The U.S. Economy After COVID-19: The Transmission Mechanisms of Monetary Policy *

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Abstract

We explore the dynamic effects of monetary tightening cycles on macroeconomic activity and inflation. We identify the traditional IS-channel as a main transmission mechanism of U.S. monetary policy—attesting for the dynamic effects of monetary interventions on macroeconomic aggregates and the role of real and financial frictions. For our baseline calibration of the IS-channel, a reduction in inflation will come along with a larger output contraction. Considering current sources and persistence of inflation, under this baseline calibration we assess the timing and intensity of a future recession for the U.S. economy.

1 Introduction

COVID-19 may be fading away, but it has left profound scars in the world economy. In this healing process, inflation seems a most visible long-term economic concern. After several years of subdued price growth, central banks made bold moves (e.g., *quantitative easing*) and pushed for zero interest rates to favor economic growth. In the meantime, various negative shocks—the Russian invasion of Ukraine, supply chain hurdles, and declines in the labor participation from COVID-19—have hit world markets and exacerbated the severity and

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persistence of U.S. inflation at interest rates near the lower bound. Energy, commodities, food, housing, and stock values jumped sharply. Besides, inflation is taking a toll on economic uncertainty and income distribution.

It is clear that central banks have a lot of work to do. Now, their main task is to cure inflation without unduly hurting GDP growth. Nonetheless, there is no consensus as to the stance of monetary policy and the persistence of inflation. Most diagnostics about the state of the economy and inflation forecasts have been too optimistic. Analysts are further coming to terms—repainting a more negative economic outlook. In spite of all these misconceptions, however, the U.S. Fed—as well as many other central banks—seems determined to restore its set-in-stone targets and wield its own monetary policy program gradually.

To center the debate, we intend to clarify the transmission mechanisms of monetary policy: the effects of central bank interventions on the various components of GDP and inflation. Usually, every research question starts with a set of empirical regularities or stylized facts that one wants to understand or rationalize. Hence, our objective is to pin down some basic facts on the propagation channels of monetary interventions.[1] We focus on some major economic recessions, and identify the traditional IS-channel as a main transmission mechanism for U.S. monetary policy. For a baseline calibration of this channel, a reduction in inflation will come along with a larger output contraction. Considering current sources and persistence of inflation, under this baseline calibration we assess the timing and intensity of a future recession for the U.S. economy.

Reduced to the bare essentials, our formulation of the IS-transmission mechanism of monetary policy builds on two basic postulates. After an increase in the interest rate: (i) the demand of consumer durables and investment goes down, and the ratio of consumer durables and investment over output also goes down; and (ii) the demand of consumer nondurables and services goes down, and the ratio of consumer nondurables and services over output goes up. Moreover, consumer durables and investment lead output, and their variation accounts for the lion's share of the output change.[2] For benchmark values of the involved elasticities

[1] These stylized facts should not be confused with structural estimation which must deal with underlying technical issues (e.g., identification, exogeneity, changing government interventions) supported by auxiliary assumptions. Stylized facts could nevertheless be a good starting point for model building.

[2] For the U.S. economy, consumption of nondurables and services accounts for about 60 percent of nominal GDP, and consumer durables and investment account for about 25 percent.

in (i)-(ii), we get that a reduction in inflation is much lower than the percentage change in the output contraction.

Several macroeconomic models fail to mimic basic aspects of the IS-channel. An increase in the FFR generates a “response chain” of key macroeconomic aggregates lowering output and inflation:

$$\uparrow i \Rightarrow I \downarrow \Rightarrow Y \downarrow \Rightarrow P \downarrow \Rightarrow U \uparrow \Rightarrow W \downarrow \Rightarrow M \downarrow .$$

Here, i denotes the interest rate, I denotes investment, Y denotes output, P denotes the price level, U denotes the unemployment rate, W denotes the average nominal wage, and M denotes a representative monetary aggregate. Moreover, we break down consumption C into consumer durables C_{dur}, consumer nondurables C_{ndur}, and services C_{srv}. Changes in i will translate into end-effects in Y and P. Under the IS-channel, $C_{dur} + I$ drives Y. The elasticities of the various components of $C_{dur}+I$ with respect to $(1+i)$ have been observed to range between 2 and 4. Since the share of $C_{dur}+I$ in Y is about 0.25, the elasticity of Y with respect to $(1+i)$ is usually less than 1. The elasticity of P with respect to $(1+i)$ is usually much lower. More precisely, the elasticity of $C_{ndur}+C_{srv}$ with respect to $(1+r)$ could be just below 0.4, and these latter items make up for a great part of the inflation basket. We should therefore expect P to have a smaller response than Y upon a change in i. Furthermore, W and U usually lag Y and P. We determine the time interval in which each variable would be reacting to the cumulative increase of the interest rate. These time intervals may overlap. Certainly, the duration and magnitude of these effects will depend on the state of the economy, price and wage rigidities, and other built-in frictions affecting the timing of investment. Leading and lagging indicators of output may enlighten our understanding of the underlying economic frictions. The fall in output growth could actually be dampened by countercyclical fiscal policy and the induced effects on international trade.

We then present some ballpark figures to portray the extent of the monetary tightening and the current state of the economy, which appears to go more in the direction of a *hard landing*. We would like to remark that we shall draw upon solid economic theory as well as the empirical evidence pervading every chosen economic recession. *In light of current macroeconomic conditions, under our baseline calibration of the IS-channel we get that the Fed should hike the Federal Funds Rate (FFR) to 700 basis points to meet the pre-specified inflation targets, but we posit that 550 basis points for the FFR is possibly a red line not*

to be surpassed. Both are conservative estimates inferred from previous data under the assumptions of low financial risk and moderate inflation persistence from external sources. Consequently, the main current policy issue is rather to determine an *upper limit* for the cumulative FFR increase compatible with acceptable losses in investment, output, and employment. The Fed will at least need over two or three years to restore its 2-percent inflation target at the risk of falling into a severe economic downturn. In our benchmark scenario, the real interest rate will be positive but core inflation will only get down to 3 percent. These policy adjustments to hold back current inflation trends will steer the economy toward a few quarters of negative GDP growth. The total output contraction could be up to 5 percent—considering this output fall as a deviation from trend—and the unemployment rate may jump to 7 percent. Because of the dual mandate the Fed faces an inflation-output trade-off; still, a high FFR may end into a deep recession and even into a financial meltdown. In the Great Recession of 2007-2009, our measure of the credit spread went up to 600 basis points, and the unemployment rate to 10 percent. A more gradual approach to inflation may be necessary, while sustaining economic growth and employment.
The dynamic effects of monetary policy on the economy have been the $leitmotif$ of a large strand of the literature [e.g., Boivin, Kiley and Mishkin (2010) and Ramey (2016)]. The topic, however, is still quite far from settled, which has prompted various authors to pursue different modeling strategies. Thus, understanding the transmission mechanisms of monetary policy is a key step for model building—drawing attention to certain economic assumptions and the relevance of some real and financial frictions as well as the interpretation of cross-correlations and estimates from VAR methods and related econometric techniques. In the absence of a well-established consensus as to the set of basic propagation channels that a good monetary model should be able to reproduce, there is a legitimate controversy as to the significance of major macroeconomic models for policy analysis [Cochrane (2022), Chari, Kehoe and McGrattan (2009), Linde, Smets and Wouters (2016), and Rupert and Susteck (2018)]. Essentially, these authors confirm that the most paradigmatic macroeconomic models are not supported on robust microeconomic evidence, and under limited conditions in these models an increase in the interest rate may generate lower output and inflation.

Macroeconomic models typically build on certain assumptions such as habit formation in consumption, substitution effects, liquidity constraints, and consumer heterogeneity. The necessity, relevance, and economic meaning of these assumptions has always been controversial, since they may be picking up propagation effects of monetary transmission mechanisms. Various influential models of monetary economics [Christiano, Eichenbaum and Evans (2005), Kaplan, Moll and Violante (2018), and Smets and Wouters (2007)] display a careful representation of the consumption and production sectors, but lump together all forms of consumption, and assume frictionless capital markets for the most part. In short, these models are not intended to replicate the IS-transmission mechanism of monetary policy whose effects may be magnified under credit frictions for prolonged increases in the interest rate—especially in times of heightened risk; e.g., Woodford (2010). More recent efforts have been directed toward financial intermediation and the ability of the central bank to provide collateral to the private sector and avert a financial crisis [Bianchi and Bigio (2022) and Gertler and Karadi (2011)]. Still, these modeling approaches—embedding credit frictions—are in a primitive stage to replicate the dynamics of real and monetary aggregates upon interest rate changes and other policy instruments.

We organize the discussion around a basic small-scale, short-run model of aggregate supply and demand in which labor participation, total factor productivity (TFP), and physical capital are predetermined. We focus on some episodes of persistent monetary tightening in which the Fed attempts to cool off economic activity to combat inflation. Unlike other central bank interventions to output and inflation, these *predetermined* policy shifts would be most suitable to establish the direction of causality among changes in the interest rate, economic activity, and inflation. Following Bernanke and Blinder (1992) and Romer and Romer (1989), most researchers generally assume that the FFR measures the stance of monetary policy. This line of research has dived into deep, technical identification issues to assess the economic effects of *monetary shocks,* but does not specifically get into identifying and testing the monetary transmission mechanism; cf., Ramey (2016). We take a step further and quantify the effects of monetary policy within the lenses of the IS-transmission mechanism. We go into great detail to study leading and lagging economic aggregates for output upon cumulative changes in the interest rate; e.g., see the Online Appendix below. We also provide some rough estimates for the elasticities of investment, output, and inflation over those cumulative changes in the interest rate.[3] We rely on U.S. data, and hence some of

[3] Bernanke and Blinder (1992), Romer and Romer (1989), and the related literature [e.g., Ramey (2016)]

these patterns may not fully extend to most other countries in which exchange rate and credit channels and further economic policy considerations are not on par with the U.S. economy. The U.S. dollar operates as the international reserve currency. Both the U.S. dollar and the public debt have proved to be very resilient—enjoying top credit ratings. The U.S. Fed has a dual mandate, which has been reflected in a disposition for more active policies towards stabilization of the economy as compared to many other central banks in advanced economies. Presently, most of Europe is undergoing an acute energy crisis. Along with monetary policy, several of these governments are coordinating and implementing further regulations and direct market interventions to stop inflation.

In fact, the U.S. economy is quite unique in regard to the differential impacts of energy, food and commodity prices, housing appreciation, a tight labor market, and very expansionary monetary and fiscal policies. As this constellation of forces bears on the persistence of inflation, it may be necessary to take an integrated approach to restrain cost-push factors. Energy and labor costs permeate the whole economy. The Fed has to juggle with too many balls at once—as many other central banks. The post-COVID-19 recovery seems indeed quite challenging. While some inflation sources are external to our economy, the Fed must have a well-defined policy plan; i.e., a time-table to reduce inflation. Economic activity does not respond immediately to monetary policy. Lagging effects preclude a fine-tuning of the economy and may result in suboptimal interventions of the form: *too little too late* or *too much too late*. The transmission mechanisms of monetary policy should prescribe central bank strategies.

In Section 2 we lay out our framework of analysis. We aim to characterize the effects of monetary policy on the dynamics of output, inflation, and employment. We take a close look at four salient periods of systematic interest rate hikes. Then, in Section 3 we review this empirical evidence under the IS-transmission channel of U.S. monetary policy and discuss

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are concerned with the direction of causality of monetary policy instruments to economic activity, but do not arrange the empirical evidence as per the transmission mechanisms of monetary policy. As a proxy for economic activity, Romer and Romer (1989) consider the index of total industrial production (IP) which is conveniently available on monthly data since 1919. The IP has been overshadowed by the service sector in the U.S. economy. Using quarterly data since 1947, our filtered measures of IP and real GDP exhibit a correlation of 0.9, but *the volatility of IP is twice the volatility of real GDP*. Hence, their estimates magnify the real effects of monetary policy. These authors and the ensuing literature do not intend to gauge the impact of FFR fluctuations on the various GDP components to configure the propagation channels of monetary policy.

some implications for economic modeling. In Section 4 we evaluate current sources and persistence of inflation. We start this discussion with what we call *the conventional model of inflation.* With all this background, in Section 5 we debate about the future state of the economy and advance some prescriptions for monetary policy. We conclude in Section 6 with a summary of our main findings. An Online Appendix goes over various quantitative exercises about the timing and impact of leading and lagging indicators of output, and some other claims made in the general course of the discussion.

2 Transmission Mechanisms of U.S. Monetary Policy

We begin with a reduced-form model of real aggregate supply and demand. The equilibrium condition determines both the general level of economic activity and employment. We then go to the data and look at the evolution of the output components and their further effects on inflation upon changes in the interest rate.

