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Sovereign debt and inflation – did we tame the ghost? Debt in times of crisis and its cointegration with inflation

With sovereign debt levels at record highs in western democracies – a problem exacerbated by the pandemic – the world faces the question of induced rising inflation on the horizon. This article presents a comprehensive review of literature about the most severe world economic crisis in the 20th and 21st centuries – the great depression and the great recession – as well as the debt levels preceding and following them. Furthermore, it investigates root causes of inflation and its connection with sovereign debt in developed economies. Finally, applying a vector error correction model, it shows the existence of a cointegrating relationship between debt and inflation in the US (and a positive sign of the former on the latter), confirming a moderate macroeconomic correlation between the two. Hence, despite the long period of high debt and low inflation fueling a recent-experience bias, the answer to question posed in the title is negative. The conclusion is that without substantial debt reduction over time, the (Western) world economies will again see a rising inflation regime. Informed and independent central banks are therefore ever-more important.

Keywords: great depression, great recession, debt–inflation nexus, inflation targeting, vector error correction model

JEL classification: C5, E5, E5, H5, N1

Introduction – current sovereign debt situation

With sovereign debt[1] rising to historically high levels in absolute as well as relative debt to GDP ratio terms [IMF, 2020], and monetary and fiscal stimuli (overall budget deficits) simultaneously at record levels due to the global pandemic, hinting at even bigger extremes in the future, the question of the consequences of these debt levels is being asked more and more frequently.

[1] This article mainly considers gross national debt (if not indicated otherwise) and does not consider and net (in any form) the claims (and debt security holdings) against other countries. It also does not add corporate or household debt which also generally rised in recent decades (on average among countries).

A new study [DB, 2020] showed that the world's sovereign debt amounts to USD 248 trillion, whereas before the 2008 global financial crisis – labeled as the great recession or great financial crisis and followed by bank bail-outs, massive government stimuli packages, "unconventional" QE measures by central banks, and a European sovereign debt crisis amid Greece's double deficit and (short) default-on-debt a few years later[2] – it was only USD 172 trillion.

In macro-economic research, various kinds of relationships between debt (ratios) and other standard macro-variables like GDP growth, output gap, money aggregates (like M3), short/long term interest rates and corresponding interest tenures/curves, asset prices, consumption, CPI/inflation or expectations thereof have been investigated in either direction. Models in use are equilibrium-based ones like DSGE models (e.g. with Kalman-filter-type estimators), regressive, time-series ones like vector auto-regressive VARIMA/VAR, or vector error correction ones with long-and short term factors (VECM). The null hypothesis of our article (H0) is that there is no positive correlation between debt and inflation (i.e. "we tamed the ghost"). A VECM model will be used here to estimate the effects of debt on inflation and to show that there is a positive correlation between debt and inflation (i.e. higher debt leads to higher inflation). However, first, other causes and implications of debt are presented. Then, origins of inflation are briefly discussed, and the model evaluated.

Especially after the 2008 crisis, the impact of debt on GDP growth and even debt-bearing ability (default-expectations) was well researched. The reason for the debt – apart from long-running deficits in countries like Italy or Greece, due to structural economic problems – was the financial crisis and its policy response by governments and central banks.

This policy response was primarily due to the lessons learned from the most severe recession in the 20th century, the great depression.

1. Sovereign debt

1.1. The great depression and crisis, their causes and (economic) policy responses

The causes of the great depression have been extensively discussed and are in some specific areas a matter of ongoing debate [Humphrey, Timberlake, 2019], but a widely accepted consensus – albeit assigning different weights to the underlying factors – was achieved after the publication on certain seminal works [Friedman,

[2] Greece defaulted on a USD 1.7 billion IMF payment on 29 June 2015.

Schwartz, 1963; Temin, 1976; Bernanke, 1983; Field, 1984; Romer, 1993; Eichengreen, 1992].

In the cascade of events, a stock market crash (1929), high debt levels (shares on margin/debt), and the following banking and financial crisis spurred a recession in the real economy and spilled over to most other countries (especially in Europe). In the US alone, between 1929 and 1933, industrial production fell 47%, the GDP declined by more than 30%, and unemployment reached a peak of more than 20% [Duignan, 2020].

