Fiscal Influences on Inflation in OECD Countries, 2020-2022*

Tests of the Fiscal Theory of the Price Level

Robert J. Barro, Harvard University, and
Francesco Bianchi, Johns Hopkins University

January 2024

Abstract

The fiscal theory of the price level (FTPL) has been active for 30 years, and the interest in this theory grew with the recent global surges in inflation and government spending. This study applies the FTPL to 37 OECD countries for 2020-2022. The theory's centerpiece is the government's intertemporal budget constraint, which relates a country's inflation rate in 2020-2022 (relative to a baseline rate) to a composite government-spending variable. This variable equals the cumulative increase in the ratio of government expenditure to GDP from 2020 to 2022, divided by the ratio of public debt to GDP in 2019 and the duration of the debt in 2019. This specification has substantial explanatory power for recent inflation rates across 20 non-Euro-zone countries and an aggregate of 17 Euro-zone countries. The estimated coefficients of the composite spending variable are significantly positive, implying that 40-50% of effective government financing came from the inverse effect of unexpected inflation on the real value of public debt, whereas 50-60% reflected conventional public finance (increases in current or future taxes or cuts in future spending). Within the Euro area, inflation reacts mostly to the area-wide government-spending variable, not to individual values.

*We have benefited from comments and assistance with data by Laura Alfaro, Marco Bassetto, Jeremy Bulow, Gabriel Chodorow-Reich, John Cochrane, Adriano Fernandes, David Laibson, Eric Leeper, Pierfrancesco Mei, David Miller, Casey Mulligan, Jon Steinsson, Richard Stern, and Philip Stokoe, and from research assistance by Qingyuan Fang and Victoriah Verna. We also benefited from discussions at presentations at Arizona State University, Harvard University, the Heritage Foundation, Johns Hopkins University, and Stanford University's Hoover Institution and from support by the Michael S. Chae Macroeconomic Policy Fund at Harvard University.

The fiscal theory of the price level, FTPL, has been around since the early 1990s. Major contributions include Leeper (1991), Woodford (1995, 2001), Sims (1994), Dupor (2000), Cochrane (2001), and Bassetto (2002). This research was summarized and extended in the recent book by Cochrane (2023). However, despite its theoretical elegance, the FTPL was not taken seriously by mainstream macroeconomists as an empirical model of the price level and inflation until recently. This neglect arose partly because inflation has been associated much more with monetary policy and partly because the inflation rate in many countries has been low and stable from the mid-1980s until 2020. The global expansion of government spending and the accompanying surge of inflation after 2019 in the wake of the COVID crisis changed the picture. There is now broader receptivity toward the idea that, at least in extreme circumstances such as the COVID crisis, fiscal expansion can be a key driver of inflation and that the FTPL offers a coherent framework for understanding these effects.

In this study, we examine the role of fiscal expansion as a determinant of inflation rates in 37 OECD countries since 2019. We first use the key ingredients of the FTPL to work out a simple relation between inflation rates and government spending. Then we apply this specification empirically, using measures of CPI headline and core inflation rates along with information on changes in general government primary expenditure, public-debt levels, and debt duration. Our conclusion is that estimation of a well-specified equation supports the idea that the recent fiscal expansion has been a key driver of inflation rates in the OECD countries.

The framework that we apply empirically relies on a frictionless setting with no nominal rigidities, in the spirit of Cochrane (2001). In this respect, we depart from empirical work that integrates the insights of the FTPL into models with nominal rigidities to explain the evolution of inflation (Davig and Leeper [2006], Bianchi and Ilut [2017], Bianchi and Melosi [2017, 2023], Leeper, Traum, and Walker [2017]). Further, while most of the existing empirical evidence regarding the FTPL is based on U.S. data, we work instead with a cross-section of OECD countries. We show that, unlike accommodative monetary policy going back to the early 2000s, the large recent fiscal interventions related to the COVID crisis "succeeded" in generating high inflation.

I. Conceptual Framework based on the Fiscal Theory of Price Level

The centerpiece of the fiscal theory of the price level (FTPL) is the government's intertemporal budget constraint, which equates the market value of the initial real public debt to the present value of expected real primary surpluses:

$$\frac{B_t}{P_t} = \sum_{i=0}^{\infty} \frac{(T_{t+i} - G_{t+i})}{(1+r)^i} \quad (1)$$

where B_t is the nominal market value of (short-term and long-term) public debt outstanding at the beginning of period *t*, P_t is the price level at the start of period *t*, T_{t+i} and G_{t+i} are the government's real taxes and primary real spending,[1] respectively, in period $t+i$, and r is a constant real discount rate. (In our analysis, the length of the period plays no economic role and is assumed to be very short.) The assumption is that, as of the start of period *t*, the full path of T_{t+i} and G_{t+i} is known, so that the realized values can be used instead of the expected values.

As is well-known, the validity of Eq. (1) depends on a no-Ponzi condition, which precludes the government financing itself in the long run through perpetual rolling-over of principal and interest on its bonds. We assume throughout that this no-Ponzi condition holds. Note that G_{t+i} is the sum of real government purchases and transfers and excludes interest

[1]We do not deal here with seignorage associated with governmental issue of paper money. This seignorage can be viewed as part of the government's tax revenue.

payments. Equation (1) says that the outstanding stock of public debt has to be financed by a corresponding present value of expected real primary surpluses, although the timing of these surpluses is flexible.

For the application to the recent surge of inflation in OECD countries, the idea is that a rise in government spending stimulated by the COVID recession lowered the right side of Eq.(1) for most countries. In particular, the expectation was that the large, unexpected increase in spending would not be matched fully by rises in current or future revenue or reductions in future spending. Instead, the government's intertemporal budget constraint would have to be satisfied through a cut in the real market value of public debt on the left side of Eq.(1). If the public debt is denominated in domestic currency, this depreciation of the real debt could be accomplished—in the absence of formal default—by increases in current or future price levels; that is, by a sustained period of inflation that was unexpected prior to period *t*. To make these ideas applicable to empirical estimation across countries, the analysis uses a series of simplifications that leads to a tractable functional form that can be readily implemented empirically.

Suppose that a crisis, such as the COVID pandemic, begins at the start of period *t* and features an unexpected surge in government spending that raises G_{t+i} for $i = 0, \ldots, M$. The assumption is that, after period $t+M$, real spending returns to its previous path—that is, the higher real spending is temporary.[2] Let $\Delta G_{t+i} \equiv G_{t+i} - E_{t-1}G_{t+i}$ be the real spending in period

[2]For the 37 OECD countries in the empirical analysis, the mean ratio to GDP of general government spending exclusive of interest payments is 0.385 in 2019, 0.444 in 2020, 0.426 in 2021, and 0.407 in 2022. Hence, the average spending ratio rose on net by 0.022 from 2019 to 2022. The mean ratio of general government revenue to GDP is 0.394 in 2019, 0.393 in 2020, 0.401 in 2021, and 0.403 in 2022. Therefore, this average ratio rose on net by 0.009 from 2019 to 2022. The average ratio of the primary deficit to GDP rose on net by 0.013 from 2019 to 2022, going from -0.009 to 0.004. Therefore, it is plausible that the permanent change in the ratio of the primary deficit to GDP was small.

$t+i$, relative to that expected from the perspective of period t-1. The present value of these changes is

(2) real present value of spending surge = $\sum_{i=0}^{M} \frac{\Delta G_{t+i}}{(1+r)^i}$.

Suppose that real GDP, Y_{t+i}, grows at the constant rate g and that g=r applies from period t to period $t+M$. Assume further that G_{t+i} has the same trend growth rate, g=r, as real GDP, so that $E_{t-1}G_{t+i} = G_{t-1}(1+r)^{i+1}$. Define $\Delta\left(\frac{G_{t+i}}{Y_{t+i}}\right) \equiv \frac{G_{t+i}}{Y_{t+i}} - \frac{G_{t-1}}{Y_{t-1}}$; that is, the spending-GDP ratio expressed relative to the pre-crisis ratio. In that case, the expression in Eq.(2) can be written as

(3) real present value of spending surge = $Y_t \cdot \sum_{i=0}^{M} \left[\Delta\left(\frac{G_{t+i}}{Y_{t+i}}\right)\right]$.

That is, given the assumptions about trend growth rates, the spending surge depends on the sum of spending-GDP ratios expressed relative to the pre-crisis ratio. These changes in real spending ratios are assumed to be unknown before period t but fully known at the start of period t.

A general analysis would include changes in real government revenue in the form of the present value:

(4) real present value of revenue surge = $\sum_{i=0}^{M} \frac{\Delta T_{t+i}}{(1+r)^i}$.

Again, the changes after date $t+M$ are assumed to be zero. In practice, for 2020-2022, the government spending surge dominated the changes in government revenue. For example, for general government for the 37 OECD countries considered in the empirical analysis, the cumulative rise in ratios to GDP over 2020-2022 compared to the ratio in 2019 averaged 0.122 for primary government spending and only 0.016 for government revenue. Our main analysis omits the revenue side, shown in Eq. (4), and focuses on the contribution to real primary deficits from the spending surge, shown in Eq. (3).

The analysis is carried out within the frictionless (flexible-price) version of the FTPL described by Cochrane (2001; 2023, Chs. 1-3). In particular, the paths of real GDP, Y_t, and the real interest rate, $r_t=r$, are assumed to be invariant with the fiscal/monetary shocks. More broadly, the assumption is that the path of inflation rates is not substantially influenced by changes that occur in real variables.

At time *t,* the aggregate amounts of nominal payouts due on government bonds at the start of each period—for coupons and principal payments—are $B_t^0, B_t^1, \ldots, B_t^T$, where T is the maximum debt maturity. The key idea is that these nominal obligations are effectively hostage to choices that the government makes that determine the price level at the corresponding dates. By raising the price level in the various periods in a manner not anticipated before period *t*, the government reduces the real value of its payouts. We can study these effects by examining the total nominal market value of government bonds outstanding at the start of period *t*:

$$(5) \qquad B_t = B_t^0 + \frac{B_t^1}{(1+r)(1+\pi_{t+1})} + \frac{B_t^2}{(1+r)^2(1+\pi_{t+1})(1+\pi_{t+2})} + \cdots + \frac{B_t^T}{(1+r)^T(1+\pi_{t+1})\ldots(1+\pi_{t+T})}$$

where π_{t+i} is the inflation rate for period $t+i$. The assumption is that these inflation rates were unknown before period *t* but are fully anticipated as of the start of period *t,* when the path of real primary deficits also becomes known. Therefore, if R_{t+i} is the nominal interest rate for period $t+i$, this rate moves along with the inflation rate, π_{t+i}, so that $(1+ R_{t+i})=(1+r)\cdot(1+ \pi_{t+i})$.

To simplify the algebra, the aggregate nominal payments due on bonds are assumed to rise over time in accordance with a baseline (past) inflation rate, π^*, and the growth rate of real GDP, $g=r$. That is, before period *t,* the government is assumed to have arranged its debt composition so that the total nominal payments due rise from date *t* to date $t+T$ along with the anticipated path of nominal GDP. In that case, Eq.(5) becomes

(6) $$B_t = B_t^0 \left[1 + \frac{1+\pi*}{1+\pi_{t+1}} + \frac{(1+\pi*)^2}{(1+\pi_{t+1})(1+\pi_{t+2})} + \cdots + \frac{(1+\pi*)^T}{(1+\pi_{t+1})\ldots(1+\pi_{t+T})}\right]$$

When all (actual and expected) inflation rates equal the baseline rate, $\pi*$, the relation between the total nominal market value of debt and the amount of short-term debt paid off in period t is

(7) $$B_t^* = B_t^0 \cdot (1+T)$$

where B_t^* is the baseline nominal value of public debt; that is, the value prior to the deviation of inflation rates from the baseline rate.

The reaction to the surge in spending from Eq.(3) is assumed to be a surge in the sequence of inflation rates, $\pi_{t+1}, \ldots, \pi_{t+T}$, above the baseline rate, $\pi*$. The assumption is that $\pi*$ is fixed (and, thereby, pins down the long-term future inflation rate). The shifts in inflation rates, when anticipated, lower the nominal market value of bonds outstanding in accordance with Eq.(6). (This analysis rules out a jump in the price level at the start of period t, though that change could be introduced.) The idea is that lowering the real value of public debt effectively pays for part of the increase in the present value of real primary deficits in Eq.(3).[3] The change in the nominal market value of debt generated by a shift in (actual and expected) inflation rates from $\pi*$ to the sequence $\pi_{t+1}, \ldots \pi_{t+T}$ is given from Eqs.(6) and (7) by

(8) $$\Delta B = \left(\frac{B_t^*}{1+T}\right)\left\{\left[\frac{1+\pi*}{1+\pi_{t+1}} - 1\right] + \left[\frac{(1+\pi*)^2}{(1+\pi_{t+1})(1+\pi_{t+2})} - 1\right] + \cdots + \left[\frac{(1+\pi*)^T}{(1+\pi_{t+1})\ldots(1+\pi_{t+T})} - 1\right]\right\}$$

Note that a boost to the inflation rates, $\pi_{t+i} > \pi*$, implies a negative value of ΔB.

