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Deflation and Public Finances: Evidence from the Historical Records

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Abstract

This paper examines the impact of deflation on fiscal aggregates. With deflation relatively rare in modern history, it relies mostly on the historical records, using a dataset panel covering 150 years and 21 advanced economies. Empirical evidence shows that deflation affects public finances mostly through increases in public debt ratios, reflecting a worsening in interest rate–growth differentials. On average, a mild rate of deflation increases public debt ratios by almost 2 percent of GDP a year, this impact being larger during recessionary deflations. Using a simulation model that accounts for composition effects and price expectations, we also find that, for European countries, a 2 percentage point deflationary shock in both 2015 and 2016 would lead to a deterioration in the primary balance of as much as 1 percent of GDP by 2019.

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I. Introduction

With falling oil and commodity prices, inflation has been declining in advanced economies and is running significantly below targets, raising concerns over the risk of deflation. Fear of deflation is generally premised on the belief that it is associated with recession (Stern, 2003), reflecting developments during the 1930s, when the combination of deflation and economic contraction triggered debt deflation.[2] This experience has helped shape the belief that deflation is deeply perilous and should be avoided: falling prices would harm economies through rigid interest rates and price-setting mechanisms and a spiral of expectations and deflation (DeLong, 1999; Bernanke, 2002; Furhrer and Tootell, 2003; Svensson, 2003; and Beckworth, 2008).

Understanding the consequences of deflation on fiscal aggregates is a key question for policymakers. The focus of this paper is to assess how deflation may buffet already-strained public finances and further complicate fiscal policy. Specifically, what are the effects of declining prices on fiscal aggregates? Deflation is clearly associated with mechanical increases in debt-to-GDP ratios: debt mostly consists of preexisting stocks, and its term structure, together with downward rigidities in sovereign interest rates, tends to further compound this increase. At the same time, a number of nominal flow variables—such as revenue and nominal GDP but also, to a smaller extent, expenditure—tend to decrease mechanically. This study investigates the impact of falling prices on public finances using historical records. In particular, it explores whether the impact of deflation on fiscal aggregates is asymmetrical from that of inflation. It uses an original panel dataset covering a long timeframe (over 150 years) and data for inflation, growth, and fiscal aggregates—including debt-to-GDP ratios for 21 advanced economies.[3]

What does available evidence tell us? In the literature, much of the attention has focused on either the effect of fiscal stances on price dynamic (Catao and Terrones 2005) or the fiscal consequences of very high inflation (Oliveira, 1967 and Tanzi, 1977, Aghevli and Kahn, 1978 and Heller, 1980).[4] Existing research on the effects of deflation on fiscal aggregates is scant, compared to the abundant literature on the corresponding effects of high inflation. In

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[2] Debt deflation—a term coined by Irving Fisher (1933)—is a vicious circle where a fall in the price level raises the real value of debt, weighing in turn upon domestic demand and exacerbating the cost of deflation.

[3] In this paper, we focus on consumer price inflation. Recent work by Borio et al. (2015) documents a strong link between asset price deflation and economic outcomes in the postwar period, but asset prices are likely to impact the fiscal accounts more marginally than GDP and consumption prices.

[4] Using a panel data of 107 countries over 1960–2001, Catao and Terrones (2005) showed a strong positive association between deficits and inflation among high-inflation and developing country groups, but not among low-inflation advanced economies. Oliveira (1967) and Tanzi (1977) find that double-digit inflation worsens fiscal deficits in real terms because of lags in tax collections. In addition, Aghevli and Kahn (1978) and Heller (1980) document that nominal fiscal stances are affected as well when nominal expenditures adjust less quickly than nominal revenues.

addition, the existing literature on deflation has focused mostly on the role of fiscal policy to inflate aggregate demand with a view to exiting from deflation (Auerbach and Obstfeld, 2004; Cochrane, 2011). Another strand of the literature investigates the link between deflation and recession.[5] Studies based on records of deflation over the past two centuries argue that, with the exception of the Great Depression, deflation was not systematically associated with persistent and deep economic recession but was often driven by increases in aggregate supply. Borio and Filardo (2004, 2005) proposes three broad categories of deflation: good deflations, which arise from positive supply shocks; bad deflations, which are associated with recessions and include the experience of Japan in the 1990s; and ugly deflations, which represent periods of steep declines in prices associated with severe recessions, such as the early 1930s Great Depression. Both bad and ugly deflations stem from a collapse in aggregate demand.[6]

Our findings center around three key messages. First, while deflation negatively affects debt-to-GDP ratios, it also impacts nominal budgetary variables, that is, government revenue and expenditure. Piloting fiscal policy in the midst of deflation might be challenging, similar to the context created by negative output growth. This points to asymmetric economic behaviors and responses, which was noted in Fisher (1928)'s money illusion theory.[7] Yet, deflation signals more a strain to achieving fiscal targets than a terrible accident, and what ultimately matters is the authorities' capacity to steer expenditure skillfully in the context of declining revenues. Second, we find that linkages have evolved over time. Public finance management has changed from a fiscal policy that was relatively marginal, nominally-driven and cash constrained, to modern governments operating on large aggregates and with indexation mechanisms; deflation episodes have been relatively rare in the recent period, with the notable exception of Japan in the 1990s.[8] Finally, we find that not all deflations are alike and, in particular, the impact is very different between deflations associated with positive growth and deflations accompanied with recessions.

Our findings agree with the recent literature on the macroeconomic consequences of deflation, which highlights that deflations are not necessarily detrimental to public finances. Our findings are also supported by the deflationnary experience of Japan. Overall, deflation

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[5] See Atkeson and Kehoe 2004; Borio and Filardo 2004; Bordo and Filardo 2005; Guerrero and Parker 2006; and Benhabib and Spiegel 2009.

[6] As a matter of fact, the deflationary experiences that shape the modern economic psyche, i.e. the Great Depression in the 1930s and Japan in the 1990s, are not truly representative of all deflation outcomes. Instead, most deflationary episodes were aggregate supply-driven (Stern, 2003; Bordo and Redish, 2004; Bordo, Lane, and Redish, 2004; Farrell, 2004; Bordo and Filardo, 2005).

[7] Kahneman and Tersky (1979)'s prospect theory also describes fundamentally asymmetric economic behaviors.

[8] There have been a few other deflationary episodes among industrial countries in the post-World War II period. Canada, Norway, and Sweden had small and short-lived declines in consumer prices in the late 1980s.

in Japan was associated with deteriorating fiscal aggregates, mostly the debt-to-GDP ratio. Public debt doubled, due primarily to a snowball effect (*i.e.*, an unfavorable differential between interest rate and growth); the denominator effect of deflation explains roughly one fifth of the debt increase. The impact of deflation on the primary deficit was blurred by the combination of demographic changes and policy responses (Appendix A). Expenditure-to-GDP ratios increased largely because of rising age-related spending and explicit downward rigidities.[9] The impact on the tax-to-GDP ratio is more difficult to identify, as new tax measures were introduced simultaneously with a shift in the tax base. In addition, as deflation was protracted and anticipated, its effect could be partially offset in the annual budgets.

Yet, some caveats refrain from translating these results directly to the current situation in advanced economies. First, historical data relate only to *ex-post* outturns and incorporate discretionary measures adopted in the face of deflation, including new tax measures aimed at boosting revenue. As a result, underlying trends are difficult to identify. Second, to a large extent, these data do not account for structural changes introduced in policymaking in recent decades, given that deflation has been relatively rare during that period. A prospective simulation exercise, built to include expectations and modern features of today's governments under a no-policy change assumption, confirms nevertheless that piloting fiscal policy in the midst of deflation might be a complicated task. In particular, consideration should be given to composition effects within the fiscal balance and the role of expectations.

In addition, the present paper strictly follows a positive approach and does not analyze the optimal response of fiscal policy makers to deflation.[10] It is organized as follows. The next section discusses how deflation could theoretically affect fiscal aggregates. It gives the general intuition that deflation should matter for fiscal policymakers. Section III describes our empirical methodology and the historical dataset that we built in order to encompass a sufficient number of deflation episodes. Section IV reports the results of the analysis, which Section V attempts to put in a narrative, historical perspective. Section V closes by presenting a deficit-debt simulation exercise for the Euro Area that would capture modern features of public finances. Section VI draws some tentative policy implications from our main results.

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[9] For instance, the indexation mechanism for pension benefits, which would have called for an absolute decline in order to preserve the sustainability of the system, was not applied from 2000–02 and was suspended after 2004 (Hosen 2010).

[10] In particular, it might be wise for governments not to adjust their fiscal stance and bear the costs of deflation, especially when deflation arises from a demand shock.

II. THEORETICAL BACKGROUND

Public finances are vulnerable to deflation on several accounts. The effect of deflation on debt ratios was described as early as in the 1930s by Fisher (1933). In addition, deflation can affect primary balances through its impact on revenue and expenditure.

A. Primary Balance

During deflation periods, the primary balance is affected according to the magnitude and speed of the respective paces of adjustment of revenue and expenditure.

Revenue

The net impact of deflation on public revenue is affected by a variety of factors. An immediate impact is the loss of seigniorage revenue, which represents the real revenues governments acquire by using newly issued money to buy goods and non-money assets. Under a fiat money system and without any monetary policy action, seigniorage revenue is equivalent to an inflation tax, given by the product of the inflation rate and real money balances. In principle, deflation reduces seigniorage for a given level of real money balances—thus generating a "deflation subsidy". However, if deflation leads to an increase in holdings of real money balances, the effective tax base will augment, leading to a possible increase in seigniorage revenue. Recent evidence suggests that potential gains of seigniorage are limited in today's advanced economies, as base money is small relatively to GDP.[11]

Under a fully proportional tax system, deflation would have no impact on the revenue-to-GDP ratio: every component of GDP would be similarly taxed, and both nominal revenue and GDP would react in similar proportions, leaving the ratio unchanged.[12] However, in real life, as tax systems always include distortionary features, there are reasons to think that revenue ratios will be affected by deflation.

Some factors tend to decrease revenue-to-GDP ratios during deflation times. First, the progressivity of the tax system matters. In a progressive system, when tax brackets are not perfectly indexed to inflation, deflation will tend to curb revenue ratios by moving some taxpayers to lower tax brackets, leading to lower revenue collections; and *vice versa*, in a regressive system (Hirao and Aguirre, 1970). Second, revenue-to-GDP ratios will tend to

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[11] Simulations by Akitoby and others (2014) for G7 countries indicate that one additional point of inflation would lead today to about 0.12 percent of GDP annually additional seigniorage revenue. This effect is thought to have been much bigger in the past, before financial innovations, when broad money and base money were closely linked.

[12] However, the composition of the price shock matters since tax bases could diverge both in nominal and real terms. For instance, an oil price shock will have a larger effect on private consumption prices than on GDP deflators.

suffer from deflation if tax exemptions are widespread. Such exemptions are often set in nominal terms, and their ensuing costs increase when prices fall.

Some other factors tend to push revenue ratios up during deflation times. First, some revenue components, such as excises and non-tax revenues, are by nature more price-inelastic than income taxes. Their inertia in the face of deflation thus tends to boost revenue as a percent of GDP.[13] Second, deflation can have effects on tax bases through behavioral effects. During deflation, consumption tends to shift toward higher-scale goods, in part because prices adjust more quickly than incomes. Since these goods tend to be more heavily taxed, this will help improve revenue.[14] Similarly, if consumption prices drop more rapidly than the GDP deflator, then the revenue ratio will tend to rise.[15] Finally, central bank actions against protracted deflationary pressures, in the form of quantitative easing policies, can generate seigniorage revenue.

The above effects could be mitigated if tax brackets are indexed. Under a full indexation mechanism, during deflation tax provisions are automatically revised downwards—including minimum income tax thresholds and tax brackets—to maintain the tax pressure constant.[16] The net effect of these indexation mechanisms will be similar to that described under a non-distortionary system, with revenue-to-GDP ratios immune from deflations.

Expenditure

In general, public expenditure tends to be more sensitive to deflation than revenue collections because of nominal rigidities in the design of some of its components. It may be politically difficult to reduce wages and social transfers when prices are falling. As a result, during deflation periods, freezing nominal spending may be the only feasible option, leading to increases in expenditure-to-GDP ratios. This is particularly true for social transfers to households (pensions and other benefits) and wages.[17]

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[13] For instance, transfers or received interest payments are often pre-established.

[14] The case was made, for instance, that tax collections in the early 1930s remained relatively strong in a number of European countries, as consumption was resilient while investment fell sharply. See for example the case of France described in Sauvy (1965).

[15] Lags in tax collections might also play a role for double-digit deflation rates under cash-basis accounting (Oliveira, 1967; and Tanzi, 1977).

[16] Political factors may prevent the application of downward indexation during deflation periods. It is politically difficult to increase nominal taxes given the traditional monetary illusion that prevails in such circumstances (Fuhrer and Tootell 2003). Even with indexation, any expectation error tends to be positively correlated with tax revenues.

