Fiscal Influences on Inflation in OECD Countries, 2020-2023*

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

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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 this approach and the related idea of fiscal dominance to 37 OECD countries for 2020-2023. The theory's centerpiece is the government's intertemporal budget constraint, which relates a country's inflation rate in 2020-2023 (relative to a baseline rate) to a composite government-spending variable. This variable equals the increases in ratios of government expenditure to GDP in 2020 and 2021, 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 about 80% of effective government financing came from the inverse effect of unexpected inflation on the real value of public debt, whereas only around 20% 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.

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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 for 2020-2023. 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:

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

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, 0.423 in 2021, 0.399 in 2022, and 0.404 in 2023. Hence, the average spending ratio rose by 0.019 from 2019 to 2023. The mean ratio of general government revenue to GDP is 0.394 in 2019, 0.393 in 2020, 0.401 in 2021, 0.402 in 2022,and 0.399 in 2023. Therefore, this average ratio rose by 0.005 from 2019 to 2023. The average ratio of the primary deficit to GDP rose by 0.014 from 2019 to 2023, going from -0.009 to 0.005. 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, especially for the years 2020 and 2021 that featured the main fiscal expansion in OECD countries, 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 sum of the rise in ratios to GDP for 2020 and 2021, compared to the ratio in 2019, averaged 0.097 for primary government spending and only 0.006 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, π^*, 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, π^*. The assumption is that π^* 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 π^* to the sequence $\pi_{t+1}, \ldots \pi_{t+T}$ is given from Eqs.(6) and (7) by

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

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). Viewed alternatively, in our application to the COVID crisis, we assume that fiscal dominance applied.

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

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

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

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

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 $\pi - \pi *$.

[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.

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 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

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

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-

[5]The assumption is that the initial debt-GDP ratio, B_t^*/P_tY_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). This condition would be satisfied for the OECD countries in our empirical application to the COVID crisis.

[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).

contingent fiscal-deficit policies described by Lucas and Stokey (1983) in the context of 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.

[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."

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 the share of financing from inflation. We think of η as a governmental choice that can vary across countries in a given time period. However, in the regression analysis, we estimate η as a single coefficient to test whether the pandemic might have triggered a similar policy response across countries.

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.

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, other country specific shocks, 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 2023, 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 and 2023). 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.

A. 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 2020-2023 (crisis) are in Table 1. Part I applies to headline CPI inflation and part II to core CPI inflation, which excludes energy and food.[9]

B. 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 2023. In practice, we argue that the main spending surge applies to 2020 and 2021 and we therefore focus on ratios of government spending to GDP for 2020 and 2021 expressed relative to a base ratio, taken to be that for 2019

[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.

(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.

C. 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. 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 consolidated 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 the public debt numbers 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—257% 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 9% for Canada, 236% and 152% for Japan, 32% and 7% for New Zealand, 36% 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.

D. 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.

E. 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).

F. 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 2023 from movements in government spending over an earlier period. In practice, we focus on ratios of general government primary spending to GDP for 2020 and 2021. The 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 increases in ratios of government spending to GDP for 2020 and 2021, 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 in 2020 and 2021, depended on exogenous differences in political structure or in the perceived severity of COVID infections.

One concern is that the increases in ratios of general government spending to GDP for 2020 and 2021 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

$$(12) \quad \Delta(G/Y)\ (2020\text{-}2021) = \underset{(0.018)}{0.051^{***}} - \underset{(0.22)}{0.70^{***}} \cdot \Delta Y\ (2019\text{-}2020) + \underset{(6.9)}{6.9} \cdot COVID$$

$$\text{R-squared}=0.31,\ \sigma=0.045,$$

where standard errors of estimated coefficients are in parentheses, $\Delta(G/Y)$ is the cumulative increase in the ratio of general government primary spending to GDP for 2020 and 2021 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. (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.)

[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*.

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

$$\text{(13)} \quad \text{government-spending variable} = \underset{(0.0090)}{0.0242^{**}} + \underset{(0.11)}{0.15} \cdot \Delta Y\,(2019\text{-}2020) + \underset{(3.5)}{3.8} \cdot COVID$$

$$\text{R-squared}=0.06,\ \sigma=0.023,$$

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 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 $\Delta(G/Y)$ shown in Eq. (12).

[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.

[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.

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.

The identification in our analysis comes from cross-sectional variation across OECD countries in inflation rates (for 2020-2023 relative to those for 2010-2019) and in composite government-spending variables (cumulations of ratios to GDP for 2020-2021 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 2023.

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. Regression results

1. Baseline results

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 outside the Euro zone and an aggregated version of the Euro zone.

The dependent variables in the regressions are based on headline or core CPI inflation rates. The main analysis considers mean annual inflation rates for 2020-2023 measured relative to mean annual rates in the pre-crisis, ten-year period 2010-2019. That is, in Eq. (11), the mean inflation rate for 2020-2023 is a measure of π and the mean inflation rate for 2010-2019 is a measure of the target inflation rate, π*.

The right-hand side of Eq. (11) contains a sum of deviations of ratios of primary government spending to GDP, $\Delta\left(\frac{G_t}{Y_t}\right) + \Delta\left(\frac{G_{t+1}}{Y_{t+1}}\right) + \cdots + \Delta\left(\frac{G_{t+M}}{Y_{t+M}}\right)$. Each term is the spending ratio, $\frac{G_{t+i}}{Y_{t+i}}$, measured relative to that in a base year, taken to be 2019. For the 21-economy sample, the means of $\frac{G_{t+i}}{Y_{t+i}}$ are 0.360 for 2019, 0.414 for 2020, 0.391 for 2021, 0.364 for 2022, and 0.370 for 2023. This pattern suggests that the rise in spending ratios may be temporary and, after two years (corresponding to *M*), the spending ratios reverted to their pre-crisis levels from 2019. Hence, we measure the spending surge as the sum of the primary spending ratios for 2020 and 2021, each expressed relative to the ratio for 2019. To construct the composite government-spending variable on the right-hand side of Eq. (11), we divide the measured spending surge by the ratio of public debt to GDP in 2019 and by the duration of the debt in 2019.

Table 4 provides statistics for the variables used in the regressions. Table 5 reports OLS regressions for CPI inflation rates. 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 use as explanatory variables only constant terms and the composite government-spending variable.[19] The estimated coefficients of this variable are positive and highly statistically significant: 0.86 (s.e.=0.21) for headline inflation in column 1 and 0.89 (0.16) for core inflation in column 3.