As stressed by Cochrane (2001), there is a multiplicity of future inflation rates corresponding to a given ΔB on the left side of Eq.(8). In particular, if the debt maturity, T, is long, part of the inflation surge can occur in the distant future. Cochrane argues that it may be

[3] More generally, changes in current and future price levels could also affect the real values of governmental liabilities and assets beyond those represented by formal public debt. For example, the real value of depreciation allowances might be affected. Our present empirical analysis is limited to the gross public debt of general government, as defined by the IMF.

optimal to smooth out the required boost to inflation rates and that monetary policy can be used to achieve the desired path of inflation, while generating a given value of ΔB in Eq.(8). In the present analysis, we work directly with the time path of inflation rates and not with the changes in monetary instruments, including short-term nominal interest rates, that support this path. That is, we assume that the monetary authority cooperates with the fiscal authority to generate the chosen time path of inflation rates (and that the underlying monetary actions do not impact the time paths of real variables). Moreover, we focus on the extreme case of smoothing in which the higher inflation rate, π_{t+i}, is constant at a value $\pi > \pi^*$ for $i=1, \ldots, T$.[4] In that case, Eq.(8) can be shown to simplify to

(9) $$\Delta B = (\frac{B_t^*}{1+T}) \cdot \left\{ \left(\frac{1+\pi*}{\pi-\pi*}\right) \left[1 - \left(\frac{1+\pi*}{1+\pi}\right)^T\right] - T \right\}$$

The expression on the right side of Eq. (9) includes the maximum debt maturity, T. We approximate the term $\left(\frac{1+\pi*}{1+\pi}\right)^T$ with a second-order expansion around one, assuming $(\pi-\pi^*)\cdot T<<1$. If we also assume $T>>1$ (with T measured in numbers of periods), then Eq. (9) simplifies to

(10) $$\Delta B \approx -B_t^* \cdot \frac{1}{2} T \cdot (\pi - \pi *)$$

Note again that a negative value of ΔB corresponds to a boost in the inflation rate, $\pi > \pi *$. Moreover, as is important later, for a given value of ΔB, larger values of B_t^* or T associate with smaller values of $\pi - \pi *$.

If the surge in inflation "financed" 100% of the increase in government expenditure, the magnitude of the real value $\Delta B / P_t$, where ΔB is given in Eq.(10), would equal the present value

[4] An alternative assumption is that the government chooses a path of inflation rates to minimize a term that represents the costs of inflation—modeled as the sum of squared deviations of π_{t+i} from π^*—for a given amount of effective revenue, ΔB, from Eq. (8). The resulting values of π_{t+i} are positive and monotonically decreasing from period t to period $t+T$. However, for reasonable parameters, the decreases in π_{t+i} are "small," so that a constant value may be a reasonable approximation.

of the increase in real primary deficits from Eq.(3).[5] We can readily generalize to the case where the surge in inflation pays for the fraction η of the spending surge, where $0 \leq \eta \leq 1$, so that the fraction 1-η is paid for by cuts in spending beyond date $t+M$ or by increases in current or future government revenue.[6] The resulting expression for the rise in the inflation rate, π-π*, is

$$(11) \qquad \pi - \pi * \approx \eta \cdot \left[\Delta\left(\frac{G_t}{Y_t}\right) + \Delta\left(\frac{G_{t+1}}{Y_{t+1}}\right) + \cdots + \Delta\left(\frac{G_{t+M}}{Y_{t+M}}\right)\right] / [\left(\frac{B_t^*}{P_t Y_t}\right) \cdot \left(\frac{T}{2}\right)]$$

The object *T/2* represents the "average maturity" of the outstanding stock of public debt at the start of period *t*. Note that Eq. (11) implies a non-negative slope coefficient, η ($0 \leq \eta \leq 1$), and an intercept of zero; that is, $\pi = \pi^*$ when the increments to ratios of government spending to GDP add to zero.

The case $\eta = 0$ applies in Eq. (11) when the surge in primary government spending up to date $t+M$ in Eq. (3) is matched by an expectation of offsetting cuts in spending further in the future or increases in current and future government revenue. This case can be regarded as standard intertemporal public finance in the sense of the government always respecting the constraint that an increase in today's real primary deficit must be balanced by corresponding reductions in future real primary deficits (all measured as real present values). Therefore, we would expect $\eta = 0$ to hold in most circumstances, with $\eta > 0$ applying only during economic emergencies, such as the COVID crisis or a large war. Hence, the discussion fits with the state-contingent fiscal-deficit policies described by Lucas and Stokey (1983) in the context of

[5]The assumption is that the initial debt-GDP ratio, $B_t^*/P_t Y_t$, is large enough so that driving its value to zero is sufficient to cover the surge in the *G/Y* terms shown in the brackets in Eq. (3). For the main sample in the empirical analysis, the mean of the term in brackets (for 2020-2022) is 0.10 and the mean of the debt-GDP ratio (in 2019) is 0.72.

[6]Bianchi, Faccini, and Melosi (2023) argue that the extent to which fiscal shocks are unfunded—that is, not balanced by corresponding changes in future primary real deficits—is the key to the connection between fiscal expansion and inflation. Learning about the path of primary real deficits is central to the analysis of Bassetto and Miller (2023).

wartime, notably World War II.[7] The upshot of this perspective is that fiscal deficits and inflation might not be much related during "normal" economic times but could be closely connected during unusual events.[8] This perspective fits with our empirical application to OECD countries in the context of the COVID crisis.

Equation (11) provides the functional form used in the main empirical work. Note that this form implies, not surprisingly, that the rise in the inflation rate is higher the larger the cumulative rise in G_{t+i}/Y_{t+i} for $i=1, \ldots, M$. Less intuitively, the rise in the inflation rate is larger the *smaller* the baseline debt-GDP ratio, B_t^*/P_tY_t. This result follows because a smaller debt-GDP ratio implies that a higher inflation rate is required to get the decline in the real market value of public debt needed to balance the specified fraction of the surge in real primary deficits. A higher average debt maturity, $T/2$, also implies a smaller increase in the inflation rate. The reason is that, with the size of the cumulative increase in G/Y held fixed and the inflation rate equalized over T periods, a higher T implies that a smaller inflation rate is required each period to generate the requisite reduction in the real value of public debt. This decrease in the real market value of debt results from revaluation effects generated by increases in expected inflation rates and, correspondingly, nominal interest rates. Overall, the model says that the inflation rate reacts to a composite government-spending variable, which equals the cumulative surge in ratios of government spending to GDP divided by the initial debt-GDP ratio and the average debt maturity.

Given the value of the composite government-spending variable, Eq. (11) says that the deviation of the inflation rate, π, from the fixed π^* depends on the parameter η, which specifies

---

[7]However, price controls are often important in assessing wartime data.

[8]This result accords with Bassetto and Miller (2023, abstract), who argue "This setting explains why there can be long stretches of time during which government surpluses have large movements with little inflation response; yet, at some point, something snaps, and a sudden inflation takes off that is strongly responsive to fiscal news."

the share of financing from inflation. We think of η as a governmental choice that can vary across countries in a given time period (although, in the regression analysis, we estimate η as a single coefficient).

Another margin of choice that could be introduced concerns the smoothing of inflation rates—these were taken to be equalized over the interval of T years, which likely exceeds the interval M associated with the surge in government spending. Governments could instead choose to react faster or slower in terms of the response of near-term inflation (see n.3).

In the application of Eq. (11) to cross-country macroeconomic data, we think of adding on an error term that "explains" why the R-squared of the regressions is not one. This residual can arise because of measurement error in the left- and right-side variables, differences in expectations about future government spending or current and future taxes, and variations in the coefficient η, which represent differences in how much of extra government spending is financed via inflation. Some of these variations across countries would reflect governmental choices derived from differences in political structure and in the nature and extent of COVID infections.

In the empirical application of Eq. (11) to inflation rates across OECD countries from 2020 to 2022, the main explanatory variable is the composite government-spending variable. The analysis allows in addition for an effect from the Ukraine-Russia War (in 2022). Countries that share a common border with Ukraine or Russia are found to have substantially higher inflation rates than would otherwise be predicted.

II. Data

This section contains a description of the variables used in the regressions. The tables below contain more details.

CPI inflation rates

The left side of Eq.(11) requires data on each country's inflation rate over various periods. The analysis calculates inflation rates from information on consumer price indexes (CPI) values, as reported in *OECD.STAT*. The numbers used for 37 OECD countries for the periods 2010-2019 (pre-crisis) and 2020-2022 (crisis) are in Table 1. The analysis considers in part I the headline CPI inflation rate and in part II the core CPI inflation rate, which excludes energy and food.[9]

Government spending

The terms in brackets on the right side of Eq.(11) involve changes in each country's spending levels expressed as ratios to GDP. This variable comes from information for general government on primary expenditure, which includes government purchases and transfer payments but excludes interest payments. These data are from IMF, *World Economic Outlook Data Base, Government Finance Statistics,* and *Article IV Staff Reports*. The *WEO* data is the primary source because its coverage extends to 2022. The calculations use the cumulative annual changes in ratios of government spending to GDP from 2020 to 2022 expressed relative to a base ratio, taken to be the value for 2019 (pre-crisis). These values are in Table 2, column 1. The analogous variable for general government revenue, which we do not use in our main analysis, is in Table 2, column 2.

[9]This approach does not deal with differences across countries in CPI construction outside of energy and food. For example, countries differ in their treatment of housing costs, notably in the inclusion or exclusion of implicit rentals on owner-occupied housing.

Quantities of public debt

The right side of Eq. (11) includes in the denominator the ratio of the stock of public debt to GDP in a base year, taken in the empirical analysis to be the end of 2019. The concept of public debt used in the main analysis is the gross debt of general government, coming from the IMF sources (primarily the *WEO* data base). These numbers are mostly at estimated market value but sometimes are at face value. Ratios of gross public debt to GDP for general government in 2019 are in Table 2, column 3.

An alternative procedure adjusts the gross public debt for amounts denominated in foreign currency or in inflation-indexed form. These parts of the debt would not be subject to direct reductions in real value due to effects of domestic inflation on domestic nominal interest rates for given real interest rates. Since we are neglecting any changes in real interest rates, it may be appropriate to filter out these parts of the gross public debt. However, measurement issues may make the unadjusted data preferable, and our main analysis uses the unadjusted gross public debt.

The estimated shares of public debt denominated in foreign currency or in inflation-indexed form come mostly from Bank for International Settlements (BIS), *Central and General Government Debt Securities Markets*, Tables C4 and C2. These values are in Table 3, columns 3 and 4. The numbers for debt denominated in foreign currency apply to general government. The numbers for debt in inflation-indexed form apply to central government. We adjusted these numbers by ratios of central to general government expenditure (from the IMF's *GFS* data base) to estimate the values applicable to general government (assuming that only central governments issue inflation-indexed bonds). The ratios to GDP of adjusted gross public debt—with amounts denominated in foreign currency or in inflation-indexed form filtered out—are in Table 2, column 4.[10]

In principle, we would carry out the analysis for the consolidated government sector. The IMF's concept of general government, described in International Monetary Fund (2014, Chapter 2), includes various layers of government (central, state, local, etc.) along with social security funds. This concept excludes public corporations, which include central banks. (The IMF includes public corporations in a broader measure called the public sector.) The consolidation of central banks with general government would be desirable for the purposes of studying inflation. In this broader consolidation, the debts of central banks, including reserves held by financial institutions and others, would be added to the gross public debt. However, in a net calculation, the assets held by central banks would be deducted.[11] If the assets and debts of central banks largely cancel, this broader consolidation would not have much impact on a net concept of public debt but would likely lower the average maturity of the debt—because central bank liabilities tend to be shorter term than central bank assets. In any event, data are not available for this broader consolidation.

The IMF also provides information on "net debt," which subtracts out holdings by general government of assets comparable to government bonds (see IMF [2014, pp. 207-208]). However, the net-debt measures (shown in Table 2, column 5) were not used because they filter

[10]It may also be desirable to adjust for public debt issued in floating-rate form. Since these coupon payments adjust automatically for changes in expected inflation (given the values of real interest rates), the corresponding part of the value of outstanding bonds should be filtered out in the calculation of adjusted public debt. However, we have data (from the BIS) on the floating-rate share of gross public debt only for central governments and only for 14 countries. The average share of government bonds in floating-rate form for these countries in 2022 is only 9%, and only the coupon parts of the values of these bonds should be filtered out. Therefore, the neglect of an adjustment for floating-rate bonds may not have major consequences.

[11]As an example, the gross public debt of Japan is the largest in relation to GDP—260% in 2022, but slightly over half of this debt in 2023 is held by the central bank (as reported by *Japan Times*, May 2023). In addition, unlike other countries, Japan's gross debt for general government is reported without the consolidation of social-insurance funds.

out unknown quantities of assets denominated in foreign currency.[12] As extreme examples, using the IMF reported data for 2019 shown in Table 2, columns 3 and 5, the ratios to GDP of gross and net public debt are, respectively, 41% and -74% for Norway, 90% and 8% for Canada, 236% and 152% for Japan, 32% and 7% for New Zealand, 35% and 5% for Sweden, 65% and 27% for Finland, and 22% and -14% for Luxembourg. Although netting out asset holdings by various parts of government is attractive in principle, we think at this point that the data on gross public debt are better for our purposes than the data on net public debt.

Duration of public debt

We began with data from the OECD on a standard measure, the "average remaining maturity" of the public debt, a concept that considers only the timing of the principal payouts due on each bond. The values for general government of average remaining debt maturity in 2019 (coming mostly from OECD, *Sovereign Outlook for OECD Countries, Survey on Central Government Marketable Debt and Borrowing*) are in Table 3, column 1.

A more appropriate concept is the duration of a bond, which considers also the amounts and timings of coupon payments. We define the duration in the usual (Macaulay [1938, Chapter II]) sense as the weighted average of due dates for each coupon and principal payout, where the weights are the market values corresponding to each payout expressed relative to the total market value of bonds. Although the duration of the public debt can be calculated

[12]For example, sovereign wealth funds hold large amounts of U.S. Treasury bonds. Using *Wikipedia* for data for 2020 on the U.S. dollar value of sovereign-wealth funds, the largest of these funds among the OECD countries when measured in relation to the U.S. dollar value of GDP (taken from World Bank, *World Development Indicators*) are for Norway (237% of GDP), France (51%), Turkey (31%), Canada (16%), New Zealand (15%), South Korea (12%), Australia (8%), Austria (8%), and Chile (8%). The parts of sovereign-wealth holdings denominated in foreign currency should not be netted out from gross public debt for the purpose of analyzing inflation.

from detailed knowledge of all government bonds outstanding at a given point in time, this calculation is challenging for the set of 37 OECD countries used in the empirical analysis. We have also found little in direct reporting on the duration of the public debt.[13] Therefore, it is useful to be able to approximate the debt duration given the typically available data, which include the average remaining maturity based only on principal payments and the nominal interest rates paid on government bonds.