[17] Though public wages are generally indexed to official inflation expectations, some downward rigidities are likely to be observed because of political economy considerations. In Japan, for instance, indexation mechanisms, which would have otherwise triggered reductions in nominal terms for some social expenses, were suspended for several years during the deflation period.

Contractual arrangements, such as multiyear agreements and lagged price indexation provisions, may also delay the transmission of deflation to capital spending (Aghevli and Khan, 1978; Heller, 1980).[18] This feature can also apply to some recurrent expenses, if they are specified in multi-annual contracts (maintenance, IT outsourcing, etc.). In those cases, price adjustments will be limited to new and renewed contracts, and will take some time to be fully reflected in fiscal aggregates.

Finally, the design of budgets or fiscal rules could delay the response to an unexpected shock of deflation. Because budgets are usually prepared and executed in nominal terms, it may be difficult to adjust spending lines to unexpected deviations from the budget forecasts within a given fiscal year.

B. Debt

Deflation has a negative impact on debt ratios if not fully anticipated in the level of nominal interest rates. This effect operates through the initial debt stock and the combined effect of the real interest rate and the primary balance. First, for any given debt stock and real growth rates, deflation mechanically increases the debt-to-GDP ratio: It lowers nominal GDP, pushing the ratio up. Second, as discussed in the previous section, the primary balance may deteriorate unexpectedly in a deflationary environment, leading to a further increase in the debt burden. Third, for any given nominal interest and real growth rates, deflation raises the real value of the interest bill. If interest rates are sticky or deflation is not anticipated, nominal rates will not immediately adjust to absorb the shock.[19] In general, interest payments are largely based on contractual interest rates, which are mostly fixed and do not adjust to domestic prices in the short run. The impact of this channel depends on the maturity structure and the currency denomination of the sovereign debt, as well as the share of price-indexed bonds in the total debt (Akitoby and others, 2014).

These mechanisms can be summarized within the debt dynamic equation, which links year-on-year changes in the debt-to-GDP ratio to the existing debt stock through the impact of nominal interest rates, inflation, and output growth to the primary balance, and any stock-flow adjustments.[20]

$$\Delta d_t = \frac{i_t - \pi_t - g_t}{(1+g_t)(1+\pi_t)} d_{t-1} - p_t + SF_t \qquad (1)$$

[18] Price indexation mechanisms are generally provisioned under long-term contracts only, such as PPPs or leasing arrangements.

[19] According to Fisher's law, interest rates would remain constant in real terms under perfect expectation.

[20] By convention and because of data limitations, we define real interest rate as the difference between the nominal interest rate and the actual inflation rate.

Equation (1) summarizes the direct channel through which inflation affects the debt-to-GDP ratio: d_t is the stock of government debt as a percent of GDP in year t; p_t represents the primary balance as a percent of GDP; i_t, g_t, and π_t denote the nominal interest rate, the real GDP growth rate, and the inflation rate in year t; and SF_t designates stock-flow adjustments (as a percent of GDP); Δ is the first-difference operator. In equation (1), the term $(i_t - \pi_t - g_t)$ can have a significant impact on debt dynamics. If it is greater than zero, it means that the debt stock increases over time, even in a situation of primary surplus.

III. Empirical Strategy

A. Methodology

To investigate how deflation affects public finances, we assess first the effects on the changes in debt, primary balance, revenue, and expenditure, expressed as ratios to GDP. As argued above, these variables depend upon inflation and growth rates, two key inputs of budget formulation and execution. Accounting for potential persistence effects, we use the following autoregressive model:

$$\Delta x_{i,t} = \alpha_0 + \sum_{j=0}^{T} \alpha_{1,j}^{x} \pi_{i,t-j} + \sum_{j=0}^{T} \alpha_{2,j}^{x} g_{i,t-j} + \sum_{k=1}^{K} \alpha_{3,k}^{x} T_k + \alpha_4^{x} \Delta x_{i,t-1} + \varepsilon_{i,t}^{x} \quad (2)$$

x stands for either debt, the primary deficit, primary expenditure, or revenues, in percent of GDP. The use of first-differences accounts for possible non-stationarity of the debt series.[21] The change in each fiscal ratio is assumed a function of lags and current and past values of inflation and output growth; $\varepsilon_{i,t}^{x}$ captures classic error terms and shocks unrelated to inflation and growth; and $\alpha_{1,0}$ is the main parameter of interest to be estimated, as it captures the different channels through which inflation impacts the fiscal variables. For instance, with respect to equation (2), current-year higher inflation and growth are expected to reduce the debt stock (*i.e.*, $\alpha_{1,0}^{debt} < 0$, $\alpha_{2,0}^{debt} < 0$). The T_k are dummy variables that capture historical breaks in the estimated parameters. As we are using a long timeframe (1851–2013), we include all estimates dummy variables to account for strucural breaks corresponding to the pre-Great Depression (1851–1928); the Great Depression (1929–34); and the post-WWII (1946–2013) periods.[22] In some specifications for debt, we also control for the primary balance and the effective interest rate.

[21] With respect to the methodology used, it is well-known that persistent macroeconomic series such as inflation and fiscal variables contain at least one unit root (especially over longer timeframes) that prevent the application of classic econometric inference. Using the traditional statistical tests (Appendix B), we verify that inflation and growth are stationary, while fiscal aggregates exhibit at least a unit root, supporting the use of first-differences in the regressions.

[22] Our regressions also include year and country fixed effects. Another natural break is the exit from the Gold standard, but the number of deflation episodes post-1972 is too restrained.

In this paper, we examine whether the regime of inflation—high, low, or negative inflation—matters for fiscal ratios. Hence, we explore whether the impact of deflation is different from that of inflation.[23] To that end, we break down the inflation term into positive and negative inflations and estimate the following equation:

$$\Delta x_{i,t} = \beta_0 + \sum_{j=0}^{T} \beta_{1,j}^{x+} (\pi > 0)_{i,t-j} + \sum_{j=0}^{T} \beta_{1,j}^{x-} (\pi \leq 0)_{i,t-j} + \sum_{j=0}^{T} \beta_{2,j}^{x} g_{i,t-j} + \sum_{k=1}^{K} \beta_{3,k}^{x} T_k + \beta_4^x \Delta x_{i,t-1} + \nu_{i,t}^{x} \quad (3)$$

In order to test asymmetry in the effect of deflation, we also scrutinize the effect of a set of dummy variables U_t capturing different regimes of inflation and growth.

$$\Delta x_{i,t} = \gamma_0 + \sum_{j=0}^{T} \gamma_{1,j}^{x} U_{i,t-j} + \sum_{j=0}^{T} \gamma_{2,j}^{x} g_{i,t-j} + \sum_{k=1}^{K} \gamma_{3,k}^{x} T_k + \gamma_4^x \Delta x_{i,t-1} + \eta_{i,t}^{x} \quad (4)$$

Admittedly, estimating equations (2)–(4) poses several challenges. The first, main challenge is the potential reverse causality between fiscal policy and inflation, as fiscal deficits play a role in the formation of the price level. Instrumental variable methods are the typical, technical solution for correcting such a bias. However, good instruments—i.e., variables excluded from the main regressions that would be highly correlated with inflation but uncorrelated with the error terms—are difficult to find, especially over a timeframe as long as the one we use in this paper.[24] We explored unsuccessfully a few instrumental variables, including lagged inflation and an index of imported inflation.[25] An alternative approach is the generalized method of moments (GMM), which takes advantage of the lagged structure of the data. However, this technique is not well-suited for our focus on historical data, as it produces biased estimates when the time dimension is larger than the cross-sectional one. For this reason, the GMM approach was ruled out. Yet, we mitigate the simultaneity bias by including possible lagged effects of inflation in equations (2)–(4).

Another key challenge includes the possibility that some omitted variable is correlated with fiscal performance and inflation. Possible candidates are war, colonization, and political

[23] Zero is the natural threshold to define deflation, but, in order to warrant our results against the upward bias of price indices, we also differentiate using a threshold of 1 percent, without finding substantially different results.

[24] Barro (1995) used institutional variables such as the independence of the central bank and prior colonial status, which are difficult to construct for the period under investigation.

[25] Effective exchange rates would have also been a desired instrument, but are unavailable over such a long period of time.

instability periods. To mitigate this problem, we control for idiosyncratic and common factors by allowing for both country and year fixed effects. We also have dummy variables to account for strucural breaks corresponding to the pre-Great Depression (1851–1928), the Great Depression (1929–34), and the post-WWII (1946–2013) periods. An additional challenge is a potential multi-colinearity between inflation and other control variables. So far, we have kept the description of the framework simple and have abstracted from second order effects, such as the cross-linkages between inflation, interest rates and growth. In reality, the phenomena behind equations (2)–(4) are complex and their parameters are intertwined (Barro, 1995). For instance, a fiscal adjustment leading to a larger primary balance could affect growth and the nominal interest rate (Clinton and others, 2011).

We test the optimal lag length. For each country, we use the well-known Akaike, Hannan-Quinn, and Schwarz information criteria. In Appendix C, we find that the optimal lag length is between 1 and 3. To account for the entire autocorrelation structure, all estimates are conducted with 3 lags whenever possible. Finally, to produce robust results, autocorrelation and heteroskecasitycty are corrected following the usual practice.

B. Dataset

Episodes of deflation were much more commonplace in the 19th and early 20th centuries than in modern times (since the end of World War II). In moderne times, deflation has been rare (5 percent of observations). Therefore, we rely mostly on the historical records.

The first, main variable is inflation. We use the CPI-based inflation taken form Bordo and Filardo (2005) through 1997, complemented by data from the IMF's *World Economic Outlook* (WEO). When observations are missing in Bordo and Filardo's dataset, we use Warren Weber's dataset, which contains information on prices and output from 1810–1995.[26] Second, economic growth is used as control variable. In order to charaterize the role of growth regimes, we similarly compile the information on real GDP growth rates from Bordo and Filardo (2005), complemented by recent WEO figures. Third, debt ratios are taken from Abbas and others (2010), supplemented with recent WEO data. The dataset compiles government gross debt-to-GDP ratios covering a large set of countries, spanning a long time period. Finally, the other fiscal variables are culled from Mauro and others (2013). Their dataset contains fiscal flows, such as primary balances and their main components; it also includes interest payments, which allows us to compute effective interest rates.

Data limitations are a serious issue for any historical approach, especially when they cover the pre-WWI period. In order to reduce biases related to the presence of outliers, we exclude improbable events or extreme outliers in price dynamics, such as hyperinflation episodes (inflation above 100 percent). The dataset is an unbalanced panel of data for 21 developed

[26] http://www.minneapolisfed.org/research/economists/wewproj.cfm#intldata.

economies dating from as early as 1851.[27] We define deflation as negative inflation, low inflation as an inflation rate between 0 and 2 percent, and recession as a negative annual growth rate in real GDP.

Descriptive statistics show that inflation is more dispersed than growth: the average inflation rate is 4 percent, with a standard deviation of 8.1 percent; and the average growth rate is 3 percent, with a standard deviation of 4.1 percent (Table 1). The average of the public debt-to-GDP ratios is 53 percent and the primary balance is estimated to show a surplus of 0.5 percent of GDP on average, with both revenue and primary expenditure estimated at around 23 percent of GDP. About one fifth of the total historical sample corresponds to deflation, but this ratio shrinks significantly over the most recent period. Public debt-to-GDP ratios seem the most vulnerable to deflation. They grow on average by 1.7 percentage points of GDP a year during deflation periods, thrice faster than the sample average (Figure 1). The deterioration is worse when deflation is combined with negative growth (depression). On average, the primary balance tends to worsen, but at a moderate pace during deflation (mostly when combined with recession) on the back of stalling revenue-to-GDP and increasing expenditure-to-GDP ratios.

IV. Evidence from the Historical Records

In this section, we discuss key findings from the historical database. To that effect, we present the main findings; test for asymmetries between positive and negative inflations; and assess possible differences across growth regimes.

A. Effects of Deflation on Fiscal Ratios

Overall, evidence from the historical records suggests that deflation increases the debt-to-GDP ratio primarily through a worsening of the interest rate-growth differentials. Primary balances are found to remain broadly unaffected.

Debt

We examine first the impact of inflation on debt accumulation. To that effect, we estimate equation (2) and report the results in Table 2, column (1). We focus mostly on the contemporaneous effect of inflation on the debt-to-GDP ratio.[28] The empirical examination identifies a strong and immediate impact of price dynamics on debt-to-GDP ratios. The

[27] The countries include Australia, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

[28] We estimate the relationship between inflation and debt with and without the growth term. The coefficient on inflation is found to be stable, suggesting that the likelihood of colinearity between growth and inflation is negligible.

coefficients are significant at the 5 percent level and are in line with expectations in the debt accumulation equation. All other things equal, higher inflation helps curb the debt-to-GDP ratios. A 1 percentage point increase in the rate of inflation reduces the debt-to-GDP ratio by 0.15 percentage point. There is a delayed positive effect of inflation on the debt ratios after two years. The change in debt-to-GDP ratio is persistent. The dependence coefficient is positive, below unity in absolute terms.