Because the dummy variable for whether a country shares a common border with Ukraine or Russia has significant 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, 0.025 (s.e.=0.008) for headline inflation in column 2 and 0.017 (0.006) for core inflation in column 4, are positive and statistically significant at least at the 5% level.[21]

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[19]The regressions in Table 5 use unadjusted gross public debt in the construction of the composite government-spending variable. The results are broadly similar if the gross public debt is adjusted to eliminate the parts estimated to be denominated in foreign currency or in inflation-indexed form. 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 composite 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 0.0078 (0.0041) + 0.695 (0.146)·govt-spending variable, R-squared = 0.602, σ=0.0099, and that for core inflation becomes 0.0006 (0.0037) + 0.779 (0.131)·govt-spending variable, R-squared = 0.702, σ=0.0089.

The inclusion of the border dummy variable does not greatly change the estimated coefficients of the composite government-spending variable. The estimated coefficients on this variable are now 0.76 (s.e.=0.17) for headline inflation in column 2 and 0.82 (0.14) for core inflation in column 4.[22]

As noted before, the coefficient of the composite government spending variable, denoted by η in Eq. (11), corresponds to the share of excess government spending in 2020 and 2021 that is "paid for" by the inverse effect of inflation on the real market value of the initial public debt (in 2019). In Table 5, these estimated coefficients are significantly positive and not significantly different from one. The point estimates in columns 2 and 4 suggest that roughly 80% of the required financing for the excess spending came from the negative effect of inflation on the real market value of the public debt, whereas only about 20% came from the more standard method of intertemporal public finance, involving cuts in future spending or raises in future revenue. The fact that the estimated coefficients are not statistically different from one means that the surge in inflation may have financed the entirety of the fiscal surge.

Another result in Table 5 is that the estimated constant terms differ insignificantly from zero. Therefore, if the composite government spending variable equals zero (and the border dummy variable equals zero), the inflation rate should equal its target rate; that is, $\pi = \pi^*$in Eq. (11).

[22]We have added the composite-revenue variable (the revenue-GDP ratio for 2020 and 2021 relative to that in 2019, divided by the ratio of gross public debt to GDP in 2019 and by the estimated duration of the debt in 2019) to the regressions for headline and core inflation in Table 5, columns 2 and 4, respectively. The estimated coefficients of this variable are -0.41 (s.e.=0.42) for headline inflation and -0.27 (0.33) for core inflation. The estimated coefficients of the other variables change little from those shown in Table 5, columns 2 and 4..

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 2023 and include country fixed effects. In this case, the regressions for headline and core CPI inflation rates are:

$$\text{(14)}\quad \pi\ (\text{headline CPI}) = \underset{(.0051)}{0.0196^{***}} + \underset{(.088)}{0.899^{***}}\cdot \text{composite G variable} + \underset{(.0086)}{0.0690^{***}}\cdot \text{border},$$

R-squared=0.56, σ=0.019, N = 21 countries and 294 observations,

$$\text{(15)}\quad \pi\ (\text{core CPI}) = \underset{(.0038)}{0.0196^{***}} + \underset{(.065)}{0.775^{***}}\cdot \text{composite G variable} + \underset{(.0064)}{0.0466^{***}}\cdot \text{border},$$

R-squared=0.61, σ=0.014, N = 21 countries and 294 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 2020-2023 and zeroes entered otherwise), border is the dummy variable for a common border with Ukraine or Russia (entered only for 2022 and 2023), 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 and 2023 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 of the inflation rates with the border dummy variable are filtered out.

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 are not driven by extreme observations.

2. Three components of composite government-spending variable

The regressions in Table 5 include the composite government-spending variable, which equals $\Delta(G/Y)$, the cumulation for 2020 and 2021 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 0.084 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 2, the R-squared falls dramatically, from 0.662 to 0.348, and the log(likelihood) falls by 6.9.

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 0.001 for headline and 0.000 for 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 0.045 for headline inflation (Table 6, column 3) and 0.005 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 headline inflation, the weight attached to the restricted model is 0.001 for *Δ(G/Y)*, 0.003 for the debt-GDP ratio, and 0.118 for debt duration. For core inflation, the weight on the restricted model is 0.000 for *Δ(G/Y),* 0.000 for the debt-GDP ratio, and 0.021 for debt duration. Thus, overall, the conclusions are similar to those found before—there is strong support for combining the influences from *Δ(G/Y)*, the initial debt-GDP ratio, and the initial debt duration in the manner prescribed by the model.

Possibly, a more transparent way to assess the three components of the composite government-spending variable is to enter them individually into the regressions using a linear approximation.[25] Specifically, we linearize the composite spending variable around its cross-sectional "mean," $\overline{\Omega}$, defined as $\overline{G}/(\overline{B}\cdot\overline{D})$, where $\overline{G}$, $\overline{B}$, and $\overline{D}$ are the respective cross-sectional means of *Δ(G/Y)*, the initial debt-GDP ratio, and the initial debt duration. We then use the approximate relation between the change in the inflation rate and the three components:

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

We then run a regression of the change in the inflation rate on the three linearized components. The results are in Table 7. As before, the fit improves when including the border dummy variable (columns 2 and 4), and we concentrate on these cases. The coefficients enter as predicted by the model, with β_G positive and β_B and β_D negative. As an example, for headline inflation in column 2, the estimated coefficients are 0.75 (s.e.=0.33) for *Δ(G/Y)*, -0.52 (0.28) for the initial debt-GDP ratio, and -0.53 (0.64) for the initial debt duration. Crucially, we test

[24]The *AIC* equals *2k-2·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 the relative likelihood, $RL=exp[(AIC_1\text{-}AIC_2)/2]$, 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).

[25]It does not work to take logs of the left and right sides of the regression equation because each side may be negative and there is a constant term on the right side.

whether the coefficients on these three variables are the same in absolute value; that is, $\beta_G + \beta_B = 0$ and $\beta_B = \beta_D$. The p-values for these restrictions, shown in Table 7, are all well above 10%; that is, we do not reject the model's restrictions at usual critical values.

3. Rolling regressions back to 2012

The underlying framework views the inflation response in 2020-2023 to the corresponding fiscal surge in terms of the fraction, η, of the excess spending effectively financed by the negative effect of unexpected inflation on real public debt. The estimates suggested that roughly 80% of the COVID-related spending surge was paid for through this channel. However, the view was that, in "normal" times, η would be small, so that today's fiscal deficits would be financed mainly through conventional intertemporal public finance—cuts in future spending or increases in future revenue.

We can check this idea by applying regressions of the form of those in Table 5 to earlier periods. Specifically, we go back to 2012 (involving lagged data back to 2009). The regressions involve inflation rates over 3-year periods for 2010-2012, 2011-2013, …, 2020-2022, all expressed relative to the ten-year average inflation rate for 2010-2019. The right-hand side of each regression contains the composite government spending variable for each period. This variable includes the spending surge, $\Delta(G/Y)$, constructed from spending-GDP ratios over the previous two years, expressed relative to the ratio three years previously. The composite government spending variable then equals $\Delta(G/Y)$ divided by the product of the debt-GDP ratio three years prior and the debt duration for 2019. The border dummy variable is not included in these regressions.