2.1 The Aggregate Supply and Demand

From the supply side, assume that GDP or aggregate output, Y, can be represented by a production function $F(A, K, hL)$, where A is total factor productivity, hL is hours worked or employment, and K is physical capital. We can think of h as the employment fraction of the active population, L. Hence,

$$Y = F(A, K, hL).$$

In the following discussion, A, K and L are predetermined variables. Regarding the demand side, Consumption, C, Investment, I, and Net Exports, NX, are functions of output produced, Y, the interest rate, i, and policy variables, Σ; cf., Friedman (1970). Government Expenditure, G, is exogenously given. We break down C into consumption of nondurables, services, and durables:

$$Y = C_{ndur}(Y, i, \Sigma) + C_{srv}(Y, i, \Sigma) + C_{dur}(Y, i, \Sigma) + I(Y, i, \Sigma) + G + NX(Y, i, \Sigma).$$

Besides G and the interest rate, i, we can think of other related policy variables, Σ, that determine the demand of the domestic and foreign sectors. Hence, Σ may include monetary aggregates, M, and fiscal variables such as taxes, and public budget deficits. Changes in these policy variables may be thought as unexpected policy shocks or innovations, but for the most part we want to interpret these changes as desired policy actions or systematic, unconditional moves towards the accomplishment of certain targets.

For fixed (G, i, Σ), our above two equations determine aggregate output, Y, and the fraction h of the employed population, or hours worked, hL. From the data, we further reexamine the interaction of real variables with prices and monetary aggregates. The modeling of prices and nominal wages appears to be a complex task that will take us too far from our original goals.

We would like to remark that under the IS-channel, investment I is a main driver of output. However, consumer nondurables and services $C_{ndur}(Y, i, \Sigma) + C_{srv}(Y, i, \Sigma)$ are the main components of the inflation basket. Therefore, there could be an asymmetric response of output and inflation to a systematic interest rake hike. Employment and wages usually lag output and inflation.

2.2 The Evolution of Real and Monetary Aggregates and the Federal Funds Rate (FFR)

(*i*) *Consumption of Nondurables and Consumption of Services:* $C_{ndur} + C_{srv}$. Figure 1 depicts the evolution of $(C_{ndur}+C_{srv})/Y$ and the FFR. Observe that this consumption ratio has been quite flat for a few decades. Therefore, $(C_{ndur} + C_{srv})/Y$ is quite insensitive to changes in the FFR, and $C_{ndur}+C_{srv}$ moves evenly with Y. As explained below, $(C_{ndur}+C_{srv})/Y$ picks up slightly in the shaded areas—time periods of business recession as determined by the NBER. In spite of the stability of this ratio, there have been secular shifts within C_{ndur} and C_{srv}. Over time, C_{ndur}/Y has trended downwards, and C_{srv}/Y has trended upwards. Also, with COVID-19, C_{srv}/Y went down roughly from 0.465 to 0.445, which was compensated by a similar and corresponding upward move in C_{ndur}/Y. In conclusion, $(C_{ndur} + C_{srv})/Y$ just hovers around 0.60.

(*ii*) *Consumption of Durables and Investment:* $C_{dur} + I$. Figure 2 depicts the evolution of $(C_{dur} + I)/Y$ and the FFR. As in the business cycle literature [e.g., Lucas (1977)], we can group together C_{dur} and I. From this literature it is known that this investment measure is about three times more volatile than output. Besides the FFR, several other sources such as technological innovations may account for the volatility of investment.

Fluctuations of the ratio $(C_{dur}+I)/Y$ accord with the traditional investment channel—playing second fiddle in most macroeconomic models. In this channel, $C_{dur} + I$ is a leading indicator of Y, and may trigger a major recession. Therefore, it becomes key to pin down the sensitivity of the ratio $(C_{dur}+I)/Y$ to changes in the FFR. This ratio hovers around 0.25, but can go up till 0.30, and in the Great Recession of 2007-2009 came down to 0.20.

(*iii*) *Government Expenditure and Net Exports:* G and NX. Figure 3 depicts the evolution of G and the FFR. Observe that G/Y fluctuates much less than our measure of the investment rate, $(C_{dur} + I)/Y$. Moreover, G/Y usually picks up in the shaded areas or time periods of business recessions. As discussed below, while investment is initially a leading indicator of output, in the recovery phase investment may even lag output. Hence, there could be some role for fiscal policy to boost output growth at the end of the propagation effects of systematic increases in the FFR. Moreover, $Y - C - I - G$ is generally countercyclical, which amounts to net exports, NX. The open-economy framework may dampen the multiplier effects of $C_{dur} + I + G$ on economic activity upon changes in the interest rate.

(*iv*) *Output, Employment, and Wages.* Figure 4 depicts the FFR and a smooth and detrended measure of output. For detrended data, we use a band-pass filter[4] isolating frequencies of the variable between 6 and 32 quarters [Christiano and Fitzgerald (2003)]. Observe that in a severe recession, from peak to trough our measure of output could go from 3 to -5. This move would represent an output contraction of 8 percent as the cumulative value of the deviation from its deterministic exponential trend. Unemployment is the opposite reflection of output; i.e., unemployment increases when output goes down; see Figure 5. In some severe recessions the unemployment rate has gone over 10 percent. Also, wages move together with unemployment albeit in the opposite direction; see Figure 6. Again, in severe recessions the reduction in wage growth could be of the order of 6 percent. As discussed below, wages slightly lag unemployment, and unemployment lags output. That is, for these three aggregates the ups and downs are not fully synchronized. Further, even under our filtered measure of output, changes in

[4]For comparison, we shall later report some results using the Hodrick-Prescott (HP) filter.

the unemployment rate are of smaller order of magnitude as those of output growth, and changes in nominal wage growth are slightly above those of the unemployment rate.

(v) *Output, Inflation, and Bank Credit.* As discussed below, inflation lags output; see Figure 7. This inflation lag points at price rigidities. While the FFR is a primary policy variable and should lead output growth, bank credit accommodates to changes in the interest rate, the available amount of bank reserves, output, and prices. It follows that $M2$ is influenced by both the initial monetary tightening and the propagation effects of monetary policy; see Figure 8. Therefore, broad monetary aggregates like $M2$ and $M3$ would not be good predictors of output growth [cf., Bernanke and Blinder (1992) and Ramey (2016)]. This is to be expected since the FFR is a primary policy variable, while monetary aggregates accommodate to the operation of the monetary transmission mechanism. Obviously, monetary aggregates can also be used as policy tools (i.e., helicopter drops, stimulus checks), and replicate some moves in the FFR. Figure 9 depicts the evolution of a measure of credit spread and the FFR. The credit spread ranges from 150 basis points in regular times to the 600 basis points of the Great Recession of 2007-2009. The credit spread picks at the end of every recession—further depressing investment and bank credit.

2.3 Monetary Tightening Cycles in the U.S.

While the above empirical evidence is quite suggestive about the effects of the FFR on output and inflation, several other explanatory factors may be reshaping these trends. Following Romer and Romer (1989), we now pick some time intervals in which the *Fed has declared a war on inflation.* These are cycles of systematic monetary tightening *to curb economic activity with the sole purpose to cure inflation.* The idea of replicating a *monetary shock*—identified as a carefully setup and controlled *economic experiment*—has been present at least since the *Monetary History* of Friedman and Schwartz (1963). Macroeconomic theorists have been elaborating on the *crucial experiment;* e.g., see Christiano, Eichenbaum and Evans (2005) and Gertler and Karadi (2015). Therefore, a monetary tightening cycle would be thought as an *exogenous policy change* instrumented for cooling down economic activity—to combat inflation. Our main objective here is to identify the monetary transmission mechanisms and quantify these effects of central bank interventions on economic activity over such isolated episodes.

Table 1 reports four episodes of systematic interest rate increases ending up in sizable drops in output levels. More specifically, we have selected the following time periods of steady FFR hikes: 1967-Q3–1969-Q3, 1972-Q1–1974-Q3, 1977-Q1–1981-Q2, 2004-Q2–2007-Q2. Bernanke and Blinder (1992) and Romer and Romer (1989) identify the first three episodes as deliberate Fed's attempts to slow down the pace of economic activity—lowering inflation. We are just adding the monetary tightening that ended in the Great Recession of 2007-2009. Table 1 reports various measures of inflation from the PCE and CPI indexes, filtered measures of output and its various components, employment and average nominal wages, and monetary aggregates. Below each macroeconomic aggregate the table lists the corresponding time interval in which this variable was continuously falling or increasing as the case may be.

We have discarded some notable recessions in the interwar period since quarterly data are mostly available from the national accounts that start in 1947. Besides, structural changes in the implementation of monetary policy make these earlier episodes hard to compare. Financial panics and banking crises surrounded some well-known crashing times of negative output growth.

By including the time period in which a given aggregate was falling or rising, we can dig into leading and lagging indicators of output, as well as the magnitude of the impact of a cumulative increase in the FFR.

(*i*) *Monetary Tightening Cycles.* In all cases, the cumulative increase in the FFR goes over 400 basis points. These gradual increases in the FFR span over two years.

(*ii*) *Leading and Lagging Indicators of Output: Real Variables. TFP, Consumer Durables and Investment Lead Output. Unemployment Usually Lags Output.* Note that TFP is the first economic aggregate to decline, and the first one to recover. This points to readjustments of labor and capital utilization in the production sector for initial changes in output. Then, consumer durables drops a few quarters before output; investment drops slightly before output; and unemployment usually lags the output fall. Government expenditure goes up upon the fall in output—avoiding a bigger decline in economic activity. In the recovery phase, unemployment and investment move more slowly than durable goods and output, which accords with the behavior of TFP and suggests the existence of adjustment costs and information frictions in the allocation of the factors of production.

(*iii*) *Leading and Lagging Indicators of Output: Price Variables. Inflation Lags Output, and Wages Lag Inflation.* These lagging indicators point at price and wage stickiness, which may result from firms' competition and optimization behavior. Inflation lags output for approximately two quarters, and wage growth lags inflation. Bank credit accommodates to the propagation effects of monetary policy and lags output. $M2$ follows more closely the monetary tightening cycle because of direct Fed intervention.

(*iv*) *Magnitude of the Changes in Output, Employment, and Inflation.* Over these four episodes, the average cumulative increase of the FFR was 775 basis points; the average cumulative drop in our filtered measure of output was 6.50 percent; and the average cumulative drop in our two measures of core inflation was 4.55 percent.

Certainly, leading and lagging indicators vary in both timing and the relative magnitude of the change across these severe recessions; see the Online Appendix. Hence, a closer look at the economic conditions surrounding each episode is necessary to account for specific deviations from the average figures. We will again touch upon these issues in Section 5 below, while assessing the present economic situation. Bernanke and Blinder (1992), Romer and Romer (1989), and the related literature [e.g., Ramey (2016)] run a battery of econometric experiments attesting for the real economic effects of monetary policy. This is actually short of our purposes. More specifically, we want to review the empirical evidence within the lenses of the IS-transmission mechanism. Romer and Romer (1989) consider the index of total industrial production and the unemployment rate. Total industrial production obviously accounts for a rather small employment fraction, and does not conform to the variation in GDP. Cochrane (1994) claims that their estimated effects appear to be quite large. As already pointed out, under the IS-channel certain GDP components may be quite sensitive to changes in monetary policy and do not reflect the general change in economic activity. In the Great Recession of 2007-2009, total industrial production went down 15 percent, while our GDP measure went down 5.10 percent.

The increase in the FFR that ended in 2007-Q2—extending into the financial crisis—was prompted by soaring energy inflation and one of the biggest housing bubbles. (Between January 2000 and January 2006, the Case-Shiller U.S. National Home Price Index went from 100 to 184.6.) The unemployment rate peaked at 10 percent in October 2009, and over 15 million people were unemployed. The drop in inflation was much smaller than average and the drop in output was bigger. The FFR went up by 424 basis points while the average of the two measures of core inflation only decreased 2.05 percent, and our filtered measure of output decreased 4.70 percent. In 2004-2007 there was a timely monitoring of inflation, and hence the ensuing variation in core inflation turned out to be quite small. As is well known, this *flattening of the Phillips curve* may reflect a more responsive stance of monetary policy in recent times. Because of the housing bubble and subsequent financial crisis, the output fall was much larger than average—even in spite of considerable government outlays. As discussed below, housing investment is an important pillar of the IS-transmission mechanism of monetary policy.

There were actually two systematic monetary tightenings between 1977-Q1 and 1981-Q2. We are just looking at their combined effects because it takes time for the various propagation channels to affect monetary policy. For instance, Romer and Romer (1989, p. 168) write: "In the postwar era the maximum depressing effect of anti-inflationary shifts in monetary policy occurs after roughly *two and one half years,* and there appears to be only a limited tendency for real activity to then return toward its pre-shock path." This tightening cycle comprises the smallest relative effect of the interest hike on output. The cumulative increase in FFR was over 1300 basis points while the drop in our output measure was 6.85 percent and the drop in average core inflation was 8.44 percent. As in the subsequent developments, we want to analyze these effects from the perspective of the IS-channel starting with the drop in the various types of investment as well as the fiscal boost of the Reagan Administration (cf., The Economic Recovery Tax Act of 1981) leading to higher government expenditure and pronounced budged deficits. The relatively large reduction in inflation seems due to the sharp fall in the oil price immediately after the peak and further credibility issues at the start of the Reagan-Volcker eras.