The Keynesian perspective initially attributed the depression to a fall in demand and lower aggregate expenditures in the economy that contributed to a massive decline in income and employment well below the average. Instead of fiscal expansion, the government tried to balance the budget. While this definitely contributed to the depression [Keynes, 2007; Hayes, 2006], Friedman and Schwartz [2008, p. 247; 1963] showed that the main reason for (the severity of) the great depression was the failure of the Federal Reserve to swiftly lower interest rates, extend the monetary base and supply, and inject liquidity into the banking and financial system as monetary contraction was at 35% and prices dropped by an average of 33% [Cecchetti, 1992, pp. 141–156; Mendoza, Smith, 2006, pp. 82–114]. Nowadays, there is mainstream support for the debt deflation theory developed by Fisher [1933, pp. 337–357] and Minsky, and later extended by Bernanke [1983, pp. 257–276], and the expectations hypothesis [Romer, 1993, pp. 19–39] that builds further on the monetarist research. These are accompanied by several (less impactful) non-monetary explanations like communication (guidance) failures, trade barriers (e.g. Smoot–Hawley tariff act), and rising protectionism [Madsen, 2001, pp. 848–868; Timothy, Prescott, 2007; Eichengreen, Irwin, 2010, pp. 871–897]. An additional factor to be considered as contributing to the situation was the then-existing gold standard [Bernanke, James, 1991, pp. 33–68; Eichengreen, 1992], forcing central banks to have less flexibility and putting inherent deflationary pressure on the economy.

The reasons and developments are summarized by Eichengreen and Parker, in a well-written manner by Caldwell and O'Driscoll, but mainly by Bernanke, who also proves that incomplete adjustment of nominal wages was a further important factor leading to monetary non-neutrality and warning of "credit crunches" [Eichengreen, 2014; Parker, 2003; Caldwell, O'Driscoll, 2007, pp. 70–74; Bernanke, 2004; 1995].

Having attributed the causes of the 1929 financial crisis mainly to "mismanagement" (not enough money supply, too high interest rates, not enough liquidity/LTRO-tenders) of the central bank, Bernanke along with his G7 colleagues made sure central banks lowered interest rates (Fed fund rate, ECB main refinancing rate) to around 0% (zero lower-bound) and announced a plan to maintain it

for a longer timeframe (forward guidance), lowered intermediate- and long-term interest rates with large-scale asset purchases (quantitative easing), provided liquidity and emergency loans to banks and acted as lender of last resort. This was accompanied by a common pledge from G20 governments to maintain free trade and act against protectionism, create central bank swap lines, e.g. for the dollar, use joint (prudential) regulatory oversight[3], raise capital buffers (P2R/Gs, CBRs[4] including systemic buffers), undertake deleveraging efforts, and introduce deficit- and debt-controlling mechanisms (debt limits by law or even constitutions) for the long run. Furthermore, prudential financial oversight [Bernanke, 2011], including the observation of asset prices [Bean, 2003] and non-gaussian correlations (e.g. within collateralized debt obligations, credit default swaps, and its pricing models) and distributions with heavy tails ("black swan events") were strengthened as well as interbank lending regulated in an improved way[5].

These additional financial stability regulations were needed, since, i.a., intentional mispricing of (subprime) housing loans and excessive (overdebt based) expansion in the housing sector triggered the great recession. It was further fueled by mispriced derivatives and MBAs[6] relying on non-realistic Gaussian models and correlations and wrong non-default considerations, as well as and (non-)premia considerations with regard to counterparties and inter-banks in the short run – not to mention wrong-way risks. Moreover, insufficient capital buffers and too much financial leverage, combined with moral hazards (like "too big to fail" – banks, disincentivized rating agencies relying on the so-called Greenspan put, i.e., that the central bank is buying enough assets and will ensure liquidity if a recession occurs) accelerated the great recession [FCIC, 2011; Bernanke, 2010; Islam, Verick, 2019; 2011; Coghlan et al., 2018; Hayford, Malliaris, 2011, pp. 73–90; Fligstein, Goldstein, 2014; Solimano, 2020].