Part A2 of the appendix derives a formula for the duration of a standard bond that pays a constant stream of nominal coupons and a nominal principal in year T. We assume for date t (taken to be 2019 in the empirical analysis) that bonds were "trading at par" in the past when the nominal interest rate was R_{t-L} (measured empirically by averages of long-term nominal interest rates on government bonds going back from 2018 the number of years corresponding to the estimated duration). At date t (2019), the nominal interest rate on government bonds is observed to be R_t, which can differ from R_{t-L}.[14] For this case, the formula in the appendix relates the duration, D_t, to the reported average maturity and to the interest rates R_t and R_{t-L}. The resulting estimates of the duration of the public debt in 2019 are in Table 3, column 2.

It would be desirable to estimate the duration applying only to the public debt denominated in domestic currency and not indexed for inflation. However, we lack the breakdown of debt maturity needed to make that calculation for most countries.

[13]In the past, *OECD.STAT*, *Central Government Debt, Average Term to Maturity and Duration,* reported the Macaulay duration or, alternatively, the modified duration of the central government's debt for many OECD countries (although some of the reported numbers for duration appear to be inaccurate). In any event, the relevant table was terminated as of 2010.

[14]The data on interest rates on long-term government bonds for 37 OECD countries are from *OECD.Stat* and IMF, *International Financial Statistics.* Data for Costa Rica are for 2014-2019. Data for Estonia begin in 2015 and are approximated by 6-month Euribor interest rates reported by the Central Bank of Estonia.

Euro-area data

In our main specification, we consider the Euro area as a single economic entity. There are 17 OECD countries that use the Euro.[15] Except for duration and some other debt-related variables (average debt maturity and shares of gross public debt denominated in foreign currency or in inflation-linked form), we weight all country-level variables by the relative values of GDP in current prices from the IMF. For duration and the other debt-related variables, we weight by the size of outstanding gross public debt (using the IMF data on the ratio of gross debt to GDP, along with the GDP weight).

Proximity to war in Ukraine

We constructed measures for 37 OECD countries on distance to Ukraine and Russia, based on country capitals and on an array of major cities. We also constructed shares of each country's trade with Ukraine and Russia. However, we found in the analysis of inflation rates that the main explanatory power came from a simple dummy variable for whether a country shared a common border with Ukraine or Russia (of which 3 had a border with Ukraine and 6 had one with Russia, with Poland having a border with both). Our analysis focuses on this border dummy variable.

[15]The countries are Austria, Belgium, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Portugal, Slovakia, Slovenia, and Spain. Three non-OECD countries also use the Euro: Malta, Croatia, and Cyprus.

III. Empirical Results

A. Identification

In a general sense, we seek to isolate effects on inflation rates from exogenous movements in government spending. An ideal setting would be a controlled experiment whereby governments in various countries randomly set levels of real spending—or ratios of spending to GDP—at sharply differing values. Of course, these kinds of large-scale, vastly expensive experiments will never be carried out, as is true in most macroeconomic contexts. So, instead, our econometric procedure uses the available macroeconomic data for a cross-section of countries to attempt to isolate effects on inflation rates from movements in government spending. That is, we rely on "old-style econometrics."

More concretely, in the context of the COVID-related recession and recovery, the cross-country regressions seek to isolate effects on inflation rates from 2020 to 2022 from movements in government spending over the same period. This analysis is helped by the use of a particular functional form—shown in Eq.(11)—that the fiscal theory of the price level says should matter for inflation. Specifically, the composite government-spending variable on the right side of Eq. (11) factors in cumulative increases in ratios of general government spending (exclusive of interest payments) to GDP from 2020 to 2022 gauged relative to the ratio for 2019, divided by the debt-GDP ratio in 2019 and by the debt duration in 2019. The property needed for identification is that the cross-country variations in this composite government-spending variable are exogenous with respect to inflation. For example, it might be that government-spending decisions after 2019, particularly on transfer payments, depended on exogenous differences in political structure or in the perceived severity of COVID infections.

One concern is that the cumulative increases in ratios of general government spending to GDP from 2020 to 2022 responded positively to the size of the economic downturn, which is concentrated for most countries in the negative growth rate of real GDP from 2019 to 2020. The average of this annual growth rate for the 37 OECD countries in this study is -4.2%. The interaction of the increases in government spending with the extent of the decline in real GDP may then also imply interactions with inflation.

An OLS regression that illustrates the connection between changes in government spending and the extent of the economic downturn for the 37 OECD countries in the sample is

$$\text{(12)}\quad \Delta(G/Y)\ (2020\text{-}2022) = \underset{(0.027)}{0.046^*} - \underset{(0.33)}{1.14^*}\Delta Y\ (2019\text{-}2020) + \underset{(10.4)}{11.3^*}COVID$$

R-squared=0.34, σ=0.069,

where standard errors of estimated coefficients are in parentheses, *Δ(G/Y)* is the cumulative increase in the ratio of general government primary spending to GDP from 2020 to 2022 expressed relative to the ratio for 2019, *ΔY* is the growth rate of real GDP from 2019 to 2020, and *COVID* is cumulative COVID-related mortality per capita up to July 2023.[16] The estimated coefficient on the growth rate of real GDP is negative and statistically significant at the 1% level, indicating that countries with larger downturns reacted with more government spending. The estimated coefficient on the *COVID* variable is positive but not significantly different from zero.

[16]The data on COVID-related mortality are from the World Health Organization, *WHO Coronavirus (COVID-19) Dashboard* . Results are similar if the COVID outcomes are cumulated only up to December 2021. The data on real GDP are values in 2015 US dollars from World Bank, *World Development Indicators*.

(We had hoped to use the *COVID* variable as an instrument for government spending, but the weak empirical connection between these two variables precludes this procedure.)

The issue for our empirical analysis is whether the tendency for the surge in government expenditure to be larger when the economic downturn is more severe would tend to generate a spurious positive association between government spending and inflation. To get this result, we would have to see a larger economic downturn typically followed by *higher* inflation. However, this relationship conflicts with the usual empirical pattern whereby the association between real economic activity and inflation at business-cycle frequencies tends to be positive.[17]

If we change the dependent variable in Eq. (12) to be the composite government-spending variable dictated by the fiscal theory of the price level, then the regression for the 37 countries becomes

(13) government-spending variable = 0.019 + 0.10*ΔY (2019-2020) + 6.7**COVID*

(0.011) (0.14) (4.3)

R-squared=0.07, σ=0.029,

where the dependent variable is $\Delta(G/Y)$ from Eq. (12) divided by the ratio of gross public debt to GDP in 2019 and by the duration of the debt in 2019. The other variables are the same as in Eq. (12). In contrast to Eq. (12), the estimated coefficient on the growth rate of real GDP in Eq. (13) does not differ significantly from zero, and the R-squared value is close to zero. The main reason for the differing results is that the initial debt-GDP ratio (for 2019) has a substantial

[17]See Bianchi, Nicolo, and Song (2023) and Justiniano, Primiceri, and Tambalotti (2013) for discussions of the relation between inflation and real economic activity over the business cycle.

negative association with the growth rate of real GDP from 2019 to 2020.[18] Since the debt-GDP ratio enters inversely into the composite government-spending variable, this negative association offsets the negative relation between the growth rate of real GDP and *Δ(G/Y)* shown in Eq. (12). Because this offset is nearly complete, the connection between the growth rate of real GDP and the composite government-spending variable in Eq. (13) turns out to be negligible. This finding lessens the concern that endogeneity in the government-spending variable would lead to a spurious positive association between this variable and inflation. Accordingly, we treat the composite government-spending variable as exogenous in the cross-country OLS regressions for inflation rates reported below. We are hoping to go further by using appropriate instruments for the composite government-spending variable, possibly involving differences in political structure across the OECD countries.

We have constructed comparable variables for the revenue side of the government, including the variable *Δ(REV/Y)* (Table 2, column 2) and the corresponding composite government-revenue variable. However, we are not confident that this composite revenue variable can be treated as exogenous with respect to inflation. Moreover, from 2020 to 2022, the changes in the spending variable, *Δ(G/Y),* dominate the changes in the corresponding revenue variable, *Δ(REV/Y)*—the means and standard deviations for 2020-2022 are, respectively, 0.122 and 0.082 compared with 0.016 and 0.037. Therefore, the spending side of the surge in real primary deficits likely captures the principal fiscal influence on inflation rates in this period. For this reason and because of concerns about endogeneity of the composite government-revenue variable, we limit the main regressions below to effects from government spending.

[18]Possibly this pattern arises because the outstanding debt is a good proxy for the fiscal capacity of a country. Specifically, countries with larger ratios of public debt to GDP may be more economically fragile and, therefore, less able to deal effectively with crises such as the one associated with the COVID pandemic.

The identification in our analysis comes from cross-sectional variation across OECD countries in inflation rates (for 2020-2022 relative to those for 2010-2019) and in composite government-spending variables (cumulations of ratios to GDP for 2020-2022 compared to the ratio in 2019). The form of this estimation precludes the common practice of including country fixed effects as regressors, because this procedure would eliminate the cross-sectional variation needed to estimate the coefficients. However, we allow for country fixed effects in an alternative specification that considers the full annual time series of inflation rates for each country from 2010 to 2022.

The OLS regressions that we use also assume that the error terms in the equation for inflation are independent across countries. A correction for spatial correlation of error terms might improve the calculation of standard errors but our baseline setup with only one time-series observation for each country provides no way to assess this spatial correlation.

B. Regressions

The sample comprises 37 OECD countries, 20 outside of the Euro zone and 17 in this zone. Within the Euro zone, the constraint of a common currency and high mobility of goods and factors may preclude much independent variation in inflation rates, which would have to represent changes in relative prices across these countries. Therefore, we start with a setting in which the 17 Euro-zone countries are combined (through weighted averages involving GDP and other variables) into single aggregate observations. That is, the initial regression sample consists of 21 economies; 20 countries outside of the Euro zone along with an aggregated version of the Euro zone.

Table 4 provides statistics for the variables used in the regressions. Table 5 reports OLS regressions for changes in CPI inflation rates—gauged by average rates over the crisis years 2020-2022 considered relative to average rates over the pre-crisis, ten-year period 2010-2019. Columns 1 and 2 consider headline CPI inflation, and columns 3 and 4 consider core CPI inflation, computed without energy and food.

Columns 1 and 3 of Table 5 use as explanatory variables only constant terms and the composite government-spending variable.[19] The estimated coefficients of the government-spending variable are positive and highly statistically significant: 0.37 (s.e.=0.10) for headline inflation in column 1 and 0.42 (0.09) for core inflation in column 3.

Because the dummy variable for whether a country shares a common border with Ukraine or Russia has substantial explanatory power for inflation, our discussion emphasizes the results that include this border dummy, as shown in Table 5, columns 2 and 4.[20] Eight of the 37 OECD countries in the full sample share a common border with Ukraine or Russia but only three of these are outside of the Euro zone: Hungary, Norway, and Poland. The estimated coefficients on the border dummy, 0.028 (s.e.=0.005) for headline inflation in column 2 and 0.022 (0.005) for core inflation in column 4, are positive and highly statistically significant.[21]

[19]The regressions in Table 5 use unadjusted gross public debt in the construction of the composite government-spending variable. Results shown in Table A1 of the appendix, which adjusts the debt to eliminate the parts denominated in foreign currency or in inflation-indexed form, are broadly similar. The fits of the regressions also change negligibly if the reported average debt maturity (Table 3, column 1) is used instead of the estimated duration (Table 3, column 2). This finding is not surprising because the correlation for the 21 economies in 2019 between the average debt maturity and the estimated duration is 0.95.

[20]OECD countries having a common border with Ukraine are Hungary, Poland, and Slovak Republic. Those sharing a border with Russia are Estonia, Finland, Latvia, Lithuania, Norway, and Poland.

[21]Results for the government-spending variable are similar if, instead of entering the border dummy variable, the economies that border Ukraine or Russia are excluded from the sample. For 17 economies, the regression for headline inflation becomes 0.0077 (0.0032) + 0.428 (0.090)*govt-spending variable, R-squared = 0.600, σ=0.0085, and that for core inflation becomes -0.0031 (0.0028) + 0.570 (0.079)*govt-spending variable, R-squared = .777, σ=.0075.

The inclusion of the border dummy variable raises the estimated coefficients of the composite government-spending variable. Specifically, the estimated coefficients on this variable are now 0.42 (s.e.=0.06) for headline inflation in column 2 and 0.47 (0.06) for core inflation in column 4.[22]

Although the estimated effects of the composite government-spending variable on the changes in the inflation rates in Table 5 are significantly positive, they are also significantly different from one, which is the coefficient η that applies in Eq. (11) when all of the excess government spending from 2020 to 2022 is "paid for" by the inverse effect of inflation on the real market value of the initial public debt. A more realistic scenario is that part of the added spending is expected to be financed by the more conventional method of eventually cutting real primary deficits; that is, by reducing government spending from 2023 onward or by raising government revenue from 2020 onward. A coefficient of 0.4-0.5 (as in Table 5, column 2 and 4) suggests that 40-50% of the required financing comes from the negative effect of inflation on the real market value of the public debt, whereas the remaining 50-60% comes from more standard methods of intertemporal public finance.

Results are similar to those in Table 5 if we estimate with OLS applied to the full time series of each country's annual inflation rate from 2010 to 2022 and include country fixed effects. In this case, the regressions for headline and core CPI inflation rates are:

$$(14)\quad \pi\text{ (headline CPI)} = 0.0206^{***} + 0.540^{***}\cdot\text{composite G variable} + 0.0864^{***}\cdot\text{border},$$

[22] We have added the composite-revenue variable (excess revenue from Table 2, column 2, divided by the gross public debt from Table 2, column 3 and by the estimated duration from Table 3, column 2) to the regressions for headline and core inflation in Table 5, columns 2 and 4, respectively. The estimated coefficients of this variable are -0.21 (s.e.=0.15) for headline inflation and -0.03 (0.16) for core inflation. The estimated coefficients of the other variables change little from those shown in Table 5, columns 2 and 4..