3 The IS-Transmission Mechanism of Monetary Policy

Our purpose here is to quantify the propagation effects of systematic interest hikes within the IS-transmission mechanism of monetary policy. The literature usually talks about the *real interest rate transmission mechanism of monetary policy* [Boivin, Kiley and Mishkin (2010) and Ireland (2008)], while we refer to the *investment or IS-transmission mechanism of monetary policy.* For our purposes, the reference to the real interest seems unduly restrictive since nominal interest rates could have their own investment effects because of liquidity constraints and other forms of market imperfection. Indeed, the FFR influences a variety of interest rates affecting different types of investment decisions; further, nominal interest rates commove with real rates in the very short term.

Our formulation of the IS-transmission mechanism of monetary policy starts with the following postulates. Upon an increase in the interest rate i:

(i) $C_{ndur} + C_{srv}$ goes down, and $(C_{ndur} + C_{srv})/Y$ goes up, and

(ii) $(C_{dur} + I)$ goes down, and $(C_{dur} + I)/Y$ goes down.

C_{dur} resembles I, rather than $C_{ndur}+C_{srv}$. But there are some differences between C_{dur} and I in both the timing and their sensitivity to changes in i. Usually, residential investment is the most sensitive component of I predating other types of investment and consumer durables, while investment in infrastructures is less sensitive to changes in i.

We now go over propagation channels of this transmission mechanism of monetary policy to evaluate changes in GDP and inflation. From some simple computations we want to illustrate the orders of magnitude of the response of different variables to systematic changes in the FFR.

3.1 Dynamics of Economic Aggregates

(i) Elasticities of Investment Over Cumulative Increases in the FFR. In Table 2 we report percentage changes in consumer durables, residential investment, and total investment upon cumulative increases in the FFR. The drop in consumer durables happens before investment and it leads output for about two quarters. Hence, C_{dur} leads I. Indeed, it may be harder for consumers to access credit and to diversify risks; moreover, consumer durables may be used less intensively than investment goods by firms. From Table 2,

the average elasticity of C_{dur} with respect to $(1+i)$ is 2.23. In contrast, from Table 1 the average elasticity of our filtered measure of output with respect to $(1+i)$ is 0.78, the average elasticity of C_{ndur} with respect to $(1+i)$ is 0.36, and the average elasticity of C_{srv} with respect to $(1+i)$ is 0.29.

The drop in I usually leads the drop in Y for about one quarter. From Table 2, the elasticity of I with respect to $(1+i)$ is 3.68. This higher elasticity is driven by residential investment. The elasticity of residential investment with respect to $(1+i)$ is 4.36. Residential investment predates other forms of investment [Bernanke and Gertler (1995)]. Contractors need time to build and must anticipate adverse economic conditions. Several papers find that residential investment substantially affects employment; e.g., Mian and Sufi (2014). Equipment goods are also quite sensitive to the interest rate while other types of infrastructures and inventories display smaller fluctuations.

Table 2 also reports a measure of credit spread with the highest value during the Great Recession of 2007-2009. This higher spread may explain why investment was quite sensitive to the interest rate increase during this recession.

(ii) Accounting for Output Changes. In Table 1, we report three measures of output: real GDP, real GDP using a standard version of the HP-filter, HP-GDP, and real GDP using the band-pass filter isolating frequencies for this variable between 6 and 32 quarters, BP-GDP. These two filtered measures are adequate to report the output contraction upon systematic changes in the interest rate. The variation in HP-GDP is greater than the variation in BP-GDP. From the average elasticities just computed, it follows that about one-half of the variation in HP-GDP comes from I, about one-fourth of the variation in HP-GDP comes from C_{dur}, and the remaining one-fourth comes from $C_{ndur} + C_{srv}$. As already pointed out, the average elasticity of BP-GDP with respect to $(1+i)$ is 0.78,

Fiscal policy is usually countercyclical—mitigating the extent of output fluctuations from the drop in consumer durables and investment. Moreover, the multiplying effects of investment may greatly differ in the open-economy framework. A decline in aggregate domestic demand would decrease purchases of imported goods and may stimulate exports.

From our analytical framework of Section 2, the loss in production would also be accommodated with a fall in employment—exerting downward pressure on wages. In general, the increase in the unemployment rate is smaller than the percentage output loss; i.e., Okun's law. In the Great Recession of 2007-2009 the increase of the unemployment rate was greater than the percentage loss in output because of the implosion in residential investment.

(iii) *Accounting for Inflation and Wage Growth Changes.* In the face of a lower aggregate demand and decreasing labor costs, prices for final goods and services will start to recede. From a quantitative point of view, the fall in core inflation is usually smaller than in our filtered measures of output. For the above parameter values, the explanation for this empirical regularity is to be found in the IS-channel. First, the average elasticities of $C_{ndur} + C_{srv}$ with respect to $(1 + i)$ are fairly small (i.e., much smaller than one) but $C_{ndur} + C_{srv}$ are major components of the inflation basket; hence, the inflation pressure should be low. And second, the elasticity of $C_{dur} + I$ with respect to $(1 + i)$ is around 3, and hence the percentage output contraction would be bigger.

Regarding wages, we can see from Table 1 that the decline in average nominal wage growth is roughly similar to the one in core inflation albeit with a lag. Also, the drop in nominal wage growth is slightly greater than the increase in the unemployment rate. As can be seen from Table 1, labor market indicators usually lag output and inflation. In fact, producers may react to changes in final demand by adjusting the price markup rather than wages; see Nekarda and Ramey (2020) for a broad discussion of the cyclical behavior of the price-cost markup.

To summarize, monetary tightening cycles will substantially affect output and inflation. Under the IS-channel, investment is the main driver of output. The elasticities of the various components of $C_{dur} + I$ with respect to $(1 + i)$ have been observed to range between 2 and 4. Since the share of $C_{dur} + I$ in Y is about 0.25, the elasticity of Y with respect to $(1 + i)$ is usually less than 1. Also, the elasticity of $C_{ndur} + C_{srv}$ with respect to $(1 + r)$ is below 0.4. Hence, inflation has a lower response than output to a change in i. Furthermore, employment and wages usually lag output and inflation. From the point of view of economic modeling, the challenge is then to understand the underlying real and financial frictions generating these quantitative effects. The fall in output would be higher, the greater are the elasticities of investment with respect to the interest rate. And the reduction in inflation would be higher the greater is the fall in demand on consumer nondurables and services.

3.2 Implications for Economic Modeling

Real and Financial Frictions. We have pointed at price and wage rigidities along with adjustment costs in factor relocation. Price rigidities generate real effects and delay the impact of monetary policy on inflation.

Financial frictions play a major role in some models highlighting the credit channel [e.g., Christiano, Motto and Rostagno (2014) and Gilchrist and Zakrajsek (2012)] and may affect the timing and response of leading and lagging indicators of output. Financial frictions may stem from the ability to access credit and to diversify risks under information asymmetries. These frictions may interact with the level of indebtedness of the consumption and production sectors, the health of the banking system, the public debt, and fiscal policy.

The transmission mechanisms of monetary policy should also be useful to assess the relevance of some assumptions presupposed in macroeconomic models. Parameter estimates for the degree of habit formation and the elasticity of intertemporal substitution in consumption may just reflect the variability of consumer durables. Certainly, models are idealized representations and their parameters will pick a wide variety of effects. Therefore, it is essential to delve into the main forces driving these effects. Consumer nondurables and services are less volatile and move evenly with income. This is not to deny the existence of liquidity constrains and wealth effects—albeit these effects seem quite small for consumer nondurables and services.

The Monetary Nature of the U.S. Business Cycle. Optimal monetary policy may magnify the effects of some other initial shocks. A structural modeling of the business cycle must deal with the transmission mechanisms of monetary policy. Most major U.S. economic recessions have occurred after prolonged increases in the FFR. These long Fed's interventions impact real economic aggregates. Further, the Fed is continuously monitoring output growth and inflation—impacting high-frequency output fluctuations. Therefore, policy intervention rules and the transmission mechanisms of monetary policy may magnify or mitigate the influence of primary forces on economic activity [e.g., McLeay and Tenreyro (2019)].

Reputation and commitment may be effective tools to quell inflation—being much less disruptive than the present propagation channels of monetary policy. While communication and *forward guidance* could usher agents' actions and expectations [Bowman (2002)], we argue below that COVID-19 has shattered the *conventional model of inflation.* These are not normal times: various inflation sources are contributing to the current state of uncertainty. The Fed needs to fit all the pieces together to address the persistence of inflation and anchor expectations.

A Money Supply Rule. What would happen if the Fed were to follow a monetary supply rule rather than the existing interest rate interventions? This is another version of the IS-transmission mechanism of monetary policy. A monetary rule could be a slower way to stabilize inflation since it may take time for the interest rate to adjust to the money supply change. Monetary aggregates could then be leading indicators of inflation and output—regaining predictive power. Further, in conjunction with the IS-channel there could be a direct effect of money creation (i.e., helicopter drops, stimulus checks) on expenditure—increasing the aggregate demand for final goods and services—and available bank reserves.

4 Sources of Inflation

The Fed has vowed to restore its 2-percent target for Headline *PCE (HL-PCE)* inflation, currently at 6.25 percent; see Table 3. This benchmark projection can be hampered by expectations about the future state of the economy and various sources of inflation: (i) *Uncertainties in the Global Economy:* soaring costs of food, energy, and other raw materials arising from the global geopolitical turbulence and supply-chain disruptions, (ii) *Wages and Price Markups:* inflationary wages originating from negative labor supply shocks. Pass-through or cost-push inflation from increasing wages into prices of final products, (iii) *The Housing Bubble:* lagging and persistent effects of housing rents in shelter-inflation as well as the future evolution of housing rental costs, (iv) *Expansionary Economic Policies:* inflationary effects of monetary and fiscal policies. The inflation rate was about 6 percent while the FFR hitting the lower bound [e.g., Blanchard (2022)]. By the IS-channel, negative real interest rates over long time periods generate inflation pressures through excessive investment and other expenditures.

In conclusion, as compared to other episodes of pronounced price growth the Fed has to juggle with too many balls at once to bring inflation down to the desired target. Observe that (i)-(ii) are supply shocks and (iii)-(iv) are demand shocks. Since headline inflation depends on external sources (energy and food data), for most of our discussion we focus on core inflation. Moreover, for convenience of the exposition we will focus on *CPI*-inflation.[5]

4.1 The Conventional Model of Inflation

Headline inflation will refer to *CPI*-inflation. Core inflation refers to *CPI*-inflation less food and energy. In the past, core inflation has hovered around 2 percent, and only in some short periods has deviated from headline inflation; see Figures 10-11.

What we term *the conventional or traditional model of inflation* is just a view as to how inflation has evolved from *the Great Moderation* since the late 1980s: (i) relatively high inflation for services, (ii) low or negative inflation for commodities, (iii) some sharp but relatively short fluctuations in energy and food prices, and (iv) nominal wage growth following core inflation plus TFP growth but losing against headline inflation.

As compared to commodities, services are usually non-tradable, labor intensive, and experience less productivity growth. Hence, services should be more inflationary than commodities because of *capital-biased technological progress and international trade.* Energy and food prices are fairly volatile, but usually peak within two or three years; then, they sharply go down. In spite of computerization, the U.S. share of labor compensation in *GDP* at current national prices remained constant over the last decade at around 59.50 percent (e.g., see FRED).

Inflation. Services account for about 60 percent of *CPI*-inflation, and commodities for 40 percent. Within these categories, food items make up 13.70 percent of the *CPI*, and energy items make up 8 percent. Between January 2000 and December 2019, inflation in services less energy averaged 2.76 percent, and inflation in commodities less food and energy averaged 0.01 percent; see Table 3. Energy inflation peaked at about 30 percent in the energy crises of 2003-2006 and 2007-2008, but both price cycles were relatively short to awaken fears

[5]The *PCE* price index, is the Fed's preferred inflation measure since 2000 [Monetary Policy Report to the Congress (2000)]. The *PCE* price index is quite similar to the *CPI* price index, but they differ in some respects. While expenditure weights in the *PCE* price index are continuously updated to take into account changes in the consumption bundle, these weights are adjusted periodically in the *CPI*. Both energy and housing costs make up a larger share of the basket of items included in the *CPI*; hence, *CPI* inflation is usually higher and more volatile.

of entrenched inflation. Within the 20-year period, energy inflation average 4.27 percent, and food inflation averaged 2.30 percent. Average *CPI*-core inflation over quarterly data averaged 2.1 percent over the twenty-year period, and *CPI*-headline inflation averaged 2.17 percent. Headline *PCE*-inflation averaged 1.86 percent, and core *PCE*-inflation averaged 1.75 percent.