A coordinated response followed in terms of expansionary monetary and fiscal policy. Enormous stimuli packages like the ARRA in the US, tax cuts, and strengthening of automatic stoppers and fiscal stabilizers like subsidised short-time employment[7] within the economic areas and countries, as well as international G20 coordination including treasuries/finance ministers, heads of state and

[3] Basel III, Financial Stability Board's Global Systemically Important Banks, Single Supervisory Mechanism, Single Resolution Mechanism with a credit counterparty (default) risk revision and Banking Recovery and Resolution Directive in the EU, as well as the Dodd–Frank Act and the Volcker rule in the US.

[4] Pillar 2 Requirements and Guidances, i.e. additional regulatory capital after pillar 1 (4% CET-1, 1.5 % AT-1, 2.5 % Tier-2 as RWA %) for internal measurements and controlling coming e.g. from ICAAP and CBR.fter taking credit counterparty risks into account, CVA and CCR models were introduce

[5] Ad. Regulation here was improved with the so called "small"- and "big-bang"-concept, leading further to new interbank offered rates (SOFR, SONIA, ESTER).

[6] Mortgaged-backed assets/securites, ABS-vehicles with mortagages as loans.

[7] Termed "Kurzarbeit", first introduced in Germany and Central European countries and then copied throughout the world.

central banks (including the BIS), were all efforts used to stabilize the respective economies.

Swift and coordinated measures probably prevented the world from a second depression were widely credited and viewed as generally successful [Bernanke, 2011; Eskander, 2017]. However, the result inevitably was record sovereign debt. Furthermore, there was fear of high inflation[8] after monetary expansion and leveraging (expansion) of central banks' balance sheets – which did not occur, as we will see later.

1.2. The consequence of the crisis – debt and ways to reduce it

There are three main ways of reducing debt (more precisely debt/GDP ratios) without cutting spending [Best et al., 2019; RBC GAM, 2020; Sunder-Plassmann, 2014]. The first and most sustainable one is a higher growth rate and hence GDP expansion by way of higher economic activity, employment and sales, and thus higher income tax. However, it is obviously a tool more readily available for emerging economies, which in developed (post-)industrial countries would have a more negligible effect. The second possibility is to use seigniorage and inflation (if the debt is mainly domestic) to "inflate away" (nominal) debt by allowing higher inflation rates, which are hard to scale back, while controlling for other factors, which are hard to control. Inflation reduces debt levels best when it is unanticipated and temporary. It is commonly combined with low-interest rates, capital controls, high reserve requirements, etc., and then called "financial repression". Yet in a globalized economy, an extreme form of financial repression is hard to maintain as capital flight is inevitable; furthermore, the quantitative findings suggest only moderate success [Fukunaga et al., 2019]. The third way is default or restructuring (haircuts, discounts, prolongation of bonds, etc.). This implicates mistrust on the part (future) investors, massive distortion and negative economic impact (shocks) with high loss of welfare in the short run (in the long run it is better than the second option and sometimes unavoidable to prevent an even more severe future default – otherwise the costs are too high) [Best et al., 2019]. Across 45 crisis episodes, debt relief averaged 21% of GDP for advanced economies (1932–1939) and 16% of GDP for emerging markets (1979–2010) [Reinhardt, Trebesch, 2014].

Often various combinations were used by governments in the past. To summarize, the best option is (longer-term) GDP growth, yet more demanding to achieve for developed economies, and structural reforms (avoiding new deficits) need time to unfold. Default or restructuring can only be advised in rare, unbearable cases to prevent long-suffering and eventually more cost-intensive defaults

[8] Especially in countries very hard hit by hyperinflation in the past, like Germany in the 1930s, but partly also in the US in the late 1970s (until the Fed regained control in the early 1980s under Volcker).