(.0012) (.067) (.0108)

R-squared=0.49, σ=0.018, N = 21 countries and 273 observations,

(15) π (core CPI) = 0.0181*** + 0.446***·composite G variable + 0.0494***·border,

(.0008) (.046) (.0074)

R-squared=0.57, σ=0.012, N = 21 countries and 273 observations,

where π is the annual inflation rate, composite G variable is the government-spending variable used in Table 5 (with the same value used for each year in 2020-2022 and zeroes entered otherwise), border is the dummy variable for a common border with Ukraine or Russia (entered only for 2022), and σ is the standard-error of the regression. The estimated coefficients on the government-spending and border variables are close to those in columns 2 and 4 of Table 5 (taking account that the border dummy applies only to 2022 in Eqs. [14] and [15]). The estimated constant terms in Eqs. (14) and (15) correspond to sample averages of headline and core inflation rates, respectively, for 2010-2019. Each country's estimated fixed effect is close to that country's average inflation rate for 2010-2019—and, thereby, corresponds to the (assumed fixed) target inflation rate, π^*, for that country.

Returning to Table 5, the cross-country relationships between the dependent variable (the change in the headline or core CPI inflation rate) and the composite government-spending variable are depicted for headline inflation in Figure 1 and core inflation in Figure 2.[23] Each

[23] In the figures, the estimated relationships with the border dummy variable are filtered out from the government-spending variable and the changes in the inflation rates.

country is marked by its standard acronym. Note that the points for the United States are not outliers—they lie slightly above the middle of the sample with respect to the government-spending variable and the change in the headline or core inflation rate. The points for the Euro area are below those for the United States with respect to the inflation rates and slightly below with respect to the government-spending variable. Overall, the figures show clear positive slopes that do not seem to be driven by extreme observations.

The regressions include the composite government-spending variable, which equals $\Delta(G/Y)$, the cumulation from 2020 to 2022 of ratios of general government spending to GDP gauged relative to ratios for 2019, divided by the ratio of gross public debt to GDP in 2019 and by the debt duration in 2019. As already noted, the estimated coefficients of this variable are positive and highly statistically significant.

We can assess how the statistical significance of the composite government-spending variable relates to the individual contributions from its three components; $\Delta(G/Y)$, the debt-GDP ratio, and the debt duration. We focus on the cases from Table 5, columns 2 and 4, that include the border dummy for Ukraine or Russia. Table 6 reports corresponding regressions in which each component of the composite government-spending variable is set, one at a time, at its sample mean. That is, each designated variable is restricted not to contribute to the explanation of the cross-sectional variations in inflation rates. For example, in column 1, $\Delta(G/Y)$ for each country is constrained to equal the sample mean of 0.101 and, therefore, no longer helps to explain the cross-sectional variations in the change in the headline CPI inflation rate. Note that, in comparison with Table 5, column 1, the R-squared falls dramatically, from 0.790 to 0.320, and the log(likelihood) falls by 12.4.

In one approach, we think of constraining each variable to equal its sample mean as amounting to one coefficient restriction imposed on the estimation. Then we test for the validity of this restriction by using the condition that -2*log(likelihood ratio) is distributed asymptotically as a Chi-squared variable with one degree of freedom. For example, in Table 6, column 1, the resulting p-value for $\Delta(G/Y)$ is 0.000. This result also applies for core inflation (column 4). Hence, $\Delta(G/Y)$ is individually statistically significant for explaining headline and core inflation rates.

The same conclusion applies to the initial ratio of gross public debt to GDP. The p-values associated with this variable are 0.000 for headline and core inflation (Table 6, columns 2 and 5). Therefore, the initial debt-GDP ratio is individually statistically significant for explaining inflation rates.

The initial duration of the public debt is statistically significant with p-values of 0.007 for headline inflation (Table 6, column 3) and 0.021 for core inflation (column 6). Therefore, the initial debt duration is individually statistically significant for explaining inflation rates.

An issue with this approach is that the model in which all three components of the composite government-spending variable enter (Table 5, columns 2 or 4) and the models where one of the components is restricted to equal its sample mean (Table 6, columns 1-3 or 4-6) are not nested. In fact, it is possible that imposing the condition that a variable enter only at its sample-mean value would raise the likelihood, although that outcome does not materialize in any of our cases. As an alternative, we compare the models using the Akaike information criterion (*AIC*), which amounts to another procedure for assessing the likelihood ratios for the various models.[24] According to the *AIC,* for both headline and core inflation, the weight attached to the

[24]The *AIC* equals $2k\text{-}2\cdot log(\mathcal{L})$, where k is the number of free parameters and $\mathcal{L}$ is the likelihood. In our case, k is the same for all of the alternative models and does not affect the calculations. The models can be compared using

restricted models is 0.000 for *Δ(G/Y)* and the debt-GDP ratio. For debt duration, the weight on the restricted model is 0.027 for headline inflation and 0.070 for core inflation. Thus, overall, the conclusions are similar to those found before—there is strong support for the model in which the composite government-spending variable combines influences from *Δ(G/Y)*, the initial debt-GDP ratio, and the initial debt duration.

We consider a further test to determine whether the size of the fiscal stimulus, the amount of outstanding debt, and its duration affect inflation as predicted by the FTPL. Specifically, we linearize the composite spending variable around its cross-sectional mean, $\overline{\Omega}$, defined as $\overline{G}/(\overline{B}\cdot\overline{D})$. Here $\overline{G}$, $\overline{B}$, and $\overline{D}$ are the cross-sectional average values of spending, debt, and duration.

We obtain the following approximate relation relating the change in inflation to the three components of the composite spending variable:

$$\pi - \pi * \approx c + \left[\eta_G \cdot (G - \bar{G}) \cdot \frac{\bar{\Omega}}{\bar{G}} + \eta_B \cdot (B - \bar{B}) \cdot \frac{\bar{\Omega}}{\bar{B}} + \eta_D \cdot (D - \bar{D}) \cdot \frac{\bar{\Omega}}{\bar{D}}\right]$$

We then run a regression of the change in inflation on the three linearized components. The results are reported in Table 7. The coefficients enter as predicted by the FTPL, with η_G positive, and η_B and η_D negative. All coefficients are statistically significant. As before, the fit improves when including the border dummy. We then proceed one step further, and check whether the coefficient are the same in absolute value. Specifically, we test the null hypothesis "$\eta_G + \eta_B = 0$ and $\eta_B = \eta_D$." Even in this case, we cannot reject the null hypothesis that the coefficients are in fact consistent with the restriction predicted by the FTPL. Table A2 in the Appendix reports the estimated coefficients for the restricted regressions. When using headline inflation, we obtain

the relative likelihood, *RL=exp[(AIC₁-AIC₂)/2]*, where AIC_1 is the value from Table 5, columns 2 or 4, and AIC_2 is the value from Table 6, columns 1-3 or 4-6. The weights on the two models are then *1/(1+RL)* and *RL/(1+RL)*. See, for example, Burnham and Anderson (2002, Section 2.2).

0.6212 and 0.6184, without and with the border dummy, respectively. For core inflation, we obtain 0.6759 and 0.6739, without and with the border dummy, respectively. Interestingly, our baseline regression with the border dummy returns a better fit than its linearized counterpart, even when leaving all coefficients unrestricted. The fit is instead similar when excluding the border dummy.

A positive connection between the change in the inflation rate and incremental government spending, $\Delta(G/Y)$, would not be surprising from a Keynesian perspective that stressed the effect of government spending on aggregate demand. A distinguishing feature of the present model is the role of the two scaling variables—the initial values of the debt-GDP ratio and the debt duration. In particular, the effect of the debt-GDP ratio on the boost to inflation is negative for given $\Delta(G/Y)$, whereas an aggregate-demand model might generate the opposite sign. If we enter the fiscal variable into the regressions just as $\Delta(G/Y)$, we get estimated coefficients that are positive but only marginally significant (in contrast to the highly significant coefficients on the composite government-spending variable in Table 5). Moreover, the R-squared values are only 0.37 for headline inflation and 0.30 for core inflation, compared to nearly 0.8 for the regressions in Table 5. The results with the fiscal variable entered as $\Delta(G/Y)$ look as shown in Figure 3 (for headline CPI) and Figure 4 (core CPI). There is a positive relationship between excess government spending and the increase in each inflation rate, but the results are only marginally statistically significant. In contrast, the relationships are clearly positive in Figures 1 and 2.

We interpret the border dummy variable as a proxy for effects on inflation in 2022 from the Ukraine-Russia War (holding fixed the government-spending variable). Since the estimated coefficient on the border dummy for core inflation (Table 5, column 4) is nearly as large as that for headline inflation (column 2), the effects likely do not work primarily through energy prices.[25] The estimated positive effect on inflation likely proxies for broad negative influences of wartime on productivity, including adverse effects on transportation and supply chains.

The dependent variable in the regressions in Table 5 is the change in the annual inflation rate from the baseline period, 2010-2019, to the sample period, 2020-2022. The underlying assumption was that the high inflation rate from 2020 to a date corresponding to the duration of the public debt is fully smoothed out, so that the inflation rate from 2020 to 2022 and additional years beyond is constant. What matters for the effective revenue generated from inflation beginning in 2020 is the cumulative surge in the price level. In this broader sense, the model is not contradicted by the empirical observation that inflation rates were not constant from 2020 to 2022. For headline CPI, the average annual inflation rate for the 21 economies was 1.9% in 2019, 1.4% in 2020, 3.1% in 2021, 8.2% in 2022, and 5.5% through the third quarter of 2023. The corresponding values for core CPI inflation were 1.9%, 1.7%, 2.4%, 5.7%, and 5.7%. Therefore, the empirical pattern—which does not contradict the main implications of the theory—is that inflation built up gradually and eventually leveled off and started to fall.[26]

In Table 5, the dependent variable is the average headline or core inflation rate for 2020-2022 less that for 2010-2019. We can use instead the inflation rate for 2020-2022 as the dependent variable and add the inflation rate for 2010-2019 as an independent variable with a free coefficient. In this form, the estimated coefficient of the inflation rate for 2010-2019 turns out to be 1.21 (s.e.=0.17) in the regression for headline inflation, corresponding to Table 5,

---

[25]However, Minton and Wheaton (2022) show that oil-price changes impact an array of other price changes through network effects. Therefore, changes in energy prices can affect core inflation.
[26]However, less easy to explain is the pattern in long-term nominal interest rates on government bonds. The theory says that, with real interest rates fixed, these nominal rates should have risen quickly in 2020. In fact, the unweighted average of these rates for the 21 economies was 2.3% in 2019, 1.3% in 2020, 1.9% in 2021, and 3.8% in 2022.

column 2, and 0.97 (0.18) in the regression for core inflation, corresponding to column 4. That is, the results support the hypothesis that a country's inflation rate from 2020 to 2022 responds with a unit coefficient to its trend or long-run inflation rate, gauged by the average inflation rate for the ten years from 2010 to 2019.

We checked whether the connections between the inflation rate and the composite government-spending variable depended on the extent of the COVID-related economic downturn, measured as before by the growth rate of real GDP from 2019 to 2020. If we enter this growth rate into the regressions in Table 5, we find for headline inflation (column 2) that the estimated coefficient on the real GDP growth rate does not differ significantly different from zero, -0.052 (s.e.=0.060), and the estimated coefficients and standard errors for the other variables are virtually unchanged. Similarly, for core inflation (column 4), the estimated coefficient on the real GDP growth rate is -0.027 (s.e.=0.061), and the estimated coefficients and standard errors for the other variables are again virtually unchanged. These results suggest that the estimated effects of the composite government-spending variable on inflation rates in Table 5 do not involve a proxying for general economic conditions, in the sense of the size of the economic downturn in 2019-2020.

We now compare the results with the Euro zone treated as a single economy to those with each Euro-zone country considered individually. Table 8 shows regressions for 37 countries—20 non-Euro and 17 Euro. As in Table 5, the first government-spending variable equals excess government spending divided by gross debt and duration. For the Euro countries, this variable takes on a single value, equal to the weighted average of the government-spending variable for these countries. The regressions also include a second government-spending variable for the Euro countries—the difference between the individual value and the weighted-average value. A coefficient of zero on this second variable means that inflation in a Euro-zone country depends on government spending only through the weighted-average value, not the individual value. A coefficient on the second variable equal to that on the first variable means that inflation in each Euro country depends on that country's own spending, in the same way as for each non-Euro country.

When the border dummy variable is included in columns 2 and 4 of Table 8, the estimated coefficients of the individual government-spending variables for the Euro countries do not differ significantly from zero at the 5% level.[27] Therefore, we accept the hypothesis that inflation in each Euro-zone country responds to the Euro-wide average of the government-spending variable, rather than to the country's own spending. In this sense, the results accord with those in Table 5, which used the same government-spending variable for each Euro-zone country.[28]

In contrast, the border dummy variable in columns 2 and 4 of Table 8 enters for each country individually, including the Euro-zone countries (of which five border Ukraine or Russia).[29] This specification means that, in contrast to the government-spending variable, the border dummy does affect relative prices across Euro-zone countries. This result seems consistent with the previous interpretation of the border dummy as a proxy for negative

[27]Results are again similar if, instead of including the border dummy in the regressions, the countries that border Ukraine or Russia are excluded from the sample. For 29 economies, the regression for headline inflation is then .0091 (.0025) + .429 (.076)*govt-spending variable -.067 (.198)*govt-spending variable for Euro area, R-squared = .551, σ=.0072 and that for core inflation becomes -.0042 (.0022) + .569 (.068)*govt-spending variable - .056 (.178)*govt-spending variable for Euro area, R-squared = .728, σ=.0064.

[28]Although not formally part of the Euro zone, Denmark has maintained a nearly fixed exchange rate with the Euro for many years. As is clear from Figures 1 and 2, we would accept the hypothesis that Denmark is effectively part of the Euro zone with respect to the relation between its inflation rates and its government-spending variable. However, in contrast with some Euro-zone countries, Denmark's government-spending variable is itself similar to that for the Euro-zone aggregate.

[29]We accept at the 5% level the hypothesis that the coefficient of the border dummy for the non-Euro countries is the same as that for the Euro countries.

influences of wartime on productivity, including adverse effects on transportation and supply chains. These kinds of shocks would plausibly affect relative prices of consumer goods across countries, at least for several years.