COVID-19 broke apart this conventional model of inflation—a stronghold for anchoring inflation expectations over uncertainty and potential inflation pressures. After the COVID-19 outburst, prices for durable and non-durable goods were the first to jump. These prices are still in their two-year upward trajectory (see Table 3) because of supply chain disruptions, energy costs, and higher wages. Also, food and energy costs have skyrocketed, and these costs are not expected to go down so soon because of global geopolitical political turbulence and labor shortages. Therefore, the two most solid pillars of the conventional model of inflation to anchor price expectations [(ii)-(iii) above] have been shaken. COVID-19 also brought in labor shortages and wage growth, and continued expansionary monetary and fiscal policies rising aggregate expenditure. Housing rental prices went up over 20 percent.

Wages and Price Markups. Table 3 reports four measures of wage growth. Between January 2000 and December 2019, the average wage growth over all these measures is around 3 percent, whereas TFP growth averaged 0.76 percent. Hence, an average worker was able to secure core inflation plus TFP gains. Moreover, inflation was under Fed's control so that wages may be viewed as the endogenous variable. Now, both inflation and wages are endogenously determined; the direction of causality is much less clear.

Between August 2021 and August 2022 the average wage growth has been about 6 percent, core inflation has been 5.77 percent, and the annual growth of TFP has been 1 percent. Therefore, the average wage is still securing core inflation together with TFP growth, but is losing from headline inflation (7.77 percent). Obviously, average wages are usually more volatile than core inflation, and hence it is common (i.e., one-year observations) to see deviations of the average wage from core inflation plus TFP. As of now, the unemployment rate is quite low by historical accounts—about 3.7 percent. The low unemployment rate has been related to a drop in the labor force participation and to relative high expenditure as exemplified in the ratio $(C_{dur} + I)/Y$; see Figure 2. After extrapolating past trends, some estimates show that about 6M workers have withdrawn from labor participation. Consequently, there are indicators of labor shortages at the aggregate and sectoral levels [e.g., Ball, Leigh and Mishra (2022), Bauer, Edelberg and Estep (2022), and Blanchard, Domash and Summers (2022)], but average nominal wage growth so far fits within the conventional model of inflation—matching up core inflation and TFP growth.

At this descriptive level, we can furthermore review trends in profits and markups. From Table 3, profits have increased at an annual rate of 7.15 percent between January 2000 and December 2019. The general level of markups may have increased by 10 percent [Nekarda and Ramey (2019), Table 2] over the last decade. A few explanatory factors have been blamed for the evolution of profits. As already pointed out the above trend in the average wage suggests that the labor income share has been quite stable. Nonetheless, there has been a relative drop in the price of capital goods, and hence there is some room for the increase in profits coming from capital-biased technological progress. In a recent paper, Smolyansky (2022) computes that two thirds of the growth in profits over sales can be attached to the drops in the interest expense and the tax expense. Again, it is emphasized that these computations should be taken as a mere accounting exercise—without considering indirect economic effects of these changes on economic activity.

In conclusion, two basic pillars of the conventional model of inflation have been shaken. To meet the 2-percent inflation target, inflation in services no longer can be around 3 percent. Given the downward rigidity of nominal wages and services at very low inflation rates, one may argue that the Fed should temporarily redefine the 2-percent inflation target. The current evolution of labor markets still fits well within the conventional model of inflation: the average salary moves with core inflation and productivity gains. Profits may have been affected by lower prices for capital goods, taxes, and interest rates. We have not being able to observe structural changes in price formation for these production factors as potential drivers of cost-push inflation.

4.2 Monetary Aggregates, Asset Appreciation, and Inflation Expectations

From Table 3, between January 2000 and December 2020, average annual growth in $M2$ and bank credit has been around 6 percent. Growth of these monetary aggregates has been disconnected from the conventional model of inflation and wage growth. Likewise, inflation expectations has been disconnected from the growth of monetary aggregates. Rather, inflation expectations may have stemmed from trust and confidence that the Fed will keep core inflation at bay—safeguarding the conventional model of inflation. In this time interval, inflation in asset prices has also been below the growth of these monetary aggregates. Annual housing appreciation has averaged 4.5 percent while the S&P 500 has averaged about 5.30 percent and NASDAQ about 4.30 percent. As a matter of fact, in the past two decades the money supply has grown faster than any other relevant economic aggregate, and asset appreciation has overshadowed inflation of goods and services. Hence, broad money over nominal *GDP* has been growing consistently; see Wolf (2022). The long-trend slowdown of the money velocity conforms with declining interest rates since 1980s—converging to the lower bound. At present times, however, inflation erodes the value of money. Hence, bank deposits and government bonds become less attractive as compared to real assets—leading to further inflation in goods and services as well as asset appreciation through the investment channel.

With stimulus checks and further expansionary monetary and fiscal measures, COVID-19 witnessed the highest increase in monetary aggregates—pushing consumption and government expenditures [e.g., see Druckenmiller (2021)]. The Fed brought the *FFR* to the lower bound—increasing $C_{dur} + I$ through the investment channel. Housing appreciation has been commensurate to growth in bank credit and the money supply; see Table 3.

Inflation expectations and some financial indicators have been slow to react e.g., Chien and Bennett (2022). Inflation expectations trailed core and headline inflation, and are now moving together with salaries and core inflation. The Fed announced that it would begin to "taper" its large-scale asset purchases in November 2021, and started increasing the *FFR* in March 2022. But there was solid evidence much before that the persistence of inflation could become a serious policy issue [e.g., Summers (2021) and Druckenmiller (2021)].

5 Lessons for Managing of Monetary Policy in the Post COVID-19 Era

5.1 Persistence of Inflation

From the previous section we may now summarize several sources of inflation persistence.

(i) Energy and Food Inflation. Historically, energy and food have been important cost-

push factors of inflation—especially for commodities—and seem to be more persistent than in previous episodes. Usually, energy and food inflation faded after two years but now the geopolitical climate may expand this pricing cycle. Moreover, the following two facts are quite uncommon and signal that inflation may be quite entrenched and hard to bring down. As of August 2022, *CPI*-headline inflation is 7.77 percent and *CPI*-core inflation is 5.77 percent. Hence the gap between headline inflation and core inflation is 2 percent. Further, headline inflation has outstripped wage growth over the last two years. Real wages are falling down considerably.

(ii) *Wages and Markups.* As discussed above, over the last decade the evolution of wages and markups accords with conventional inflation patterns. Still, annual average nominal wage growth is above 5 percent. Only severe recessions have witnessed 5-percent increases and upward in the nominal wage. COVID-19 has contracted the labor supply, and increased the cost of durable goods and investment capital with added barriers in international trade. Further, interest rates and taxes are bound to increase. All these forces will exert inflation pressures on final prices of goods and services.

(iii) *CPI-Shelter Inflation.* National housing rents have experienced a cumulative increase of about 20 percent. Housing rents are a sizable part of the *CPI* and will translate into *CPI*-inflation with a lag between six and twelve months [Bolhuis, Cramer and Summers (2022)]. Hence, current double-digit housing rent inflation will factor into *CPI*-inflation at the end of 2022 and 2023.

(iv) *Monetary and Fiscal Policy.* Stimulus checks, other forms of money creation, and increased government outlays have shifted out consumer expenditure. Through the credit channel, interest rates at the lower bound have led to acute housing appreciation and increased demand of durable goods and investment. Negative real interest rates deplete savings and deposits—propping up asset prices, consumption, and investment. In March 2002 inflation indicators were marking rates over 6 percent while the FFR was still hitting the lower bound. The Fed has been lagging behind in its battle against inflation. Real interest rates are still negative.

5.2 Prescriptions for Monetary Policy

All our efforts so far have focused on a detailed account of the IS-transmission mechanism of monetary policy under systematic increases of the FFR based on the empirical evidence gleaned from four U.S. severe recessions. We now use the IS-transmission mechanism to offer some policy prescriptions based on our estimates of the propagation effects and current economic conditions.

Current Economic Conditions. (i) Persistence of Inflation: As already pointed out, there are several sources of inflation which appear to be long lasting; *(ii) Prospects of Low Economic Growth:* U.S. GDP growth is about 2 percent and TFP growth about 1 percent. After COVID-19, we may expect some increases in labor participation and mild improvements in TFP through the recovery of international trade and further efficiency from minimizing supply chain disruptions. Still, these positive supply shifts may be quite small. Because of weak economic growth, an output contraction may lead to negative GDP growth for several quarters or a long stagnation. The ratio $(C_{dur} + I)/Y$ was around 0.27; again, one could argue that this ratio is quite low since the FFR was at the lower bound and the real interest is negative; and *(iii) Weak Signs of a Financial Meltdown:* Indicators of credit risk and delinquency rates still display low values; see, however, Tanzi (2022). Hence, in our computations below for the IS-investment transmission mechanism we assume that there are no intrinsic patent risks of a financial meltdown.

The Great Recession of 2007-2009. The FFR went through a cumulative increase of 424 basis points prompted by soaring energy inflation and the housing bubble that propped up investment. Because of the financial meltdown, $(C_{dur} + I)/Y$ went from 0.285 to below 0.20. This investment drop of about 9-percentage points in $(C_{dur} + I)/Y$ generated an output fall of 5.12 percent. Housing investment went down from 6.7 percent of GDP to 2.4 percent. The output fall was mitigated by a large fiscal boost and a sudden drop in the FFR. Core PCE-inflation decreased 2 percent and headline PCE-inflation decreased over 5 percent. Inflation was timely monitored by the Fed, which may explain the relatively small drop in core inflation. The drop in headline inflation occurred within a single year, and came along with the sharp decline in energy prices. Crude oil went down from \$125 a barrel in July 2008 to \$42 in December 2008. The housing bubble increased asset values but not rental costs or shelter inflation.

Macroeconomic Laws. The following empirical regularities—reflecting some adjusting economic mechanisms discussed above—have been observed in all severe recessions considered above. *(i) Output and the FFR: The percentage contraction in output is usually smaller than the interest hike.* To gauge this contraction we have used two filtered measures of output in which the output contraction is expressed in percentage terms. In the IS-transmission mechanism the output contraction is driven by the elasticities of investment and durable goods with respect to the cumulative interest rate hike. Because investment and durable goods are about 25 percent of nominal output, these elasticities are not high enough to generate an output contraction greater than the change in the FFR. The output contraction may get worse if housing investment is high and then collapses, or in a financial meltdown. *(ii) Inflation and Output: Upon a systematic increase in the FFR the drop in inflation is smaller than the percentage output contraction.* This usually applies to both core and headline inflation—unless there is a large, sudden drop in energy and food inflation. For instance, over the above four recessions the average cumulative increase for the FFR was 775 basis points causing average core PCE-inflation to go down 3.78 percent, while the average output contraction for the HP-filtered measure of output was 6.50 percent. In fact, the cumulative drop in core PCE-inflation is 0.48 of the cumulative change in the FFR. Hence, assuming a peak value for core PCE-inflation of roughly 5.50, the required cumulative increment in the FFR would be about 700 basis points to reach the 2-percent inflation target. Again, to explain this relatively small drop of inflation to a systematic increase in the FFR from the perspective of the IS-transmission mechanism, we note that nondurable goods and services are fairly inelastic to the interest rate change but make up for a large component of the inflation basket. *(iii) The Labor Market and the FFR: Okun's law is at work. The percentage output contraction is generally greater than the increase in the unemployment rate. Moreover, the drop in wage growth is commensurate to the increase in the unemployment rate.* Finally, *(iv) Inflation and Wage Growth: Nominal wage growth usually follows core inflation plus TFP growth.* Hence, nominal wage growth may drop less than headline inflation. Markup measures are mostly countercyclical because wage growth lags inflation—not because the decline in wage growth is smaller than the drop in core inflation. As is well known, the labor income share is usually countercyclical as employment declines less than output.

Bernanke (2003) talks about *descriptive propositions* while referring to some empirical patterns regarding the timing and response of certain economic aggregates. These leads and lags may depend on various factors such as the underlying economic frictions and whether the policy change was expected or unexpected. Hence, the extent of these leading and lagging indicators seems to be a more complex topic that may deserve a closer look and may be most suitably addressed through structural estimation. We are hesitant to raise these descriptive propositions to the category of macroeconomic laws.

Bounds for Systematic Increases in the FFR. *(i) Lower bound:* By a lower bound for the FFR, we want to refer to the *minimum* cumulative FFR increase to restore the 2-percent inflation target. Annual headline *PCE*-inflation is now 6.25 percent, and headline *CPI*-inflation is 7.77. Core *PCE*-inflation is 5.01, and core *CPI*-inflation is 5.77. As already discussed, it may require a cumulative hike of about 700 basis points for the FFR to bring down all these inflation indexes to about the 2-percent target. As a matter of fact, the persistence of inflation now may be comparable—if not worse—to the one in the 1972-Q1–1974-Q3 period in which the cumulative increase in the FFR was 854 basis points, and the reduction in headline *PCE*-inflation was 6.38, in headline *CPI*-inflation was 6.86, in core *PCE*-inflation was 4.13, and in core *CPI*-inflation was 5.41. *From our computations in Section 3, a cumulative increase in the FFR of 700 basis points implies that the cumulative output contraction may be about 6.5 percent, the unemployment rate may jump to 9 percent, and nominal wage growth may get down to 1.5 percent.* Obviously, the future course of international markets for energy, food, and tradable goods will dictate the future state of the economy.