The results are in Table 8. The estimation takes a system approach, specified in a seemingly-unrelated-regression (SUR) manner, to allow for serial correlation of the error term (which is particularly important because of the overlapping data). Results apply to headline and core CPI inflation. The estimates show coefficients that are small in magnitude for most of the periods ending between 2012 and 2019. If a single coefficient is estimated for each of these eight periods, the estimated values are 0.087 (s.e.=0.012) for headline inflation and 0.070 (0.010) for core inflation. These numbers, around 8%, compare to the values of about 80% found for the 2020-2023 period in Table 5. Correspondingly, the results in Table 8 show that the estimated coefficient on the composite government-spending variable becomes large, 0.55 (s.e.=0.10) for headline inflation and 0.78 (0.06) for core inflation, for the sample ending in 2022. Similar values apply to samples ending in 2023—as shown in Table 8 for a 4-year inflation rate. These results confirm the view that the relation between fiscal deficits and inflation would be weak in "normal" times, but could strengthen significantly during exceptional events such as the COVID pandemic, during which *emergency budgets* can be partially financed with surprise inflation.

4. Results using only the spending surge

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 predict the opposite sign.

If we enter the fiscal variable into the regressions just as *Δ(G/Y)*, and also include the border dummy variable, we get estimated coefficients on *Δ(G/Y)* that are positive but insignificantly different from zero at the 10% level. This result contrasts with the highly significant, positive coefficients on the composite government-spending variable in Table 5. Moreover, the R-squared values in the *Δ(G/Y)* regressions are only 0.37 for headline inflation and 0.31 for core inflation, compared to around 0.7 for the regressions in Table 5.

The results with the fiscal variable entered as *Δ(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 not statistically significant at usual critical levels. In contrast, the relationships are clearly positive in Figures 1 and 2.

5. Border dummy variable

We interpret the border dummy variable as a proxy for effects on inflation in 2022 and 2023 from the Ukraine-Russia War (holding fixed the government-spending variable). Since the estimated coefficient on the border dummy for headline inflation (Table 5, column 2) is higher than that for core inflation (column 4), part of the effect likely involves energy prices.[26] However, the results would also reflect broad negative influences of wartime on productivity, including adverse effects on transportation and supply chains.

[26] 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.

6. Timing of inflation in 2020-2023

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, 2020-2023. 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 2023 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 2023. For headline CPI, the unweighted average annual inflation rate for the 21 economies was 1.9% in 2019, 1.4% in 2020, 3.1% in 2021, 8.1% in 2022, and 6.4% in 2023. The corresponding values for core CPI inflation were 1.9%, 1.7%, 2.5%, 5.7%, and 6.0%. 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.[27]

7. Lagged inflation rate

In Table 5, the dependent variable is the average headline or core inflation rate for 2020-2023 less that for 2010-2019. We can instead use the inflation rate for 2020-2023 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 1.26 (s.e.=0.39) in the regression for headline inflation, corresponding to Table 5, column 2, and 0.95 (0.37) in the regression for core inflation, corresponding to column 4. That

[27] 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 means of these rates for the 21 economies were 2.3% in 2019, 1.3% in 2020, 1.9% in 2021, 3.8% in 2022, and 4.6% in 2023.

is, the results support the hypothesis that a country's inflation rate from 2020 to 2023 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.

8. Relation to the economic downturn in 2019-2020

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 from zero, -0.134 (s.e.=0.091), 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 -0.072 (s.e.=0.074), 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.

9. The Euro zone as a single economy

We now compare the baseline results from Table 5 with the Euro zone treated as a single economy to those with each Euro-zone country considered individually. Table 9 shows regressions for 37 countries—20 non-Euro and 17 Euro. These regressions contain two composite government-spending variables. For the 20 non-Euro countries, the first government-spending variable equals the individual country value entered in Table 5, and the second government-spending variable equals zero. For the 17 Euro-zone countries, the first government-spending variable equals the weighted average of the values for these countries, and the second variable equals the individual value less the weighted-average value. A coefficient of zero on the second government-spending 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 9, the estimated coefficients of the second government-spending variable are small and insignificantly different from zero at the 10% level.[28] Therefore, we accept the hypothesis that inflation in each Euro-zone country responds to the Euro-wide value 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.

The results do not mean that the Euro-zone countries are effectively in a fiscal union in the sense of choosing similar values of government spending in relation to GDP. For the $\Delta(G/Y)$ variable (ratios of government expenditure to GDP for 2020 and 2021 compared to that in 2019), the standard deviation across the 17 Euro countries, 0.048, is similar to that for the 20 non-Euro countries, 0.054. Our finding is that inflation in each Euro-zone country is mainly a response to

[28]When the border dummy variable is excluded in columns 1 and 3 of Table 9, the estimated coefficient of the second government-spending variable is positive and statistically significant at least at the 10% level. However, the coefficients are much smaller than those on the first government-spending variable. Therefore, for a Euro-zone country, the main fiscal impact on inflation still comes from the Euro-zone aggregate, but there may be a small effect from the individual spending variable.

Euro-zone fiscal aggregates, rather than individual country values, not that the choices of the individual values are themselves similar.

In contrast, the border dummy variable in columns 2 and 4 of Table 9 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 composite 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 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 Euro-zone countries, at least for several years.

IV. Conclusions

In response to the COVID pandemic, many countries implemented large increases in deficit-financed government spending especially in 2020 and 2021. 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.

[29] We accept with a p-value above 10% the hypothesis that the coefficient of the border dummy for the non-Euro countries is the same as that for the Euro countries.

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 2020-2023 responded positively to a theory-motivated composite government-spending variable. This variable includes cumulated increases in spending-GDP ratios for 2020 and 2021 divided by the ratio of public debt to GDP in 2019 and by the average duration of the public debt in 2019. In contrast, across 17 Euro-zone countries, differences in the government-spending variable do not generate significant differences in inflation rates.

We find in the sample of 21 economies that the coefficient that gauges the response of the inflation rate to the composite government-spending variable is significantly positive. The point estimates of coefficients around 0.8 suggest that about 80% of the extra spending was financed through inflation, whereas the remaining 20% 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 2023 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 in 2020 and 2021, 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 1.32 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 1.32 in 2020 to 1.20 in 2022 and 1.22 in 2023, and the 21-economy ratio went from 1.22 in 2020 to 1.10 in 2022 and 1.09 in 2023. 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 especially in 2021—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 in 2022 and 2023.