IV. Conclusions

In response to the COVID pandemic, many countries implemented large increases in deficit-financed government spending from 2020 to 2022. To the extent that these fiscal interventions were perceived as not backed by current and future tax increases or future spending cuts, the fiscal theory of the price level, FTPL, predicts that countries should experience a rise in their inflation rates. In a simple setting that neglects effects on inflation from changes in real variables, the predicted increases in inflation rates are proportional to the size of the fiscal stimulus, measured by the cumulative increases in ratios of spending to GDP. However, for a given fiscal stimulus, a country's surge in inflation should be lower if it starts with a larger ratio of public debt to GDP or has a longer duration of this debt.

We find support for these theoretical predictions of the FTPL. Specifically, we show for a sample of 21 economies—20 non-Euro-zone OECD countries and an aggregated version of 17 Euro-zone countries—that headline and core inflation rates in 2020-2022 responded positively to a theory-motivated government-spending variable. This variable includes cumulated increases in spending-GDP ratios divided by the pre-pandemic level of the ratio of public debt to GDP and by the average duration of the public debt. In contrast, across 17 Euro-zone countries, differences in the government-spending variable do not generate significant differences in inflation rates. We also find in the sample of 21 economies that, while positive and statistically significant, the coefficient that gauges the response of the inflation rate to the scaled measure of government spending is significantly less than one, the value predicted when all of the extra spending is "paid for" through surprise inflation. The point estimates of coefficients of 0.4-0.5 suggest that 40-50% of the extra spending was financed through inflation, whereas the remaining 50-60% was paid for through the more orthodox method of intertemporal public finance that involves increases in current or prospective government revenue or cuts in prospective future spending.

Our empirical analysis of inflation is based on a model that neglects effects on real variables, such as real GDP, real interest rates, and real exchange rates. In this sense, our framework deviates from many existing theoretical models related to the FTPL. A natural extension would be to allow for effects on real variables. Such an extension might improve the explanation for cross-country variations in inflation rates and also provide understanding of how spending surges and the resulting inflation impact variables such as real GDP, real interest rates, and real exchange rates.

Figure 5 summarizes some of the results through the lens of time paths from 2010 to 2022 for ratios of gross public debt (at estimated market value) to GDP. The upper curve is for the United States and the lower curve is for the GDP-weighted average of the 21 economies considered in our main analysis. Because of the large fiscal deficits for 2020-2022, following the onset of the COVID crisis, we would expect to see large runups in ratios of public debt to GDP. That expectation is borne out for 2020, when the U.S. debt-GDP ratio rose from 1.09 to 1.34 and the 21-economy ratio rose from 1.03 to 1.22. Subsequently, however, the debt-GDP ratios fell as the U.S. ratio went from 1.34 in 2020 to 1.22 in 2022, and the 21-economy ratio went from 1.22 in 2020 to 1.11 in 2022. The declining parts of these time paths reflect, first, effects from rising price levels and, hence, levels of nominal GDP and, second, effects from rising nominal interest rates, which depressed market values of government bonds. That is, these negative effects on debt-GDP ratios—which more than offset the impacts from continuing fiscal deficits—reflected partly realized inflation and partly increases in expected inflation, as embodied in increases in nominal interest rates. These last two effects correspond to the effective revenue from unexpected inflation that we emphasized in our analysis. Absent this "revenue," debt-GDP ratios would have been substantially higher at the end of 2022.

Table 1 Inflation Variables for 37 OECD Countries (Turkey excluded)*

Part I: Headline Consumer Price Indexes

Country	(1) Change in inflation rate	(2) Inflation rate 2010-19	(3) Inflation rate 2020-22	(4) Fitted inflation rate 2020-22
Australia	0.0132	0.0212	0.0343	0.0403
Canada	0.0190	0.0174	0.0364	0.0406
Chile	0.0345	0.0296	0.0640	0.0550
Colombia	0.0166	0.0374	0.0540	0.0484
Costa Rica	0.0042	0.0315	0.0358	0.0336
Czech Republic	0.0568	0.0169	0.0737	0.0609
Denmark	0.0210	0.0122	0.0332	0.0212
Hungary	0.0520	0.0248	0.0768	0.0774
Iceland	0.0207	0.0313	0.0520	0.0616
Israel	0.0070	0.0107	0.0176	0.0244
Japan	0.0028	0.0047	0.0075	0.0176
Korea, South	0.0099	0.0172	0.0271	0.0397
Mexico	0.0170	0.0396	0.0566	0.0564
New Zealand	0.0270	0.0158	0.0428	0.0442
Norway	0.0140	0.0211	0.0351	0.0338
Poland	0.0601	0.0159	0.0760	0.0768
Sweden	0.0255	0.0113	0.0368	0.0249
Switzerland	0.0087	0.0003	0.0090	0.0178
United Kingdom	0.0173	0.0207	0.0380	0.0386
United States	0.0287	0.0177	0.0464	0.0401
Euro zone (weighted avg)	0.0214	0.0129	0.0342	0.0341
Mean	**0.0227**	**0.0195**	**0.0423**	**0.0423**
Euro-zone countries:				
Austria	0.0237	0.0129	0.0423	
Belgium	0.0244	0.0182	0.0426	
Estonia	0.0553	0.0233	0.0787	
Finland	0.0191	0.0129	0.0320	
France	0.0133	0.0112	0.0245	
Germany	0.0203	0.0133	0.0336	
Greece	0.0253	0.0067	0.0321	
Ireland	0.0273	0.0055	0.0328	
Italy	0.0214	0.0117	0.0331	
Latvia	0.0546	0.0147	0.0694	
Lithuania	0.0668	0.0185	0.0853	
Luxembourg	0.0158	0.0165	0.0323	
Netherlands	0.0303	0.0162	0.0465	
Portugal	0.0187	0.0116	0.0303	
Slovak Republic	0.0441	0.0155	0.0595	
Slovenia	0.0233	0.0124	0.0357	
Spain	0.0249	0.0123	0.0372	
Mean Euro zone	**0.0299**	**0.0137**	**0.0440**	

Part II: Core Consumer Price Indexes

Country	(5) Change in inflation rate	(6) Inflation rate 2010-19	(7) Inflation rate 2020-22	(8) Fitted inflation rate 2020-22
Australia	0.0103	0.0211	0.0314	0.0333
Canada	0.0120	0.0169	0.0289	0.0336
Chile	0.0259	0.0243	0.0502	0.0433
Colombia	0.0000	0.0360	0.0360	0.0394
Costa Rica	-0.0122	0.0336	0.0213	0.0273
Czech Republic	0.0570	0.0124	0.0694	0.0516
Denmark	0.0087	0.0119	0.0206	0.0131
Hungary	0.0341	0.0262	0.0603	0.0663
Iceland	0.0193	0.0309	0.0502	0.0553
Israel	0.0064	0.0105	0.0169	0.0168
Japan	-0.0023	0.0013	-0.0010	0.0067
Korea, South	0.0009	0.0169	0.0178	0.0328
Mexico	0.0107	0.0329	0.0435	0.0425
New Zealand	0.0246	0.0152	0.0398	0.0375
Norway	0.0066	0.0198	0.0265	0.0165
Poland	0.0454	0.0115	0.0568	0.0606
Sweden	0.0186	0.0090	0.0277	0.0153
Switzerland	0.0063	-0.0005	0.0058	0.0099
United Kingdom	0.0111	0.0192	0.0303	0.0300
United States	0.0204	0.0187	0.0391	0.0344
Euro zone (weighted avg)	0.0090	0.0111	0.0200	0.0252
Mean	**0.0149**	**0.0180**	**0.0329**	**0.0329**
Euro-zone countries:				
Austria	0.0131	0.0187	0.0318	
Belgium	0.0093	0.0162	0.0255	
Estonia	0.0252	0.0170	0.0422	
Finland	0.0096	0.0116	0.0213	
France	0.0070	0.0084	0.0154	
Germany	0.0097	0.0121	0.0218	
Greece	0.0049	0.0019	0.0068	
Ireland	0.0163	0.0061	0.0224	
Italy	0.0038	0.0103	0.0141	
Latvia	0.0251	0.0090	0.0341	
Lithuania	0.0388	0.0174	0.0562	
Luxembourg	0.0069	0.0160	0.0229	
Netherlands	0.0118	0.0159	0.0276	
Portugal	0.0119	0.0092	0.0211	
Slovak Republic	0.0386	0.0144	0.0530	
Slovenia	0.0178	0.0075	0.0253	
Spain	0.0076	0.0085	0.0161	
Mean Euro zone	**0.0151**	**0.0118**	**0.0269**	

Note: Inflation rates are averages over periods indicated, based on changes in annual averages of CPI values. Data are from *OECD.STAT*. Change in inflation rate in columns 1 and 5 is value for 2020-2022 less that for 2010-2019. The fitted headline CPI inflation rate 2020-2022 in column 4 is from the regression in Table 5, column 2. The fitted core CPI inflation rate 2020-2022 in column 8 is from the regression in Table 5, column 4. Observations for the Euro zone are weighted averages of data for the 17 individual countries.

*Turkey was omitted because of missing data and also because its extreme inflation rate in 2022—72% for headline CPI inflation and 59% for core CPI inflation—is unlikely to be well explained by the fiscal model. Countries currently under consideration for accession to the OECD include Argentina, Brazil, Bulgaria, Croatia, Indonesia, Peru, Romania, and Ukraine.

Table 2 Fiscal Variables Based on IMF Data for General Government
37 OECD Countries (Turkey excluded)

	(1)	(2)	(3)	(4)	(5)
Country	**Excess Govt Spending relative to GDP cum. 2020-22**	**Excess Govt Revenue relative to GDP cum. 2020-22**	**Gross debt relative to GDP 2019**	**Adjusted gross debt relative to GDP 2019**	**Net debt relative to GDP 2019**
Australia	0.074	0.029	0.467	0.443	0.278
Canada	0.176	0.034	0.902	0.772	0.087
Chile	0.098	0.048	0.283	0.125	0.080
Colombia	0.012	-0.066	0.524	0.310	0.431
Costa Rica	-0.046	0.010	0.564	0.322	0.550
Czech Republic	0.146	0.002	0.300	0.266	0.181
Denmark	-0.004	-0.054	0.337	0.324	0.123
Hungary	0.098	-0.044	0.653	0.485	0.575
Iceland	0.156	-0.002	0.665	0.358	0.544
Israel	0.035	0.033	0.592	0.299	0.568
Japan	0.173	0.067	2.364	2.350	1.517
Korea, South	0.117	0.069	0.421	0.412	0.117
Mexico	0.063	0.019	0.519	0.314	0.433
New Zealand	0.098	0.058	0.318	0.281	0.069
Norway	-0.095	0.036	0.406	0.406	-0.742
Poland	0.108	0.004	0.457	0.355	0.385
Sweden	0.017	-0.015	0.356	0.225	0.049
Switzerland	0.077	0.014	0.396	0.396	0.173
United Kingdom	0.215	0.057	0.857	0.626	0.758
United States	0.177	0.050	1.081	1.038	0.832
Euro zone (weighted avg)	0.156	0.014	0.861	0.828	0.692
Mean	**0.088**	**0.017**	**0.634**	**0.521**	**0.367**
Euro-zone countries:					
Austria	0.210	0.011	0.706	0.699	0.479
Belgium	0.118	-0.008	0.976	0.968	0.848
Estonia	0.090	-0.001	0.085	0.085	-0.022
Finland	0.073	0.002	0.649	0.632	0.270
France	0.126	0.017	0.974	0.917	0.889
Germany	0.164	0.009	0.596	0.569	0.403
Greece	0.275	0.063	1.855	1.855	1.639
Ireland	0.014	-0.063	0.571	0.571	0.489
Italy	0.226	0.017	1.342	1.282	1.217
Latvia	0.130	0.006	0.367	0.329	0.282
Lithuania	0.152	0.042	0.358	0.261	0.303
Luxembourg	0.048	-0.054	0.224	0.224	-0.141
Netherlands	0.116	-0.004	0.485	0.484	0.398
Portugal	0.151	0.042	1.166	1.133	1.099
Slovak Republic	0.114	0.015	0.480	0.455	0.431
Slovenia	0.189	0.004	0.654	0.618	0.495
Spain	0.225	0.100	0.982	0.957	0.837
Mean Euro zone	**0.142**	**0.012**	**0.733**	**0.708**	**0.583**

Note: In column 1, excess government spending is calculated from general government expenditure exclusive of interest payments. Values are cumulative ratios to GDP for 2020-2022, expressed relative to the ratio for 2019. The missing value of interest payments for 2022 for South Korea is assumed to equal the value for 2021. In column 2, excess government revenue is calculated from general government revenue. Values are cumulative ratios to GDP for 2020-2022, expressed relative to the ratio for 2019. In column 3, gross public debt is observed at the end of 2019 for general government. In column 4, the adjusted gross public debt is net of shares denominated in foreign currency or in inflation-indexed form. In column 5, net public debt for general government at the end of 2019 is based on IMF criteria for netting.

Data are from IMF, *World Economic Outlook Data Base*, *Government Finance Statistics*, and *Article IV Staff Reports*. Column 4 uses information on shares of public debt denominated in foreign currency or in inflation-indexed form from Table 3, columns 3 and 4.