[Adam, Grill, 2011; Reinhardt, Trebesch, 2014]. The break-down of the creditors and judicial clauses and renegotiation possibilities (domestic debt or not, institutions or corporate holders – PSI/private sector involvement, redemption or default clauses, etc. [Yue, 2005, pp. 176–187]) as well as future prospects of economic recovery and debt bearing ability have to be taken into consideration. Financial repression and higher (yet moderate [Bai et al., 2001, pp. 245–251]) inflation can only to some extent support reducing debt burdens; optimal financial repression (strategy) [Bencivenga, Smith, 1992, pp. 767–790] still depends on the economic circumstances and creditors' expectations and can only be optimal without commitment, in (sudden) times of crisis or during wartimes [Chari, Kehoe, 2016; Dovis et al., 2020].

Hence it becomes evident that avoiding high debt in the first place is crucial.

However, to reach a substantial reduction in fiscal deficits, the question remains when (and to what extent) one should reduce the deficit (vide Greek sovereign debt crisis).

The discussion amid this crisis evolved into an "austerity vs. expansionary fiscal battle" with Krugman and Summers on one side and Reinhart, Rogoff on the other [Mencinger et al., 2014, pp. 403–414]. However, there was agreement in the academic literature that Greece missed the opportunity to reduce its primary deficits for many years and should have balanced its budget. Pensions and social transfers increased by 7% of GDP from the time of the Euro adoption to 2009, with public wages similarly impacted. This drove the overall fiscal deficit from 4 to 15% of GDP in 2009 [Thomsen, 2019]. In the crisis itself, the Greek government first followed a deficit-reduction approach (EU-Troika and IMF requirements for further loans) for quite some time but later declined a further conditional support package and turned to a more expansive policy. The IMF changed its policy stance and promoted a more expansive fiscal policy when showing a higher (corrected) fiscal multiplier (and subsequently more contractionary damage) than expected before [Batini et al., 2014; IMF, 2013]. Nevertheless, it also promoted a longer-term debt-reducing strategy and showed willingness to communicate.

Therefore the (optimal) fiscal reduction also remains a matter of timing and determining at which point (and severity) of the economic cycle as well as in which individual debt situation (absolute debt, relation of debt/GDP, debt structure and tenure, creditor structure) a country is (when applying fiscal measures) [cf. Alesina et al., 2019, pp. 5–6]. However, fiscal and debt reduction in some forms (better reduce spending than rise taxes [Alesina et al., 2019]) and areas (e.g. pension cuts) is possible without impacting growth-friendly expansions in others.

Hence in moderate or growing (pro-cyclical) GDP times, debt reduction is favorable and high debt can have negative effects on growth and prosperity [Reinhardt, Rogoff, 2010, pp. 573–578].

Famous proponents of "sustainable" debt levels (< 90%, longer-term and for emerging countries 60% of GDP as in the European Maastricht treaty [Reinhardt, Rogoff, 2010, pp. 573–578]) and structural deficit reduction measures are – among general mainstream economists – Carmen Reinhart and Kenneth Rogoff [Reinhardt, Rogoff, 2009]. Even after some corrections had to be made to their seminal original study (due to a calculation mistake discovered by a student a.o.), other economists and Rogoff's second longer-reaching study confirmed the original findings.

As I investigate the empirical relationship between debt and inflation, I briefly discuss some origins and causes of the dependent variable inflation.