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

Part I: Headline Consumer Price Indexes

	(1)	(2)	(3)	(4)
Country	**Change in inflation rate**	**Inflation rate 2010-19**	**Inflation rate 2020-23**	**Fitted inflation rate 2020-23**
Australia	0.0186	0.0212	0.0398	0.0481
Canada	0.0196	0.0174	0.0370	0.0482
Chile	0.0374	0.0296	0.0670	0.0652
Colombia	0.0325	0.0374	0.0698	0.0472
Costa Rica	-0.0034	0.0315	0.0281	0.0335
Czech Republic	0.0650	0.0169	0.0819	0.0732
Denmark	0.0209	0.0122	0.0332	0.0316
Hungary	0.0756	0.0248	0.1004	0.0773
Iceland	0.0296	0.0313	0.0608	0.0727
Israel	0.0131	0.0107	0.0238	0.0323
Japan	0.0091	0.0047	0.0137	0.0157
Korea, South	0.0121	0.0172	0.0293	0.0354
Mexico	0.0167	0.0396	0.0563	0.0538
New Zealand	0.0306	0.0158	0.0464	0.0458
Norway	0.0190	0.0211	0.0401	0.0668
Poland	0.0701	0.0159	0.0859	0.0825
Sweden	0.0377	0.0113	0.0489	0.0318
Switzerland	0.0118	0.0003	0.0121	0.0215
United Kingdom	0.0248	0.0207	0.0455	0.0400
United States	0.0274	0.0177	0.0451	0.0462
Euro zone (weighted avg)	0.0260	0.0129	0.0389	0.0354
Mean	**0.0283**	**0.0195**	**0.0478**	**0.0478**
Euro-zone countries:				
Austria	0.0327	0.0186	0.0513	
Belgium	0.0239	0.0182	0.0421	
Estonia	0.0586	0.0233	0.0819	
Finland	0.0267	0.0129	0.0396	
France	0.0194	0.0112	0.0305	
Germany	0.0268	0.0133	0.0401	
Greece	0.0260	0.0067	0.0327	
Ireland	0.0349	0.0055	0.0404	
Italy	0.0272	0.0117	0.0389	
Latvia	0.0596	0.0147	0.0744	
Lithuania	0.0683	0.0185	0.0868	
Luxembourg	0.0171	0.0165	0.0336	
Netherlands	0.0283	0.0162	0.0445	
Portugal	0.0219	0.0116	0.0335	
Slovak Republic	0.0555	0.0155	0.0710	
Slovenia	0.0330	0.0124	0.0454	
Spain	0.0244	0.0123	0.0367	
Mean Euro zone	**0.0344**	**0.0141**	**0.0484**	

Part II: Core Consumer Price Indexes

	(5)	(6)	(7)	(8)
Country	**Change in inflation rate**	**Inflation rate 2010-19**	**Inflation rate 2020-23**	**Fitted inflation rate 2020-23**
Australia	0.0158	0.0211	0.0369	0.0428
Canada	0.0151	0.0169	0.0320	0.0428
Chile	0.0301	0.0243	0.0543	0.0554
Colombia	0.0160	0.0360	0.0519	0.0391
Costa Rica	-0.0150	0.0336	0.0186	0.0282
Czech Republic	0.0588	0.0124	0.0712	0.0660
Denmark	0.0143	0.0119	0.0262	0.0254
Hungary	0.0534	0.0262	0.0796	0.0650
Iceland	0.0278	0.0309	0.0587	0.0682
Israel	0.0126	0.0105	0.0231	0.0264
Japan	0.0048	0.0013	0.0060	0.0057
Korea, South	0.0050	0.0169	0.0219	0.0291
Mexico	0.0140	0.0329	0.0468	0.0407
New Zealand	0.0287	0.0152	0.0439	0.0403
Norway	0.0146	0.0198	0.0344	0.0513
Poland	0.0566	0.0115	0.0680	0.0657
Sweden	0.0368	0.0090	0.0458	0.0238
Switzerland	0.0087	-0.0005	0.0081	0.0150
United Kingdom	0.0181	0.0192	0.0373	0.0327
United States	0.0225	0.0187	0.0412	0.0421
Euro zone (weighted avg)	0.0161	0.0111	0.0272	0.0276
Mean	**0.0216**	**0.0180**	**0.0397**	**0.0397**
Euro-zone countries:				
Austria	0.0245	0.0187	0.0432	
Belgium	0.0195	0.0162	0.0357	
Estonia	0.0357	0.0170	0.0527	
Finland	0.0209	0.0116	0.0326	
France	0.0116	0.0084	0.0200	
Germany	0.0169	0.0121	0.0290	
Greece	0.0156	0.0019	0.0175	
Ireland	0.0255	0.0061	0.0316	
Italy	0.0106	0.0103	0.0209	
Latvia	0.0372	0.0090	0.0462	
Lithuania	0.0495	0.0174	0.0670	
Luxembourg	0.0104	0.0160	0.0264	
Netherlands	0.0189	0.0159	0.0348	
Portugal	0.0192	0.0092	0.0284	
Slovak Republic	0.0476	0.0144	0.0621	
Slovenia	0.0296	0.0075	0.0371	
Spain	0.0146	0.0085	0.0231	
Mean Euro zone	**0.0240**	**0.0118**	**0.0358**	