Table 3 Characteristics of Public Debt
37 OECD Countries (Turkey excluded)

	(1)	(2)	(3)	(4)	(5)
Country	**Average remaining maturity 2019**	**Estimated duration 2019**	**Share foreign-currency 2019**	**Share inflation-indexed 2019**	**Composite govt-spending variable**
Australia	7.7	6.8	.001	.049	0.0232
Canada	6.3	5.9	.112	.033	0.0331
Chile	11.9	8.9	.206	.353	0.0385
Colombia	8.6	6.2	.227	.181	0.0037
Costa Rica	6.4	4.5	.376	.054	-0.0180
Czech Republic	6.1	5.8	.115	.000	0.0834
Denmark	8.0	7.6	.001	.039	-0.0014
Hungary	4.6	4.2	.210	.047	0.0355
Iceland	5.4	4.6	.165	.296	0.0504
Israel	6.5	6.0	.145	.351	0.0100
Japan	9.3	9.1	.001	.005	0.0081
Korea, South	10.4	8.9	.010	.011	0.0314
Mexico	9.9	6.9	.169	.225	0.0174
New Zealand	7.7	6.7	.007	.111	0.0458
Norway	4.0	3.8	.000	.000	-0.0611
Poland	4.6	4.2	.220	.004	0.0558
Sweden	5.0	4.9	.214	.152	0.0099
Switzerland	10.4	10.0	.000	.000	0.0193
United Kingdom	15.3	12.5	.000	.269	0.0201
United States	5.7	5.3	.000	.039	0.0310
Euro (weighted avg)	7.7	7.1	.014	.025	0.0256
Mean	**7.7**	**6.7**	**.104**	**.106**	**0.0220**
Euro-zone countries:					
Austria	9.9	9.1	.010	.000	0.0325
Belgium	9.8	8.9	.008	.000	0.0136
Estonia	7.2	7.2	.000	.000	0.1474
Finland	6.3	6.1	.026	.000	0.0185
France	8.2	7.7	.015	.044	0.0168
Germany	6.9	6.7	.028	.018	0.0410
Greece	9.6	6.8	.000	.000	0.0219
Ireland	10.3	8.7	.000	.000	0.0028
Italy	7.0	6.3	.007	.037	0.0266
Latvia	9.9	8.5	.103	.000	0.0416
Lithuania	7.4	6.8	.270	.000	0.0622
Luxembourg	4.9	4.8	.000	.000	0.0444
Netherlands	8.0	7.6	.003	.000	0.0316
Portugal	6.2	5.6	.028	.000	0.0233
Slovak Republic	8.8	8.0	.051	.000	0.0298
Slovenia	9.0	7.9	.054	.000	0.0365
Spain	7.7	6.9	.001	.024	0.0332
Mean Euro zone	**8.1**	**7.3**	**.036**	**.007**	**0.0367**

Note:

In column 1, average years of remaining maturity (applying only to principal payments) come in most cases from OECD, *Sovereign Outlook for OECD Countries*, *Survey on Central Government Marketable Debt and Borrowing*, 2023, Figure 1.14 for 2022; 2022, Figure 1.15 for 2020 and 2021; and 2021, Figure 1.14 for 2019. These values are for central government debt and were assumed to apply also to general government. Value for Estonia is for 2020. Value for Chile for 2022 is from Ministerio de Hacienda Chile, *Composition de la Deuda Chile by Currency,* March 2023. Value for Costa Rica for 2022 is from Ministerio de Hacienda, Costa Rica, *Profile of the Public Debt*, July 2023. Value for Iceland for 2022 is from Office of Debt Management *Newsletter,* Iceland, July 2023.

In column 2, the average duration of the public debt is calculated from the reported average maturity (column 1) from the formula in part A2 of the appendix, using data on nominal interest rates on long-term government bonds from 2007 to 2019 from *OECD.Stat* and IMF, *International Financial Statistics*. Data on interest rates begin in 2014 for Costa Rica and in 2015 for Estonia (approximated by 6-month Euribor interest rates reported by the Central Bank of Estonia). In the formula, the lagged interest rate, R_{t-L}, corresponds to the average going back from 2018 the number of years of duration. The current interest rate, R_t, corresponds to the rate for 2019. Since (except for a couple cases) we lack separate data on maturity for bonds denominated in foreign currency or in inflation-indexed form, we made no adjustments to estimated duration because of these compositional differences.

In column 3, the share denominated in foreign currency is mostly from BIS, *Central and General Government Debt Securities Markets*, Table C4, 2020-2023. These values apply to long-term debt (maturity of one year or more) for general government. Sources for Costa Rica and Iceland are as above. Source for New Zealand is Reserve Bank of New Zealand, *Holdings of Central Government Debt Securities*, July 2023. For Costa Rica, Iceland, and New Zealand, the values of foreign-currency-denominated share for 2022 are assumed to apply also for 2019.

In column 4, the share inflation-indexed is mostly from BIS, Table C2, 2020-2023. These values are for central-government debt. Sources for Chile, Costa Rica, Iceland, and New Zealand are as above. Value for Japan for 2023 came from communication with the Bank of Japan. This value was assumed to apply also in 2019. Value for France for 2020 is from World Bank, *What Is the Role of Inflation-Linked Bonds for Sovereigns?,* 2022, Figure 2.5. Value for Sweden for 2022 is from CEICdata.com. Values of zero were confirmed by central banks of Norway and Switzerland. Reported inflation-indexed shares, which apply to central government, were multiplied by the ratio for 2019 of central to general government expenditure from IMF, *Government Finance Statistics*. The resulting values for inflation-indexed shares are estimated values for general government, assuming that only central governments issue inflation-linked bonds. For some countries, the values of inflation-indexed share for 2022 are assumed to apply for 2019.

In column 5, the composite government-spending variable is excess government spending from Table 2, column 1, divided by the ratio of gross public debt to GDP from Table 2, column 3, and divided by the estimated duration from Table 3, column 2.

Table 4

Means and Standard Deviations of Variables

	Mean	s.d.	Max	Min
Headline CPI inflation rate, 2010-2019	0.0195	0.0101	0.0396	0.0003
Headline CPI inflation rate, 2020-2022	0.0423	0.0197	0.0768	0.0075
Change in headline CPI inflation rate	0.0227	0.0162	0.0601	0.0028
Core CPI inflation rate, 2010-2019	0.0180	0.0100	0.0360	-0.0005
Core CPI inflation rate, 2020-2022	0.0329	0.0179	0.0694	-0.0010
Change in core CPI inflation rate	0.0149	0.0160	0.0570	-0.0122
Energy CPI inflation rate, 2010-2019	0.0268	0.0153	0.0676	0.0002
Energy CPI inflation rate, 2020-2022	0.0968	0.0425	0.1688	0.0261
Change in energy CPI inflation rate	0.0700	0.0466	0.1445	-0.0165
Food CPI inflation rate, 2010-2019	0.0216	0.0130	0.0503	-0.0018
Food CPI inflation rate, 2020-2022	0.0575	0.0339	0.1341	0.0005
Change in food CPI inflation rate	0.0359	0.0247	0.0978	0.0024
Δ(G/Y) (primary govt spending as ratio to GDP, cum. 2020-22 vs. 2019)	0.0881	0.0799	0.2152	-0.0952
Δ(REV/Y) (govt revenue as ratio to GDP, cum. 2020-22 vs 2019)	0.0173	0.0381	0.0689	-0.0662
Gross public debt/GDP (2019)	0.6345	0.4534	2.3638	0.2833
Gross public debt adjusted/GDP (2019)	0.5208	0.4725	2.3502	0.1250
Estimated public-debt duration (2019)	6.6682	2.2114	12.4739	3.8427
Composite govt-spending variable	0.0220	0.0291	0.0834	-0.0611
Composite govt-spending variable adjusted	0.0301	0.0379	0.0942	-0.0611
Composite govt-revenue variable	0.0039	0.0127	0.0270	-0.0209
Dummy for border with Ukraine or Russia	0.1447	0.3579	1.0000	0.0000

Note: Statistics refer to the 21 economies considered in Table 5 (20 non-Euro-zone countries and the weighted average of the 17 countries in the Euro zone). The headline and core CPI inflation rates are in Table 1. *Δ(G/Y)* is the cumulative ratio of primary general government expenditure to GDP from 2020 to 2022 expressed relative to the ratio for 2019 (Table 2, column 1). *Δ(REV/Y)* is the cumulative ratio of general government revenue to GDP from 2020 to 2022 expressed relative to the ratio for 2019 (Table 2, column 2). The estimated duration of the gross public debt in 2019 is from Table 3, column 2. The adjusted gross public debt (adjusted for amounts denominated in foreign currency or in inflation-linked form) is from Table 2, column 4. The composite government-spending variable from Table 3, column 5, equals *Δ(G/Y)* divided by the ratio of gross public debt to GDP in 2019 and by the estimated debt duration in 2019. The composite govt-spending variable adjusted uses instead the ratio of adjusted gross public debt to GDP. The composite government-revenue variable equals

Δ(REV/Y) divided by the ratio of gross public debt to GDP in 2019 and by the estimated debt duration in 2019.

Table 5

Regressions for Change in Inflation Rate

Euro zone treated as one economy

	Headline CPI inflation rate		Core CPI inflation rate	
	(1)	(2)	(3)	(4)
Constant	0.0150*** (0.0035)	0.0096*** (0.0024)	0.0061* (0.0031)	0.0018 (0.0024)
Excess govt spending/(gross debt)* duration	0.3532*** (0.0987)	0.4126*** (0.0621)	0.4018*** (0.0866)	0.4485*** (0.0631)
Border with Ukraine or Russia	--	0.0283*** (0.0051)	--	0.0223*** (0.0051)
Number of Observations	21	21	21	21
R-squared	0.402	0.783	0.531	0.771
s.e. of regression	0.0129	0.0080	0.0113	0.0081
log(likelihood)	62.6869	73.3010	65.4502	72.9819

Note: The sample is 21 economies (20 non-Euro zone and the Euro zone considered as an aggregate). For the Euro zone, each variable is a weighted average of the values for the 17 Euro-zone countries. The regressions are by OLS, with standard errors of estimated coefficients in parentheses. The dependent variable in column 1, shown in Table 1, column 1, is the average headline CPI inflation rate for 2020-2022 less that for 2010-2019. In column 2, the dependent variable, shown in Table 1, column 5, is the average core CPI inflation rate for 2020-2022 less that for 2010-2019. The composite government-spending variable equals the cumulation of ratios of general government primary spending to GDP from 2020 to 2022 expressed relative to the ratio for 2019 (Table 2, column 1), divided by the ratio of gross public debt to GDP in 2019 (Table 2, column 3) and by the estimated duration of the debt in 2019 (Table 3, column 2). The border dummy variable equals one for countries with a common border with Ukraine or Russia and equals zero otherwise.

Table 6

Regressions for Change in Inflation Rate

Euro zone treated as one economy, selected variables set at sample means

	Headline CPI inflation rate			Core CPI inflation rate		
	(1)	(2)	(3)	(4)	(5)	(6)
Variable set at sample mean:	Govt spending	Gross debt	Duration	Govt spending	Gross debt	Duration
Constant	0.0099 (0.0075)	0.0113*** (0.0038)	0.0073** (0.0032)	0.0009 (0.0079)	0.0038 (0.0040)	-0.0011 (0.0031)
Excess govt spending/(gross debt)*duration	0.3555 (0.2512)	0.3752*** (0.1181)	0.4797*** (0.0929)	0.4342 (0.2633)	0.4030*** (0.1255)	0.5420*** (0.0897)
Border with Ukraine or Russia	0.0163 (0.0098)	0.0259*** (0.0075)	0.0311*** (0.0061)	0.0084 (0.0103)	0.0196** (0.0079)	0.0256*** (0.0059)
Number of Observations	21	21	21	21	21	21
R-squared	0.324	0.519	0.698	0.243	0.446	0.712
s.e. of regression	0.0140	0.0119	0.0094	0.0147	0.0126	0.0091
log(likelihood)	61.3995	64.9638	69.8389	60.4128	63.6909	70.5724
p-values:	0.000	0.000	0.009	0.000	0.000	0.028
Relative likelihood(AIC)	0.000	0.000	0.031	0.000	0.000	0.090

Note: See the notes to Table 5. The regressions for the headline CPI inflation rate correspond to Table 5, column 2. The ones for the core CPI inflation rate correspond to Table 5, column 4. Each column in Table 6 sets the indicated part of the composite government-spending variable for each country to its sample mean. These parts are excess government spending for 2020-2022 (Table 2, column 1), gross public debt as a ratio to GDP in 2019 (Table 2, column 3), and duration of the public debt in 2019 (Table 3, column 2). The p-values come from treating -2*log(likelihood ratio) as distributed asymptotically as a chi-squared variable with one degree of freedom. For headline CPI inflation, the calculations use the difference between the log(likelihood) shown in Table 5, column 2, from those shown in Table 6, columns 1-3 For core CPI inflation, the difference is between the log(likelihood) shown in Table 5, column 4, from those shown in Table 6, columns 4-6. The relative likelihood, based on the Akaike information criterion and using the same likelihood values, is the weight attached to the model in which the indicated variable is set at its sample mean and, therefore, does not contribute to the explanation of the cross-sectional variations in inflation rates. One minus these relative likelihoods is the weight attached to the model shown in Table 5, column 2 or 4.

