the peak seen at the start of the crisis (20%). Lastly, from a sectoral point of view, the use of these schemes was particularly large in the sectors most affected by restrictions and social distancing measures, such as accommodation and food services, arts and entertainment, wholesale and retail trade.

EU-wide policies

On top of the national measures adopted, the EU's response has also been significant and complemented national efforts. First, as the health situation in the EU worsened, the European Commission and the Council of the European Union activated the general escape clause of the Stability and Growth Pact in March 2020. The activation of this clause allowed Member States to temporarily depart from the normal budgetary requirements of the Pact. This facilitated Member States taking steps to sustain the economy during the pandemic and support a sustainable recovery, while safeguarding fiscal sustainability.[11] Moreover, on 9 April 2020, the Eurogroup decided to put in place additional financial tools to deal with the consequences of the health crisis and facilitate the reopening of the economy: a) the creation by the European Investment Bank (EIB) of a pan-European guarantee fund that could leverage loans amounting to €200 billion to SMEs; b) the establishment by the European Stability Mechanism (ESM) of a special lending mechanism, through the existing Enhanced Conditions Credit Line (ECCL), enabling Member States to access credit at almost zero interest rates without additional conditions, equal to 2% of their GDP at the end of 2019; and c) the establishment by the European Commission of a temporary lending instrument for the protection of employment in the form of low-interest loans totalling up to €100 billion (SURE programme). Through the temporary SURE instrument, EU Member States can obtain funding for the deployment of new or the extension of already existing job retention schemes, such as short-time work and wage subsidy schemes, as well as for health-related measures. The European Commission estimates that SURE supported about 31.5 million workers and 2.5 million businesses in 2020, and that nine million people participated in SURE-funded job retention schemes in 2021. On 27 May 2020, the European Commission presented a proposal for the creation of a new recovery instrument covering the period 2021-2026, the so-called "Next Generation EU" programme with a total envelope of €750 billion consisting of grants (up to €500 billion) and loans (up to €250 billion).

2.2 UNITED STATES

In the United States, the cumulative change in the primary fiscal balance relative to 2019 was larger than in the euro area and is estimated at 14.9% of GDP in 2020-21 and 17.4% of GDP in 2020-22. Unlike euro area countries, discretionary support in the United States was provided mostly through directly budget-relevant (above-the-line) measures. Thus, on the basis of IMF data, out of a total of discretionary fiscal measures amounting to 28% of GDP (announced in the United States between January 2020 and June 2021 with an implementation horizon from 2020 onwards), above-the-

11 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0123.

line measures accounted for slightly more than 25% of 2020 GDP, i.e. 7.5 p.p. above the figure for the euro area country with the most generous above-the-line package (see Chart 2).[12] It is indicative that directly budget-relevant measures were about twice as high as the liquidity-providing measures for businesses.[13]

Table 1 shows the major components of the United States' fiscal response, totalling $5.2 trillion. Around 19% of the total was allocated to business support, 18% to income support, 17% to state and local governments, more than 16% to direct payments to households and 13% to public health measures. More specifically, $808 billion of the Business Support component was allocated to the Paycheck Protection Programme which provided forgivable loans to small businesses if they maintained payrolls, while $711 billion of the Income Support component was allocated to unemployment benefits.

Specifically, the Coronavirus Aid, Relief, and Economic Security (CARES) Act[14] in 2020 provided direct economic assistance for American workers, households, small businesses and industries, amounting to about 11% of GDP ($2.3 trillion).[15] Through Economic Impact Payments, amounting to about 6% of GDP, households received relief payments of up to $1,200 per adult for eligible individuals and $500 per qualifying child.[16] At the same time, owing to soaring unemployment and the relatively modest unemployment benefits in the United States (compared with Europe), the US administration announced Short-Time Compensation (STC) programmes as part of the CARES Act. However, the use of STC programmes remained rather weak and the US administration introduced various temporary wage subsidy schemes, such as the Paycheck Protection Program (PPP)[17] and the Employee Retention Tax Credit (ERTC)[18]. Notwithstanding this, most employers in the United States opted for temporary lay-offs. Respectively, on their part, many unemployed persons lacked incentives to seek employment, as they received unemployment benefits plus an additional weekly payment of $600 for four months under the CARES Act (Springford and Tilford 2020).

Table 1 Deficit impact of US pandemic-related measures

Provision	Impact on deficit (USD billions)
Business support	995
Income support	963
State & local funding	868
Direct payments	859
Health spending	690
Tax policy	418
Other spending	428
Total	5,221

Source: Committee for a Responsible Federal Budget (CRFB) Covid Money Tracker, https://www.covidmoneytracker.org/explore-data/interactive-table, accessed 16 May 2023.

As part of the 2020 Annual Capital Expenditures Survey (ACES), US companies were asked about the impact of the COVID-19 pandemic on business operations (see Table 2). In total, 62.8% of companies with employees received financial assistance in 2020. In more

12 It should be recalled that the change in the primary balance reflects the effect of discretionary measures and automatic stabilisers, but does not capture the effect of measures without a direct fiscal impact, while the IMF definition includes measures with or without a fiscal impact and excludes the effect of automatic stabilisers.

13 According to a study by Bruegel, the United States spent $561 billion on payment deferrals for taxes and social security contributions to ease liquidity conditions for firms and workers, as well as another $560 billion on liquidity-providing measures through government loans and public guarantees to firms. The respective amount for immediate fiscal impulse measures, i.e. additional government spending (such as expenditure on health care, job retention schemes, subsidising SMEs, public investment and forgone revenues) was $1,940 billion. For further information, see https://www.bruegel.org/dataset/fiscal-response-economic-fallout-coronavirus.

14 https://home.treasury.gov/policy-issues/coronavirus/about-the-cares-act.

15 https://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19#U.

16 For a four-member family, these payments provided direct economic relief totalling up to $3,400. For further information, see https://home.treasury.gov/policy-issues/coronavirus/assistance-for-american-families-and-workers/economic-impact-payments.