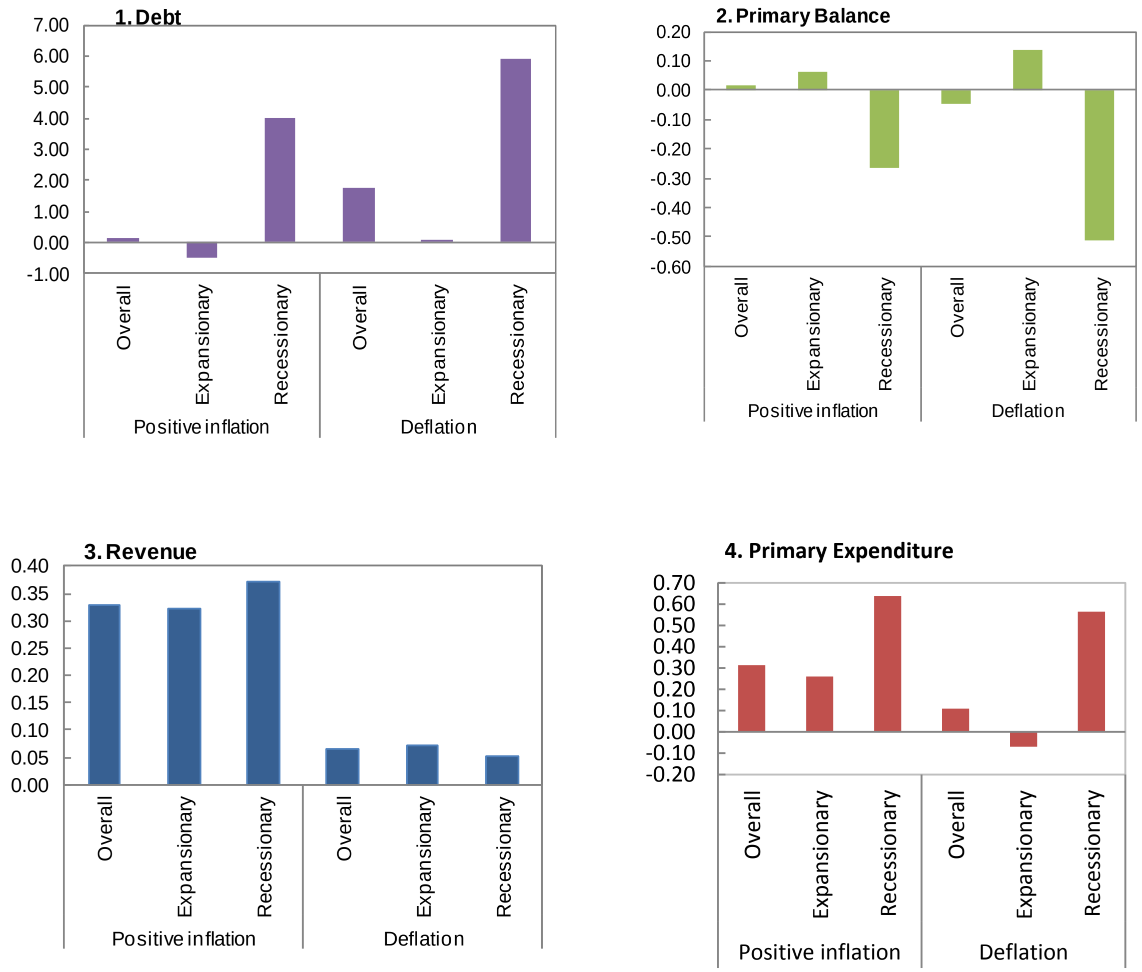
Other controls variables have the expected signs. Higher economic growth also reduces the debt build-up, and at a faster pace (a 1 percentage point increase leads to a decline of 0.40 percentage point in the debt-to-GDP ratio). The impact in the following year is positive, estimated at 0.14 percentage point. A higher nominal interest rate is also associated with a faster debt build-up: a 100 basis points increase in the nominal rate raises the debt-to-GDP ratio by 0.65 percentage point. The delayed impact is negative, though with a lower magnitude.

Table 1. Descriptive Statistics

(Percent)

	Mean	Std. Dev.	Minimum	Maximum	N
Inflation	4.0	8.1	-20.287	96.954	2380
Growth	3.0	4.1	-21.709	31.004	2380
Debt-to-GDP	52.9	38.2	0.665	269.798	2380
Primary balance-to-GDP	0.5	4.5	-47.670	20.245	2380
Revenue-to-GDP	23.7	16.3	0.771	65.273	2380
Primary expenditure-to-GDP	23.1	16.2	0.560	66.428	2380
Δ Debt-to-GDP	0.4	6.1	-52.529	41.303	2380
Δ Primary balance-to-GDP	0.0	2.5	-26.380	29.280	2380
Δ Revenue-to-GDP	0.3	2.0	-12.062	27.477	2380
Δ Primary expenditure-to-GDP	0.3	2.9	-21.577	25.868	2380

Figure 1. Change in Fiscal Aggregates and Inflation Regimes



Source: Authors

To assess the particular effect of deflation, we split inflation into deflation and positive inflation. We estimate equation (3). In Table 2, column (2), the estimated coefficients are statistically significant. When inflation is positive, a 1 percentage point increase in its rate translates into a reduction of the debt ratio of 0.15 percent of GDP in a year. When inflation is negative, it leads to an increase of a similar magnitude in the public debt ratio (0.19 percentage point).

Given that our dataset spans a long timeframe, we verified the stability of our results on deflation over three separate periods: before the Great Depression (1851–1928); during the Depression (1929–34); and after World War II. Results are presented in Table 2, columns (4–6). They suggest that deflation was associated with a worsening in debt-to-GDP ratios mostly during the periods prior to World War II, when deflation episodes were more frequent. Before the Great Depression, the debt-to-GDP ratios rose by almost 0.3 percentage point a year; during the depression, they rose by 0.5 percentage point.[29]

The relevant literature underscores that not all deflations are alike. The origin and impact of deflation are different in recessions and expansions. Atkeson and Kehoe (2004) documented that, although the 1929 deflation was correlated with the Great Depression, the empirical link is not robust from historical perspective. Accordingly, Atkeson and Kehoe (2004) and Borio and Filardo (2004) argued that the effects of deflation depend on the growth regime. In a similar vein, Bordo, Lane, and Redish (2004) use a panel VAR to investigate the United States, the United Kingdom, and Germany during the late 19th century, and find that, overall, deflation over that period was "primarily good" for the real economy. Bordo, Lane, and Redish (2004) also conclude that deflation has received a "bad rap" and stress the importance of distinguishing between good and bad deflations.

In order to test for asymmetry in the effect of deflation on the debt-to-GDP ratio, we estimate equation (4). We consider deflation, recessionary deflation (deflation combined with negative growth), and expansionary deflation (deflation combined with positive growth). The results confirm that a state of deflation permanently increases the debt ratios (Table 3). The debt-to-GDP ratio increases by almost 1.7 percent a year, and this impact varies across growth regimes. As previously assessed, deflation has adverse effects on debt when combined with recession ("bad" or "ugly" deflations). During such episodes, the debt-to-GDP ratio is assessed to increase by 3.2 percent a year. Conversely, expansionary deflations have no impact.

Primary Balance

As developed in the theoretical section, deflation can affect the debt-to-GDP ratios through the primary balance. We investigate whether the impact of deflation on debt documented above operates only through the interest rate-growth differential channel, or if it also operates through an impact on the primary balance. We first estimate equation (2). Results are reported in Table 4, columns (1)–(3). Overall, higher inflation reduces both the revenue and expenditure ratios by similar magnitudes (0.04 percentage point of GDP), leaving the primary balance broadly unchanged.[30] The estimated coefficient is positive but not

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[29] Differentiating between the fiscal impact of temporary and permanent deflation shocks is difficult empirically, because of the lack of protracted deflation episodes apart from the Great Depression. Implicitly, by focusing on the Great Depression, we assess whether permanent deflation shocks matter for the results. We find that the fiscal impact of deflation is higher when the shock is permanent. We also identified persistent deflation in our sample (by detecting turning points in five-year moving averages, following the established literature), reaching similar results.

[30] It is worth noting the convergence in the change in revenue-to-GDP ratio. The dependence coefficient is negative, below unity in absolute terms, and significant at 5 percent.

Table 2. Inflation, Deflation, and Debt 1851−2013

	Dependent variable: Δ Debt-to-GDP t					
	All sample 1851-2013			Deflation sample		
				All (1851-2013)	Pre-GD (1851-1928)	GD (1929-34)
	(1)	(2)	(3)	(4)	(5)	(6)
Inflation t	-0.162**	-0.156***				
	(0.0589)	(0.0535)				
Inflation t−1	0.0247	-0.00531				
	(0.0313)	(0.0250)				
Inflation t-2	0.0998***	0.104***				
	(0.0235)	(0.0197)				
Inflation t-3	-0.0142	0.00376				
	(0.0261)	(0.0281)				
Positive Inflation t			-0.154***			
			(0.0530)			
Positive Inflation t−1			0.00536			
			(0.0303)			
Positive Inflation t-2			0.0796**			
			(0.0305)			
Positive Inflation t-3			0.0327			
			(0.0371)			
Deflation t			-0.189*	-0.290***	-0.306***	-0.466**
			(0.0949)	(0.0701)	(0.0968)	(0.178)
Deflation t−1			-0.0724	0.00689	0.00318	0.331
			(0.0860)	(0.0605)	(0.0838)	(0.407)
Deflation t-2			0.166***			
			(0.0507)			
Deflation t-3			-0.166**			
			(0.0697)			
Growth t		-0.401***	-0.403***	-0.473***	-0.406**	-0.451
		(0.0952)	(0.0957)	(0.117)	(0.140)	(0.284)
Growth t−1		0.140**	0.142**	-0.115	-0.0652	-0.295
		(0.0650)	(0.0657)	(0.100)	(0.114)	(0.191)
Growth t−2		0.0393	0.0316			
		(0.0394)	(0.0365)			
Growth t−3		-0.0316	-0.0247			
		(0.0351)	(0.0339)			
i-rate t		0.652***	0.653***	1.750***	2.013**	2.090**
		(0.171)	(0.172)	(0.497)	(0.732)	(0.978)
i-rate t−1		-0.350**	-0.353**	-0.539	-0.607	-0.239
		(0.164)	(0.165)	(0.483)	(0.614)	(0.759)
i-rate t−2		-0.115**	-0.115**			
		(0.0456)	(0.0449)			
i-rate t−3		0.0332	0.0336			
		(0.0813)	(0.0818)			
Δ Primary Balance-to-GDP t		-0.324***	-0.322***	-0.163	0.418	-0.314
		(0.0875)	(0.0872)	(0.226)	(0.253)	(0.592)
ΔPrimary balance-to-GDP t−1		-0.272***	-0.272***	0.0701	0.0571	0.215
		(0.0475)	(0.0476)	(0.134)	(0.217)	(0.386)
ΔPrimary balance-to-GDP t−2		-0.143	-0.139			
		(0.0929)	(0.0931)			
ΔPrimary balance-to-GDP t−3		-0.0722*	-0.0783*			
		(0.0418)	(0.0431)			
ΔDebt-to-GDP t−1	0.369***	0.406***	0.405***	0.198	0.152	0.0623
	(0.0512)	(0.0569)	(0.0577)	(0.120)	(0.160)	(0.122)
Pre-Great Depression dummy	-11.06**	-11.10***	-6.785**	-11.48***		
	(3.964)	(3.479)	(2.487)	(2.815)		
Great Depression dummy	-6.208*	-7.778**	-7.371**	-6.109***		
	(3.048)	(3.310)	(3.518)	(1.741)		
Post-WWII dummy	-17.98***	-8.227**	-7.942**	0.522		
	(5.640)	(3.320)	(3.277)	(4.021)		
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,171	2,171	2,171	439	302	70
R-squared	0.394	0.502	0.505	0.523	0.459	0.421
Country	21	21	21	21	16	17

Note: Dependent variable: First difference of fiscal aggregate in percent of GDP. Robust standard errors are in parentheses. Regressions include intercepts and time fixed effects.
*** p<0.01, ** p<0.05, * p<0.1