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 2020-2023 less that for 2010-2019. The fitted headline CPI inflation rate 2020-2023 in column 4 is from the regression in Table 5, column 2. The fitted core CPI inflation rate 2020-2023 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 2020-21**	**Excess Govt Revenue relative to GDP 2020-21**	**Gross debt relative to GDP 2019**	**Adjusted gross debt relative to GDP 2019**	**Net debt relative to GDP 2019**
Australia	0.086	0.021	0.467	0.443	0.278
Canada	0.169	0.028	0.902	0.772	0.087
Chile	0.097	0.005	0.283	0.125	0.080
Colombia	0.014	-0.050	0.524	0.310	0.431
Costa Rica	-0.016	-0.004	0.564	0.322	0.550
Czech Republic	0.115	0.002	0.300	0.266	0.181
Denmark	0.043	0.001	0.337	0.324	0.123
Hungary	0.076	-0.030	0.653	0.485	0.575
Iceland	0.142	-0.007	0.665	0.358	0.544
Israel	0.070	0.009	0.592	0.299	0.568
Japan	0.125	0.033	2.364	2.350	1.517
Korea, South	0.057	0.027	0.421	0.412	0.117
Mexico	0.036	0.005	0.519	0.314	0.433
New Zealand	0.066	0.037	0.318	0.281	0.069
Norway	0.029	-0.027	0.406	0.406	-0.742
Poland	0.089	0.013	0.457	0.355	0.385
Sweden	0.032	-0.009	0.356	0.225	0.049
Switzerland	0.077	0.016	0.396	0.396	0.173
United Kingdom	0.180	0.023	0.857	0.626	0.758
United States	0.164	0.023	1.081	1.038	0.832
Euro zone (weighted avg)	0.121	0.008	0.861	0.828	0.692
Mean	**0.084**	**0.006**	**0.634**	**0.521**	**0.367**
Euro-zone countries:					
Austria	0.160	0.007	0.706	0.699	0.479
Belgium	0.101	-0.005	0.976	0.968	0.848
Estonia	0.084	0.004	0.085	0.085	-0.022
Finland	0.068	-0.002	0.649	0.632	0.270
France	0.100	0.004	0.974	0.917	0.889
Germany	0.118	0.004	0.596	0.569	0.403
Greece	0.221	0.038	1.855	1.855	1.639
Ireland	0.038	-0.045	0.571	0.571	0.489
Italy	0.158	0.010	1.342	1.282	1.217
Latvia	0.094	0.007	0.367	0.329	0.282
Lithuania	0.122	0.027	0.358	0.261	0.303
Luxembourg	0.038	-0.037	0.224	0.224	-0.141
Netherlands	0.100	0.001	0.485	0.484	0.398
Portugal	0.124	0.029	1.166	1.133	1.099
Slovak Republic	0.095	0.009	0.480	0.455	0.431
Slovenia	0.146	0.004	0.654	0.618	0.495
Spain	0.175	0.066	0.982	0.957	0.837
Mean Euro zone	**0.114**	**0.007**	**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 sums of ratios to GDP for 2020 and 2021, expressed relative to the ratio for 2019. In column 2, excess government revenue is calculated from general government revenue. Values are sums of ratios to GDP for 2020 and 2021, 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	0.001	0.049	0.0269
Canada	6.3	5.9	0.112	0.033	0.0319
Chile	11.9	8.9	0.206	0.353	0.0384
Colombia	8.6	6.2	0.227	0.181	0.0043
Costa Rica	6.4	4.5	0.376	0.054	-0.0061
Czech Republic	6.1	5.8	0.115	0.000	0.0657
Denmark	8.0	7.6	0.001	0.039	0.0168
Hungary	4.6	4.2	0.210	0.047	0.0274
Iceland	5.4	4.6	0.165	0.296	0.0459
Israel	6.5	6.0	0.145	0.351	0.0198
Japan	9.3	9.1	0.001	0.005	0.0058
Korea, South	10.4	8.9	0.010	0.011	0.0153
Mexico	9.9	6.9	0.169	0.225	0.0100
New Zealand	7.7	6.7	0.007	0.111	0.0310
Norway	4.0	3.8	0.000	0.000	0.0185
Poland	4.6	4.2	0.220	0.004	0.0462
Sweden	5.0	4.9	0.214	0.152	0.0184
Switzerland	10.4	10.0	0.000	0.000	0.0193
United Kingdom	15.3	12.5	0.000	0.269	0.0168
United States	5.7	5.3	0.000	0.039	0.0289
Euro (weighted avg)	7.7	7.1	0.014	0.025	0.0198
Mean	**7.7**	**6.7**	**0.104**	**0.107**	**0.0238**
Euro-zone countries:					
Austria	9.9	9.1	0.010	0.000	0.0248
Belgium	9.8	8.9	0.008	0.000	0.0116
Estonia	7.2	7.2	0.000	0.000	0.1375
Finland	6.3	6.1	0.026	0.000	0.0172
France	8.2	7.7	0.015	0.044	0.0134
Germany	6.9	6.7	0.028	0.018	0.0295
Greece	9.6	6.8	0.000	0.000	0.0176
Ireland	10.3	8.7	0.000	0.000	0.0076
Italy	7.0	6.3	0.007	0.037	0.0186
Latvia	9.9	8.5	0.103	0.000	0.0302
Lithuania	7.4	6.8	0.270	0.000	0.0497
Luxembourg	4.9	4.8	0.000	0.000	0.0357
Netherlands	8.0	7.6	0.003	0.000	0.0271
Portugal	6.2	5.6	0.028	0.000	0.0192
Slovak Republic	8.8	8.0	0.051	0.000	0.0247
Slovenia	9.0	7.9	0.054	0.000	0.0283
Spain	7.7	6.9	0.001	0.024	0.0258
Mean Euro zone	**8.1**	**7.3**	**0.036**	**0.007**	**0.0305**

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, 2020-2023	0.0478	0.0232	0.1004	0.0121
Change in headline CPI inflation rate	0.0283	0.0202	0.0756	-0.0034
Core CPI inflation rate, 2010-2019	0.0180	0.0100	0.0360	-0.0005
Core CPI inflation rate, 2020-2023	0.0397	0.0198	0.0796	0.0060
Change in core CPI inflation rate	0.0216	0.0180	0.0588	-0.0150
Energy CPI inflation rate, 2010-2019	0.0268	0.0153	0.0676	0.0002
Energy CPI inflation rate, 2020-2023	0.0790	0.0353	0.1366	0.0270
Change in energy CPI inflation rate	0.0522	0.0393	0.1164	-0.0368
Food CPI inflation rate, 2010-2019	0.0216	0.0130	0.0503	-0.0018
Food CPI inflation rate, 2020-2023	0.0680	0.0341	0.1555	0.0123
Change in food CPI inflation rate	0.0465	0.0264	0.1251	0.0129
Δ(G/Y) (primary govt spending as ratio to GDP, cum. 2020-21 vs 2019)	0.0844	0.0531	0.1796	-0.0156
Δ(REV/Y) (govt revenue as ratio to GDP, cum. 2020-21 vs 2019)	0.0060	0.0219	0.0368	-0.0499
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	0.0238	0.0161	0.0657	-0.0061
Composite govt-spending variable adjusted	0.0322	0.0254	0.0870	-0.0108
Composite govt-revenue variable	0.0005	0.0077	0.0172	-0.0172
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 sum of the ratio of primary general government expenditure to GDP for 2020 and 2021 expressed relative to the ratio for 2019 (Table 2, column 1). *Δ(REV/Y)* is the sum of the ratio of general government revenue to GDP for 2020 and 2021 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	0.0079 (0.0060)	0.0066 (0.0049)	0.0005 (0.0044)	-0.0004 (0.0039)
Excess govt spending/(gross debt)* duration	0.856*** (0.209)	0.758*** (0.175)	0.887*** (0.156)	0.822*** (0.137)
Border with Ukraine or Russia		0.0251*** (0.0079)		0.0166** (0.0062)
Number of Observations	21	21	21	21
R-squared	0.468	0.660	0.631	0.737
s.e. of regression	0.0151	0.0124	0.0112	0.0097
log(likelihood)	59.328	64.037	65.565	69.125

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 columns 1 and 2, shown in Table 1, column 1, is the average headline CPI inflation rate for 2020-2023 less that for 2010-2019. In columns 3 and 4, the dependent variable, shown in Table 1, column 5, is the average core CPI inflation rate for 2020-2023 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 2021 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.