17 Under the PPP, businesses employing up to 500 persons could apply for loans in order to cover their payroll costs and retain their employees. For further information, see https://home.treasury.gov/policy-issues/coronavirus/assistance-for-small-businesses/ paycheck -protection-program.

18 The ERTC provides a tax credit to businesses whose sales dropped by more than 50%. For further information, see https://www.irs.gov/newsroom/faqs-employee-retention-credit-under-the-cares-act.

Table 2 Financial assistance requested and received by companies with employees, by source

(% of companies with employees, 2020)

NAICS code	Industry	Paycheck Protection Programme (PPP)		Economic Injury Disaster Loans (EIDL)		Small Business Administration (SBA) Loan Forgiveness	
		Requested	Received	Requested	Received	Requested	Received
	Total[1]	61.7	58.3	21.6	18.5	21.0	16.2
21	Mining	70.2	68.7	12.2	11.8	11.3	10.4
31-33	Manufacturing	69.3	65.7	21.2	19.1	24.4	19.5
44-45	Retail trade	69.9	66.3	25.1	21.3	24.9	19.2
61	Educational services	69.1	67.9	27.8	23.9	23.8	17.9
62	Health care and social assistance	71.0	67.3	26.2	23.3	26.9	22.7
71	Arts, entertainment and recreational services	58.8	56.2	27.9	23.8	19.5	15.6
72	Accommodation and food services	74.1	67.7	40.7	33.5	32.5	23.1

Source: US Annual Capital Expenditure Survey for 2020.
1 Total across all sectors. Companies were able to select more than one survey response.

detail, the financial assistance requested (received) during the coronavirus pandemic in 2020 by companies with employees, broken down by source, is as follows: (i) 61.7% of companies requested financial assistance from the PPP (received by 58.3%); (ii) 21.6% from the Economic Injury Disaster Loan (EIDL) (received by 18.5%)[19]; (iii) 21% from the Small Business Administration (SBA) Loan Forgiveness programme (received by 16.2%)[20]. Furthermore, 61% of companies with employees received financial assistance from one or more sources and used the funds to rehire or maintain employees on their payroll, 20.1% used the funds to pay the rent/mortgage, 15.3% to pay for utilities, 2.2% for capital expenditures and 5.6% for all other expenses. Looking at the sectoral breakdown, companies in the accommodation and food services sector requested (and received) the largest amount of financial assistance from all sources.

3 THE ECONOMIC IMPACT OF THE PANDEMIC AND THE SUPPORT MEASURES

The macroeconomic shock caused by the COVID-19 pandemic affected both supply and demand. The pandemic crisis started as a supply-side shock due to government interventions imposing supply-side restrictions to contain the spread of the virus. The supply-side shock turned into a demand-side shock due to the high uncertainty related to the pandemic.

In an effort to counteract low aggregate demand and bring the economy back to its full working capacity, policymakers intervened with support measures. As aforementioned, the focus of fiscal support measures differed between the euro area and the United States. Euro area countries have used short-time working and wage subsidies together with guaranteed loans and liquidity-providing measures for firms, aiming to keep workers attached to firms. The United States relied upon lending, increased unemployment insurance and tax rebates for households. These differences have

19 The EIDL programme, administered by the US Small Business Administration (SBA), was designed to provide economic relief to businesses that were experiencing a temporary loss of revenue due to COVID-19. For further information, see https://www.sba.gov/funding-programs/loans/covid-19-relief-options/covid-19-economic-injury-disaster-loan/about-covid-19-eidl.

20 The Small Business Administration (SBA) Loan Forgiveness programme was available to companies that defaulted on a loan during the coronavirus pandemic. After making some payments, a company could apply for the forgiveness of the loan and generally a certain percentage of the loan would be forgiven.

important consequences for growth, jobs and inflation. In what follows, we study the imprint of these different strategies on the two economies in the short run.[21]

3.1 ECONOMIC RECOVERY

Despite the timely response of governments to support their economies, the recession caused by the pandemic was deep, albeit short-lived. The economic slowdown was stronger in the euro area than in the United States and the return of GDP to its pre-pandemic level was achieved in the first quarter of 2021 for the United States, compared with the third quarter of 2021 for the euro area (see Chart 5).

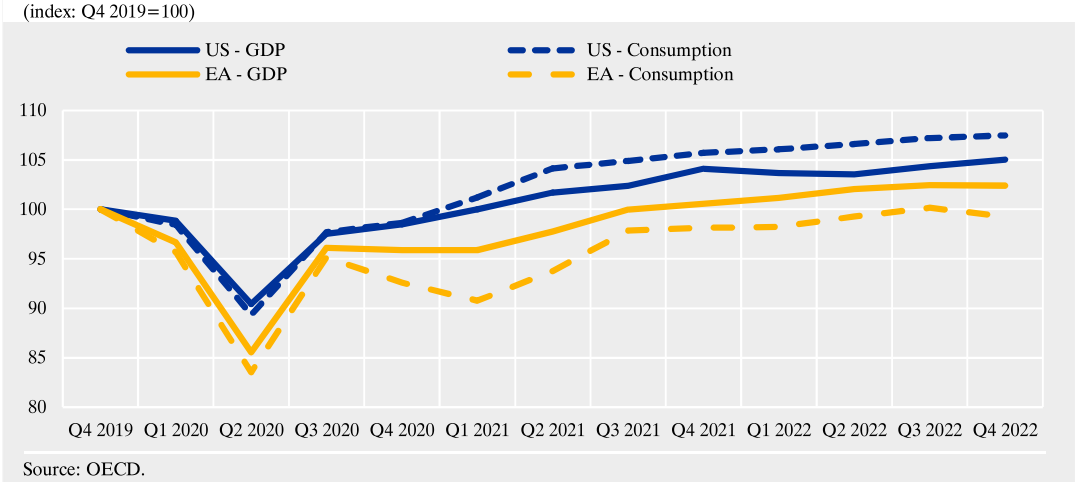
Private consumption declined less in the United States than in the euro area (see Chart 5). This was mainly due to the direct transfers to households, which boosted real disposable income in 2020 and 2021. Moreover, in the United States consumption recovered faster compared to GDP, while the growth rate of GDP was lower than the growth rate of consumption in the euro area. Against this backdrop, private consumption in the United States had already returned to pre-pandemic levels by the first quarter of 2021, whereas euro area consumption recovered in the third quarter of 2022, before falling below the pre-pandemic level again in the following quarter. However, it should be noted that the slow recovery of euro area consumption was also due to a worsening in the terms of trade caused by the euro area's greater energy reliance on natural gas imports compared with the United States, which is reducing disposable income.