***significant at 1%.
**significant at 5%.
*significant at 10%

Table 7

Regressions for New F Tests

Euro zone treated as one economy

	Headline CPI inflation rate		Core CPI inflation rate	
	(1)	(2)	(3)	(4)
Constant	0.0227*** (0.0027)	0.0196*** (0.0025)	0.0149*** (0.0025)	0.0126*** (0.0025)
$(\boldsymbol{G}-\bar{\boldsymbol{G}})\cdot\bar{\boldsymbol{\Omega}}/\bar{\boldsymbol{G}}$	0.6033*** (0.1770)	0.6371*** (0.1467)	0.6791*** (0.1657)	0.7038*** (0.1515)
$(\boldsymbol{B}-\bar{\boldsymbol{B}})\cdot\bar{\boldsymbol{\Omega}}/\bar{\boldsymbol{B}}$	-0.5636** (0.2086)	-0.5731*** (0.1724)	-0.6119*** (0.1953)	-0.6189*** (0.1781)
$(\boldsymbol{D}-\bar{\boldsymbol{D}})\cdot\bar{\boldsymbol{\Omega}}/\bar{\boldsymbol{D}}$	-1.2588** (0.4377)	-0.7458* (0.4004)	-1.1209** (0.4098)	-0.7460* (0.4137)
Border with Ukraine/Russia		0.0217*** (0.0073)		0.0159* (0.0075)
Number of Observations	21	21	21	21
R-squared	0.512	0.687	0.564	0.659
s.e. of regression	0.0123	0.0101	0.0115	0.0105
log(likelihood)	64.8205	69.4646	66.2005	68.7793
Test: F statistic	1.302	0.097	0.682	0.115
Test: p-value	0.298	0.908	0.519	0.892

Note: The regressions are parallel to Table 5. "Test: F statistic" and "Test: p-value" are the F-statistic and p-value for the test "$\eta_G + \eta_B = 0$ and $\eta_B = \eta_D$", respectively

$$\pi - \pi * \approx c + \left[\eta_G \cdot (G - \bar{G}) \cdot \frac{\bar{\Omega}}{\bar{G}} + \eta_B \cdot (B - \bar{B}) \cdot \frac{\bar{\Omega}}{\bar{B}} + \eta_D \cdot (D - \bar{D}) \cdot \frac{\bar{\Omega}}{\bar{D}}\right]$$

Table 8

Regressions for Change in Inflation Rate

Euro-zone countries considered individually

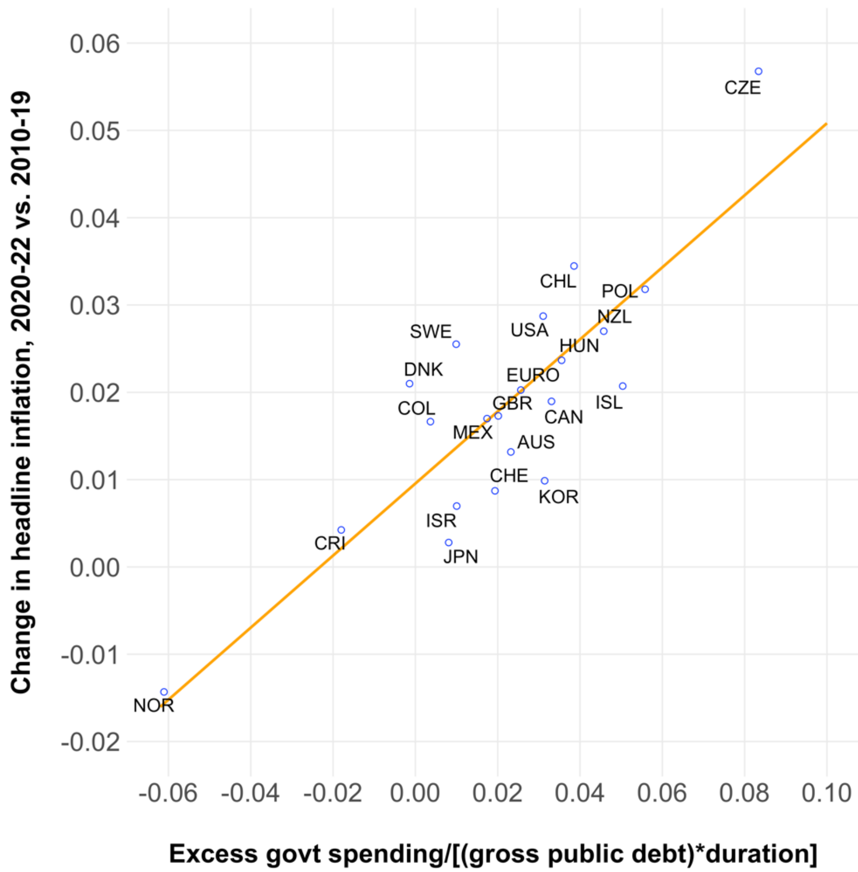
	Headline CPI inflation rate		Core CPI inflation rate	
	(1)	(2)	(3)	(4)
Constant	0.0161*** (0.0032)	0.0106*** (0.0023)	0.0052* (0.0027)	0.0010 (0.0021)
Excess govt spending/(gross debt)* duration	0.3586*** (0.0988)	0.4062*** (0.0674)	0.3974*** (0.0830)	0.4339*** (0.0621)
Excess govt spending/(gross debt)* duration: Euro area	0.3094*** (0.0986)	0.1212 (0.0730)	0.1213 (0.0828)	-0.0232 (0.0673)
Border with Ukraine/Russia		0.0246*** (0.0038)		0.0188*** (0.0035)
Number of Observations	37	37	37	37
R-squared	0.409	0.737	0.428	0.693
s.e. of regression	0.0129	0.0087	0.0108	0.0081
log(likelihood)	110.0029	124.9532	116.4786	127.9926

Note: The regressions correspond to Table 5. The first government-spending variable corresponds to the one in Table 5, where the value for each of the 17 Euro-zone countries equals the weighted average of values for these countries. The second government-spending variable for each Euro-zone country is the individual value less the weighted average of this variable for the 17 Euro-zone countries.

***significant at 1%.
**significant at 5%.
*significant at 10%

Figure 1

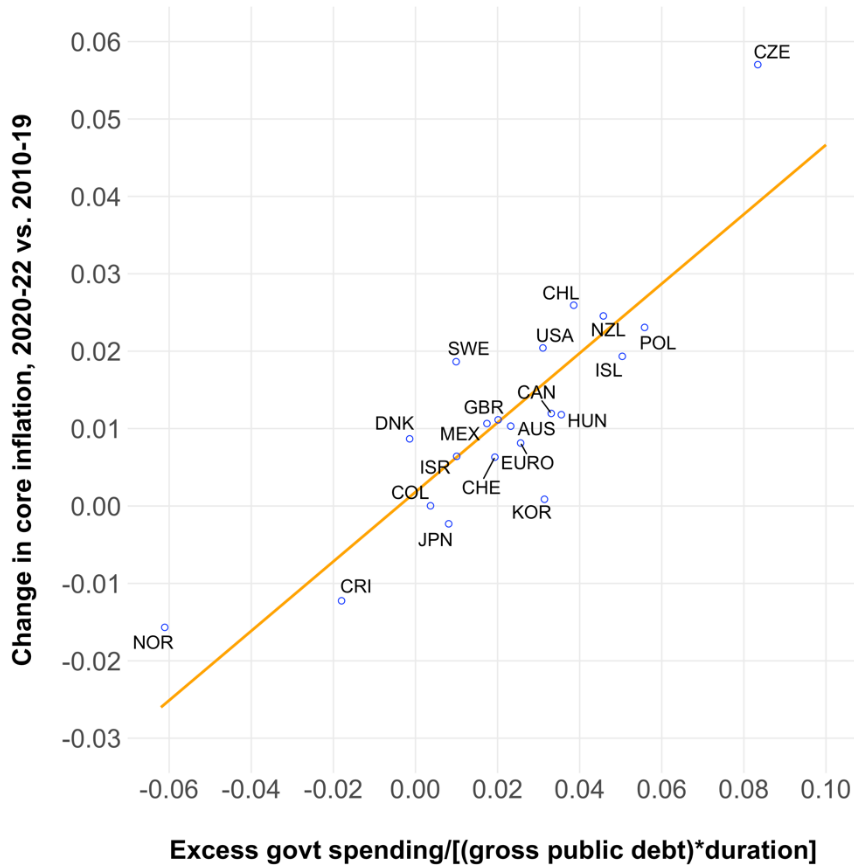
Change in Headline CPI Inflation Rate versus Composite Government-Spending Variable



Note: The sample is 21 economies—20 non-Euro countries plus the Euro zone considered as an aggregate. The labels are standard acronyms for countries (used, for example, by the IMF). The vertical axis has the change in the headline CPI inflation rate net of the border dummy effect. This variable is the average rate for 2020-2022 minus that for 2010-2019 (Table 1, column 1), filtered out for the estimated relationship with the border dummy variable.[30] The spending variable is the ratio of general government primary spending to GDP (cumulation for 2020-2022 relative to the ratio for 2019 in Table 2, column 1) divided by the ratio of gross public debt to GDP in 2019 (Table 2, column 3) and by the estimated duration of the public debt in 2019 (Table 3, column 2).

[30] To do this, we first run the regression: $\Delta\pi^{head} = 0.0079 + 0.0279 * border + 0.424 * \Delta G + \epsilon$, where ϵ is the residual. Then we define $\widetilde{\Delta\pi}^{head} = \Delta\pi^{head} - 0.0279 * border$ and plot it on the vertical axis.

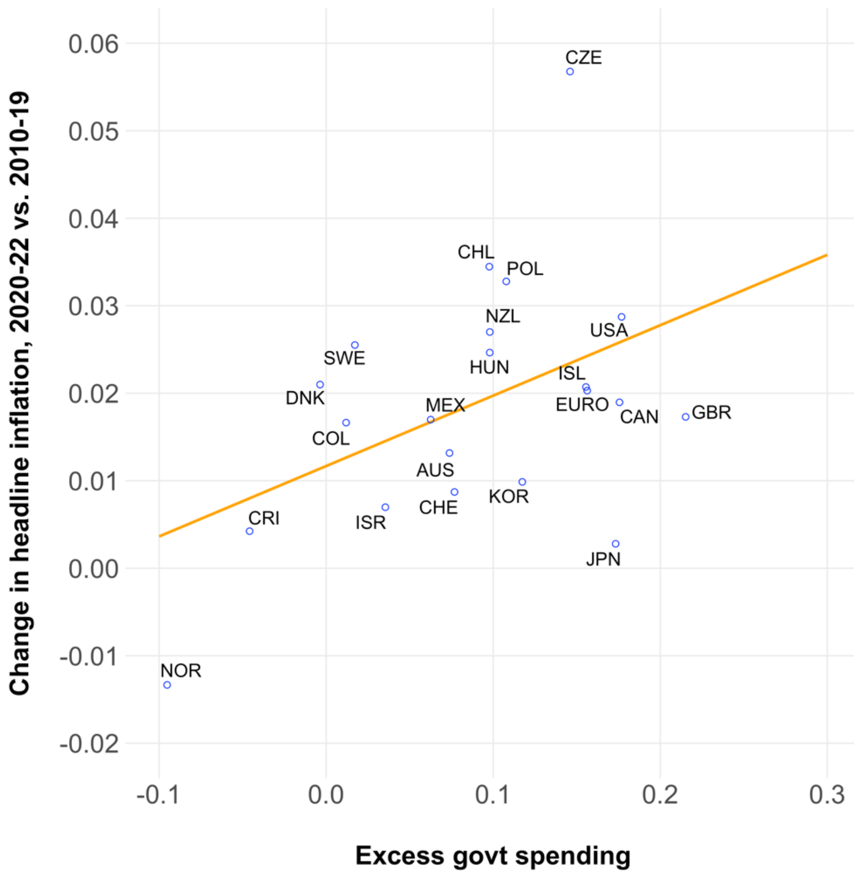
Figure 2
Change in Core CPI Inflation Rate versus Composite Government-Spending Variable



Note: See the notes to Figure 1. The difference from Figure 1 is that the inflation rates are based on core CPI inflation rates (Table 1, column 5).

Figure 3

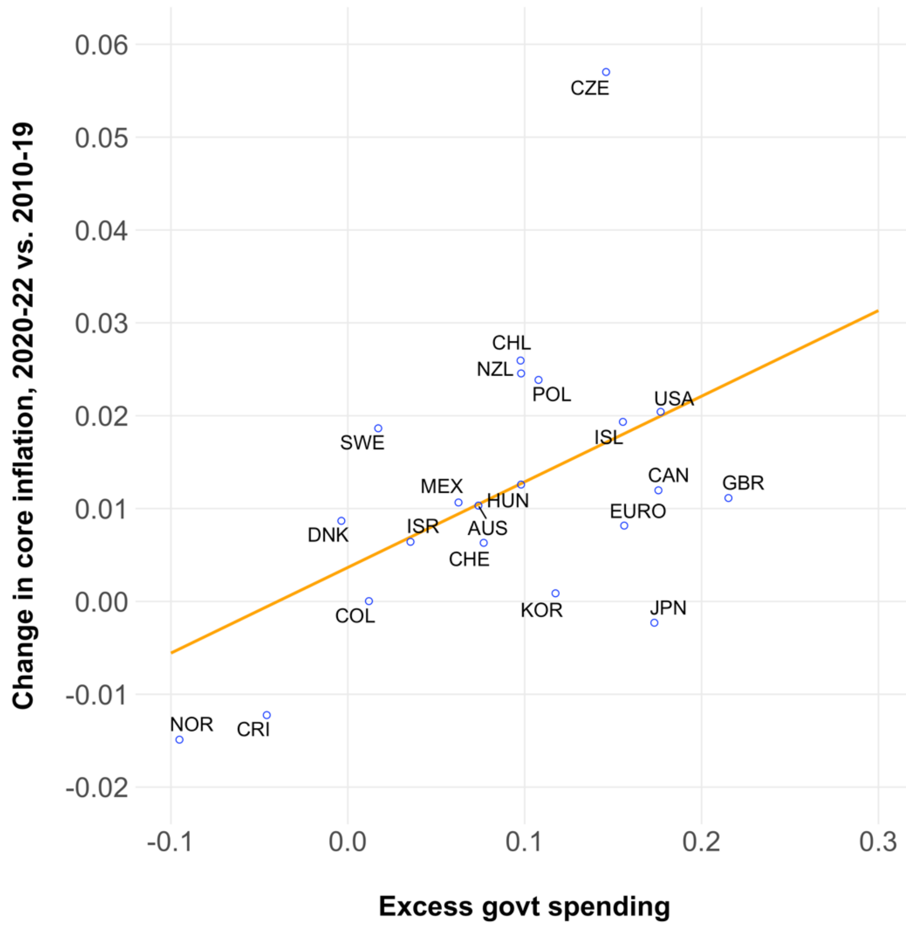
Change in Headline CPI Inflation Rate versus Government Spending



Note: The difference from Figure 1 is that the horizontal axis has the ratio of general government primary spending to GDP (cumulation for 2020-2022 relative to the ratio for 2019).