2. The roots and causes of inflation

The common causes of inflation are less "slack" in the product or labor markets, upward pressure on prices, and rising wages. The wage-price spiral is better understood from the demand side. However, prices are often empirically "sticky" (neo-Keynesian approach), and relative prices must be considered. Furthermore, Friedman [1977, pp. 451–472] showed that there is no long-run trade-off between unemployment and inflation (cf. famous flat Philipps curve result), and inflation expectations (and "anchoring") are an important supply-side factor (among other factors, like production costs, which in most cases are related to higher labor costs or demand for natural resources) [Schwarzer, 2018, pp. 195–210; Cochrane, 2020]. Hence monetary policy alone (incl. forward guidance and controlling expectations) can, in a lagged fashion [Batini, Nelson, 2001], control inflation. However, recent empirical findings on long-term monetary expansion without inflation and fiscal arguments hint that Friedman's ideas are not comprehensive enough (financial sector specifics and an equilibrium real interest rate have to be taken into account); at the same time, one can now reject neo-Fisherian explanations with empirical confidence [Batini, Nelson, 2001; Demary, Hüther, 2015]. Other factors, like globalization with its pressure on wages and relative money supply [Fed, 2013], "saving gluts" [Rachel, Smith, 2015] from demographical trends [Summers, 2014; Weizsäcker, 2014, pp. 42–61], the flight of money into assets like stocks and houses ("asset price inflation"), and oil prices, play an important role as well. Governments must therefore contribute through, e.g., sufficient investment in infrastructure, demographic incentives ("family policy") and, most importantly, productivity-enhancing measures. With more substantial recovery, inflation seemed to return, and the Fed could slowly rise rates; up until 2019 the problem was less dramatic, with a slightly lower "new normal" [Brainard, 2015, pp. 414–422; Feldstein, 2018, pp. 415–422; Powell, 2019; DW, 2020].

The rising inflation in the western hemisphere at the beginning of 2021 (already in Q4 2020 in the US and the Eurozone), when the economies started to slowly recover after lockdown, could be seen even more clearly.

The IMF further adjusted the CPI to pandemic-related purchasing patterns (as they shifted dramatically during that time) and conducted a study which showed that inflation during the first three months of the pandemic was considerably higher than before (using the pre-COVID-19 CPI) [Reinsdorf, 2020].

The St. Louis Fed explained the implications of the pandemic on future CPI measurement and baskets of purchases in more detail and found out that with an adjusted CPI measure, inflation was rapidly approaching 2% at the end of 2020 and is roughly 50 base points higher than non-adjusted [McCracken, Amburgey, 2020]. In either case, due to massive government spending and monetary expansion, inflation is accelerating along an upward slope, in a textbook fashion. NBER confirmed the findings [Maas, 2020] based on the original work done in another NBER paper [Cavallo, 2020].

Ongoing discussions about the impediments and precise impact of the forecast inflation (and its projected absolute values) point to scenarios ranging from relatively moderate increases to extreme spikes [e.g. Harvey, Dunn, 2020]. Even Keynesian economists and self-described fiscal "doves" are increasingly concerned about rising inflation and the too large COVID-19 stimulus legislation program of the Biden administration, as mentioned by former IMF chief economist [Blanchard, 2021].

There is also a fiscal, debt-related side left to inflation – Friedman noted that it is only inflationary to run deficits if they are financed by "printing money", yet recent research hints that it is only part of the explanation [Cochrane, 2011], for in both explanations debt plays an important role [Borio, 2018, pp. 29–31].

Discussions (regarding the representativeness, the very core inflation definition, appropriateness of technological substitutes/progress, etc.) surrounding CPI as a standard measure for inflation are not further illustrated here, nor are other aspects of money supply, e.g. an interest rate linked monetary policy (instead of direct money aggregates) aimed at inflation targeting (ca. 2% in the US and Europe) [Jahan, 2017; Gali, 2008], as explicitly or implicitly followed by most major central banks (empirically relatively consistent with the Taylor rule [Hammond, 2012] and based on works such as [Hall, Sargent, 2018; Bernanke et al., 1997; Woodford, 2012]), which worked very well over the last 30 years. This was especially true during the "great moderation" period in the 1980s and 1990s [Woodford, 2004; 2013; Mishkin et al., 2012].

3. The VECM model linking debt to inflation

Linking debt (and deficits) and inflation, I will introduce a VECM model investigating the (cointegrating) relationship of these two variables. The aim of VECM models is to establish a long-run relationship between dependent (here inflation) and independent variables (here i.a. debt/GDP ratio) and to show short-run deviations and disturbance from them (and correct for the errors). Cointe gration means two or more integrated variables indicating a common long-run development.