With the consumption boom in the United States, pressures on prices shot up, while inflation also increased in the euro area, although at a slower pace (see Chart 6). The successive waves of the pandemic caused major supply chain disruptions, which were exacerbated with the outbreak of the war in Ukraine, initially leading to higher prices of commodities and food and subsequently pushing core inflation upwards due to pass-through effects. Meanwhile, the phasing-out of pandemic-related restrictions led to the release of pent-up demand, especially in the services sector, which in turn strengthened upward price pressures. Lastly, the euro area economy had been affected by imported inflation from the United States.[22] The increase in private consumption

21 For an analysis of the impact in the long run, see, among others, Barisic and Kovac (2022).

22 See an intervention by Bank of Greece Governor Yannis Stournaras at the panel "Monetary policy fit for today and tomorrow" of the 13th Limassol Economic Forum, 21.10.2022, available at https://www.bankofgreece.gr/en/news-and-media/press-office/news-list/news?announcement=05be290a-c8d9-4dc1-b331-8f45a060786a. See also Hall, S.G., G.S. Tavlas and Y. Wang (2022).

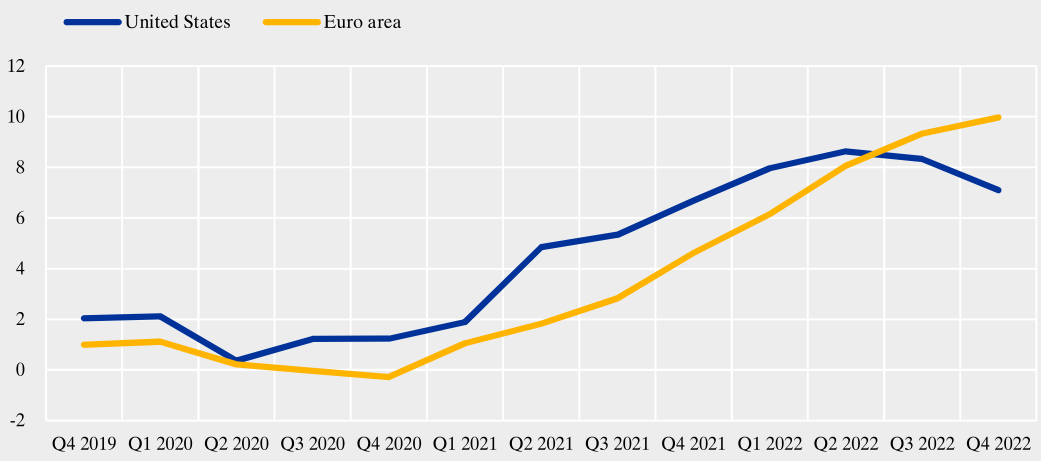
Chart 5 GDP and consumption



Source: OECD.

Chart 6 CPI inflation rate

(year-on-year percentage change)



Source: OECD.

in the United States indicates that rising inflation largely reflects demand-side effects, alongside supply-side effects. By contrast, in the euro area, inflation was mainly driven by a series of supply-side shocks, with high energy costs being the key driver.[23]

3.2 IMPLICATIONS FOR THE LABOUR MARKET

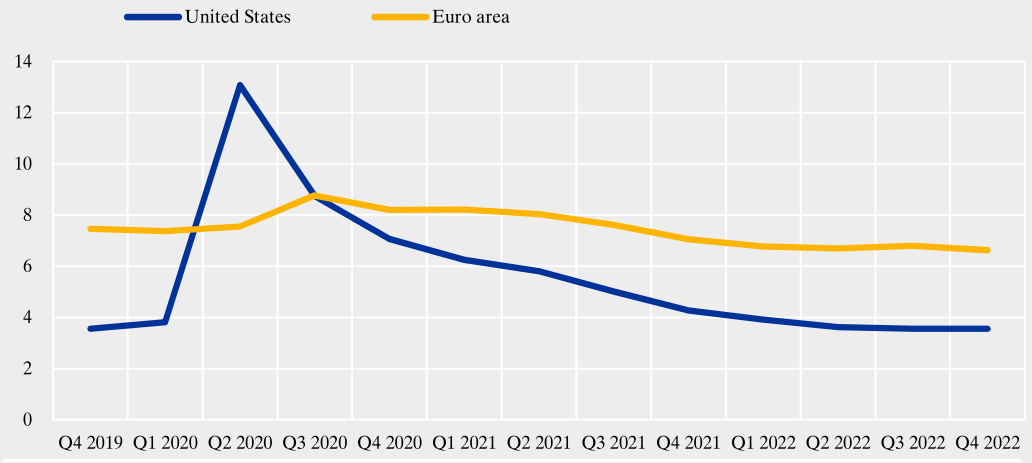
The unprecedented recession resulted in very negative labour markets outcomes. However, despite comparably sized economic shocks and stimulus packages, developments in the United States and euro area labour markets were different. The literature suggests that the cyclical volatility of (un)employment is much more pronounced in the relatively less regulated labour market of the United States than in continental Europe (see, among others, OECD 2009; Elsby et al. 2011). But this alone is probably not enough to explain the disparity observed during and after the period of the pandemic. It was the focus of the US policies on supporting disposable income, as opposed to the euro area policies of protecting existing jobs, that resulted in a sharp increase of unemployment in the United States, compared to more stable outcomes in the euro area (see Chart 7).