Table 3. Inflation and Growth Regimes and Debt, 1851–2013

	Dependent variable: Δ Debt-to-GDP t		
	All sample, 1851-2013		
	Deflation	Expansionary Deflation	Recessionary Deflation
	(1)	(2)	(3)
Dummy t	1.732***	3.279***	0.435
	(0.593)	(0.803)	(0.360)
Dummy t-1	0.0986	-0.407	0.323
	(0.274)	(0.508)	(0.389)
Dummy t-2	-0.403	0.0466	-0.432
	(0.236)	(0.653)	(0.326)
Dummy t-3	-0.0742	1.000	-0.422
	(0.363)	(0.612)	(0.476)
Growth t	-0.388***	-0.330***	-0.401***
	(0.0876)	(0.0788)	(0.0923)
Growth t−1	0.133*	0.110	0.120*
	(0.0668)	(0.0657)	(0.0639)
Growth t−2	0.0423	0.0389	0.0487
	(0.0479)	(0.0534)	(0.0505)
Growth t−3	-0.0249	-0.00926	-0.0248
	(0.0321)	(0.0346)	(0.0348)
i-rate t	0.650***	0.649***	0.651***
	(0.174)	(0.174)	(0.176)
i-rate t−1	-0.342*	-0.338*	-0.339*
	(0.170)	(0.165)	(0.169)
i-rate t−2	-0.113**	-0.111**	-0.112**
	(0.0495)	(0.0519)	(0.0504)
i-rate t−3	0.0309	0.0236	0.0281
	(0.0916)	(0.0890)	(0.0903)
Δ Primary Balance-to-GDP t	-0.315***	-0.303***	-0.321***
	(0.0875)	(0.0897)	(0.0886)
ΔPrimary balance-to-GDP t−1	-0.272***	-0.280***	-0.280***
	(0.0521)	(0.0521)	(0.0520)
ΔPrimary balance-to-GDP t−2	-0.159*	-0.149*	-0.165*
	(0.0864)	(0.0839)	(0.0890)
ΔPrimary balance-to-GDP t−3	-0.0601	-0.0654	-0.0587
	(0.0502)	(0.0510)	(0.0497)
ΔDebt-to-GDP t−1	0.400***	0.403***	0.397***
	(0.0569)	(0.0570)	(0.0581)
Pre-Great Depression dummy	-11.43***	-8.356**	-10.62***
	(3.759)	(3.793)	(3.509)
Great Depression dummy	-8.386**	-7.725**	-7.025**
	(3.325)	(3.433)	(3.186)
Post-WWII dummy	-13.64**	-14.03**	-13.73**
	(5.157)	(5.032)	(5.141)
Country Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Observations	2,171	2,171	2,171
R-squared	0.491	0.495	0.486
Country	21	21	21

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4. Deflation and Primary Balance, 1851–2013

Dependent variable	ΔPrimary balance-to-GDP t	ΔRevenue-to-GDP t	ΔPrimary expenditure-to-GDP t	ΔPrimary balance-to-GDP t	ΔRevenue-to-GDP t	ΔPrimary expenditure-to-GDP t	ΔPrimary balance-to-GDP t	ΔRevenue-to-GDP t	ΔPrimary expenditure-to-GDP t
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Inflation t	0.00248	-0.0309**	-0.0328*						
	(0.0147)	(0.0142)	(0.0174)						
Inflation t−1	-0.00277	0.0207	0.0267						
	(0.0199)	(0.0128)	(0.0223)						
Inflation t-2	0.0140	0.00672	-0.0107						
	(0.0107)	(0.0107)	(0.0117)						
Inflation t-3	0.00490	0.00256	-0.00253						
	(0.0114)	(0.00853)	(0.0130)						
Positive Inflation t				0.00744	-0.0394**	-0.0454*			
				(0.0191)	(0.0173)	(0.0258)			
Positive Inflation t−1				-0.00886	0.0205	0.0332			
				(0.0304)	(0.0128)	(0.0319)			
Positive Inflation t-2				0.0169	0.0133	-0.00760			
				(0.0128)	(0.0142)	(0.0156)			
Positive Inflation t-3				0.00183	0.00363	0.00147			
				(0.0151)	(0.0100)	(0.0184)			
Deflation t				-0.0149	0.00587	0.0167			
				(0.0292)	(0.0257)	(0.0382)			
Deflation t−1				0.0208	0.0221	0.00160			
				(0.0338)	(0.0321)	(0.0392)			
Deflation t-2				0.00326	-0.0140	-0.0201			
				(0.0274)	(0.0198)	(0.0354)			
Deflation t-3				0.0270	-0.00806	-0.0354			
				(0.0194)	(0.0215)	(0.0233)			
Deflation Dummy t							-0.0825	0.109	0.208
							(0.186)	(0.0908)	(0.185)
Deflation Dummy t-1							0.159	-0.0446	-0.221
							(0.104)	(0.108)	(0.146)
Deflation Dummy t-2							0.0815	-0.128	-0.209
							(0.186)	(0.0903)	(0.156)
Deflation Dummy t-3							-0.283**	-0.0732	0.236*
							(0.116)	(0.126)	(0.122)
Growth t	-0.0386	-0.0369*	0.00585	-0.0373	-0.0388**	0.00286	-0.0389	-0.0366*	0.00631
	(0.0262)	(0.0183)	(0.0326)	(0.0262)	(0.0180)	(0.0321)	(0.0250)	(0.0182)	(0.0319)
Growth t−1	-0.0171	0.0495***	0.0727**	-0.0174	0.0482***	0.0720**	-0.0173	0.0494***	0.0732**
	(0.0204)	(0.0165)	(0.0267)	(0.0217)	(0.0165)	(0.0284)	(0.0211)	(0.0170)	(0.0271)
Growth t−2	-0.0212	0.000985	0.0132	-0.0208	0.00259	0.0142	-0.0182	0.00279	0.0120
	(0.0146)	(0.0145)	(0.0151)	(0.0141)	(0.0147)	(0.0138)	(0.0148)	(0.0138)	(0.0130)
Growth t−3	-0.00832	0.0121	0.0228	-0.00899	0.0130	0.0244	-0.00689	0.0106	0.0197
	(0.0113)	(0.0144)	(0.0174)	(0.0126)	(0.0145)	(0.0182)	(0.0115)	(0.0147)	(0.0186)
ΔPrimary balance-to-GDP t−1	0.120			0.121			0.121		
	(0.0829)			(0.0837)			(0.0826)		
ΔRevenue-to-GDP t−1		-0.0820**			-0.0825**			-0.0812**	
		(0.0333)			(0.0334)			(0.0328)	
ΔPrimary expenditure-to-GDP t−1			0.0995			0.101			0.102
			(0.0726)			(0.0727)			(0.0722)
Pre-Great Depression dummy	-0.698	-1.413**	-0.405	-1.429	-1.173***	0.357	-0.568	-1.272*	-0.417
	(0.929)	(0.617)	(1.030)	(1.030)	(0.389)	(0.909)	(0.759)	(0.629)	(0.863)
Great Depression dummy	-1.477	-1.332**	0.349	-1.869**	-0.604	1.540	-1.490	-1.158**	0.522
	(0.995)	(0.475)	(0.950)	(0.857)	(0.600)	(0.921)	(0.866)	(0.506)	(0.889)
Post-WWII dummy	7.218***	-2.204**	-8.030***	7.203***	-2.122**	-7.965***	7.149***	-2.304**	-8.055***
	(2.073)	(0.823)	(2.520)	(2.098)	(0.832)	(2.540)	(2.057)	(0.840)	(2.514)
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171
R-squared	0.271	0.133	0.247	0.272	0.134	0.248	0.271	0.129	0.246
Number of ifscode	21	21	21	21	21	21	21	21	21

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5. Low Inflation and Debt, 1851–2013

Dependent variable	Δ Debt-to-GDP t	Δ Primary balance-to-GDP t	Δ Revenue-to-GDP t	Δ Primary expenditure-to-GDP t
	(1)	(2)	(3)	(4)
Low Inflation t	-0.183	0.0457	-0.0538	-0.0853
	(0.225)	(0.131)	(0.0712)	(0.120)
Low Inflation t−1	0.485*	0.0305	0.0417	0.0161
	(0.233)	(0.116)	(0.0699)	(0.116)
Low Inflation t−2	-0.356*	-0.0338	-0.0576	-0.0328
	(0.203)	(0.0901)	(0.0713)	(0.0979)
Low Inflation t−3	-0.130	0.124	0.103	-0.0103
	(0.175)	(0.0980)	(0.0724)	(0.113)
Deflation t	-0.191*	-0.0165	0.00661	0.0185
	(0.0993)	(0.0287)	(0.0258)	(0.0383)
Deflation t−1	-0.0934	0.0200	0.0219	0.00229
	(0.0889)	(0.0334)	(0.0314)	(0.0377)
Deflation t-2	0.189***	0.00513	-0.0113	-0.0190
	(0.0514)	(0.0284)	(0.0210)	(0.0366)
Deflation t-3	-0.162**	0.0214	-0.0125	-0.0348
	(0.0708)	(0.0192)	(0.0213)	(0.0233)
Inflation above 2% t	-0.156***	0.00757	-0.0398**	-0.0458*
	(0.0542)	(0.0197)	(0.0178)	(0.0262)
Inflation above 2% t−1	0.0173	-0.00818	0.0211	0.0331
	(0.0311)	(0.0301)	(0.0133)	(0.0316)
Inflation above 2% t−2	0.0734**	0.0158	0.0118	-0.00814
	(0.0294)	(0.0133)	(0.0139)	(0.0162)
Inflation above 2% t−3	0.0290	0.00325	0.00490	0.00148
	(0.0356)	(0.0151)	(0.0100)	(0.0180)
Growth t	-0.402***	-0.0374	-0.0391**	0.00278
	(0.0955)	(0.0263)	(0.0180)	(0.0321)
Growth t−1	0.144**	-0.0172	0.0483***	0.0720**
	(0.0666)	(0.0218)	(0.0164)	(0.0283)
Growth t−2	0.0288	-0.0210	0.00225	0.0141
	(0.0363)	(0.0140)	(0.0148)	(0.0138)
Growth t−3	-0.0232	-0.00848	0.0135	0.0244
	(0.0339)	(0.0126)	(0.0145)	(0.0183)
i-rate t	0.653***			
	(0.172)			
i-rate t−1	-0.350**			
	(0.167)			
i-rate t−2	-0.129***			
	(0.0447)			
i-rate t−3	0.0423			
	(0.0788)			
Δ Primary Balance-to-GDP t	-0.322***			
	(0.0853)			
ΔPrimary balance-to-GDP t−1	-0.272***	0.122		
	(0.0463)	(0.0837)		
ΔPrimary balance-to-GDP t−2	-0.138			
	(0.0919)			
ΔPrimary balance-to-GDP t−3	-0.0804*			
	(0.0425)			
ΔDebt-to-GDP t−1	0.405***			
	(0.0581)			
ΔRevenue-to-GDP t−1			-0.0822**	
			(0.0334)	
ΔPrimary expenditure-to-GDP t−1				0.101
				(0.0729)
Pre-Great Depression dummy	-6.736**	-1.491	-1.233**	0.357
	(2.663)	(1.046)	(0.441)	(0.943)
Great Depression dummy	-7.284**	-1.875**	-0.618	1.531
	(3.458)	(0.863)	(0.605)	(0.919)
Post-WWII dummy	-7.900**	7.178***	-2.166**	-7.971***
	(3.282)	(2.089)	(0.835)	(2.542)
Country Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	2,171	2,171	2,171	2,171
R-squared	0.507	0.272	0.135	0.248
Country	21	21	21	21

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

statistically significant.[31] We then break down the inflation term into positive and negative inflations, to assess the specific effect of deflation on the primary balance. Results are reported in Table 4, columns (4)–(6). We find that deflation has no significant impact on the primary balance and its components as ratios of GDP. The effect of overall inflation previously identified is attributed to positive inflation—revenue and primary expenditure ratios contract with positive inflation but appear insensitive to deflation. We further check the effect of deflation by substituting a dummy variable to the inflation term (equation (4)) and confirm that deflation has no effect on the primary balance.

As a robustness check, we explore whether low inflation measured as inflation between 0 and 2 percent has an impact on fiscal aggregates different from that of deflation. The 2 percent threshold is set arbitrarily, as in recent decades several advanced economies experienced moderate inflation often below that threshold. From the historical records, we break inflation down into deflation, low inflation (between 0 and 2 percent), and inflation above 2 percent. Results are reported in Table 5. We find that low inflation has no specific effect on debt. Conversely and as documented above, deflation increases the debt-to-GDP ratio while inflation above 2 percent curbs it. We also conduct the same estimates for the primary balance and its components as ratios of GDP and find low inflation (between 0 and 2 percent) has no significant effect on the primary balance.