The VECM model is a type of a VAR model, adding error correction possibilities and solving the problem of spurious regression. VAR is the multivariate (multi-dimensional) extension of well-known ARIMA (auto-regressive integrating moving average) models. In VAR, all variables can be treated as endogenous (hence also considering two-way relationships). A VECM model can be introduced as follows with the order (p – 1):

$$\Delta X_t = \mu + AB^T X_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + u_t \qquad [1]$$

where:

μ – deterministic shift-vector,
Γ_i – (k × k) parameter matrix of the lagged stationary differences,
B – (k × r) matrix of the k-dimensional cointegrating vectors,
A – (k × r) matrix of error correction coefficients (and u_t is the i.i.d. error).

The matrix hence illustrates the long-run relationship between the variables in X_t and Γ_i denotes the short-run coefficients. The vector X_t is assumed to be (vector-)integrated of order 1 (i.e. I(1)), hence ΔX_t is vector-stationary

4. Analysis overview

My empirical analysis starts with the unit root tests to show the effects of shocks on variables over time[9]. All tests are statistically significant at the 5% level (95% confidence interval). The Augmented Dickey-Fuller (ADF), Phillip Perron (PP), and Ng Perron (NP) tests can be used to confirm stationarity.

First, each variable is tested independently for integration and stationarity using the ADF. Then, if necessary, the differences (Δ) or lagged differences are brought to equal levels, but might lose interpretability; using another integration

[9] The tests are also quite useful for forecasting and testing whether a regression is spurious, cf. e.g. [Asteriou, Hall, 2011].

test later is not, however, necessary here. The test is done with a constant/intercept and with a constant plus trend (when necessary).

Afterward, an appropriate lag length selection is executed to obtain suitable homoscedastic, normally distributed error terms without autocorrelation. A standard comparer is also used as a lag length selection criterion – the Aikake Information Criterion (AIC) – in order to obtain the model with the lowest values. Alternatives are the SC or HQ test (cf. e.g. [Liew, 2004]).

The Johannsen cointegration test is then conducted. Its advantage e.g. compared to the Engle-Granger-test (not Granger-causality) is that it allows for the possibility of having more than one cointegrating relationship [Chang et al., 2011]. If a series is not co-integrated (i.e. that any shock to the system in the short-run quickly adjusts to the long-run, short-run model just to be estimated), a VAR model is used; if it is – VECM. Sims, Hanssen and Johanssen contributed to developing the theory of VECMs. In case the series (the single ones) are integrated in different orders or mutually cointegrated (I(0) and I(1) existing, not I(2)), a cointegration test is also required such as the Bounds test/ARDL test [Pesaran et al., 2001], after which one would continue depending on the result with ARDL or ECM. However, it is possible to use the Johanssen test in this case. The number of cointegrating vectors (rows in B^T) can be determined as the rank of the matrix AB^T. The test can take the form of maximum eigenvalue of Π or of the trace (sum of diagonal elements) of Π. After that, the model can be estimated (A, B, Γ) essentially by a maximum likelihood estimator (MLE, alternatively GLS). A diagnostic (and stability) analysis can be applied at the end.

Most standard statistical software (R language, STATA, SPSS, GRETL) can be used for VECM and the Johannsen test; some, like SPSS, need further extensions (based on R) or packages. I will use GRETL here.

5. Data sources

The data sources are official time series for economic research from the Federal Reserve of St. Louis. For inflation, it is the Consumer Price Index for All Urban Consumers: All Items Less Food and Energy in the U.S. City Average, hence Core Consumer Price Index (CPI, and for model purposes not the absolute values but ln-measures which means the inflation). The index is normalized with Index 1982 – 1984 = 100, and the monthly values (X-12 seas. ARIMA) are seasonally adjusted. Code is CPILFESL. For debt, I use the series with code GFDEGDQ188S, which is Federal Debt: Total Public Debt as Percent of Gross Domestic Product, Percent of GDP, quarterly data, seasonally adjusted. As the instrument for inflation targeting and central bank money control (IL-link), I add the federal funds rate (FFR). Its

corresponding series is BOGZ1FL072052006A (code) named: Interest Rates and Price Indexes, Effective Federal Funds Rate (Percent), Level, Percent, annual, not seasonally adjusted (as the period is already annual). The first two series are filtered as annual and as they are absolute values with no (moving/adjusted) averages or (percentage) changes, 1 January of each year can be taken as the date (time-synchronized).