The findings are similar for employment (see Chart 8). Specifically, employment in 2020 declined by 5.5% in the United States and recovered to pre-pandemic levels in the third quarter of 2022. In the euro area, the decline averaged 1.8% and employment recovered to pre-pandemic levels in the third quarter of 2021, i.e. four quarters earlier than in the United States. The picture is different when considering hours worked. The extended use of job retention schemes in the euro area resulted in a considerable adjustment in hours worked, which also occurred in the United States, albeit to a smaller degree (see Chart 8). Hours worked in the euro area had declined sharply already since the first quarter of 2020, as lockdown measures were immediately imposed, while it took one more quarter for the United States. During the first half of 2020, hours worked in the euro area fell by 17%, i.e. much more than employment, which fell by 2.3%. This difference is explained by the fact that people in job retention schemes were recorded as employed. Hours worked in both regions started recovering in the third

23 For a detailed discussion of the role of demand and supply in driving inflation in the United States and the euro area, see Bank of Greece (2023), *Summary of the Annual Report 2022*, Box 1.

Chart 7 Unemployment rate

(% of active population)



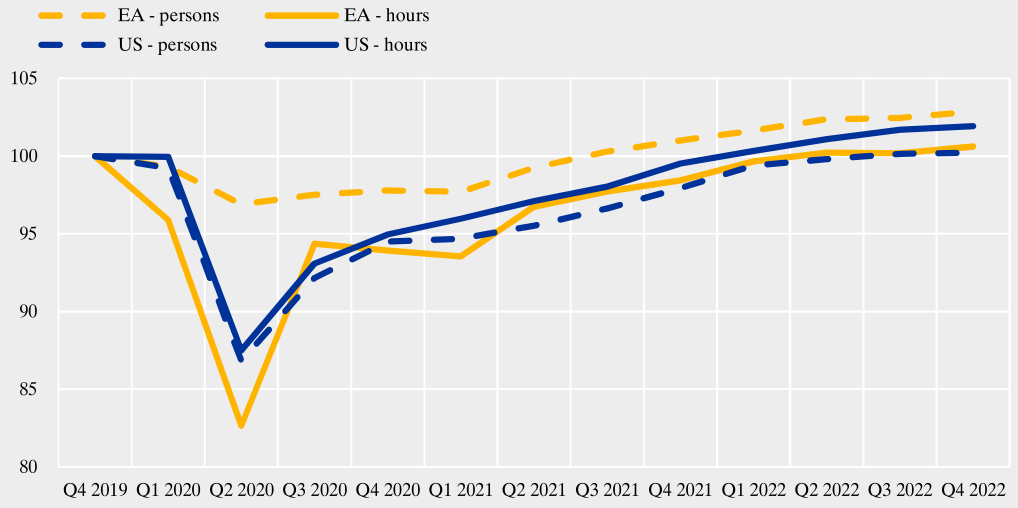
Source: OECD.

quarter of 2020, when lockdown measures were lifted. This recovery has been continuous for the United States, unlike the euro area: hours worked in the euro area stalled again in the last quarter of 2020 and the first quarter of 2021, as extensive lockdown measures were re-introduced.

Developments also differed between the two economies in terms of participation rates in the labour market. Participation declined in both regions, but the contraction was larger and longer lasting in the United States than in the euro area (see Chart 9). Low participation rates are explained by the pandemic, in the

Chart 8 Employment - headcount and hours worked

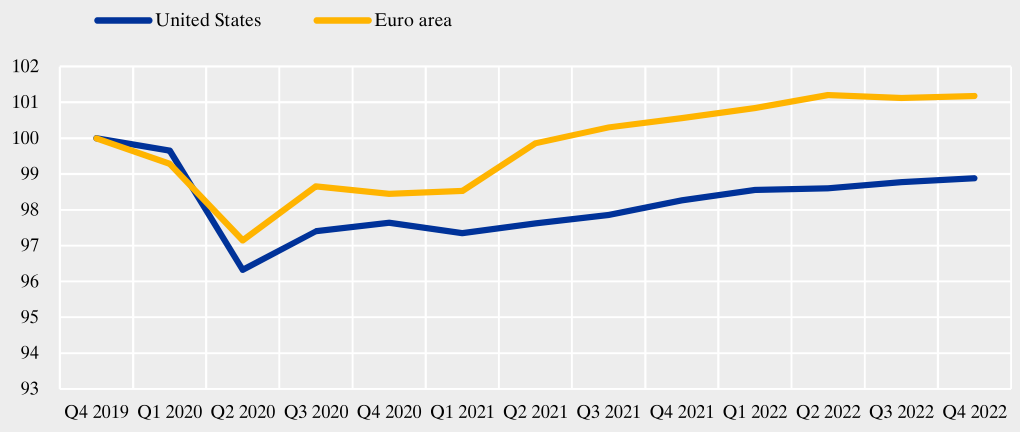
(index: Q4 2019=100)



Sources: Eurostat and US Bureau of Labor Statistics.

Chart 9 Participation rate

(index: Q4 2019=100)



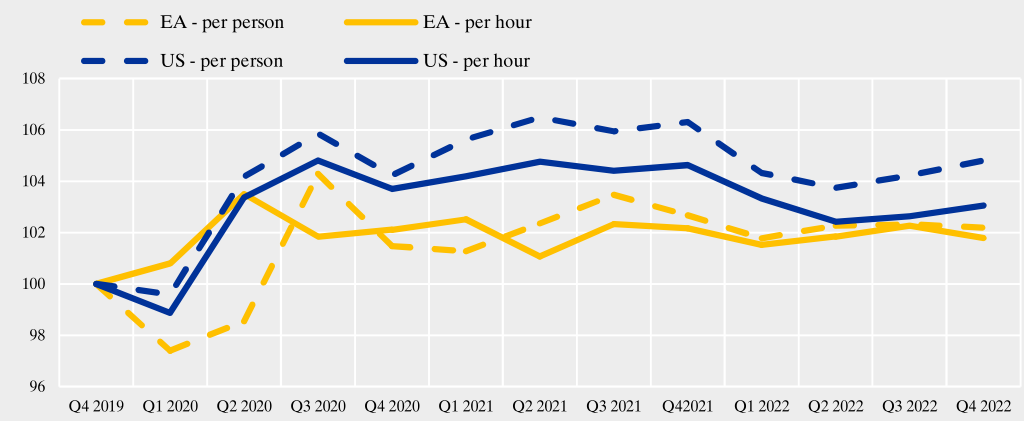
Source: OECD.

sense that people exited the labour force due to caregiving needs and for fear of the virus. In the case of the United States, low participation also coincided with record-high levels of voluntary quits from jobs, a phenomenon that came to be known as the "great resignation". However, Fuller and Kerr (2022) allege that although a record number of workers did quit their jobs in 2021, the phenomenon reflected the long-term trend of increased rates of resignation. In 2020, because of the uncertainty brought on by the COVID-19 pandemic, the resignation rate slowed as workers held on to their jobs. In 2021, as stimulus policies were adopted and the uncertainty abated, a record number of workers quit their jobs. Today, participation rates have recovered to a great extend, although they are still below their pre-crisis level in the case of United States.