B. Beyond Ratios: Nominal Changes in Fiscal Aggregates

So far, we focused on fiscal ratios. The analysis of fiscal aggregates expressed in percent of GDP suggests that the denominator effect is preponderant on the results, and some of the impact of deflation on the numerator (the nominal fiscal variable) may thus be muted. In an attempt to quantify the impact of deflation on nominal variables, we need to find a way to circumvent the limitation of the data that, for historical records, we only have ratios, not the nominal values. We thus need to mute the denominator effect and, to that effect, we build "pseudo-nominal" changes in the fiscal variable $x = X/Y$ by using the following formula:

$$\Delta_a x_t \coloneqq \frac{\Delta X_t}{Y_{t-1}} = \Delta x_t + \big((1 + g_t)(1 + \pi_t) - 1\big)x_t \tag{5}$$

The change adjusted from the denominator effect, $\Delta_a x_t$, proxies the nominal increase, as measured in terms of previous year GDP. We use the specifications in equations (2)–(4) to scrutinize the effects of deflation on these "pseudo-nominal" variables, focusing on primary expenditure and revenue. We obtain the following three additional results, which are robust when we consider a broader definition of deflation (*i.e.*, any inflation rate below 1 percent). This finding is not a surprise, given the upward bias in modern chained price indices, which

[31] With delays, higher growth increases both revenue and primary expenditure.

is exacerbated by the use of more rudimentary indices at times.[32,33]

First, both nominal expenditure and nominal revenue are positively correlated with inflation. We find that revenue and expenditure are historically more responsive to inflation than to deflation (Tables 6–7, columns (3)). This means that, whereas positive inflation boosts nominal revenue and expenditure, deflation does not deflate them as much. This result is a sign of downward rigidities in expenditures and, probably also, in tax provisions. In addition, the denominator effect would exacerbate these asymmetries: in deflation situations, revenue and expenditure ratios tend to increase more than they decrease in positive inflation situations.

Second, the negative effect of deflation on nominal revenue seems larger than the one on nominal expenditure, and this discrepancy gains significance over time.[34] The right-hand sides of Tables 6–7 slice our sample according to historical periods. The sensitivity of nominal expenditure and revenue to deflation has been historically increasing. Nonetheless, the coefficients we find for expenditure are consistently lower than those for revenue. Consequently, governments should experience downward pressures on their fiscal deficits during deflation, but unfortunately we do not detect significant effects on primary balances.

Third, when we use regime dummies, as in equation (4), the results broadly hold: deflation is associated with lower nominal revenues and lower nominal expenditure (Table 8). When deflation is combined with positive growth, the primary balance deteriorates on the back of declining revenue and rising expenditure (though the estimated coefficient on public expenditure loses its significance). In recessionary deflation (deflation combined with negative growth), expenditure cuts exceed revenue shortfalls. While the latter result may largely reflect Great Depression episodes, the former is of critical importance for today's European economies. Interestingly, only the negative response of revenue persists once we restrict the sample to the 1946–2013 period. This may reflect modern governments' increasing reluctance to downsize spending when faced with revenue shortfalls.

[32] This broader definition tries to address concerns among policy makers and analysts that low inflation situations could actually characterize deflationary situations, because price indices tend to overestimate actual increases in the cost of living (Akerlof and others, 1996; Fuhrer and Sniderman, 2000; Reifschneider and Williams, 2000). The upward bias in the CPI is well-documented (Lebow and Rudd, 2003). It comes from the fact that indices do not capture well substitutions effects following changes in relative prices, or quality-improving substitutions within product categories. Then, inflation near the zero bound could literally mean deflation.

[33] We have also estimated endogenous threshold models *à la* Hansen (2000), in order to find the most statistically significant inflation threshold. We find a significant inflation threshold, ranging between -2 and +4 percent, depending on the considered variable and historical period.

[34] Aghevli and Khan (1978) postulated that governments have fiscal targets that differ for expenditure and revenues: while they aim for a desired level of tax burden (or revenue-to-GDP ratio), they tend to have a real target for expenditure—a certain level of public services. Nevertheless, government instruments to achieve these targets are spelled out in nominal terms and cannot, for technical and political reasons, be too volatile.

Table 6. Inflation, Deflation, and Nominal Expenditure, 1851−2013

	Dependent variable: ΔPrim.Expenditure-to-GDP (adjusted)								
	All sample	Deflation sample				Inflation below 1 percent			
	1851-2013	All (1851-2013)	Pre-GD (1851-1928)	GD (1929-34)	Post-WWII (1946-2013)	All (1851-2013)	Pre-GD (1851-1928)	GD (1929-34)	Post-WWII (1946-2013)
	(3)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Positive Inflation t	**0.148*****								
	(0.0498)								
Positive Inflation t−1	0.0223								
	(0.0304)								
Positive Inflation t-2	0.000499								
	(0.0192)								
Positive Inflation t-3	0.00426								
	(0.0253)								
Deflation t	**0.0630**	**0.107****	**0.0927****	**0.219**	**3.564***				
	(0.0569)	(0.0469)	(0.0421)	(0.187)	(1.781)				
Deflation t−1	-0.0219	0.0712	0.0121	0.303*	-1.049				
	(0.0416)	(0.0645)	(0.0636)	(0.159)	(0.941)				
Deflation t-2	-0.0438	-0.0246	-0.0829	0.135	6.890**				
	(0.0344)	(0.0416)	(0.0527)	(0.147)	(2.910)				
Deflation t-3	-0.0408	-0.00454	-0.0433	-0.0389					
	(0.0302)	(0.0437)	(0.0401)	(0.0907)					
Low inflation t						**0.103****	**0.0972****	**0.0376**	**0.376*****
						(0.0422)	(0.0383)	(0.131)	(0.0722)
Low inflation t−1						0.00497	-0.0132	0.285*	-0.127
						(0.0450)	(0.0480)	(0.138)	(0.132)
Low inflation t-2						-0.0425	-0.0535	0.0358	-0.0613
						(0.0394)	(0.0465)	(0.103)	(0.112)
Low inflation t-3						-0.00380	-0.00245	-0.0306	
						(0.0253)	(0.0250)	(0.0557)	
Growth t	0.151***	0.0643*	0.0559*	0.145	-0.149	0.0767***	0.0707**	0.154*	0.165*
	(0.0387)	(0.0341)	(0.0282)	(0.0910)	(0.206)	(0.0224)	(0.0246)	(0.0759)	(0.0887)
Growth t−1	0.0680**	0.0249	0.0238	-0.0836	0.650**	0.0592***	0.0247	-0.0128	0.141
	(0.0309)	(0.0304)	(0.0357)	(0.125)	(0.233)	(0.0199)	(0.0193)	(0.0907)	(0.0934)
Growth t−2	0.00749	0.00853	-0.0162	-0.0738		0.0169	-0.000192	-0.00668	
	(0.0188)	(0.0323)	(0.0379)	(0.111)		(0.0200)	(0.0280)	(0.0762)	
Growth t−3	0.0328*	-0.0179	-0.0377	-0.0330		0.0132	-0.0201	0.0426	
	(0.0189)	(0.0291)	(0.0415)	(0.0770)		(0.0240)	(0.0328)	(0.0450)	
i-rate t	0.322**	-0.0132	0.424*	-0.0381	-1.319	0.256	1.032**	-0.231	0.182
	(0.143)	(0.389)	(0.229)	(0.653)	(2.371)	(0.286)	(0.479)	(0.510)	(0.155)
i-rate t−1	-0.184	-0.465	-0.860**	-0.0763	1.608	-0.201	-1.172**	-0.0398	-0.157
	(0.118)	(0.367)	(0.358)	(0.259)	(1.724)	(0.130)	(0.407)	(0.156)	(0.115)
i-rate t−2	-0.0793	0.494**	0.200	0.774		0.0250	-0.0233	0.621**	
	(0.0475)	(0.185)	(0.424)	(0.482)		(0.252)	(0.248)	(0.224)	
i-rate t−3	0.0248	0.0245	0.0766	0.615		-0.0806	0.178	0.256	
	(0.0517)	(0.179)	(0.175)	(0.521)		(0.0973)	(0.161)	(0.240)	
ΔPrim.Expenditure-to-GDP t−1	0.178**	-0.112	-0.00783	-0.474***	-0.110	-0.0320	-0.0593	-0.282***	-0.184***
	(0.0752)	(0.107)	(0.0994)	(0.157)	(0.405)	(0.0560)	(0.0942)	(0.0794)	(0.0384)
Pre-Great Depression dummy	-0.760								
	(0.968)								
Great Depression dummy	1.641								
	(1.053)								
Post-WWII dummy	-7.894***								
	(2.467)								
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,171	390	268	63	56	863	394	74	361
R-squared	0.479	0.395	0.471	0.526	0.988	0.390	0.519	0.439	0.618
Country	21	20	16	16	18	21	17	16	21

Note: Dependent variable: First difference of fiscal aggregate in percent of GDP. Robust standard errors are in parentheses. Regressions include intercepts and time fixed

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

Table 7. Inflation, Deflation, and Nominal Revenue, 1851−2013

	Dependent variable: Δ Revenue-to-GDP (adjusted)								
	All sample	Deflation sample				Inflation below 1 percent			
	1851-2013	All (1851-2013)	Pre-GD (1851-1928)	GD (1929-34)	Post-WWII (1946-2013)	All (1851-2013)	Pre-GD (1851-1928)	GD (1929-34)	Post-WWII (1946-2013)
	(3)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Positive Inflation t	**0.142*** **								
	(0.0402)								
Positive Inflation t−1	0.0363**								
	(0.0163)								
Positive Inflation t-2	0.0307**								
	(0.0147)								
Positive Inflation t-3	0.0119								
	(0.0141)								
Deflation t	**0.0713**	**0.0911***	**0.0678**	**0.164**	**4.347*** **				
	(0.0423)	(0.0481)	(0.0428)	(0.152)	(1.389)				
Deflation t−1	0.00442	0.100	0.0443	0.305*	-1.296*				
	(0.0361)	(0.0667)	(0.0772)	(0.162)	(0.714)				
Deflation t-2	-0.0432*	-0.0279	-0.0457	-0.139	8.116***				
	(0.0245)	(0.0298)	(0.0459)	(0.0972)	(2.051)				
Deflation t-3	-0.0137	0.0426*	0.0105	0.0986					
	(0.0230)	(0.0205)	(0.0215)	(0.0801)					
Low inflation t						**0.0971*** **	**0.0727** **	**0.0307**	**0.353*** **
						(0.0328)	(0.0292)	(0.113)	(0.0747)
Low inflation t−1						0.0454	0.0439	0.286*	-0.108
						(0.0420)	(0.0440)	(0.140)	(0.130)
Low inflation t-2						-0.0425*	-0.0358	-0.105	-0.0781
						(0.0219)	(0.0278)	(0.0789)	(0.116)
Low inflation t-3						0.0363	0.0335	0.0517	
						(0.0232)	(0.0194)	(0.0523)	
Growth t	0.108***	0.0787**	0.0808***	0.203**	-0.141	0.0895***	0.0674***	0.156**	0.172*
	(0.0241)	(0.0298)	(0.0257)	(0.0745)	(0.174)	(0.0239)	(0.0217)	(0.0630)	(0.0898)
Growth t−1	0.0611***	0.0350	0.0335	-0.0256	0.666***	0.0623***	0.0302	0.00450	0.141
	(0.0183)	(0.0290)	(0.0329)	(0.112)	(0.203)	(0.0192)	(0.0280)	(0.0746)	(0.0938)
Growth t−2	-0.00165	0.00533	-0.00767	-0.112		0.0109	-0.00682	-0.0652	
	(0.0168)	(0.0333)	(0.0429)	(0.117)		(0.0256)	(0.0314)	(0.0868)	
Growth t−3	0.0237	0.00452	-0.00516	-0.0657		0.0191	-0.00298	0.00383	
	(0.0140)	(0.0286)	(0.0407)	(0.0789)		(0.0158)	(0.0272)	(0.0397)	
i-rate t	0.291**	-0.0606	0.343	-0.124	-2.814	0.116	0.401***	-0.141	0.208
	(0.130)	(0.339)	(0.227)	(0.472)	(2.210)	(0.150)	(0.119)	(0.429)	(0.151)
i-rate t−1	-0.163	-0.195	-0.613	0.413	2.489	-0.152	-0.531	0.273	-0.159
	(0.110)	(0.302)	(0.450)	(0.243)	(1.690)	(0.114)	(0.318)	(0.217)	(0.113)
i-rate t−2	-0.0430	0.123	-0.0775	0.466		0.0143	-0.0934	0.418	
	(0.0339)	(0.107)	(0.298)	(0.371)		(0.147)	(0.209)	(0.253)	
i-rate t−3	-0.0242	0.133	0.219	0.819*		0.0419	0.195**	0.456	
	(0.0229)	(0.0974)	(0.127)	(0.439)		(0.0629)	(0.0855)	(0.274)	
Δ Revenue-to-GDP t-1	0.0402	-0.196*	-0.133	-0.358**	0.0586	-0.0835	-0.170	-0.272**	-0.183***
	(0.0384)	(0.0945)	(0.160)	(0.135)	(0.232)	(0.0500)	(0.139)	(0.112)	(0.0351)
Pre-Great Depression dummy	-1.991***								
	(0.422)								
Great Depression dummy	-0.246								
	(0.683)								
Post-WWII dummy	-1.539**								
	(0.705)								
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,171	390	268	63	56	863	394	74	361
R-squared	0.524	0.474	0.404	0.622	0.990	0.449	0.385	0.537	0.499
Country	21	20	16	16	18	21	17	16	21