(ii) Upper bound: By an upper bound for the FFR, we want to refer to the *maximum* cumulative FFR increase compatible with an acceptable output contraction and unemployment rate. In the last two decades we have observed time spells of low economic growth while the FFR was hitting the lower bound. Hence, reasonably high FFR values may bring the economy into stagnation. From Figure 2 we observe that $(C_{dur} + I)/Y$ is now at around 0.27 and has never been below 0.20. Hence, letting $(C_{dur} + I)/Y$ go from 0.27 to 0.22 may increase credit risk and may lead to an output contraction over 6.5 percent which appears to be untenable. Therefore, it would be reasonable for the ratio $(C_{dur} + I)/Y$ not to go

below 0.23. Again, considering the monetary adjustments of 1972-Q1–1974-Q3 and 2004-Q2–2007-Q2, *the FFR could get to 500 basis points under current economic conditions of low economic growth. Accordingly, the total contraction for our filtered measure of output would be up to 5 percent, while unemployment may be shooting up to 7 percent. Inflation would near 3 percent and nominal wage growth 2.5 percent.*

Prescriptions for Monetary Policy. As these two bounds for the interest rate encompass regions with empty intersection, one would think that the Fed needs to decide between low output growth (or high unemployment) or high inflation. The economy, however, cannot get into a stall. More precisely, the FFR would need to jump to around 700 basis to bring down the above measures of inflation to the 2-percent target. The unemployment rate could then jump to 9 percent and the output contraction would be around 6.5 percent. The economy may get into a long recession (under our computations about 6 quarters of negative real GDP growth). Even if the Fed is seriously concerned about inflation there is an upper bound to FFR hikes. In the Great Recession of 2007-2009 the credit spread went up to 600 basis points and the unemployment rate to above 10 percent. We posit that 550 basis points for the FFR is a red line not to be surpassed. Also, the cumulative increase in the FFR cannot be too low. Indeed, should the FFR be lower than 500 basis points, then all economic agents may perceive that the Fed does not battle inflation seriously. Inflation expectations may become heavily rooted while real and financial markets would be operating under negative real interest rates.

6 Concluding Remarks

This paper contributes to three related areas of monetary policy. First, using a well-defined economic experiment or *monetary shock* we study in some depth the impact of systematic monetary policy interventions on economic activity and inflation. Second, as an outcome of this exercise we identify the IS-channel as a main transmission mechanism of monetary policy. And third, for a baseline calibration of the IS-channel we discuss some prescriptions for monetary policy under the current state of the economy and persistence of inflation.

We carry out a detailed study of the effects of systematic increases in the Federal Funds Rate (FFR) on economic activity. We assess the timing and response of the various components of GDP, inflation, and the labor market. Building on an approach pioneered by Romer and

Romer (1989), we focus on certain time periods—surrounding four U.S. severe recessions—in which the Fed is deliberately attempting to cool off real activity to combat inflation. These monetary tightening cycles are most adequate to establish the direction of causality from government interventions to changes in economic activity. We push this line of research a step further and document the workings of the IS-transmission mechanism of monetary policy. Most researchers usually appeal to VAR methods to capture the dynamic effects of monetary policy on economic activity, but these propagation effects are not built into the framework of the IS-transmission mechanism. An important lesson that emerges from the IS-transmission mechanism is that a monetary tightening cycle may risk a severe economic downturn because of the involved high output cost to quell inflation.

We quantify the direct influence and multiplying effects of prolonged, systematic interest hikes on investment, output, and inflation. The fall in output is driven by the elasticities of the various types of investment with respect to the interest rate hike; for instance, housing investment is usually very sensitive to interest rate changes. The persistence of inflation is driven by the fall in demand of consumer nondurables and services. Some of these consumption items can be be fairly inelastic to changes in the interest rate, and may require a further fall in income and wealth (housing values, and financial and monetary assets).

From the IS-channel we draw some important lessons for the managing of monetary policy, which may deserve to be raised to the category of *macroeconomic laws: (i) Output and the FFR.* The percentage output contraction would be smaller than the cumulative increase in the FFR unless there is a financial meltdown affecting the whole economy. *(ii) Inflation and Output.* Upon a cumulative interest rate increase the reduction in inflation is lower than the percentage output contraction. *(iii) Unemployment and Wages.* Related to *Okun's Law,* the percentage output contraction would be higher than the increase in unemployment; further, the increase in unemployment and the drop in wage growth are commensurate. And *(iv) Inflation and Wage Growth.* Related to *the conventional model of inflation,* nominal wage growth moves with core inflation plus TFP growth; hence, nominal wage growth may lose against headline inflation. Markup measures are mostly countercyclical because wage growth lags inflation—not because the decline in wage growth is smaller than the drop in core inflation.

We have approached the current state of the U.S. economy after COVID-19 under *three* *premises:* (i) persistent inflation—near 6 percent—stemming from various sources, (ii) slow economic growth: a moderate economic downturn may drive the economy into long stagnation, and (iii) as of now there is no patent risk of a financial crisis; hence, we are using conservative estimates for the elasticities characterizing the IS-channel. A cumulative increase in the FFR of about 500 basis points seems adequate to slowly transition into an era of positive real interest rates which are deemed necessary for optimal resource allocation and asset valuation. In this benchmark scenario, core inflation will drop from 6 percent to 3 percent, at most. The output contraction could be up to 5 percent, which would translate in about three quarters of negative real GDP growth, an unemployment rate around 7 percent, and average nominal wage growth of about 2.5 percent. Should the cumulative increase in the FFR be lower, inflation expectations may grow, and inflation could be long lasting. And should the cumulative increase in the FFR be higher, the excessive output loss may trigger a financial meltdown. In conclusion, the most plausible scenario for the Fed to restore price stability in the U.S. economy would be through a *hard-landing.* A cumulative increase of 550 basis points for the FFR is possibly a red line not to be surpassed. The Fed may be forced to exercise patience and endure inflation for a longer time span.

In all severe recessions discussed above, every increasing phase of the interest rate spans over two years, and the propagation effects may run for two more years. The FFR is usually changed gradually, and hence we can observe increasing and declining phases of interest rates over medium-term frequencies. Fluctuations in the FFR impact the real economy and asset markets—reshaping the dynamics of economic activity. Macroeconomists have long debated about the relative importance of real and monetary forces driving the business cycle. These primary forces interact with the Fed's attempts to stabilize the economy. In the last decades the Fed has leaned towards predictable rules to anchor inflation. Hence, cross-correlations of economic aggregates and related empirical regularities (e.g., the Phillips curve) may reflect the degree of government intervention and the transmission mechanisms of monetary policy. This poses an identification problem which may possibly be circumvented by explicit modeling of economic policy. Considering that Fed's interventions greatly affect real aggregates and asset values, the business cycle appears to be a monetary phenomenon to a major extent.

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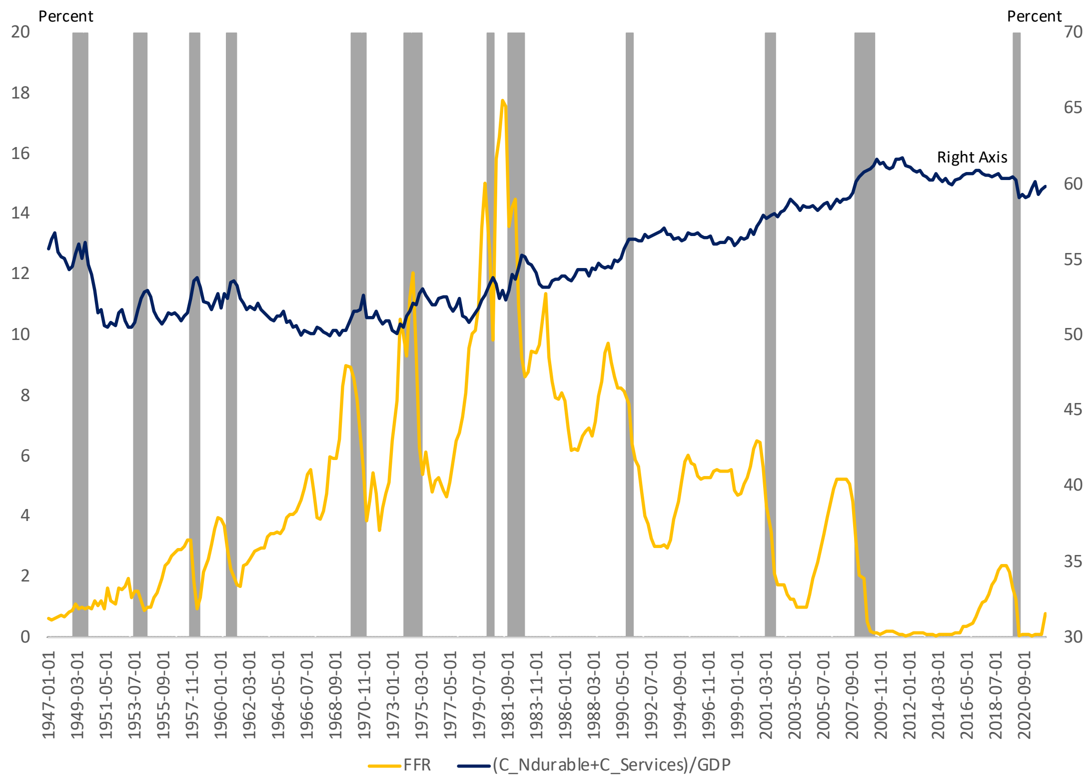
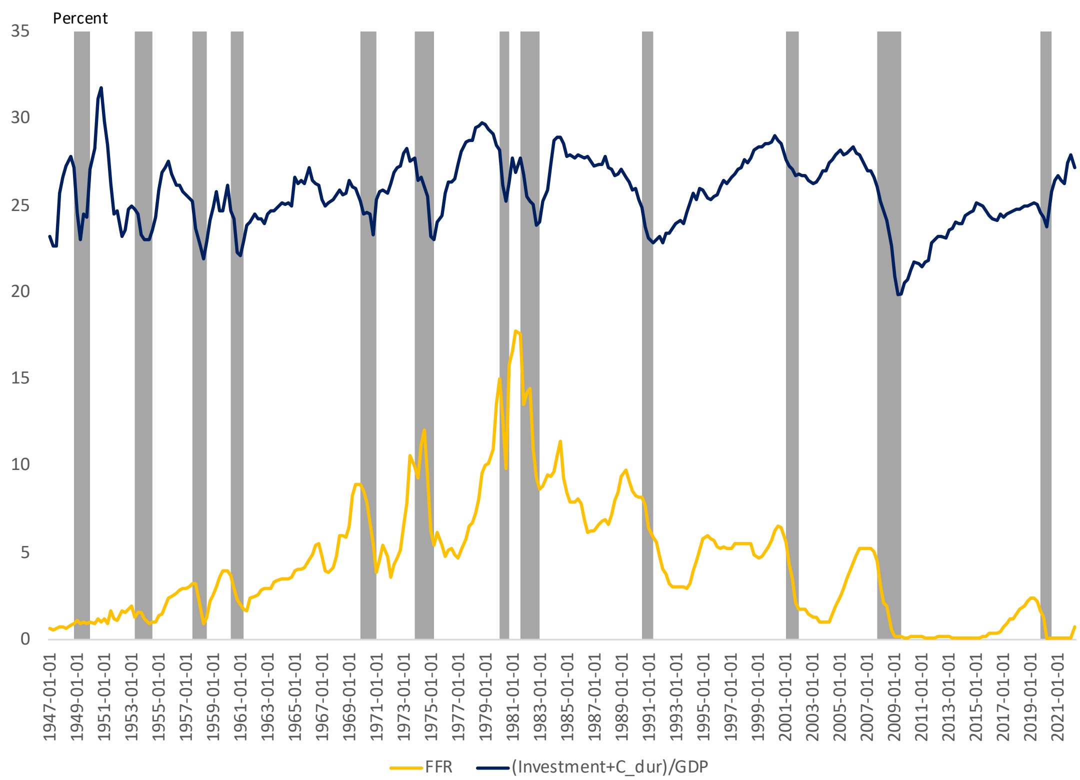
Figure 1: Nondurable Consumption and Services over *GDP*, and *FFR*