The large shifts in labour indicators together with the large shift in output led to swings in

Chart 10 Developments in labour productivity per person employed and hours worked

(index: Q4 2019=100)



Sources: US Bureau of Labor Statistics and OECD.

labour productivity in both regions.[24] During the pandemic, productivity per hour was stronger than the pre-crisis trend in both regions, although this development was more pronounced in the United States (see Chart 10) (Gomez-Salvador and Soudan 2022). This might also reflect a composition effect, as most of the job losses were in low-wage industries or among low-wage workers, thus leading to increased average labour quality (Stewart 2022). This effect waned as activity recovered. For the euro area, productivity figures differ when measured according to persons employed or hours worked. More specifically, productivity based on hours worked suggests a continuous increase since the outbreak of the pandemic and throughout 2021. However, productivity based on the number of persons employed temporarily decreased in the first two quarters of 2020, reflecting a stable employment headcount, but a large output adjustment, before increasing thereafter. Finally, labour productivity decreased (year-on-year) in 2022 for the economies of both the United States and the euro area.

3.3 SECTORAL ANALYSIS

The pandemic had asymmetric effects across the various sectors of the economy. The so-called "contact-intensive sectors" suffered the strongest impact during the pandemic period. Although support measures were often targeted towards these sectors, this was not enough to fully offset the impact. In more detail, for the euro area a large decrease in the number of persons employed/hours worked and in value added is observed in the "Trade and accommodation" and "Recreation" sectors. For the United States, the sectors with the largest drop in employment and activity were "Recreation", "Accommodation" and "Mining".[25] In the aftermath of the pandemic, some sectors have grown above their pre-pandemic employment level, possibly having benefited by the pandemic. In the euro area, these sectors are the following: (i) in terms of employment, a large increase is observed in "Information and communication", followed by smaller increases in "Construction" and "Real estate"; and (ii) in terms of value added, "Information and communication". In the United States, employment grew above its pre-pandemic level in the following sectors: (i) in terms of employment, "Transportation", "Other services" and "Information"; and (ii) in terms of value added, "Information", "Management services" and "Other services". The exceptional performance of sectors related to information and communication is in line with findings regarding the increased prevalence of teleworking and the digitalisation trend of firms during the pandemic.[26] These effects are permanent, as ICT infrastructure, security, hardware and software imply large investment costs and are thus expected to impact production procedures and the labour market beyond the short-term horizon.

Chart 11 shows developments in labour productivity. In the euro area, productivity was hurt in the second quarter of 2020 in "Recreation", "Industry" and "Public services", with rather protracted losses in "Recreation" and a strong recovery in "Industry". In the United States, productivity developments were similar. More specifically, productivity decreased sharply in "Recreation", "Transportation" and "Accommodation", while recovery was exceptional in "Management services" and "Information".[27] Today, productivity in most sectors is above its pre-pandemic level in both regions.