Note: Dependent variable: First difference of fiscal aggregate in percent of GDP. Robust standard errors are in parentheses. Regressions include intercepts and time fixed

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

Table 8. Inflation Regimes and Nominal Fiscal Aggregates, 1851–2013

Endogenous variable Y:	Dependent variable: Δ Debt-to-GDP (adjusted)			Dependent variable: Δ Revenue-to-GDP (adjusted)			Dependent variable: Δ Prim.Expenditure-to-GDP (adjusted)			Dependent variable: Δ Prim.Balance-to-GDP (adjusted)		
	All sample, 1851-2013			All sample, 1851-2013			All sample, 1851-2013			All sample, 1851-2013		
	Deflation	Expansionary Deflation	Recessionary Deflation	Deflation	Expansionary Deflation	Recessionary Deflation	Deflation	Expansionary Deflation	Recessionary Deflation	Deflation	Expansionary Deflation	Recessionary Deflation
	(1)	(2)	(3)	(4)	(5)	(6)	(10)	(11)	(12)	(13)	(14)	(15)
Dummy t	**-1.693****	**0.0607**	**-1.784*****	**-0.477*****	**-0.390***	**-0.343*****	**-0.326**	**0.356**	**-0.503*****	**-0.161**	**-0.754****	**0.155**
	(0.606)	(0.623)	(0.580)	(0.132)	(0.217)	(0.106)	(0.212)	(0.397)	(0.160)	(0.180)	(0.346)	(0.147)
Dummy t-1	1.543**	0.581	1.336*	-0.0804	0.200	-0.190	-0.260	0.0305	-0.305*	0.214*	0.145	0.161
	(0.598)	(0.805)	(0.692)	(0.155)	(0.259)	(0.136)	(0.177)	(0.392)	(0.160)	(0.109)	(0.309)	(0.151)
Dummy t-2	0.00253	1.546	-0.603	-0.0827	-0.0379	-0.0722	-0.161	-0.214	-0.0784	0.104	0.165	0.0395
	(0.448)	(1.095)	(0.409)	(0.112)	(0.251)	(0.146)	(0.194)	(0.379)	(0.165)	(0.202)	(0.374)	(0.155)
Dummy t-3	-0.152	0.0919	-0.225	-0.0333	0.0118	-0.0616	0.302**	0.0982	0.263*	-0.314**	-0.0586	-0.314**
	(0.421)	(0.592)	(0.376)	(0.124)	(0.223)	(0.0960)	(0.144)	(0.193)	(0.137)	(0.130)	(0.143)	(0.136)
Growth t	0.0962	0.104	0.136*	0.0995***	0.0929***	0.106***	0.142***	0.148***	0.149***	-0.0430	-0.0563*	-0.0436
	(0.0673)	(0.0694)	(0.0743)	(0.0202)	(0.0213)	(0.0197)	(0.0323)	(0.0338)	(0.0331)	(0.0292)	(0.0318)	(0.0313)
Growth t−1	-0.0876	-0.0832	-0.119*	0.0544***	0.0607***	0.0570***	0.0650**	0.0675*	0.0686**	-0.0219	-0.0183	-0.0234
	(0.0595)	(0.0766)	(0.0667)	(0.0163)	(0.0169)	(0.0166)	(0.0279)	(0.0343)	(0.0294)	(0.0250)	(0.0293)	(0.0249)
Growth t−2	0.0263	0.0503	0.0368	0.000364	0.000141	0.00102	0.00801	0.00660	0.0101	-0.0158	-0.0148	-0.0175
	(0.0485)	(0.0434)	(0.0476)	(0.0199)	(0.0222)	(0.0200)	(0.0214)	(0.0238)	(0.0226)	(0.0158)	(0.0183)	(0.0164)
Growth t−3	-0.00777	-0.00386	-0.00669	0.0370*	0.0394*	0.0385*	0.0423*	0.0456*	0.0373	-0.00750	-0.00819	-0.00105
	(0.0479)	(0.0484)	(0.0534)	(0.0181)	(0.0198)	(0.0188)	(0.0212)	(0.0232)	(0.0222)	(0.0113)	(0.0116)	(0.0123)
i-rate t	0.629***	0.623***	0.625***	0.295**	0.294**	0.294**	0.327**	0.325**	0.327**	-0.0346	-0.0332	-0.0358
	(0.168)	(0.167)	(0.167)	(0.133)	(0.133)	(0.133)	(0.144)	(0.143)	(0.144)	(0.0436)	(0.0437)	(0.0441)
i-rate t−1	-0.329**	-0.323**	-0.322**	-0.187	-0.189	-0.186	-0.195	-0.196	-0.194	-0.0165	-0.0173	-0.0165
	(0.148)	(0.147)	(0.145)	(0.127)	(0.128)	(0.127)	(0.120)	(0.120)	(0.120)	(0.0224)	(0.0231)	(0.0226)
i-rate t−2	-0.136*	-0.140*	-0.138*	-0.0266	-0.0262	-0.0267	-0.0760	-0.0757	-0.0769	0.0594	0.0593	0.0603
	(0.0696)	(0.0728)	(0.0724)	(0.0257)	(0.0252)	(0.0257)	(0.0443)	(0.0445)	(0.0446)	(0.0381)	(0.0386)	(0.0384)
i-rate t−3	0.0624	0.0668	0.0618	-0.0172	-0.0157	-0.0169	0.0299	0.0314	0.0303	-0.0400	-0.0403	-0.0402
	(0.115)	(0.117)	(0.115)	(0.0203)	(0.0207)	(0.0202)	(0.0484)	(0.0484)	(0.0482)	(0.0480)	(0.0477)	(0.0481)
Y t−1	-10.97***	-4.474	-5.629	-0.959	-0.665	-0.974	-0.730	-0.187	-0.539	-0.226	-0.566	-0.428
	(3.739)	(3.940)	(4.805)	(0.669)	(0.464)	(0.721)	(0.806)	(0.808)	(0.835)	(0.720)	(0.986)	(0.703)
Pre-Great Depression dummy	-10.33***	-10.82***	-11.03***	-1.292	-1.177*	-1.578*	0.0824	0.0140	-0.0933	-1.365	-1.580*	-1.479*
	(3.462)	(3.345)	(3.319)	(0.791)	(0.646)	(0.844)	(0.961)	(0.875)	(1.017)	(0.804)	(0.767)	(0.857)
Great Depression dummy	-10.66**	-10.21**	-10.68**	-0.570	-0.490	-0.545	-7.361***	-7.387***	-7.346***	7.300***	7.326***	7.306***
	(3.874)	(3.915)	(3.841)	(0.910)	(0.919)	(0.905)	(2.372)	(2.345)	(2.372)	(2.032)	(2.006)	(2.026)
Post-WWII dummy	0.458***	0.452***	0.459***	0.147	0.150	0.147	0.223***	0.224***	0.223***	0.156	0.156	0.156
	(0.0336)	(0.0351)	(0.0338)	(0.103)	(0.101)	(0.102)	(0.0735)	(0.0731)	(0.0734)	(0.0932)	(0.0927)	(0.0932)
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171
R-squared	0.469	0.464	0.469	0.461	0.460	0.461	0.445	0.444	0.446	0.285	0.285	0.284
Country	21	21	21	21	21	21	21	21	21	21	21	21

Robust standard errors in parentheses

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

V. Lessons for Modern Policymakers

A. Limits of the Historical Approach

Our findings suggest that the impact of deflation on fiscal aggregates is difficult to disentangle from other parameters. Consistently with the theoretical background, the historical records indicate that primary balances (and their subcomponents) as ratios of GDP are not affected by deflation while the analysis of "pseudo-nominal" aggregates shows that revenue and expenditure are affected by deflation. These findings indicate that other parameters tend to shroud the impact of deflation alone. Indeed, the historical data that we examined reflects the conjunction of various policies, trends, and idiosyncrasies, and it is difficult to isolate fiscal economic responses to deflation from other parameters. Considering that the impact of deflation or low inflation on nominal aggregates is small, it is not surprising that correlation is lost when looking at broad ratios, such as the ratio of primary balance to GDP. This, however, does not indicate that deflation has a neutral effect on fiscal aggregates, only that its impact is silenced by other factors in the historical records.

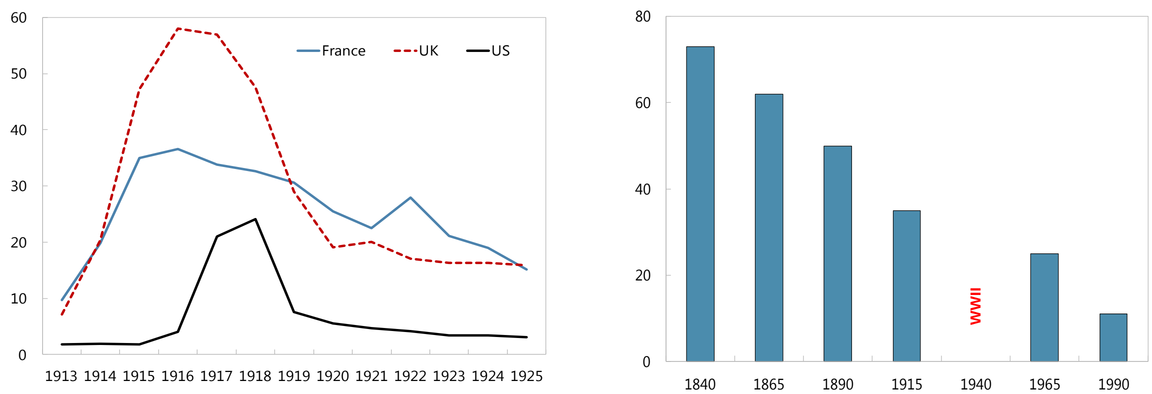
In particular, wars are likely to have a significant impact on our sample data. The period 1850–1950 is marked by a series of international conflicts (from the United States civil war to both World Wars) which can explain a large part of the evolution of expenditure aggregates over the period, as illustrated in Figure 2 for World War I. Experience shows that military expenditure does not decrease immediately after the end of a conflict but, rather, that it gradually declines, implying that conflicts impact expenditure trends over a long period. Also, funding of war-related expenditure differs across countries: the United Kingdom and the United States have had a tradition of levying exceptional taxes for the purpose of funding wars; France and Germany relied also on debt, with the expectation of reimbursing it with reparations paid by the losing side after the war.[35] Such a high volatility of revenue and expenditure around conflicts can only shroud the impact of other parameters on fiscal aggregates, including deflation.

[35] Indeed, France had to pay reparations to Germany after the Franco-Prussian war of 1870 and the German difficulties in paying its reparation costs to France after World War I led to the temporary occupation of the Western province of the Ruhr in 1923.

Figure 2. Historical Changes in Public Finance Composition

(a) Expenditure as a share of GNP, in France, the United Kingdom, and the United States around World War I

(b) Share of Excise and Customs in United Kingdom Revenue



Sources: Webber and Wildavsky (1986), OECD, authors

Our findings should thus be transposed carefully when assessing the current situation in advanced economies, given that public finances have evolved over time. To assess the impact of deflation on fiscal accounts in modern economies, it is important to acknowledge the evolving structure, role, and funding sources of government finance over time. In advanced economies, governments are now bigger in size and scope, and face challenges which require more resources than in the past. Our empirical evidence also suggests that the sensitivity of nominal fiscal aggregates to deflation is higher in recent times than in earlier periods. Modern public finances are purposely more reactive to macroeconomic parameters such as inflation than they were in the past, due to the gradual sophistication of their legal and technical regimes. The recent introduction of second generation fiscal rules, designed to avoid the cyclicality of fiscal policy, is a good illustration of how modern public financial management frameworks try to embed macroeconomic parameters closely in the decision making. As a result, they are also more prone to be impacted by shocks deriving from deflation. Additionally, monetary policy has also evolved over time, and central banks now have more instruments to push down real interest rates—which is crucial for the differential between interest rates and growth, and debt accumulation.[36]

Modern tax systems are designed to be closely linked to macroeconomic aggregates and are more sensitive to inflation. This is well illustrated by the gradual reduction of customs and excise taxes—taxes based on the volume of imports, or the consumption or certain goods—over time. In a country like the United Kingdom, the share of these taxes, which accounted

[36] Countries under the gold standard in the nineteenth and early twentieth centuries had a long-term average inflation/deflation rate of around zero, but faced shorter periods of inflation and deflation that reflected movements in the demand for and the supply of gold. This is a peculiarity of the gold standard that is also likely to drive the empirical results of the previous section.

for more than half of government revenue during the 1800s, was reduced to around 25 percent in 1965, and to 10 percent nowadays (Figure 2). In many other countries, taxes on goods and services have also gradually moved from excises to Value Added Taxes (VATs). The VATs, which have been gradually introduced since the 1950s, now account for about 20 percent of government revenue in OECD countries, up from 3 percent in the 1960s. By design, VAT collections are more sensitive to changes in nominal GDP than excises. Given this closer link, it is expected that deflation would have a more negative impact on tax collections today than in the past, when a larger share of revenue was from excise taxes.