Figure 4

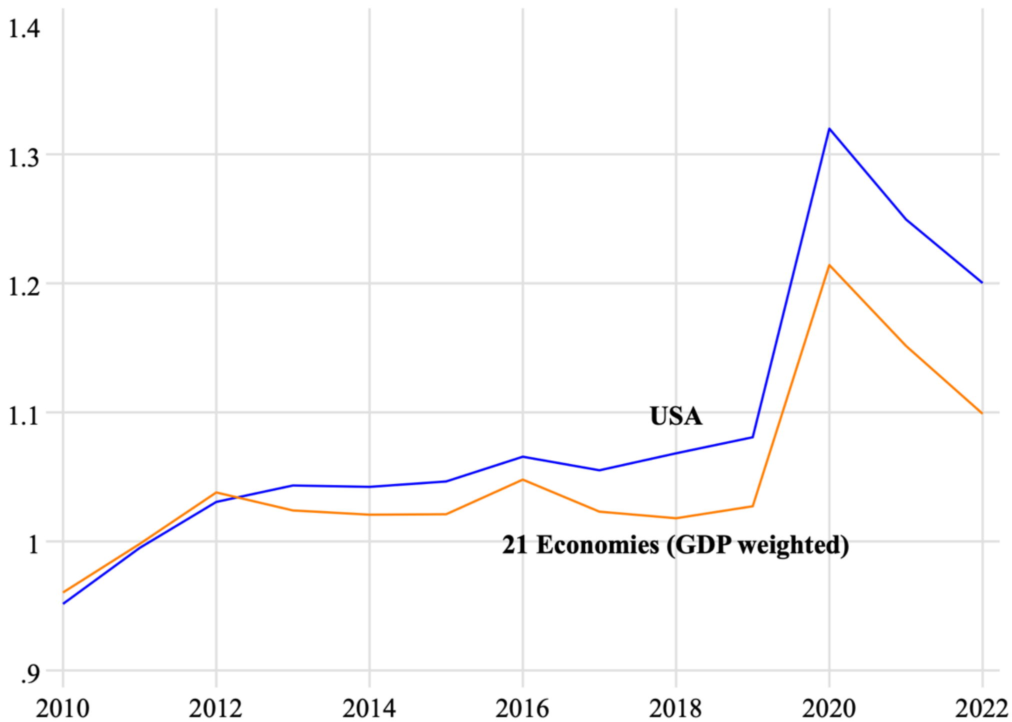
Change in Core CPI Inflation Rate versus Government Spending



Note: The difference from Figure 2 is that the horizontal axis has the ratio of general government primary spending to GDP (cumulation for 2020-2022 relative to the ratio for 2019).

Figure 5

Debt-GDP Ratios



Note: The upper curve is the ratio of gross public debt to GDP for the United States. The lower curve is the GDP-weighted average of gross public debt to GDP for the 21 economies considered in Table 5. Note that the data on public debt, from the International Monetary Fund, are mostly at estimated market value.

References

Bassetto, Marco (2002). "A Game-Theoretic View of the Fiscal Theory of the Price Level," *Econometrica*, 70, 2167-2195.

Bassetto, Marco and David S. Miller (2023). "A Monetary-Fiscal Theory of Sudden Inflations," *Quarterly Journal of Economics*, 138, forthcoming.

Bianchi, Francesco, Renato Faccini, and Leonardo Melosi (2023). "A Fiscal Theory of Persistent Inflation," *Quarterly Journal of Economics*, 138, forthcoming.

Bianchi, Francesco and Cosmin Ilut (2017). "Monetary/Fiscal Policy Mix and Agents' Beliefs," *Review of Economic Dynamics*, 26, 113-139.

Bianchi, Francesco and Leonardo Melosi (2017). "Escaping the Great Recession," *American Economic Review*, 107, 1030-1058.

Bianchi, Francesco and Leonardo Melosi (2022). "Inflation as a Fiscal Limit," Federal Reserve Bank of Kansas City, *2022 Jackson Hole Economic Symposium,* 265-319.

Bianchi, Francesco, Giovanni Nicolo, and Dongho Song (2023). "Inflation and Real Activity over the Business Cycle," NBER working paper no. 31075, May.

Burnham, Kenneth P. and David R. Anderson (2002). *Model Selection and Multimodel Inference*, 2nd edition, New York, Springer.

Cochrane, John H. (2001). "Long-Term Debt and Optimal Policy in the Fiscal Theory of the Price Level," *Econometrica*, 69, 69-116.

Cochrane, John H. (2023). *The Fiscal Theory of the Price Level*, Princeton NJ, Princeton University Press.

Davig Troy, and Eric M. Leeper (2006). "Fluctuating Macro Policies and the Fiscal Theory," *NBER Macroeconomics Annual*, 247–298.

Dupor, William (2000). "Exchange Rates and the Fiscal Theory of the Price Level," *Journal of Monetary Economics*, 45, 613-630.

International Monetary Fund (2014). *Government Finance Statistics Manual*, International Monetary Fund, Washington DC.

Jolley, L.B.W. (1961). *Summation of Series*, Dover Publications, New York.

Justiniano, Alejandro, Giorgio E. Primiceri, and Andrea Tambalotti (2013). "Is There a Trade-Off between Inflation and Output Stabilization?" *American Economic Journal:*

Macroeconomics, 5, 1-31.

Leeper, Eric M. (1991). "Equilibria under 'Active' and 'Passive' Monetary and Fiscal Policies," *Journal of Monetary Economics,* 27, 129-147.

Leeper, Eric M., Nora Traum, and Todd B. Walker (2017). "Clearing Up the Fiscal Multiplier Morass," *American Economic Review* 107, 2409–2454.

Lucas, Robert E., Jr. and Nancy L. Stokey (1983). "Optimal Fiscal and Monetary Policy in an Economy without Capital," *Journal of Monetary Economics*, 12, 55-93.

Macaulay, Fredrick R. (1938). *Some Theoretical Problems Suggested by the Movements of Interest Rates, Bond Yields, and Stock Prices in the United States since 1857*, Columbia University Press, New York.

Minton, Robert and Brian Wheaton (2022). "Hidden Inflation in Supply Chains: Theory and Evidence," unpublished, UCLA, November.

Sims, Christopher A. (1994). "A Simple Model for Study of the Price Level and the Interaction of Monetary and Fiscal Policy," *Economic Theory*, 4, 381-399.

Woodford, Michael (1995). "Price-Level Determinacy without Control of a Monetary Aggregate," *Carnegie-Rochester Conference Series on Public Policy,* 43, 1-46.

Woodford, Michael (2001). "Fiscal Requirements for Price Stability," *Journal of Money, Credit and Banking,* 33, 669-728.

Appendix

A1. Derivation of equation (10)

Equation (9) contains the term $\left(\frac{1+\pi*}{1+\pi}\right)^{T}$. This term can be written as

(A1) $$\left(\frac{1+\pi*}{1+\pi}\right)^{T} = exp\{T \cdot [\log(1+\pi *) - \log(1+\pi)]\}$$

Taking a second-order expansion of the log terms leads to:

(A2) $$\left(\frac{1+\pi*}{1+\pi}\right)^{T} \approx exp\left\{T \cdot [(\pi * - \pi) \cdot (1 - \frac{\pi+\pi*}{2})\right\}$$

Taking a second-order expansion of the exponential leads, after simplification, to:

(A3) $$\left(\frac{1+\pi*}{1+\pi}\right)^{T} \approx 1 + (\pi * - \pi) \cdot \left(1 - \frac{\pi+\pi*}{2}\right) \cdot T + \frac{1}{2}(\pi * - \pi)^2 \cdot \left(1 - \frac{\pi+\pi*}{2}\right)^2 \cdot T^2$$

Plugging this result into Eq (9) leads, after simplification, to:

(A4) $$\Delta B \approx B_t^* \cdot (1+\pi *) \cdot \left\{-\frac{1}{2}(\pi - \pi *)T + \frac{1}{2}(\pi - \pi *)(\pi + \pi *)[1 - \frac{1}{4}(\pi + \pi *)]T^2 / (1+T)\right\}$$

If T>>1, π*<<1, and π<<1, the result simplifies to that in Eq.(10):

(A5) $$\Delta B \approx -B_t^* \cdot \frac{1}{2} T \cdot (\pi - \pi *)$$

A2. Formula for estimated duration of bonds

At time t, the outstanding nominal coupons and principal payment on a bond are $B_t^0, B_t^1, \ldots, B_t^T$. Unlike in the main text, these amounts now apply to a single bond, not to the coupons and principal payments for the aggregates of bonds outstanding. Consider a "standard" bond that has constant nominal coupons followed by a single nominal principal payment at *T*, so that $B_t^0 = B_t^1 = \cdots B_t^{T-1} = B_t^i$. In that case, the standard data would report *T* to be the remaining maturity of the bond.

If the nominal discount rate at time t is R_t (applying to all future periods), the value of the bond is

(A6) $$B_t = B_t^i[1 + \frac{1}{(1+R_t)} + \cdots + \frac{1}{(1+R_t)^{T-1}}] + \frac{B_t^T}{(1+R_t)^T}$$

This result assumes that each coupon or principal payment occurs at the beginning of each period (where a period corresponds here to the time between payments of coupons or principal). Evaluating the sum leads to

(A7) $$B_t = \frac{B_t^i}{R_t}[1 + R_t - \left(\frac{1}{1+R_t}\right)^{T-1}] + \frac{B_t^T}{(1+R_t)^T}$$

The Macaulay (1938, Chapter II) duration of the bond is

(A8) $$D_t = \frac{B_t^i}{B_t} \cdot [\frac{1}{(1+R_t)} + \frac{1}{(1+R_t)^2} \cdot 2 + \cdots + \frac{1}{(1+R_t)^{T-1}} \cdot (T-1)] + \frac{B_t^T}{B_t(1+R_t)^T} \cdot T$$

Evaluating the sum inside the brackets (using Jolley, 1961, series 5) and simplifying leads to:

(A9) $$D_t = \frac{B_t^i}{B_t} \cdot \frac{1}{R_t^2}[1 + R_t - \frac{1}{(1+R_t)^{T-1}}(1 + R_t T)] + \frac{B_t^T}{B_t(1+R_t)^T} \cdot T$$

The ratio B_t^i/B_t^T is the coupon yield of the bond. For a bond issued currently at par—which we take to be the typical case for bonds—this yield would equal R_t. However, the coupon yields of long-term bonds outstanding at the start of period t would reflect past issues. We assume that the coupon yield on each of these bonds equals the discount rate that applied when the bonds were issued. In that case, B_t^i/B_t^T would correspond to an average of past discount rates, which we denote by R_{t-L}. Making this substitution into Eqs (A9) and (A7) leads to:

(A10) $$D_t = \frac{B_t^T}{B_t} \cdot \left\{\frac{R_{t-L}}{R_t^2}[1 + R_t - \frac{1}{(1+R_t)^{T-1}}(1 + R_t T)] + \frac{T}{(1+R_t)^T}\right\}$$

(A11) $$B_t = B_t^T \cdot \left\{\frac{R_{t-L}}{R_t}[1 + R_t - \frac{1}{(1+R_t)^{T-1}}] + \frac{1}{(1+R_t)^T}\right\}$$

Substitution for B_t from Eq. (A11) into Eq. (A10) leads to the formula for duration:

(A12) $$D_t = \frac{\left\{\frac{R_{t-L}}{R_t^2}[1+R_t-\frac{1}{(1+R_t)^{T-1}}(1+R_tT)]+\frac{T}{(1+R_t)^T}\right\}}{\left\{\frac{R_{t-L}}{R_t}[1+R_t-\frac{1}{(1+R_t)^{T-1}}]+\frac{1}{(1+R_t)^T}\right\}}$$

Note that D_t in Eq. (A12) can be computed from the reported average remaining time to maturity, which corresponds to T in the formula, the current interest rate on long-term government bonds, R_t, and the lagged value of this interest rate, R_{t-L}. In the empirical analysis, R_t is the long-term interest rate on government bonds in 2019 and R_{t-L} is the average of long-term interest rates on government bonds covering the period up to 2018 and going back D_t years. (The estimation involves a recursion, but only two steps were required in practice.) The important properties of the formula are that D_t is less than the reported average maturity, T, increasing in T, and decreasing in R_{t-L}, which determines the coupon yield. The estimated value of D_t for each country in 2019 is in Table 3, column 2.

A3. Regressions using adjusted gross public debt.

Table A1

Regressions for Change in Inflation Rate

Euro zone treated as one economy

	Headline CPI inflation rate		Core CPI inflation rate	
	(1)	**(2)**	**(3)**	**(4)**
Constant	0.0146*** (0.0036)	0.0099*** (0.0027)	0.0055* (0.0031)	0.0019 (0.0026)
Excess govt spending/(adj gross debt)* duration	0.2713*** (0.0759)	0.3005*** (0.0522)	0.3118*** (0.0658)	0.3342*** (0.0511)
Border with Ukraine/Russia		0.0263*** (0.0055)		0.0202*** (0.0054)
Number of Observations	21	21	21	21
R-squared	0.402	0.736	0.542	0.742
s.e. of regression	0.0129	0.0088	0.0111	0.0086
log(likelihood)	62.6796	71.2469	65.6819	71.7136

Note: These regressions are the same as those in Table 5 except that the composite government-spending variable is based on the gross public debt adjusted for shares denominated in foreign currency or in inflation-indexed form (Table 2, column 4).

A4. Restricted coefficient for new F tests:

Table A2

Regressions for New F Tests – Restricted Coefficient

Euro zone treated as one economy

	Headline CPI inflation rate		**Core CPI inflation rate**	
	(1)	**(2)**	**(3)**	**(4)**
Constant	0.0227*** (0.0027)	0.0195*** (0.0023)	0.0149*** (0.0025)	0.0126*** (0.0024)
η_{GBD}	0.6212*** (0.1616)	0.6184*** (0.1247)	0.6759*** (0.1464)	0.6739*** (0.1289)
Border with Ukraine/Russia		0.0224*** (0.0060)		0.0159** (0.0062)
Number of Observations	21	21	21	21
R-squared	0.438	0.683	0.529	0.654
s.e. of regression	0.0125	0.0096	0.0113	0.0100
log(likelihood)	63.3244	69.3379	65.3897	68.6296

Note: The table reports the coefficients for following regression:

$$\pi - \pi * \approx c + \eta_{GBD} \cdot \left[(G - \bar{G}) \cdot \frac{\bar{\Omega}}{\bar{G}} - (B - \bar{B}) \cdot \frac{\bar{\Omega}}{\bar{B}} - (D - \bar{D}) \cdot \frac{\bar{\Omega}}{\bar{D}} \right]$$