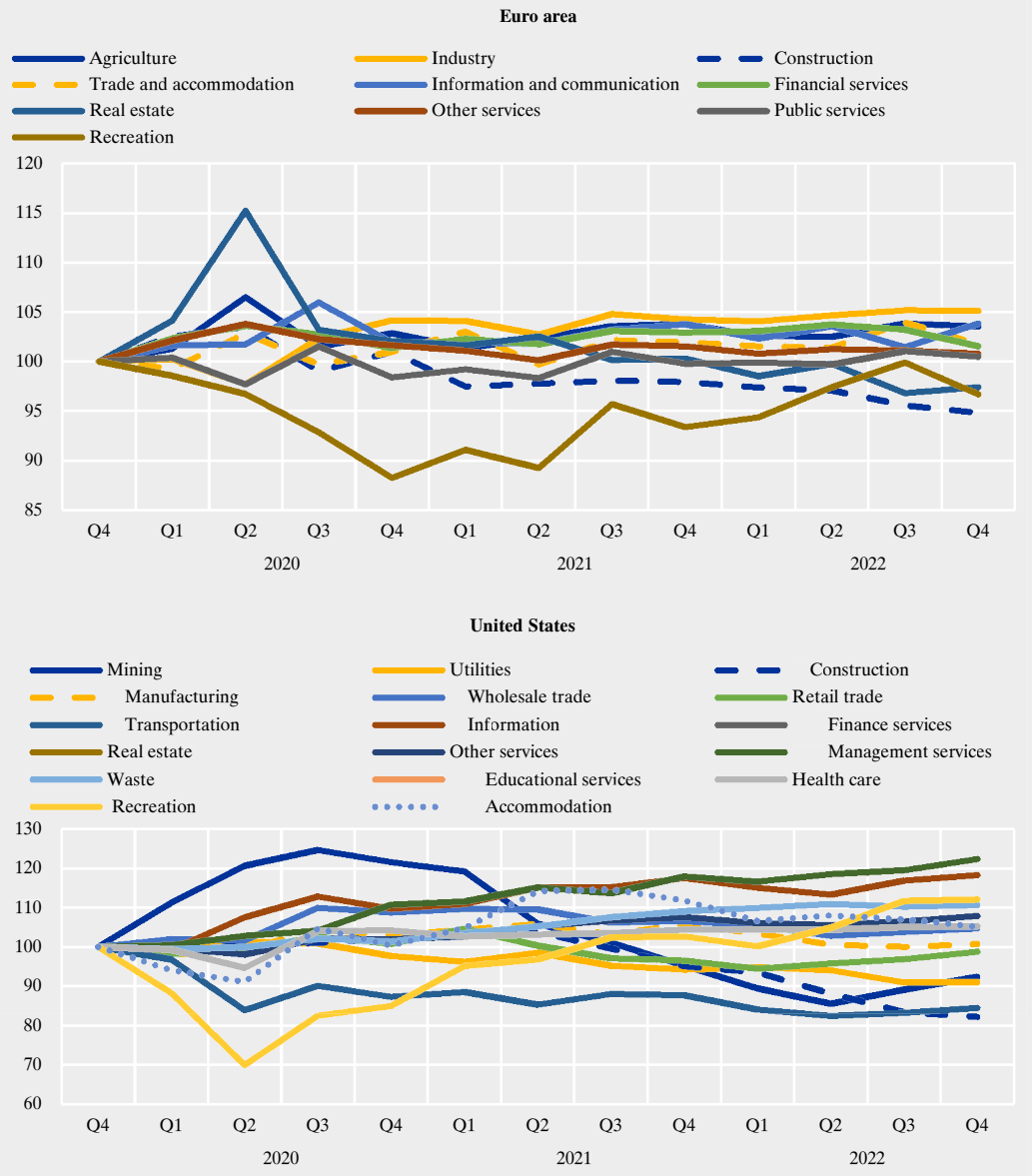
4 CONCLUSIONS

The pandemic resulted in an unprecedented recession across economies. Government

24 For a more detailed analysis of productivity developments during the COVID-19 pandemic, see "The impact of the COVID-19 pandemic and policy support on productivity" (European Central Bank 2023).
25 Production and jobs in the coal industry had already been in decline before the COVID-19 pandemic. A number of explanations have been offered, including environmental regulations, technological innovations in the extraction of natural gas impacting its supply and price, productivity gains in coal mining, etc. (Kolstad 2017). The pandemic slowed global demand for coal internationally and the US electric power sector demand for coal. A robust post-pandemic economic recovery and soaring gas prices provided opportunities for a coal rebound, although the benefits will likely be brief, as the long-term structural decline resumes (Feaster 2023).
26 See, among others, European Central Bank (2023).
27 For developments in "Mining", see footnote 25.

Chart 11 Sectoral labour productivity per hour worked

(index: Q4 2019=100)



Sources: Eurostat, US Bureau of Economic Analysis and US Bureau of Labor Statistics.

responses included lockdown measures to contain the spread of the virus and macroeconomic and financial policies to mitigate the negative impact on their economies. Both the euro area and the United States responded to the pandemic-induced economic shock with unprecedented fiscal support measures. Furthermore, the EU introduced new common fiscal instruments, which were designed to ensure broad-based and faster recoveries, signalling maybe for the first time that the EU is more than the sum of its parts.

The quantification of the fiscal measures implemented in response to the COVID-19 crisis, as well as a comparison across euro area countries

or between the euro area and the United States, can be very challenging. First, the initial estimates of the fiscal cost to euro area countries are often subject to substantial revisions, especially because of smaller actual uptakes compared to announced volumes. In fact, data from the European Systemic Risk Board (ESRB) based on the reports published by national macropudential authorities (up to September 2020) show that in the first quarter of 2021 the overall volume of announced fiscal measures stood at 18.7% of GDP, relative to 14.6% in the third quarter of 2020 (loan moratoria are not included). At the same time, the actual uptake of measures was 6.9% of GDP in the first quarter of 2021, against 4.2% in the third quarter of 2020, showing that the announced size was not fully used (see Wieland 2022). Second, it is not always easy to distinguish between discretionary measures and the result of automatic stabilisers. It should be stressed that European economies have typically incorporated much stronger automatic stabilisers than the US economy. In order to achieve an equivalent total stabilisation effect, more sizeable discretionary measures are required in the United States than in Europe.

Both the euro area and the United States have recovered markedly, with GDP now standing above its pre-pandemic level. Recovery in the United States was supported by strong consumption. In the euro area, while incomes and employment have recouped their losses, this is not the case with demand. Demand still falls short of its pre-pandemic level, because of both consumption and investment, although RRF resources will help to cover the shortfall in investment. These divergent developments suggest that the drivers of high inflation facing both economies (7.2% in the United States and 10% on average in the euro area in the fourth quarter of 2022) are different. In the United States, rising inflation is largely demand-driven. By contrast, the drivers of euro area inflation are complex and largely reflect the multiple supply-side inflationary shocks hitting the economy.

Labour market developments have been different in the two regions. Governments in the euro area aimed to protect jobs through job retention programmes, while policies in the United States allowed unemployment to rise. Thus, the United States experienced a stronger and longer contraction in the labour market compared to the euro area. The labour market has recovered by now in both regions, with the exception of the participation rate in the United States, which is still lagging behind its pre-crisis level. Finally, labour productivity has been increasing, although this is also related to a temporary compositional effect which unwinds as activity recovers in the two regions.

At the sectoral level, contact-intensive sectors (e.g. “Recreation” and “Accommodation”) suffered the strongest impact in terms of employment, value added and labour productivity. However, in the post-pandemic period certain sectors, such as “Information”, grew fast. Thus, data already show the first signs that the pandemic accelerated digitalisation and automation in ways that may transform production processes and the labour market in the future.

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WORKING PAPERS (DECEMBER 2022 – JULY 2023)

This section contains the abstracts of *Working Papers* authored by Bank of Greece staff and/or external authors and published by the Bank of Greece. The unabridged version of these texts is available on the Bank of Greece's website (www.bankofgreece.gr).

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Money under the mattress: economic crisis and crime

Working Paper No. 310
Eleni Kyrkopoulou, Alexandros Louka and Kristin Fabbe

This paper investigates the effect of a (semi) deposit run during a debt crisis on crime rates. The study focuses on Greece's protracted debt crisis (2009-2018) and analyses the response of crime to deposit outflows. It shows that deposit outflows corresponded to a significant increase in property crimes (thefts and burglaries), but not other types of offences. The findings of this paper suggest that policymakers should also consider the potential criminogenic effects of financial destabilisation.