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

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	0.0148 (0.0092)	0.0144** (0.0063)	0.0062 (0.0059)	0.0067 (0.0085)	0.0078 (0.0058)	-0.0005 (0.0051)
Excess govt spending/(gross debt)*duration	0.348 (0.321)	0.468* (0.251)	0.750*** (0.213)	0.452 (0.296)	0.520** (0.230)	0.802*** (0.183)
Border with Ukraine or Russia	0.0252* (0.0120)	0.0291** (0.0102)	0.0344*** (0.0086)	0.0155 (0.0111)	0.0209** (0.0093)	0.0267*** (0.0073)
Number of Observations	21	21	21	21	21	21
R-squared	0.348	0.418	0.589	0.303	0.387	0.620
s.e. of regression	0.0172	0.0162	0.0136	0.0158	0.0148	0.0117
log(likelihood)	57.191	58.379	62.027	58.882	60.227	65.254
p-values:	0.000	0.001	0.045	0.000	0.000	0.005
Relative likelihood(AIC)	0.001	0.003	0.134	0.000	0.000	0.021

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 and 2021, gross public debt as a ratio to GDP in 2019, and duration of the public debt in 2019. 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 the 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 linearized relation

Euro zone treated as one economy

	Headline CPI inflation rate		Core CPI inflation rate	
	(1)	**(2)**	**(3)**	**(4)**
Constant	0.0283*** (0.0040)	0.0242*** (0.0038)	0.0216*** (0.0033)	0.0188*** (0.0034)
$(\boldsymbol{G}-\bar{\boldsymbol{G}})\cdot\bar{\boldsymbol{\Omega}}/\bar{\boldsymbol{G}}$	0.756* (0.375)	0.746** (0.329)	0.829** (0.315)	0.822** (0.292)
$(\boldsymbol{B}-\bar{\boldsymbol{B}})\cdot\bar{\boldsymbol{\Omega}}/\bar{\boldsymbol{B}}$	-0.530 (0.320)	-0.517* (0.281)	-0.561* (0.268)	-0.552** (0.249)
$(\boldsymbol{D}-\bar{\boldsymbol{D}})\cdot\bar{\boldsymbol{\Omega}}/\bar{\boldsymbol{D}}$	-1.264* (0.649)	-0.527 (0.643)	-1.126* (0.544)	-0.612 (0.570)
Border with Ukraine/Russia		0.0280** (0.0114)		0.0195* (0.0101)
Number of Observations	21	21	21	21
R-squared	0.314	0.502	0.394	0.509
s.e. of regression	0.0181	0.0159	0.0152	0.0141
log(likelihood)	56.657	60.027	60.349	62.560
Test: F statistic	0.497	0.287	0.523	0.477
Test: p-value	0.617	0.755	0.602	0.629

Note: The regressions are the linearized counterpart of the ones reported in Table 5, as reported in the paper:

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

"Test: F statistic" and "Test: p-value" are the F-statistic and p-value for the hypothesis $\beta_G + \beta_B = 0$ and $\beta_B = \beta_D$, respectively.

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

Table 8

Rolling Regressions for Change in Inflation Rate, 2012-2022

	Headline CPI	Core CPI
Ending year	**GVAR**	**GVAR**
2012	0.078 (0.027)***	0.106 (0.027)***
2013	-0.046 (0.035)	-0.006 (0.032)
2014	0.078 (0.029)***	0.020 (0.022)
2015	0.047 (0.029)	0.059 (0.017)***
2016	0.178 (0.042)***	0.201 (0.028)***
2017	0.067 (0.029)**	0.096 (0.018)***
2018	-0.008 (0.024)	-0.058 (0.024)**
2019	-0.040 (0.056)	0.018 (0.032)
2020	0.037 (0.033)	0.046 (0.035)
2021	0.139 (0.021)***	0.205 (0.024)***
2022	0.554 (0.097)***	0.785 (0.063)***
2023†	0.618 (0.111)***	0.743 (0.077)***
2012-2019††	0.087 (0.012)***	0.070 (0.010)***

Note: Sample is the 21 economies used in Table 5. The CPI inflation-rate variables are averages over rolling three-year periods, ending in the year indicated. The dependent variable expresses these values relative to the 10-year average inflation rate for 2010-2019. The independent variable, denoted by GVAR, is the composite government spending variable, constructed from spending-GDP ratios for one- and two-year lags, expressed relative to that three years previously. In the denominator of this variable, the debt-GDP ratio is the three-year lag and the duration variable is the value for 2019. These regressions correspond to the ones in Table 5 that include on the right-hand side only the composite government spending variable, with the border dummy variable omitted. Estimation is by seemingly-unrelated regression (SUR). Standard errors are in parentheses.

†4-year inflation rate 2020-2023 related to GVAR based on spending for 2020-2021 and debt-GDP ratio for 2019. 201

††Results for coefficients of GVAR for 2012-2019 when these coefficients are constrained to be the same. p-value for equal coefficients for 2012-2019 is 0.0001 for headline, 0.0000 for core.