Expenditure has followed a similar pattern over time. Governments have expanded the scope of their activities, and are more service-oriented than they were in the past. Social transfers have ramped up since the end of World War I, when they were first introduced.[37] In the United States, spending on public services (education, health, and social protection, including transfers) is nowadays twice as large as spending on the core functions of government (general services, security, and defense) while they were still of broadly similar magnitudes in the early 1970s. At the same time, today's governments in advanced economies are more committed than in the past to maintaining a certain level of direct services to the public, such as schools or hospitals. As a result, governments are more likely to be unwilling to cut spending, particularly social transfers, in times of deflation. The asymmetric effect on expenditure described in the theoretical background (a nominal increase in times of inflation, and a difficulty to cut spending nominally in times of deflation) can thus be expected to materialize more frequently in modern times than in the historical sample that we use.[38]

B. A Simulation Exercise

To account for expectations and modern features of today's governments, we build a simplified deficit-debt simulation, which we apply to the Euro Area. Compared to the empirical exercise, one interesting feature of this simulation model is that it reflects compositional effects of the fiscal balance. In addition, it incorporates indexation mechanisms, fiscal rules, and modern policy-making practices, under an "unchanged policy" assumption. Overall, we explore two distinct features of fiscal responses to deflation: (i) the asymmetric reactions of impact on revenue and expenditure to deflation and (ii) the potential cost of unanticipated shocks. The primary balance is decomposed into its various components and assumptions on their responses to price change are formulated. Most

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[37] For instance, the Social Security Act in the United States was introduced in 1935.

[38] In particular explicit indexation mechanisms may prove difficult to activate in times of deflation, as reluctance to reduce entitlements (such as pensions in nominal terms) will be high for governments. Also, some indexation mechanisms are designed in such a way that indexation is provisionally granted based on the inflation forecast, with a correction in the following year. Those mechanisms are not well suited during periods of low inflation. Indeed, if the forecasting error is accidentally higher than the following year's forecast, this could require an unexpected negative indexation, which would be even more difficult to implement.

assumptions are based on existing legal and fiscal frameworks, as well as recent experience in advanced economies. This model could easily be calibrated to reflect the specific design of revenue and expenditure as well as the political economy of individual countries.[39]

We assume that impulse responses of fiscal variables X in nominal terms to inflation shocks take following form:

$$\delta\left(\frac{\Delta X}{X}\right)_t = \mu_X.\delta\pi_t + \nu_X.\delta\pi_{t-1} \tag{6}$$

$\delta\pi$ denotes the inflation shock and δ symbolizes the deviation from baseline (which is different from the year-on-year time difference Δ).We allow for a lagged response and account for some inflation indexing, which is a feature of modern fiscal accounts (*e.g.*, public wages or tax brackets), by using two different assumptions: (i) either the shock comes as a complete surprise (or during the fiscal year); or (ii) it had been anticipated by the government. Several expenditure items, such as social spending or wages, and tax provisions are indeed often based on ex ante inflation forecasts, while the benchmark against which the fiscal stance is tested ex post is realized inflation. In the equation, μ_X and ν_X represent the pass-through of current and past inflation shocks, respectively. The shocks considered here are exogenous and are not the consequence of deliberate monetary policy action; therefore, given the usual lag in monetary policy response, the quantity of base money and seigniorage remains initially unchanged in nominal terms. Parameters are described in the following sections and presented in Table 9.

With respect to primary expenditure, we form the hypothesis that it is more likely to be elastic when prices rise than when they fall, due to downward rigidities, which are as follows. For wages, we assume that, when the shock is negative, they remain unchanged whereas, when it is positive, they react immediately or with a lag, depending on whether the shock had been anticipated or not.[40] We also assume that inflation does not have any impact on the other components of public wages (bonuses and career-path effects). Public intermediate consumption is at market prices, so that an inflation shock is immediately reflected in spending. Social expenditures are supposed to be responsive to inflation through two channels: (i) in-kind benefits are assumed to be immediately impacted by price shocks; and (ii) cash benefits and allowances, which are generally indexed to expected inflation, are assumed to follow a path similar to the wage bill.[41] With respect to investment expenditure and capital transfers, we form the assumption that between a quarter and half of them follows

[39] For most European countries, results would probably be similar for the deficit but would be more scattered for the debt ratio, given that the effect on debt depends heavily on the initial level.

[40] Most countries have implicit or explicit catch-up mechanisms, if the initial forecast failed.

[41] In-kind benefits represent roughly one third of social expenditure in the Euro Area.

Table 9. Summary of Equations in the Stylized Model

Fiscal aggregate X	Share of GDP(in percent) ω	Impact of inflation shock $\delta\pi$ on the growth rate of X_t — Anticipated upward	Surprise upward	Anticipated downward	Surprise downward
Government revenues					
• Income tax revenues	14	$0.5.(\delta\pi_{t-1} + \delta\pi_t)$	$0.6 \times (\delta\pi_{t-1} + \delta\pi_t)$	$0.6.(\delta\pi_{t-1} + \delta\pi_t)$	$0.6.(\delta\pi_{t-1} + \delta\pi_t)$
• Social contributions	11	$\delta\pi_t$	$0.9 \times \delta\pi_t + 0.1 \times \delta\pi_{t-1}$	$0.9 \times \delta\pi_t$	$0.9 \times \delta\pi_t$
• Goods and services tax	10	$\delta\pi_t$	$\delta\pi_t$	$\delta\pi_t$	$\delta\pi_t$
• Excises and other tax revenues	6	0	0	0	0
• Non-tax revenues	5	0	0	0	0
Government expenditure					
• Wage bill	11	$\delta\pi_t$	$\delta\pi_{t-1}$	0	0
• Intermediate consumption	6	$\delta\pi_t$	$\delta\pi_t$	$\delta\pi_t$	$\delta\pi_t$
• Social expenditures	25	$\delta\pi_t$	$0.3 \times \delta\pi_t + 0.7 \times \delta\pi_{t-1}$	$0.3 \times \delta\pi_t$	$0.3 \times \delta\pi_t$
• Investment and capital transfers	3	$0.5 \times \delta\pi_t$	$0.3 \times \delta\pi_t$	$0.5 \times \delta\pi_t$	$0.3 \times \delta\pi_t$
• Other primary expenditure	3	$\delta\pi_t$	0	$\delta\pi_t$	0

Note: δ designates the difference from baseline, and is distinct from the year-over-year time difference Δ. The weight of each component in total GDP is taken from Eurostat 2013 data.

market prices, depending on the degree of surprise, in order to account for multiyear planning. Other primary expenditures include credits at the disposal of line ministries and are difficult to amend when facing an in-year surprise.

On the revenue side, we assume that nominal revenues respond less to inflation than GDP (whose response is immediate), mainly because of lags in income tax collections and rigidities in some other components. Income tax revenues—both corporate and personal income tax—are assumed to automatically adjust to inflation through changes in the base, in part with a one-year lag.[42] Tax brackets imply a larger than one-to-one relation, provided that tax brackets are not indexed.[43] We also suppose that social contributions respond with an average elasticity of one to inflation, with only a part of them (assumedly 10 percent) being levied on the public wage bill. Taxes on goods and services are assumed to vary in the same proportion as the value-added (nominal GDP).[44] Price shocks are immediately passed on to

[42] Some countries have indeed withholding taxes in place, while in others the CIT is subject to several in-year payment installments. We use the simplifying assumption that half of income taxes are lagged.

[43] During deflation times, in order to keep the same tax pressure in real terms, governments should revise tax provisions downwards—including tax brackets and the ceilings or floors that determine access to tax exemptions. In practice, however, they may be reluctant to do so for political economy reasons, as it would mean an increase in the nominal tax burden and could set off public discontent, given the traditional monetary illusion that prevails in such circumstances (Fuhrer and Tootell, 2004). Even with indexation, any expectation error is positively correlated with tax revenues. We suppose here that brackets are revised only for upward, anticipated shocks.

[44] We assume implicitly that all the components of the GDP are uniformly affected by the price shock (excluding, e.g., major distortion in the terms of trade).

the VAT and other consumption tax bases. Other revenues—such as excises, taxes on immovable property, and capital and non-tax revenues—are assumed to be broadly immune to price shocks.

For the sake of illustration, the model uses the April 2015 World Economic Outlook forecasts as baseline, to build several alternative scenarios. We simulate a 2 percent shock in inflation in 2015 and 2016 relative to baseline.[45] As we want to explore the possible asymmetric impact of deflation, we simulate both upward and downward shocks: while in the baseline scenario inflation averages 0.5 percent a year over the 2015–16 period, it rises to 2.5 percent in one scenario and falls to -1.5 percent in the other one. Moreover, to account for the role of anticipations in the budgets, we differentiate pure surprises from unexpected shocks from shocks that governments can anticipate.

The simulation results on primary expenditure and revenue are as follows. A persistent 2 percentage point downward surprise in inflation would yield an increase in the primary expenditure-to-GDP ratio of 1.4 percentage points by 2019. If, alternatively, the shock were to be on the upside, the primary expenditure ratio would be 0.3 percentage point lower by 2019, because ex post indexation mechanisms would kick in (Figure 3).[46] Yet, if the shock is expected, the effect would be smaller (1.2 percent of GDP), because of governments' reluctance to adjust downward (in case the inflation shock were to be on the upside, its impact would almost cancel out by 2019). Also, simulations show that by 2019 the response of revenue ratios to the permanent 2 percentage point inflation shock reaches 0.4 percent of GDP in case of a downward shock and around -0.4 percent in case of an upward shock (Figure 3).[47]

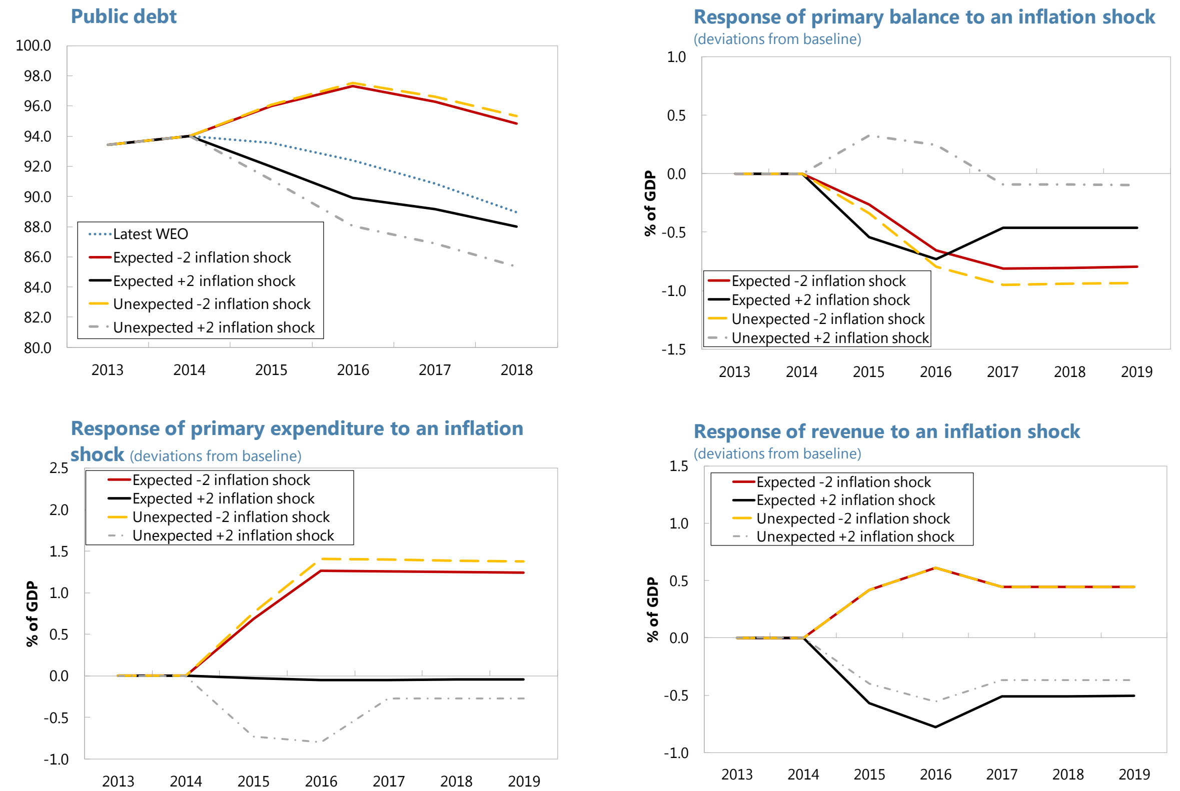
Overall, using this simplified model of fiscal account dynamics, we find that a disinflationary surprise yields a permanent increase in primary expenditure ratios, and a positive and partially temporary effect on the revenue ratios. Had the shock been anticipated, the effect on fiscal aggregates would be smaller. By comparison, inflationary surprises have, at most, a temporary effect on expenditures. As a result, a 2 percentage point decline in inflation in 2015–16 means as much as a 0.9 percentage point deterioration in the primary balance in 2019—and 0.8 if it is perfectly anticipated (Figure 3).