As FFR and thus an included "controlling" instrument of the Fed is added, the series begins with 1983 (after Volcker's "crackdown on inflation" by sudden rate hikes), covers the "great moderation" period, and includes the recent financial crises (1989, 9/11, 2008, euro crisis), and ends in 2018. COVID-19 is not included as available data might still be subject to revision. Hence the paper covers a full quarter-century.

6. Results

The steps described above are pursued for the variables l_CPIT, i.e., log of CPI-total –the inflation, DT/GDP (debt to GDP ratio), and FFR. ADF tests for the (single) variable series. The AIC criterion is used and goes down from 6 (difference) lags. The result is that for FFR ($p = 0.02484$ 0.05 (LOS)) with constant and trend, a lag 1 describing a I(1) series is obtained, and for L_CIP (p-value 0.04917 0.05 (LOS)) with constant, a lag 1 describing a I(1) series is received. For DTGDP lag 1 is suggested by GRETL, but it is not clear from the p-value. Hence the KPSS test is done of the null-hypothesis of stationary with trend against a unit root (other than Dickey-Fuller where H0 suggest non-stationarity). For lag 1 H0 is clearly denied, with a unit root problem. The differentiated DTGDP, d_ DTGDP is used and KPSS done again, and then H0 is not denied (T036, $p = 0.058$), so trend-stationarity can be assumed. Trend 1 is received, and DTGDP as I(1) can be done. All processes are therefore integrated of order 1 (I(1)); alternatively, d_DTGDP or transformations as I(0) could be done, followed by the Bounce integration test.

Next, the appropriate common lag order is tested in GRETL via the AIC-criterion going down from 4 lags. Following AIC (or BIC, HQC), lag order 2 is the result (all criteria have the lowest score here). Hence the total (common) lag order is facilitated to perform the Johannsen test with lag order 2 and up to full rank. The trace and maximum eigenvalue test are used (T034, estimation period 34, lag order 2, number of equations 3, unrestricted/constrained constant), giving the results shown in Table 1.

Table 1. Trace and Eigenvalue test

Eigenvalue	Trace-test with p-value	Lmax-test with p-value
0.36505	16.337 [0.0356] [0.046 sample size corrected]	15.443 [0.0303]

Source: Own elaboration using GRETL.

For the cointegration vector, adjustment vector, and matrices like the long-term matrix, see Appendix A.

Rank order 0 and 1 ($p < 0.05$) are clearly denied; rank 2 is obtained as cointegration rank, giving a (2) cointegrated series as a result. Cointegration leads to VECM as a method, and with $p = 2$, p-1-VECM as VECM of lag order 1 and (cointegration) rank 2 are recommended as a model. The VECM model estimate (Johanssen procedure, ML estimator) is applied, and for the coefficients of the adjustment vectors, with a case of an unconstrained constant, produces the results presented in Table 2.

Table 2. Alpha (adjustment vectors)

l_CPIT	–0.036100	0.00022319
DTGDP	–8.8496	–0.0094076
FFR	–3.5603	–0.0051166

Source: Own elaboration using GRETL.

The exact data for d_l_CPIT, d_DTGDP, and d_FFR can be found in Appendix A.

The overarching covariance matrix yields the results presented in Table 3.

Table 3. Covariance matrix

	l_CPIT	DTGDP	FFR
l_CPIT	2.3084e-005	–0.0041268	0.0021892
DTGDP	0.0041268	7.5984	–1.2057
FFR	0.0021892	–1.2057	–1.6500

Source: Own elaboration using GRETL.

Conclusions

Keeping in mind X=(l_CPIT, DTGDP, FFR) and alpha as coefficients of A, beta of B (beta cointegration vectors, alpha lt-adjustment vectors), AB^T as long-term trend, Γ_i as short-term effect parameters and the following equation, the values

presented in Table 4 indicate a moderately fast adjustment of long-term equilibrium to shocks.

$$\Delta X_t = \mu + AB^T X_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + u_t$$

Table 4. Adjustment to long-term equilibrium – coefficients

DTGDP	–8.8496	–0.0094076
FFR	–3.5603	–0.0051166

Source: Own elaboration using GRETL.