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

Table 9

Regressions for Change in Inflation Rate

Euro-zone countries considered individually

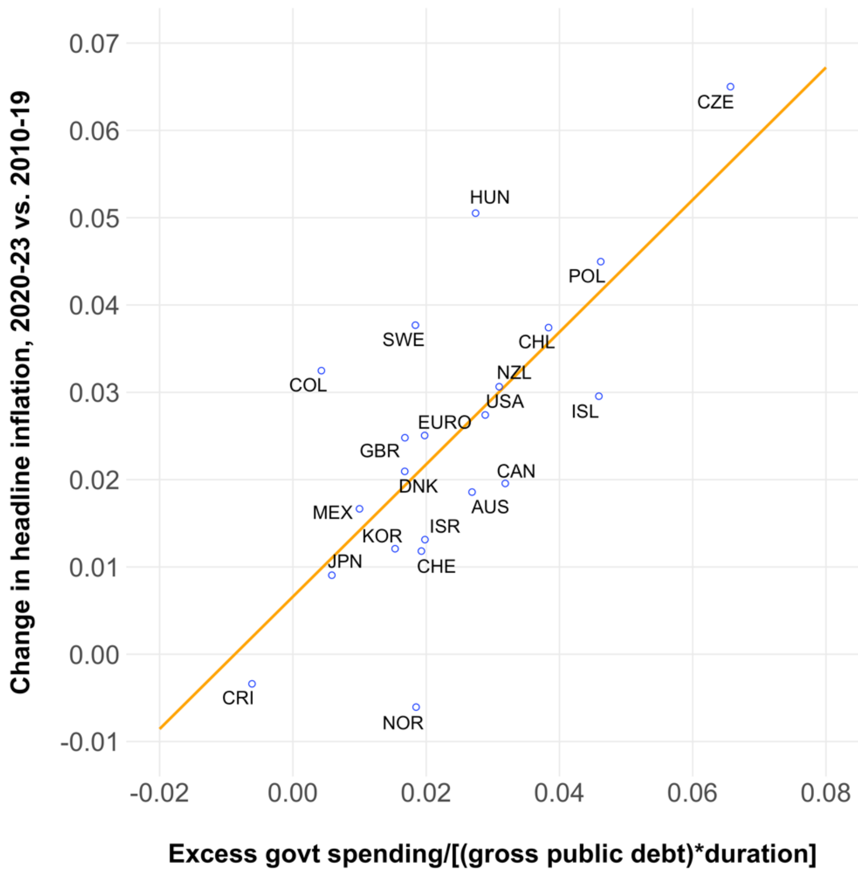
	Headline CPI inflation rate		Core CPI inflation rate	
	(1)	**(2)**	**(3)**	**(4)**
Constant	0.0116** (0.0052)	0.0090** (0.0039)	0.0030 (0.0040)	0.0011 (0.0032)
Excess govt spending/(gross debt)*duration	0.813*** (0.203)	0.728*** (0.154)	0.857*** (0.158)	0.795*** (0.125)
Excess govt spending/(gross debt)*duration: Euro area	0.3324** (0.1223)	0.1225 (0.1008)	0.1879* (0.0950)	0.0332 (0.0814)
Border with Ukraine/Russia		0.0254*** (0.0049)		0.0187*** (0.0040)
Number of Observations	37	37	37	37
R-squared	0.397	0.667	0.488	0.694
s.e. of regression	0.0149	0.0112	0.0115	0.0091
log(likelihood)	104.805	115.789	114.144	123.668

Note: The regressions correspond to Table 5, but Euro zone countries are considered individually. For the 20 non-Euro countries, the first government-spending variable equals the value entered in Table 5 and the second government-spending variable equals zero. For the 17 Euro-zone countries, the first government spending variable equals the weighted average of the values for these countries and the second variable equals the individual value less this weighted-average value.

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

Figure 1

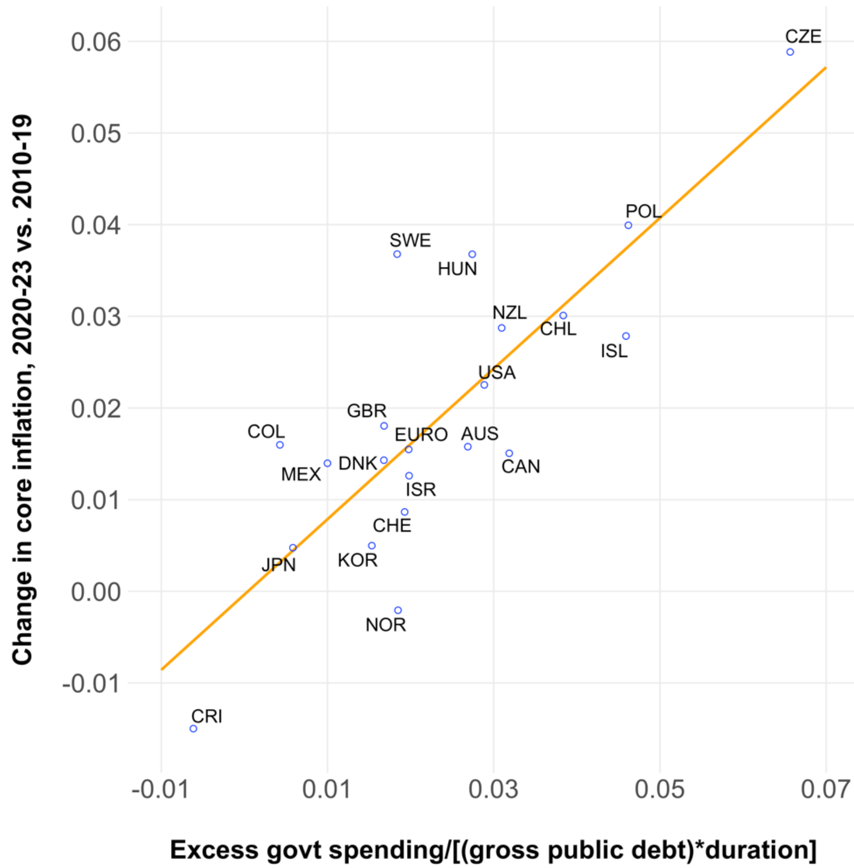
Change in Headline CPI Inflation Rate versus Composite Government-Spending Variable



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 (the average rate for 2020-2023 minus that for 2010-2019) net of the estimated border dummy effect (Table 5, column 2). The spending variable is the ratio of general government primary spending to GDP (cumulation for 2020 and 2021 relative to that for 2019) divided by the ratio of gross public debt to GDP in 2019 and by the estimated duration of the public debt in 2019.

Figure 2

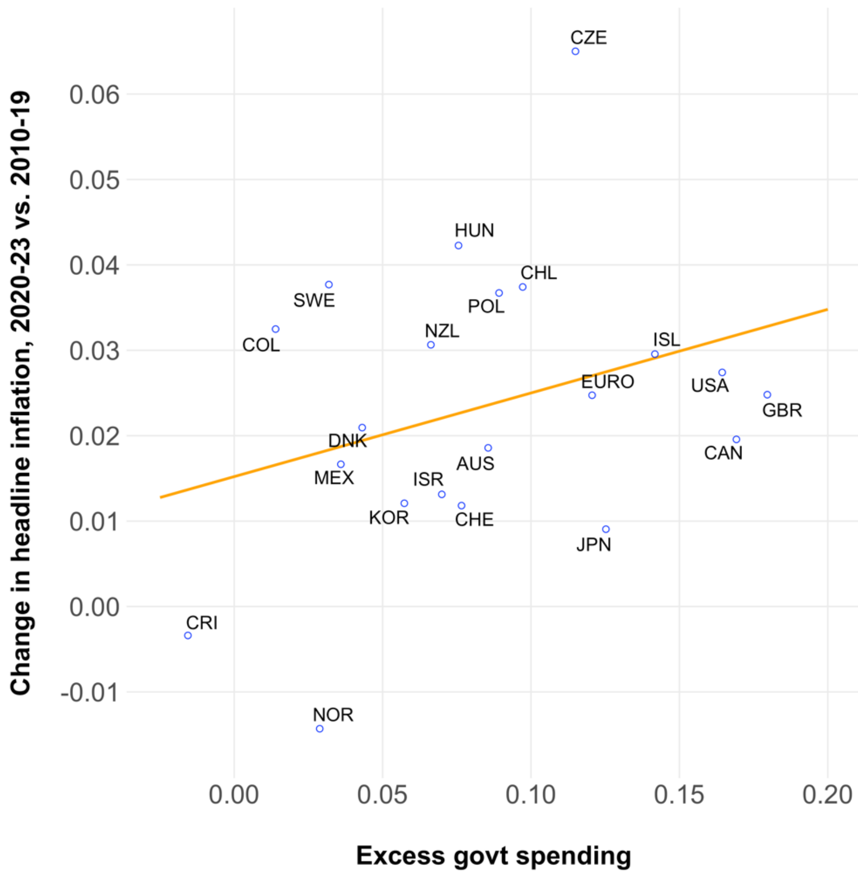
Change in Core CPI Inflation Rate versus Composite Government-Spending Variable