[45] The term inflation is used indifferently for annual changes in CPI and GDP deflator.

[46] This includes the denominator effect.

[47] For an upward shock, revenue ratio decrease more when the shock has been correctly anticipated than when it comes as a surprise, because of bracket indexation. Since we assumed indexation did not take place downward, the effect of a lower inflation is the same whether expected or not.

Figure 3. Simulation Exercise



Source: Authors

The effect on debt is larger of two main reasons. First, there is a stock effect, and the higher the initial debt levels, the more sensitive the debt ratio is going to be to price variations. Secondly, the effects of repeated shocks tend to build up through the debt accumulation process. The impact on the interest bill is both small and persistent and has the opposite sign of the effect on the primary balance. Overall, over a five year period, the debt ratios would permanently increase by 6–7 percentage points of GDP relative to baseline in case of the above-described disinflationary shock—and they would temporarily decrease by 0–3 percentage points of GDP in case of a positive shock on inflation, depending on the degree of anticipation.

VI. Conclusions

In a deflationary or low inflation environment, public finance management becomes more challenging. Similar to the impact of negative GDP growth rates, very low or negative inflation rates tend to adversely affect fiscal performance. In particular, debt-to-GDP ratios tend to mechanically increase, revenue intake is weakened, while expenditures are difficult to cut in nominal terms because of downward rigidities.

This paper has examined the empirical impact of deflation on fiscal aggregates. Using a panel dataset for 21 advanced economies covering 150 years, the study provides evidence on how fiscal accounts are affected during falling-price episodes and helps draw lessons for the current economic context. We confirmed that debt stocks rise significantly with negative inflation. While the deterioration in debt ratios is due in part to stock effects and a worsening in interest rate-growth differentials, close scrutiny of nominal evolutions also signals asymmetric pressures on expenditure and revenue. The magnitude of the effect varies across growth regimes, with debt-to-GDP ratios more sensitive to negative growth than to positive growth. During 'good' deflations—that is, deflation with positive economic growth—debt-to-GDP ratios tend to be relatively immune from the negative impact of deflation. 'Bad' deflations (deflations combined with recessions), such as during the 1929 Great Depression, have the strongest impact on debt. During such episodes, debt-to-GDP ratios tend to rise by rapidly. Recessionary deflations are most dangerous for fiscal sustainability, and the authorities should be primarily concerned by such episodes of deflation, in which aggregate demand collapses and growth slips into negative territory.

As our dataset contains few episodes of deflation in modern times, we form the view that our findings may not fully reflect the actual risks of deflation in modern times. Prior to World War I, governments still had limited scopes for intervention and their tax regimes were not capturing changes in nominal GDP growth effectively. This form of government, which worked on a "tax and spend" approach, appeared to be relatively immune to deflation. Modern times fiscal frameworks may paradoxically be more vulnerable to deflation: sophisticated tax regimes capture the variations of key macroeconomic parameters more directly, a large share of expenditure is directly or indirectly indexed to inflation, and negative indexation may prove impossible to implement because of political constraints. Although deflation appears to be detrimental to fiscal accounts, a more detailed assessment of its impact should be made in the context of three considerations. First, deflation is more harmful when accompanied with economic recession or stagnation. Policy responses need to first determine the source of deflation—whether it originated from shocks to aggregate supply or aggregate demand—and, then, act accordingly. Distinguishing between these two forms of deflationary pressures may, however, be more difficult in modern times, especially if both of them are combined. Second, the composition of revenue and expenditure appears to play a significant role, beyond the interest-growth differential effect. This means that a more tailored approach to country specifics, including elements of political economy, may be necessary. Third, expectations and surprises on the inflation rate itself could play a compounding role on developments.

Deflation times thus present policymakers with a challenge. The asymmetrical behavior of fiscal accounts to deflation underlined in this paper would seem to signal some elements of countercyclicality, supporting demand in times of deflation episodes. However, such a stand would need to be taken deliberately, since it leads to increasing fiscal deficit, and should not result from inaction against a mechanical impact. Yet, governments may find it difficult to act against deflation, especially at the beginning of such episodes or when deflation is low, as the political cost of reducing the nominal face value of civil service wages or entitlements program could initially appear too high to bear.

Sophisticated fiscal policy tools may also need to be revisited in light of the risk of low inflation and deflation. Simple indexation mechanisms work well when prices go up by comfortable margins. Fiscal rules, which have become more prominent in advanced economies, often include binding multiyear expenditure ceilings. These rules, designed to enforce discipline in spending, are often expressed in nominal terms, which raises the issue of their downward revision when inflation is below expectation. More broadly, governments should pay attention to unexpected downward revisions of inflation during budget execution and contemplate taking action rapidly to avoid unwanted ratchet effects on government expenditure. Besides, increasing the share of inflation-indexed bonds in the government's financing mix could help alleviate the negative effects of deflation on debt ratios.

Putting these findings together, lessons on the risks of deflation can be drawn for the current state of the global economy. Slipping into deflation could contribute to undoing consolidation efforts and threaten fiscal sustainability. Even low inflation rates could be a threat, given that CPIs generally overestimate inflation. With debt ratios already elevated, a deflationary spiral could propel debt ratios into unsustainable zones.

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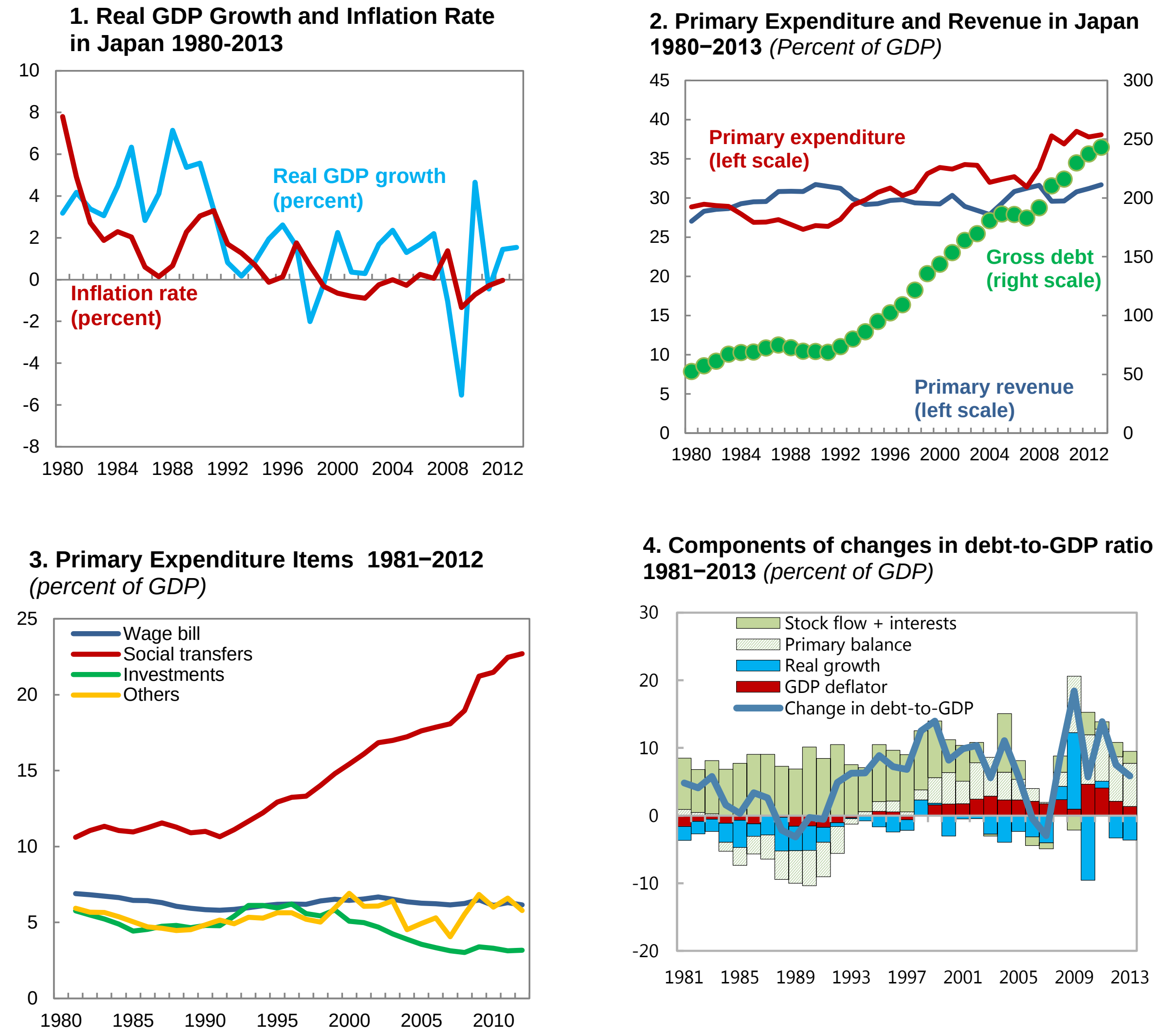
Appendix A. Deflation in Japan

During the deflationnary period (since 1990), the direct impact of deflation on the primary deficit was limited and changes in the primary balance were mostly driven by the combination of demographic changes and policy responses. On the expenditure side, the primary expenditure-to-GDP ratio rose steadily by 12 percent during 1990–2013, reflecting primarily rising social spending associated with the ageing of the population. The downward rigidity was applied lately and only for a few years. For instance, the indexation mechanism for pension benefits, which would have called for an absolute decline in order to preserve the sustainability of the system, was not applied from 2000–02 and suspended after 2004 (Hosen, 2010). On the revenue side, the revenue-to-GDP ratio declined by 4 percent during 1990–2002, reflecting mostly tax alleviation measures and financial impairment in the banking and corporate sectors; it then returned to its initial level by 2013. The direct effect of declining prices is difficult to identify, as tax revenue and the tax base moved simultaneously. Given the weak progressivity of the Japanese tax system, the effective tax rate is estimated to have remained broadly stable, except for the effects of tax policy changes (Ueda, 2012).

Deflation affected directly the Japanese fiscal accounts, mostly through an increasing of the debt-to-GDP ratio. In addition to deteriorating primary deficits, unfavorable interest-rate-growth differentials propelled public debt to unprecedented levels, from 69 percent of GDP in 1990 to 243 percent in 2013.[48] The sole denominator effect of inflation helps explain roughly one fifth of the debt increase between 1990 and 2013 (32 percentage points out of 174 percentage points). To this effect should be added the costs of discretionary fiscal policies that were aimed at unwinding the deflationary spiral, yet difficult to disentangle in the data from other economic factors.

[48] Although nominal interest rates fell during the deflationary period, they remained above the nominal growth rate on average.

Figure A1. The Recent Experience of Japan



Appendix B. Unit Root Tests

Maddala-Wu Panel Unit Root Test, All sample (1851-2013)

	ADF - Fisher Chi-square	PP - Fisher Chi-square
Inflation	492.013***	504.804***
Growth	919.863***	939.338***
Interest rate	129.411***	138.108***
Debt-to-GDP	42.549	36.726
Δ Debt-to-GDP	736.679***	724.485***
Primary expenditure-to-GDP	93.454***	54.403
Δ Primary expenditure-to-GDP	1124.085***	1132.941***
Revenue-to-GDP	34.492	23.801
Δ Revenue-to-GDP	1197.431***	1214.082***

The tests on the levels include individual effects, individual linear trends as exogenous variables. On the first-differences, the tests include only individual effects as exogenous variables. The lag length selection is based on Schwartz Information Criterion.

Appendix C. Optimal Lag Tests

Country-Specific Test for Optimal Lags in the Model

Country	Debt-to-GDP			Primary Balance-to-GDP		
	AIC	HQIC	SBIC	AIC	HQIC	SBIC
Australia	5	1	1	3	1	1
Austria	2	1	1	4	3	1
Belgium	2	1	1	2	1	1
Canada	1	1	1	1	1	1
Denmark	2	1	1	3	1	1
Finland	2	1	1	2	2	2
France	5	1	1	2	2	1
Germany	1	1	1	1	1	1
Greece	1	1	1	1	1	1
Iceland	5	1	1	2	1	1
Ireland	5	4	1	2	1	1
Italy	5	3	1	5	5	3
Japan	1	1	1	3	1	1
Netherlands	1	1	1	1	1	1
Norway	1	1	1	2	2	1
Portugal	4	1	1	4	2	1
Spain	1	1	1	2	2	1
Sweden	2	2	1	2	1	1
Switzerland	3	1	1	5	1	1
United Kingdom	5	2	1	5	3	1
United States	4	2	1	1	1	1
Average	2.8	1.4	1.0	2.5	1.6	1.1

Note: AIC stands for Akaike information criterion, HQIC for Hannan–Quinn information criterion, and SBIC for Schwarz Bayesian information criterion.