Mapping inflation dynamics

Working Paper No. 311
Catherine Kyrtsou

CPI inflation is subject to structural changes and exogenous shocks that can have a significant impact on its dynamic evolution. The observed interaction between the intrinsic side of inflation dynamics and the disturbances fuels a rich spectrum of behaviours. To accommodate the complex outcome of interactions, the author proposes a methodological strategy combining the non-parametric Recurrence Quantification Analysis (RQA), the GPH fractional integration coefficient *d* and the Phillips curve-based framework. The empirical findings demonstrate the non-linear contribution of inflation inertia to the headline inflation dynamics, mainly over the last eight quarters of the sample alongside the occurrence of price shocks.

Endogenous frequencies and large shocks: price-setting in Greece during the crisis

Working Paper No. 312
Huw Dixon, Theodora Kosma and Pavlos Petroulas

The authors utilise a unique micro price data set for Greece that underpins the Greek CPI. It spans almost two decades, during which Greece suffered a large economic shock. The authors find that during this time there were significant changes in the pricing behaviour of Greek firms. They also find that macroeconomic developments such as annual inflation and output growth are important factors in determining the frequency and size of price changes. This leads to an intertemporal inflation dynamic linking current inflation to future price behaviour and inflation. Utilising the empirical estimates from the data, they combine a Taylor rule and Euler equation with the inflation dynamic resulting from the asymmetric impact of inflation on the frequency of price increases and the frequency of price decreases. The results of the simulations capture the Greek inflation developments well. Moreover, they also capture developments in the frequency of price increases and decreases seen in other economies and over different time periods.

Financial literacy for financial resilience: evidence from Cyprus during the pandemic period

Working Paper No. 313
Panayiotis C. Andreou, Sofia Anyfantaki and Adele Atkinson

This study takes Cyprus as a case country to examine the role of financial literacy for financial resilience in the pandemic period. Responses to the survey questions to assess the level of financial literacy show that, in 2021, less than 4 out of 10 respondents had a good financial knowledge proficiency level. The results also show that more than 1 out of 3 Cypriots are financially fragile, i.e. they would not have been able to cover an unexpected financial need within a month without borrowing or asking for financial help. Moreover, about 6 out of 10 did not have a rainy-day fund to cover three months' living expenses in case of losing their main source of income. The proportions are higher for young, not employed, low-income and larger households, indicating that these subgroups were the least resilient. These findings suggest that many Cypriot households were ill prepared to face the economic consequences of the COVID-19 pandemic. Most importantly, the findings indicate that financial knowledge proficiency appears as a strong antecedent of one's proclivity of being financially resilient. An important policy implication of the study's conclusions is that financial education could help households to improve their financial resilience and prepare for future shocks.

Forecasting inflation: the use of dynamic factor analysis and non-linear combinations

Working Paper No. 314
Stephen G. Hall, George S. Tavlas and Yongli Wang

This paper considers the problem of forecasting inflation in the United States, the euro area and the United Kingdom in the presence of possible structural breaks and changing parameters. The authors examine a range of moving-window techniques that have been proposed in the literature. They extend previous work by considering factor models using principal components and dynamic factors. The authors then consider the use of forecast combinations with time-varying weights. The basic finding of this paper is that moving windows do not produce a clear benefit to forecasting. Time-varying combination of forecasts does produce a substantial improvement in forecasting accuracy.

Is COVID-19 reflected in the AnaCredit dataset? A big data machine learning approach for analysing behavioural patterns using loan-level granular information

Working Paper No. 315
Anastasios Petropoulos, Evangelos Stavroulakis, Panagiotis Lazaris, Vasilis Siakoulis and Nikolaos Vlachogiannakis

The authors explore the impact of the COVID-19 pandemic on the default risk of loan portfolios of the Greek banking system, using cutting-edge machine learning technologies, like deep learning. The analysis is based on loan-level monthly data, spanning a 42-month period, collected through the ECB AnaCredit database. The dataset contains more than three million records, including both the pre- and post-pandemic periods. The authors develop a series of credit rating models implementing state-of-the-art machine learning algorithms. Through an

extensive validation process, the authors explore the best machine learning technique to build a behavioural credit-scoring model and subsequently they investigate the estimated sensitivities of various features on predicting default risk. To select the best candidate model, the authors perform comparisons of the classification accuracy of the proposed methods, in 2-months out-of-time period. The empirical results indicate that the Deep Neural Networks (DNN) have a superior predictive performance, signalling better generalisation capacity versus Random Forests, Extreme Gradient Boosting (XGBoost) and logistic regression. The proposed DNN model can accurately simulate the non-linearities caused by the pandemic outbreak on the evolution of default rates for Greek corporate customers. Under this multivariate setup, the authors apply interpretability algorithms to isolate the impact of COVID-19 on the probability of default, controlling for the rest of the features of the DNN. The results of the study indicate that the impact of the pandemic peaks in the first year, and then slowly decreases, though without reaching yet the pre-COVID-19 levels. Furthermore, the empirical results also suggest different behavioural patterns between Stage 1 and Stage 2 loans, and that default rate sensitivities vary significantly across sectors. The current empirical work can facilitate a more in-depth analysis of the AnaCredit database, by providing robust statistical tools for a more effective and responsive micro- and macro-supervision of credit risk.

Guaranteeing trade in a severe crisis: cash collateral over bank guarantees

Working Paper No. 316
Antonis Kotidis, Margaux MacDonald and Dimitris Malliaropulos

Banks guarantee international trade through letters of credit. This paper analyses what happens to trade when the critical role of banks as trade guarantors is compromised. Using the case of the Greek capital controls in 2015, the events around which led to a massive loss of confidence in the domestic banking system, the authors show that firms whose operations were more dependent on domestic banks suffered a steep decline in imports and, subsequently, exports. This operated through letters of credit, which during the capital controls period had to be backed by firms' own cash collateral rather than the bank guarantee. As a result, cash-poor firms imported relatively less. Public intervention to guarantee transactions is shown to help mitigate some of the decline in imports.