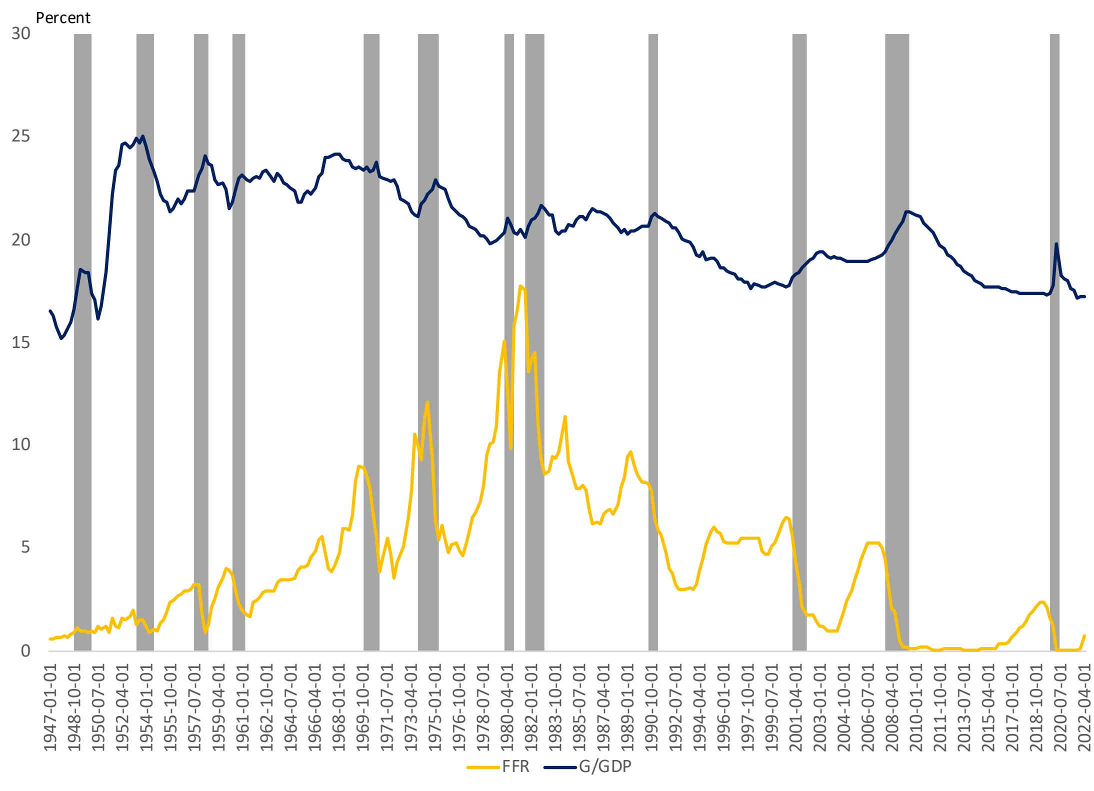
Notes: $(C\_Ndurable + C\_Services)/GDP$: Ratio of Personal Consumption Expenditures of Nondurable Goods and Services over *GDP*. *FFR*: Federal Funds Rate. Shaded areas represent periods of business recession as determined by the NBER. U.S. Bureau of Economic Analysis, Board of Governors of the Federal Reserve System (US), and FRED. Quarterly data.

Figure 2: Durable Consumption and Investment Over *GDP*, and *FFR*



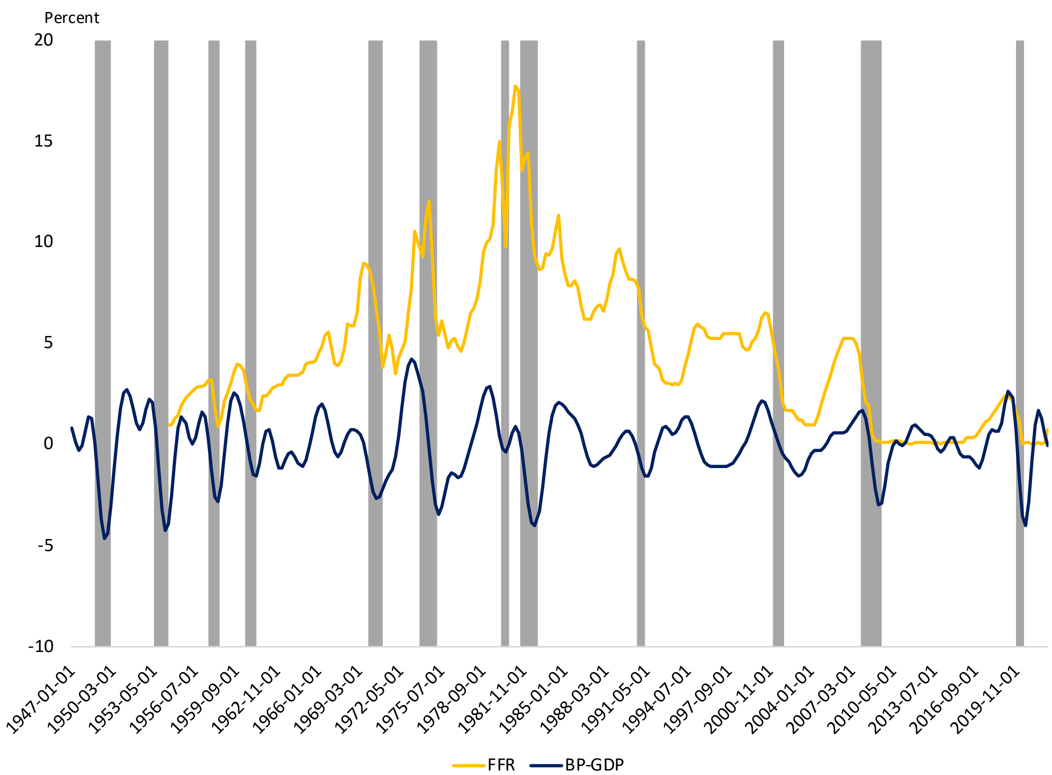
Notes: $(Investment + C\_dur)/GDP$: Ratio of Gross Private Domestic Investment and Personal Consumption Expenditures of Durable Goods over *GDP*. *FFR*: Federal Funds Rate. Shaded areas represent periods of business recession as determined by the NBER. U.S. Bureau of Economic Analysis, Board of Governors of the Federal Reserve System (US), and FRED. Quarterly data.

Figure 3: Government Consumption Expenditures and Gross Investment Over GDP, and FFR



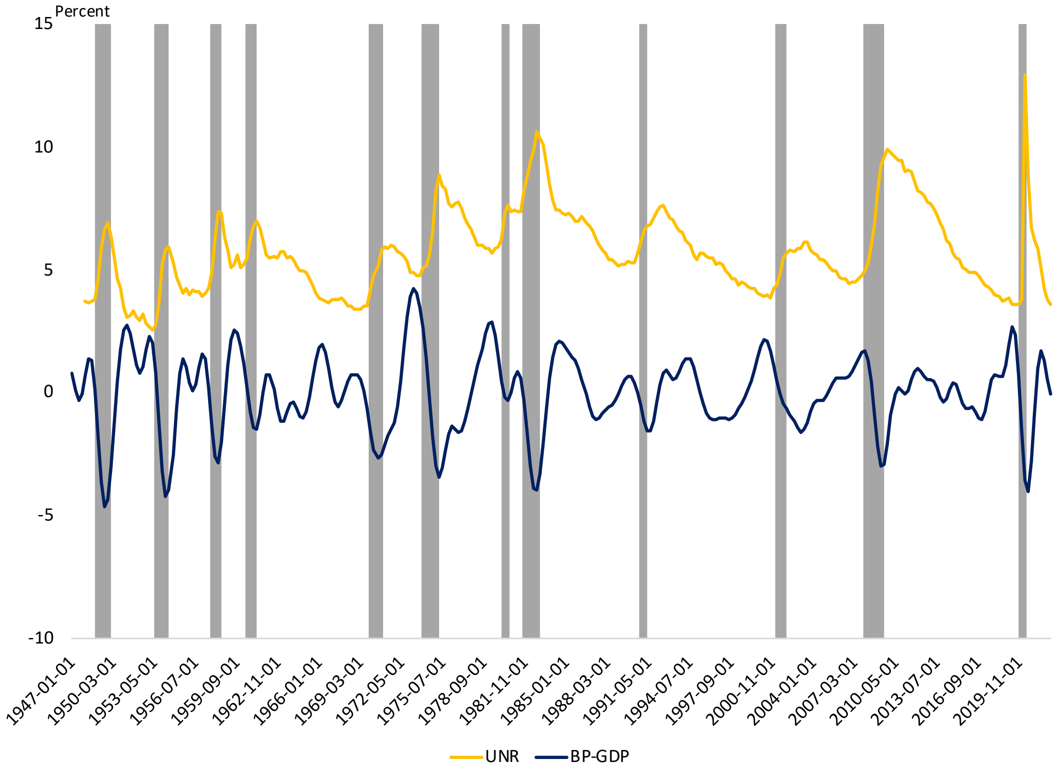
Notes: G/GDP: Ratio of Government Consumption Expenditures and Gross Investment over GDP. FFR: Federal Funds Rate. Shaded areas represent periods of business recession as determined by the NBER. U.S. Bureau of Economic Analysis, Board of Governors of the Federal Reserve System (US), and FRED. Quarterly data.

Figure 4: Filtered Real *GDP* and *FFR*



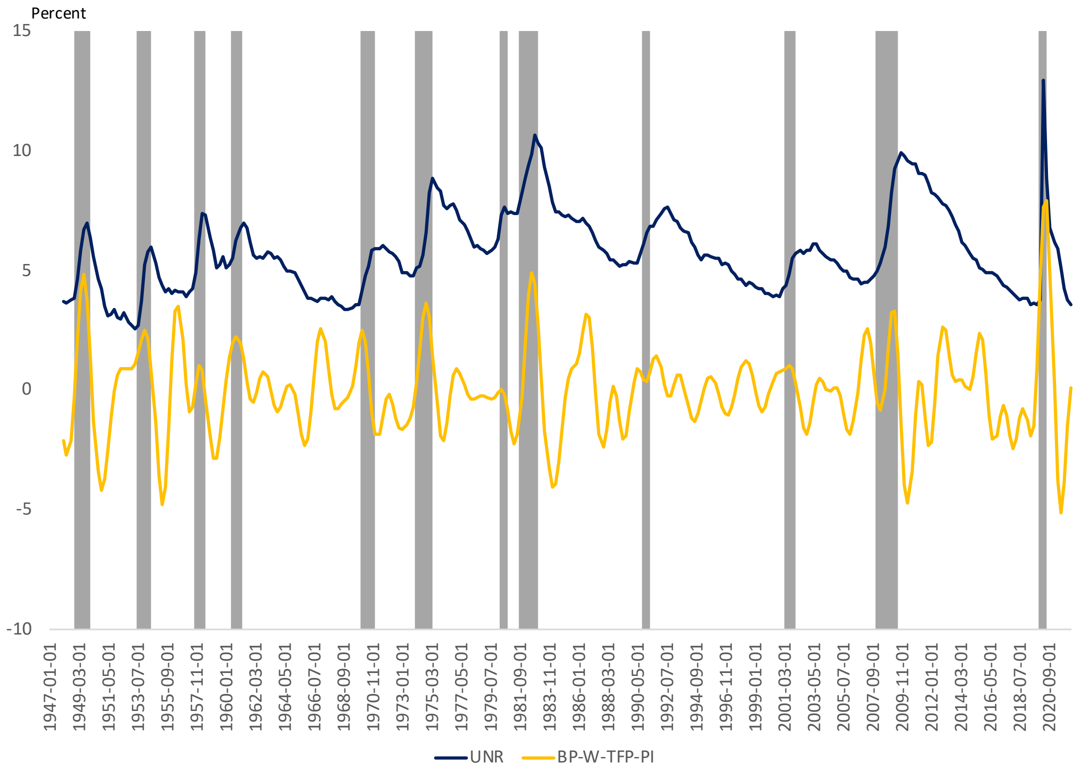
Notes: *BP-GDP*: Filtered real *GDP*. *FFR*: Federal Funds Rate. We use a band-pass filter isolating frequency bands of 6-32 quarters. Shaded areas represent periods of business recession as determined by the NBER. U.S. Bureau of Economic Analysis, Board of Governors of the Federal Reserve System (US), and FRED. Quarterly data.