The R^2 adjustment is very good for the first (single) equation above for l_CPI with nearly 80%. The other equations score satisfactorily (~20%).

The sign and strength of DTGDP and FFR show a positive versus a negative correlation for the variables with the inflation l_CPI (as heuristically feasible), with lower interest rates (FFR) leading to higher inflation and higher debts to higher inflation, yet the last is not highly significant. Nevertheless, especially during non-crisis times and in the long-run, lower debt seems to have a moderate constraining effect on inflation (0.4% for 1% debt), so deficit reduction measures should be enforced. We can therefore reject the null hypothesis H0 that there is no link between higher debt and rising inflation. The aim of the article was achieved and such a link established via the VEC-model. This becomes even more true as inflation is accelerating and considerably higher in nearly all forecasts. Yet FFR-interest rate policy and a trustworthy, credible central bank were even more critical in the US in the last 25 years.

The independence of central banks is an essential element that should be safeguarded and not lost in the current unconventional, crisis-mode driven situation. Therefore, joined with the modern inflation target policy framework [Balls et al., 2018], I would summarize – as Bernanke [2011] concludes in a speech for the Fed: "With respect to monetary policy, the basic principles of (flexible) inflation targeting-the commitment to a medium-term inflation objective, the flexibility to address deviations from full employment, and an emphasis on communication and transparency – seem destined to survive".

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Appendix A. Data series for the macro variables

Time	FFR	DT/GDP	CPIT	l_CPIT
1.01.1983	9.47	35.82911	97.6	4,580,877
1.01.1984	8.38	37.45447	102.5	4,629,863
1.01.1985	8.27	40.44121	107.1	4,673,763
1.01.1986	6.91	44.07415	111.9	4,717,606
1.01.1987	6.77	47.57835	115.9	4,752,728
1.01.1988	8.76	49.03151	120.9	4,794,964
1.01.1989	8.45	49.73276	126.5	4,840,242
1.01.1990	7.31	51.96856	132.1	4,883,559
1.01.1991	4.43	57.41652	139.5	4,938,065
1.01.1992	2.92	60.99679	145.1	4,977,423
1.01.1993	2.96	62.86657	150.1	5,011,302
1.01.1994	5.45	64.30709	154.5	5,040,194
1.01.1995	5.60	64.66271	159.0	5,068,904
1.01.1996	5.29	65.04171	163.7	5,098,035
1.01.1997	5.50	64.34428	167.8	5,122,773
1.01.1998	4.68	62.50988	171.6	5,145,166
1.01.1999	5.30	60.01334	175.6	5,168,209
1.01.2000	6.40	57.71743	179.3	5,189,060
1.01.2001	1.82	55.1304	183.9	5,214,392
1.01.2002	1.24	55.66835	188.7	5,240,158
1.01.2003	0.98	57.77057	192.4	5,259,577
1.01.2004	2.16	59.82355	194.6	5,270,946
1.01.2005	4.16	60.94141	199.0	5,293,305
1.01.2006	5.24	61.53482	203.2	5,314,191
1.01.2007	4.24	62.28400	208.6	5,340,419
1.01.2008	0.16	64.41587	213.771	5,364,905
1.01.2009	0.12	77.29970	217.346	5,381,491
1.01.2010	0.18	86.76598	220.633	5,396,501
1.01.2011	0.07	93.35519	222.803	5,406,288
1.01.2012	0.16	97.42044	227.877	5,428,806
1.01.2013	0.09	101.21783	232.229	5,447,724
1.01.2014	0.12	102.90374	235.961	5,463,667
1.01.2015	0.24	100.82572	239.811	5,479,851
1.01.2016	0.54	104.30307	245.075	5,501,564
1.01.2017	1.30	103.16562	250.519	5,523,535
1.01.2018	2.27	104.18644	255.106	5,541,679

Source: Federal Reserve of St. Louis.