The D-model for GDP nowcasting

Working Paper No. 317
Stavros Degiannakis

The paper provides a disaggregated mixed-frequency framework for the estimation of GDP. GDP is disaggregated into components that can be forecasted based on information available at higher sampling frequency, i.e. monthly, weekly or daily. The model framework is applied to Greek GDP nowcasting. The results provide evidence that more accurate nowcasting estimations require i) a disaggregation of GDP; ii) the use of a multilayer mixed-frequency framework; iii) the inclusion of financial information at daily frequency. The simulation study provides evidence in favour of the disaggregation into components despite the inclusion of multiple sources of forecast errors.

Superkurtosis

Working Paper No. 318
Stavros Degiannakis, George Filis, Grigorios Siourounis and Lorenzo Trapani

Very little is known on how traditional risk metrics behave under intraday trading. The authors fill this void by examining the finiteness of the returns' moments and assessing the impact of their infinity in a risk management framework. They show that when intraday trading is considered, assuming finite higher-order moments, potential losses are materially larger than what the theory predicts, and they increase exponentially as the trading frequency increases – a phenomenon the authors call superkurtosis. Hence, the use of the current risk management techniques under intraday trading poses threats to the stability of financial markets, given that capital ratios may be severely underestimated.

Explaining the endurance of price level differences in the euro area

Working Paper No. 319
Huw Dixon, Theodora Kosma and Pavlos Petroulas

This paper analyses price-level differences in the euro area focusing on the impact of market structure and exploring how consumer behaviour can influence firms' pricing. The authors consider two elements of market structure: producer market competition structure and the less explored structure of retail market competition. Regarding consumer behaviour, the authors focus primarily on consumer habits. To this end, they utilise an extensive dataset on retail prices and quantities for 41 product categories of fast-moving consumer goods across 58 regions in 10 euro area countries. The results of the paper indicate that observed price differences reflect effects from diverse sources. The competition structure of the goods' producers is found to be an important determinant of price differences. However, the authors also find that retail market structure and consumer habits matter as well, explaining a significant and economically meaningful share of observed price differences. This points to possible new and important determinants of price differences across countries that go beyond the traditional goods market structure.

Implications of market and political power interactions for growth and the business cycle II: politico-economic equilibrium

Working Paper No. 320
Tryphon Kollintzas and Vanghelis Vassilatos

Motivated by the politico-economic systems encountered in many countries all over the globe, including those of several Southern European countries, the authors in this paper follow a Ramsey-type optimal policy approach to endogenise government policy in the two-sector DSGE model with market and political power interactions developed in a companion paper. They thus obtain the so-called politico-economic equilibrium. That is, a contingency plan for the economy's resource allocation and government policy variables that optimise the government's objective function, subject to the private sector equilibrium. The government's objective function seeks a balance between pursuing the interests of insiders and the

interests of the representative household. The latter are in line with what Jean Tirole calls government pursuing policies for "the common good". The authors take the interests of insiders to be represented by the expected value of their income. The combination of these two defines what the authors call the "hybrid" government. They then investigate the growth implications of the politico-economic equilibrium, focusing, first, on the steady state comparison of the hybrid government politico-economic equilibrium relative to the second-best allocation implied by the Canonical Real Business Cycle economy and, second, on the asymptotic steady states of the politico-economic equilibrium of a hybrid government in a detailed economy, for different degrees of insiders' influence on government. The paper finds that increasing influence of insiders on government decision-making is quite bad for the economy. The degree of influence of insiders is a deep parameter of the model that can be estimated in the data and thereby rank countries accordingly. The extent of this influence may explain the different macroeconomic performance observed among countries that, ceteris paribus, enjoy a similar state of development.

Greek GDP forecasting using Bayesian multivariate models

Working Paper No. 321
Zacharias Bragoudakis and Ioannis Krompas

Building on a proper selection of macroeconomic variables for constructing a Gross Domestic Product (GDP) forecasting multivariate model (Kazanas 2017), this paper evaluates whether alternative Bayesian model specifications can provide greater forecasting accuracy compared to a standard Vector Error Correction Model (VECM). To that end, two Bayesian Vector Autoregression models (BVARs) are estimated: a BVAR using Litterman's (1979) prior and a BVAR with time-varying parameters (TVP-BVAR). Two forecasting evaluation exercises are then carried out: a 28-quarters ahead forecast and a recursive 4-quarters ahead forecast. The BVAR outperformed the other models in the first, whereas the TVP-VAR was the best-performing model in the second, highlighting the importance of having adjusting mechanisms, such as time-varying coefficients in a model.

Forecasting VIX: the illusion of forecast evaluation criteria

Working Paper No. 322
Stavros Degiannakis and Eleftheria Kafousaki

The paper uses daily realised volatility measures in order to gain forecast accuracy over stock market implied volatility, as proxied by the VIX Index, for a forecast horizon of 1, 5, 10 and 22 days ahead. The authors evaluate forecast accuracy by incorporating a traditional statistical loss function, along with an objective-based evaluation criterion, that is the cumulative returns earned from the different HAR-type volatility models, through a simple yet effective trading exercise on VIX futures. The findings illustrate how illusive the choice between the two metrics may be, as it ends in two contradicting results.

Exploring country characteristics that encourage emissions reduction

Working Paper No. 323
Panayiotis C. Andreou, Sofia Anyfantaki, Christos Cabolis and Konstantinos Dellis

The paper explores the relation between sound institutions favouring innovation and technology investment and firms' emissions reduction. Even though emission abatement is achieved at the firm or plant level, the authors postulate that structural and institutional factors underpinning green innovation, skills and technology adoption at the country level are of material importance. Advances in technology and infrastructure are the main drivers for the reduction of emissions and are, in turn, intrinsically linked to overall country characteristics. Sound institutions can act as enablers and accelerators for firms and industries in the green transition process; hence, the authors find an attenuating effect on emissions that is conditional on firm attributes.

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