Figure 5: Unemployment Rate and Filtered Real GDP



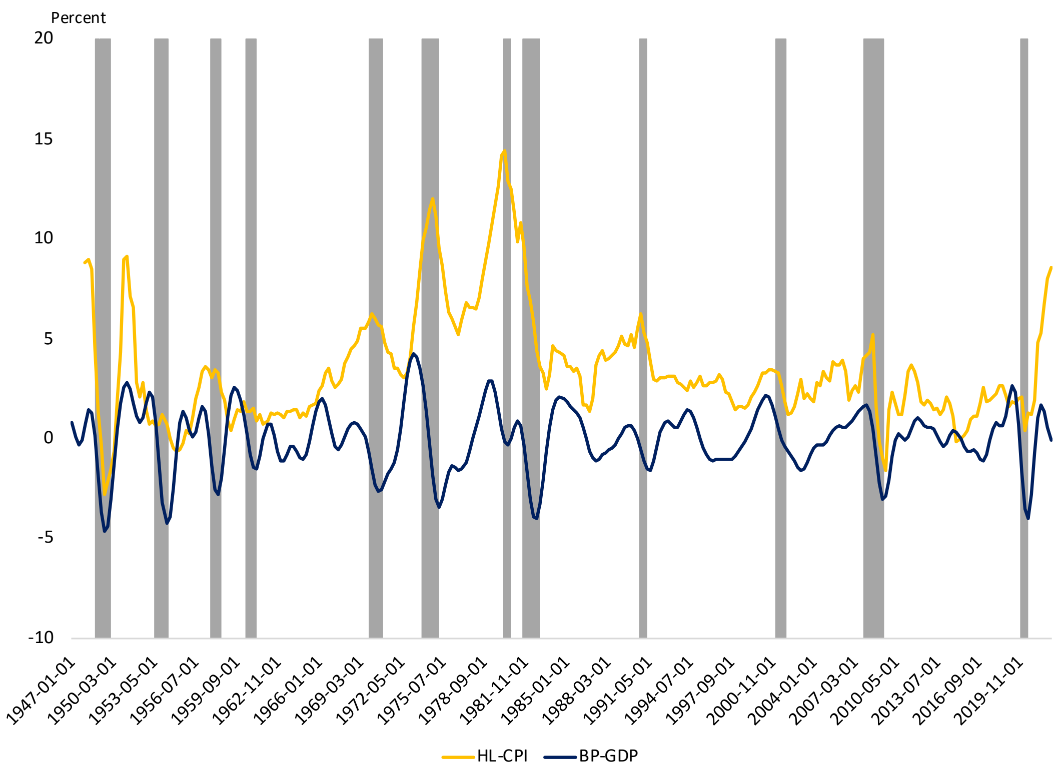
Notes: *UNR*: Unemployment rate. *BP-GDP*: Filtered real *GDP*. We use a band-pass filter isolating frequency bands of 6-32 quarters. Shaded areas represent periods of business recession as determined by the NBER. U.S. Bureau of Labor Statistics, U.S. Bureau of Economic Analysis System (US), and FRED. Quarterly data.

Figure 6: Unemployment Rate and Real Wage growth Less *TFP* Growth



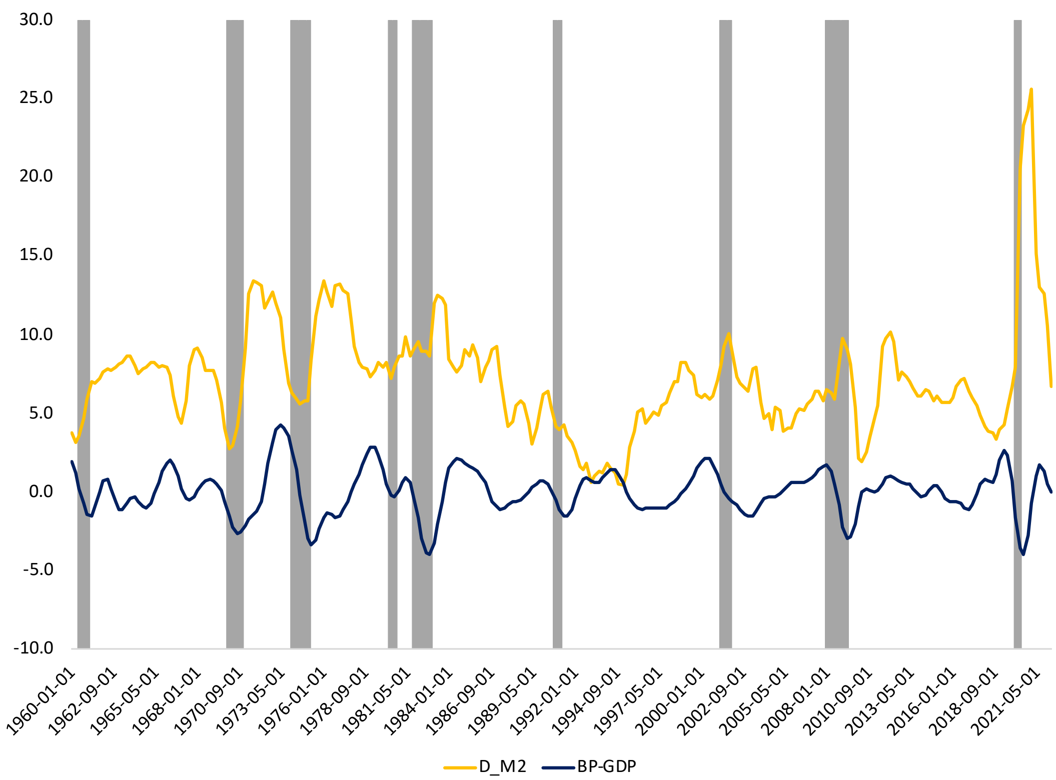
Notes: *UNR*: Unemployment rate. *BP-W-TFP-PI*: Filtered growth rate of Hourly Compensation for All Employed Persons less *TFP* growth less *CPI* inflation. We use a band-pass filter isolating frequency bands of 6-32 quarters. Shaded areas represent periods of business recession as determined by the NBER. U.S. Bureau of Labor Statistics, U.S. Bureau of Economic Analysis System (US), John Fernald's web page https://www.johnfernald.net/TFP, and FRED. Quarterly data.

Figure 7: Headline *CPI* Inflation and Filtered Real *GDP*



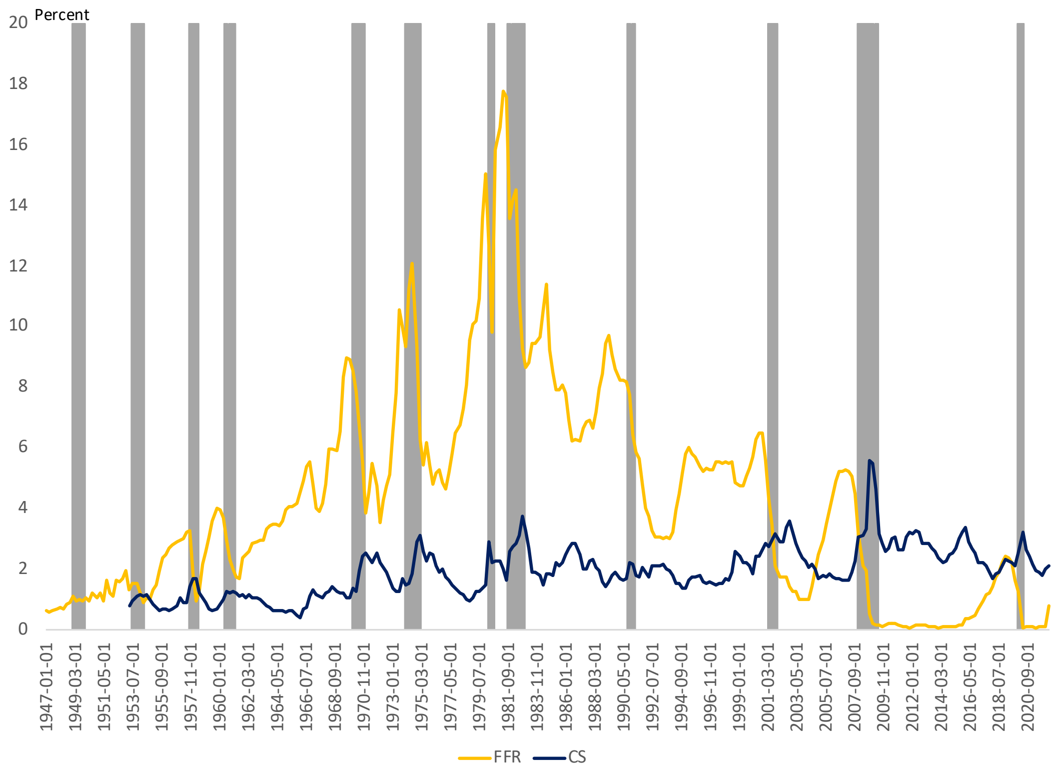
Notes: *HL-CPI*: Annual headline inflation from CPI. *BP-GDP*: Filtered real *GDP*. We use a band-pass filter isolating frequency bands of 6-32 quarters. Shaded areas represent periods of business recession as determined by the NBER. U.S. Bureau of Labor Statistics, U.S. Bureau of Economic Analysis System (US), and FRED. Quarterly data.

Figure 8: Annual Growth rate of *M2* and Filtered Real *GDP*



Notes: *D_M2*: Annual growth rate of *M2*. *BP-GDP*: Filtered real *GDP*. We use a band-pass filter isolating frequency bands of 6-32 quarters. Shaded areas represent periods of business recession as determined by the NBER. Board of Governors of the Federal Reserve System, U.S. Bureau of Economic Analysis System (US), and FRED. Quarterly data.

Figure 9: Credit Spread and *FFR*



Notes: *CS*: Federal Reserve Bank of St. Louis, Moody's Seasoned Baa Corporate Bond Yield Relative to Yield on 10-Year Treasury Constant Maturity. *FFR*: Federal Funds Rate. Shaded areas represent periods of business recession as determined by the NBER. Board of Governors of the Federal Reserve System and FRED. Quarterly data.

Table 1: U.S. Severe Recessions

	FFR Tightening Cycles			
	1967-Q3–1969-Q3	1972-Q1–1974-Q3	1977-Q1–1981-Q2	2004-Q2–2007-Q2
ΔFFR	5.09	8.54	13.12	4.24
	Inflation			
Δ*HL-PCE*	-1.73	-6.38	-7.30	-5.12
	(1970-Q1–1972-Q3)	(1974-Q4–1976-Q4)	(1980-Q1–1983-Q4)	(2008-Q3–2009-Q3)
Δ*HL-CPI*	-3.20	-6.86	-11.90	-6.86
	(1970-Q1–1972-Q3)	(1974-Q4–1976-Q4)	(1980-Q2–1983-Q3)	(2008-Q3–2009-Q3)
Δ*CORE-PCE*	-2.23	-4.13	-6.84	-1.94
	(1970-Q1–1973-Q1)	(1975-Q1–1976-Q2)	(1980-Q4–1987-Q1)	(2006-Q3–2009-Q3)
Δ*CORE-CPI*	-3.63	-5.41	-10.05	-2.17
	(1970-Q4–1973-Q1)	(1975-Q1–1977-Q1)	(1980-Q2–1983-Q3)	(2006-Q3–2010-Q4)
	GDP			
Δ*BP-GDP*	-3.43	-7.67	-6.85	-4.69
	(1968-Q4–1970-Q3)	(1973-Q2–1975-Q2)	(1979-Q2–1982-Q4)	(2008-Q1–2009-Q2)
Δ*HP-GDP*	-4.96	-7.57	-8.35	-5.12
	(1969-Q1–1970-Q4)	(1973-Q2–1975-Q2)	(1978-Q4–1982-Q4)	(2007-Q4–2009-Q2)
ΔGDP	-0.64	-2.45	-0.55	-4.00
	(1969-Q3–1970-Q1)	(1973-Q4–1975-Q2)	(1980-Q1–1982-Q3)	(2008-Q2–2009-Q2)
	TFP			
Δ*BP-TFP*	-3.18	-7.51	-4.25	-4.28
	(1968-Q3–1970-Q2)	(1973-Q1–1975-Q1)	(1978-Q4–1982-Q3)	(2006-Q1–2009-Q1)
Δ-*g*-*TFP*	-4.68	-9.70	-6.90	-6.26
	(1968-Q3–1970-Q1)	(1973-Q1–1974-Q4)	(1977-Q3–1982-Q3)	(2004-Q1–2008-Q4)
	Expenditures			
$\Delta C_{dur}/GDP$	-1.18	-1.62	-2.05	-1.90
	(1968-Q3–1970-Q4)	(1973-Q1–1974-Q4)	(1978-Q2–1981-Q4)	(2004-Q2–2008-Q4)
$\Delta I/GDP$	-2.04	-4.24	-4.68	-7.18
	(1969-Q1–1970-Q4)	(1973-Q2–1975-Q2)	(1978-Q4–1982-Q4)	(2006-Q1-2009-Q3)
$\Delta G/GDP$	0.29	1.73	1.81	2.44
	(1969-Q4–1970-Q4)	(1973-Q4–1975-Q1)	(1979-Q1–1982-Q4)	(2006-Q3–2009-Q3)
	Labor Market			
ΔUNR	2.63	4.10	4.97	5.50
	(1968-Q4–1971-Q3)	(1973-Q4–1975-Q2)	(1979-Q2–1982-Q4)	(2006-Q4–2009-Q4)
Δ*g*-*HCOMPBS*	-3.42	-5.16	-7.21	-5.41
	(1970-Q1–1971-Q4)	(1975-Q1–1976-Q2)	(1980-Q4–1983-Q4)	(2007-Q3–2009-Q1)