Note: See the notes to Figure 1. The difference from Figure 1 is that the inflation rates are based on core CPI inflation rates.

Figure 3

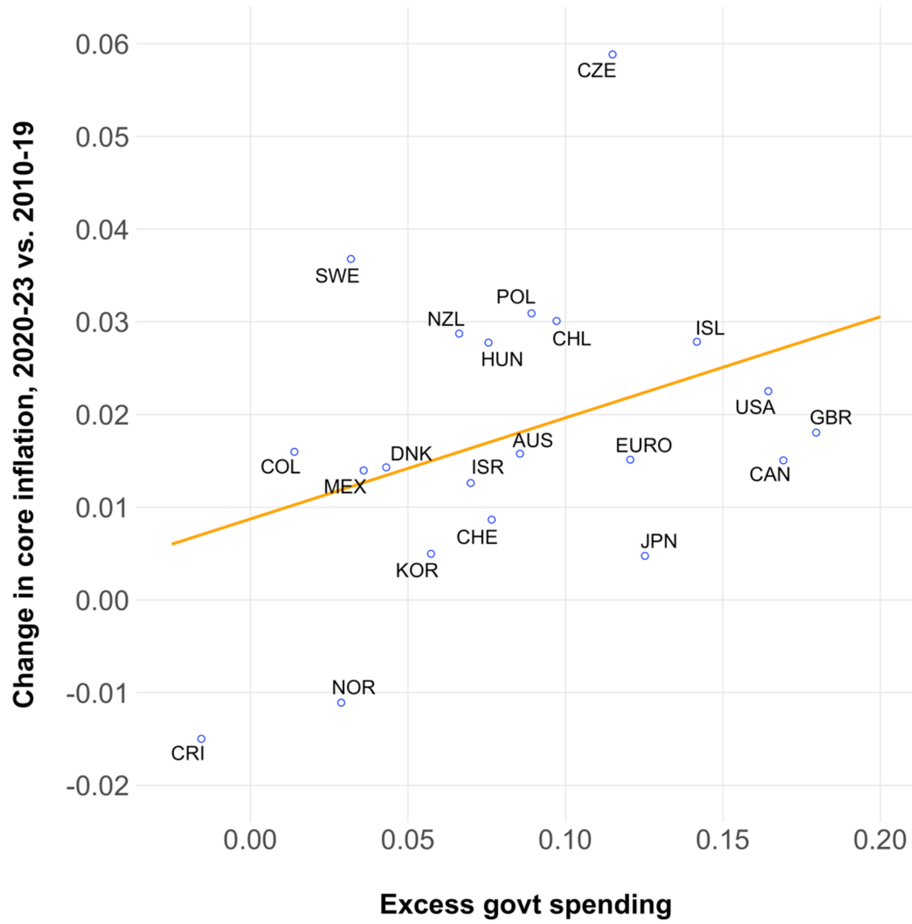
Change in Headline CPI Inflation Rate versus Government Spending



Note: The difference from Figure 1 is that the horizontal axis has the ratio of general government primary spending to GDP (cumulation for 2020-2021 relative to the ratio for 2019).

Figure 4

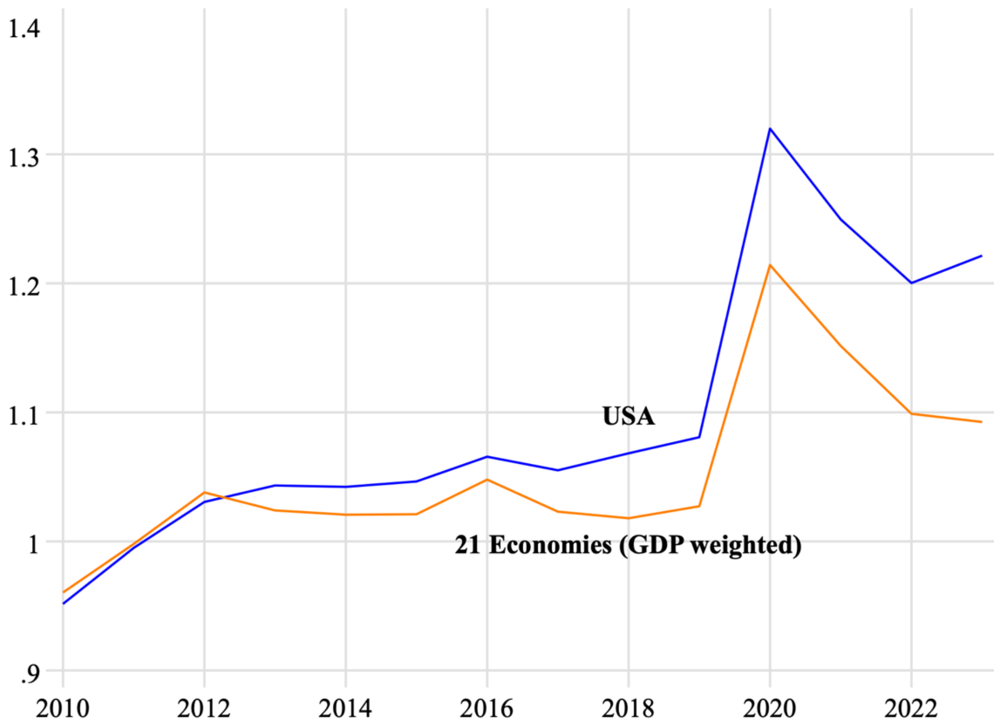
Change in Core CPI Inflation Rate versus Government Spending



Note: The difference from Figure 2 is that the horizontal axis has the ratio of general government primary spending to GDP (cumulation for 2020-2021 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.

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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 $B_t^0, B_t^1, \dots, B_t^T$. 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.