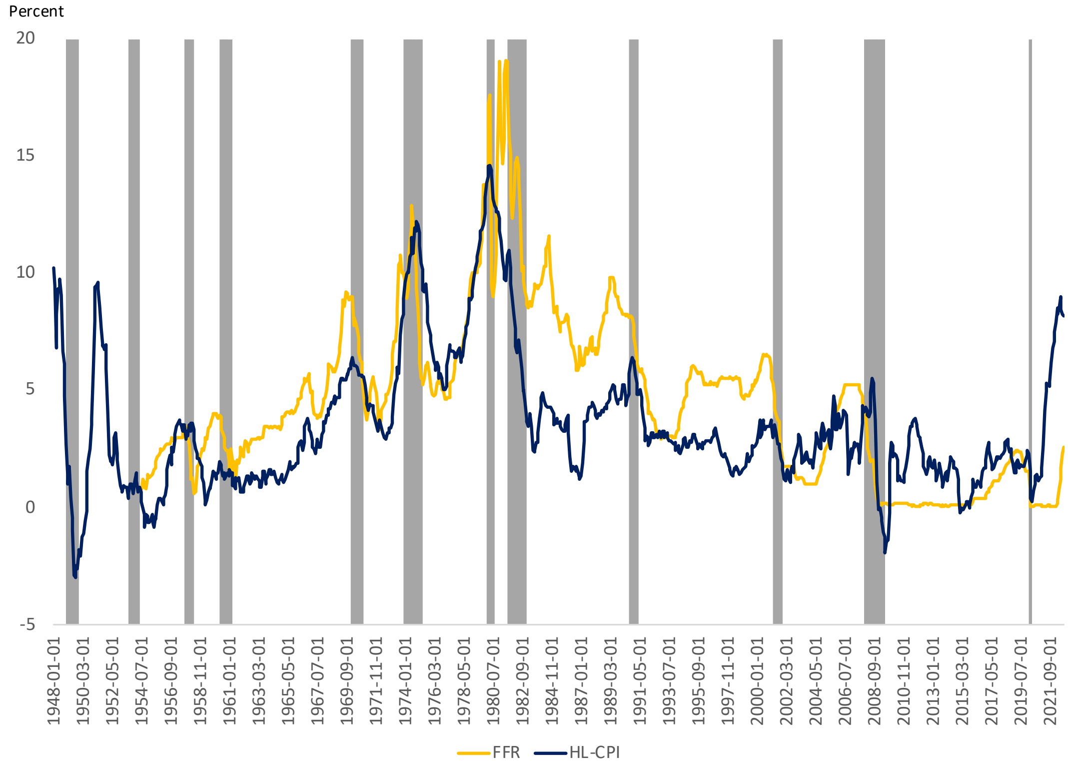
Notes: Quarterly data. For each variable, we consider the peak to through (or though to peak) percent change subsequent to the start of the corresponding monetary tightening cycle. ΔFFR: Change in *FFR*. Δ*HL-CPI*: Change in annual headline inflation from CPI. Δ*CORE-CPI* : Change in annual core (excluding food and energy) inflation from CPI. Δ*HL-PCE*: Change in annual headline inflation from the PCE deflator. Δ*CORE-PCE*: Change in annual core inflation from the PCE deflator. Δ*BP-GDP*: Change in band-pass filtered real *GDP*. Δ*HP-GDP*: Change in the Hodrick-Prescott filtered log of real *GDP*. ΔGDP: Change in real *GDP*. Δ*BP-TFP*: band-pass filtered *TFP*. Δ-*g*-*TFP*: Change in in the annual growth rate of TFP. $\Delta C_{dur}/GDP$: Change in the durable consumption over *GDP* ratio. $\Delta I/GDP$: Change in the investment over *GDP* ratio. $\Delta G/GDP$: Change in the government consumption and investment expenditures over *GDP* ratio. ΔUNR: Change in the unemployment rate. Δ*g*-*HCOMPBS*: Change in the annual growth rate of Hourly Compensation for All Employed Persons in the Business Sector. See Appendix for definitions and data sources.

Table 2: U.S. Severe Recessions (II)

	FFR Tightening Cycles			
	1967-Q3–1969-Q3	1972-Q1–1974-Q3	1977-Q1–1981-Q2	2004-Q2–2007-Q2
ΔFFR	5.09	8.54	13.12	4.24
	Investment and Durable Consumption			
$\Delta BP\text{-}I$	-11.37	-33.00	-29.60	-26.99
	(1969-Q2–1970-Q3)	(1973-Q2–1975-Q2)	(1979-Q2–1982-Q4)	(2008-Q1–2009-Q2)
$\Delta BP\text{-}I_{res}$	-19.66	-47.92	-48.56	-18.10
	(1969-Q1–1970-Q2)	(1973-Q1–1975-Q2)	(1979-Q2–1982-Q2)	(2007-Q4-2009-Q2)
ΔC_{dur}	-9.04	-23.41	-16.09	-13.44
	(1968-Q4–1970-Q3)	(1973-Q1–1975-Q2)	(1979-Q2–1982-Q2)	(2007-Q4–2009-Q2)
	Financial Indicators			
ΔCS	1.45	1.85	2.76	3.97
	(1969-Q1–1971-Q1)	(1973-Q3–1975-Q1)	(1978-Q4–1982-Q4)	(2007-Q1–2008-Q4)
ΔBCR	-8.08	-8.55	-5.58	-5.44
	(1968-Q4–1970-Q2)	(1974-Q2–1976-Q4)	(1979-Q3–1983-Q1)	(2008-Q4-2011-Q3)

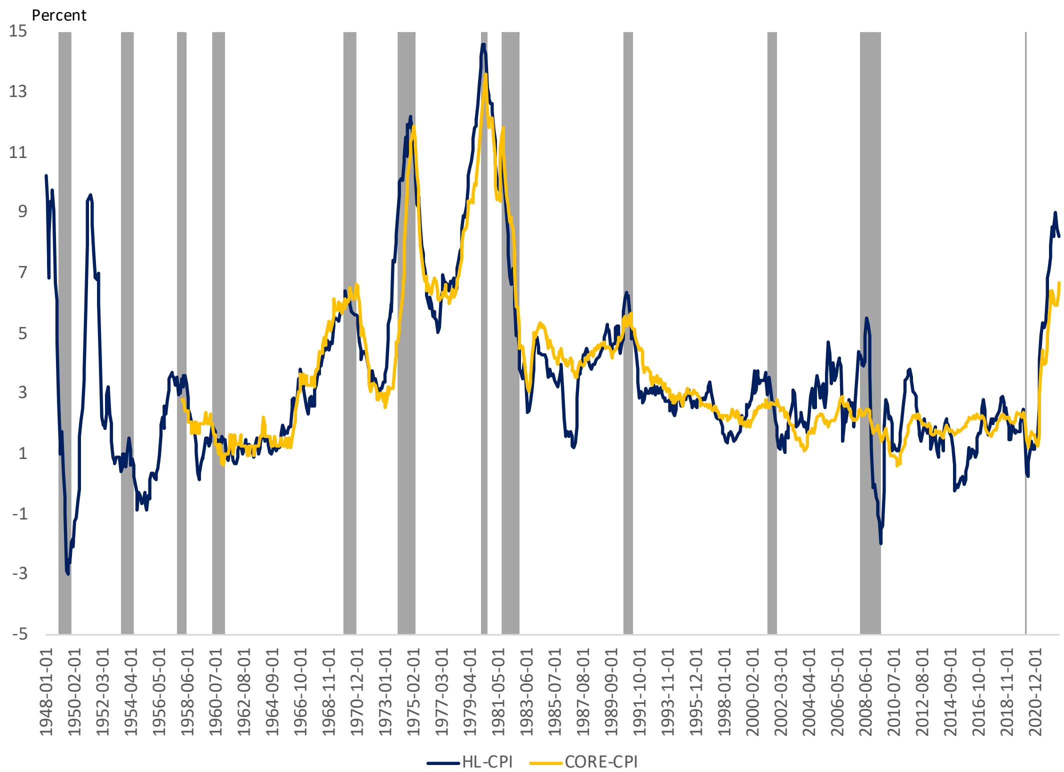
Notes: Quarterly data. For each variable, we consider the peak to through (or though to peak) percent change subsequent to the start of the corresponding monetary tightening cycle. ΔFFR: Change in *FFR*. $\Delta BP\text{-}I$: Change in filtered real gross private domestic. $\Delta BP\text{-}I_{res}$: Change in filtered real gross private domestic residential investment. ΔC_{dur}: Change in filtered real consumption of durable goods. textitCS: Change in Moody's Seasoned Baa Corporate Bond Yield Relative to Yield on 10-Year Treasury Constant Maturity. ΔBCR: Change in filtered bank credit for all commercial banks. See Appendix for definitions and data sources.

Figure 10: Headline *CPI* Inflation and *FFR*



Notes: *HL-CPI*: Annual headline inflation from *CPI*. *FFR*: Federal Funds Rate. Shaded areas represent periods of business recession as determined by the NBER. Board of Governors of the Federal Reserve System, U.S. Bureau of Labor Statistics, and FRED. Quarterly data.

Figure 11: Headline and Core *CPI* Inflation



Notes: *HL-CPI*: Annual headline inflation from *CPI*. *CORE-CPI*: Annual core inflation from *CPI* (excluding food and energy). Shaded areas represent periods of business recession as determined by the NBER. U.S. Bureau of Labor Statistics, and FRED. Quarterly data.

Table 3: Long-Run Averages

	Periods		
	2000-Q1–2019-Q4	2020-Q1–2021-Q2	2021-Q3–2022-Q2
		Inflation Measures	
HL-PCE	1.86	2.12	6.25
HL-CPI	2.17	2.43	7.77
CORE-PCE	1.75	2.06	5.01
CORE-CPI	2.01	2.30	5.77
ENERGY-CPI	4.27	3.00	31.51
FOOD-CPI	2.30	3.37	7.93
SHELTER-CPI	2.69	2.38	4.65
SERVICES-CPI	2.76	2.27	4.34
SER-LS-CPI	2.84	2.15	4.94
SER-LEN–CPI	2.76	2.29	4.81
DURCON-CPI	-0.91	4.41	14.78
COM-LFE-CPI	0.01	2.35	9.96
		Financial Variables	
BANK-CREDIT	5.89	7.79	9.02
M2	6.13	18.55	10.00
CASE-SHILLER	4.17	10.46	19.51
S&P500	5.30	20.50	14.46
NASDAQ	4.30	38.10	-23.99
PROFITS	7.15	17.60	15.00
		Wages	
AHE-PNS	2.82	4.77	6.52
ECI	2.60	2.92	4.91
ULC	1.24	3.99	7.43
HCOMPBS	3.17	6.30	7.06
ATL	3.38	3.55	5.40
		Real Growth	
GDP	2.09	1.08	3.73
TFP	0.76	1.12	1.27
TFP-UT	0.86	0.70	1.40

Notes: See Appendix for definitions and data sources.

Appendix

Δ***FFR*:** Change in *FFR*.

Δ***HL-CPI*:** Change in annual headline inflation from CPI.

Δ***CORE-CPI*:** Change in annual core (excluding food and energy) inflation from CPI.

Δ***HL-PCE*:** Change in annual headline inflation from the PCE deflator.

Δ***CORE-PCE*:** Change in annual core inflation from the PCE deflator.

Δ***BP-GDP*:** Change in filtered deviations of real *GDP* from its deterministic exponential trend (3.13% annual growth rate in 1947-Q1–2022-Q2). We use a band-pass filter isolating frequency bands of 6-32 quarters.

Δ***HP-GDP*:** Change in the Hodrick-Prescott filtered log of real *GDP*.

Δ***GDP*:** Change in real *GDP*.

Δ***BP-TFP*:** filtered deviations of *TFP* from its deterministic exponential trend (1.11% annual growth rate in 1947-Q1–2022-Q2). We use a band-pass filter isolating frequency bands of 6-32 quarters.

TFP is taken from John Fernald's web page https://www.johnfernald.net/TFP.

Δ-***g-TFP*:** Change in in the annual growth rate of TFP.

$\Delta C_{dur}/GDP$**:** Change in the durable consumption over *GDP* ratio.

Δ***I/GDP*:** Change in the investment over *GDP* ratio.

Δ***G/GDP*:** Change in the government consumption and investment expenditures over *GDP* ratio.

Δ***UNR*:** Change in the unemployment rate.

Δ***g-HCOMPBS*:** Change in the annual growth rate of Hourly Compensation for All Employed Persons in the Business Sector.

Δ***BP-I*:** Change in filtered deviations of real gross private domestic investment from its deterministic exponential trend (3.90% annual growth rate in 1947-Q1–2022-Q2). We use a band-pass filter isolating frequency bands of 6-32 quarters.

Δ***BP-***I_{res}**:** Change in filtered deviations of real gross private domestic residential investment from its deterministic exponential trend (1.98% annual growth rate in 1947-Q1–2022-Q2). We use a band-pass filter isolating frequency bands of 6-32 quarters.

ΔC_{dur}**:** Change in filtered deviations of real consumption of durable goods from its deterministic exponential trend (5.16% annual growth rate in 1947-Q1–2022-Q2). We use a band-pass filter isolating frequency bands of 6-32 quarters.

Δ***CS:*** Moody's Seasoned Baa Corporate Bond Yield Relative to Yield on 10-Year Treasury Constant Maturity.

Δ***BCR*:** Change in filtered deviations of bank credit for all commercial banks from its deterministic exponential trend (7.52% annual growth rate in 1947-Q1–2022-Q2). We use a band-pass filter isolating frequency bands of 6-32 quarters.