Inflation and Treasury Convenience*

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Abstract

Does inflation depress the convenience yield of U.S. government debt? Using a century of data, we find Treasury convenience comoves positively with inflation during the inflationary 1970s and 1980s, but negatively in the pre-WWII period and the pre-pandemic 2000s. The positive convenience-inflation relationship is strongest for supply and core components of inflation. Higher inflation tends to lead higher convenience spreads in the 1970s and 1980s, but higher convenience spreads tend to predict declines in inflation in the data. In our equilibrium model, exogenous shocks to inflation raise nominal interest rates and the opportunity cost of holding money and money-like assets, inducing a positive inflation-convenience relationship as in the 1970s and 1980s. In contrast, exogenous shocks to liquidity preferences raise the demand for Treasuries, lower consumption demand and inflation, and induce a negative inflation-convenience relationship as seen pre-WWII and post-2000. Our theory also predicts that periods with high bond-stock betas feature a more positive inflation-convenience relationship, in line with the data. However, a direct effect of inflation depressing Treasury convenience is inconsistent with our evidence.

Keywords: Treasury convenience; inflation; demand shocks; money view; New Keynesian models

JEL classification: E44, E58, G01, G28

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1 Introduction

How is Treasury convenience linked to inflation? The relationship between liquidity, interest rates, and inflation was central to the vigorous macroeconomic debates of the 20th century (Keynes (1937), Friedman (1969)). Today, it is again relevant due to renewed concerns about inflation and the status of US Treasuries. Recent progress in the understanding of Treasury markets indicates that investors value US Treasury securities more highly than assets with the same cash flows, i.e., Treasury bonds have convenience value (Longstaff, 2004; Du et al., 2018b; Krishnamurthy and Vissing-Jorgensen, 2012). Besides serving as a significant source of substantial fiscal capacity, Treasury convenience affects monetary policy transmission (Drechsler et al., 2018; Jiang et al., 2023), drives business cycle dynamics during global financial crises (Del Negro et al., 2017; Li, 2024), and is a critical component of dollar valuation and exchange-rate dynamics (Jiang et al., 2021; Du et al., 2018a).

In this paper, we use a century of US data to document secular shifts in the relationship between Treasury convenience and inflation. Figure 1 illustrates a striking fact: Convenience comoves positively with inflation during the most inflationary episode, but not before or after.[1] In periods typically associated with supply-side shocks, such as the 1970s and 1980s, higher inflation tends to go along with higher – not lower – Treasury convenience. Conversely, in periods with preeminent demand-side shocks, such as financial crises, including the pre-WWII period and the pre-pandemic 2000s, lower inflation tends to coincide with higher Treasury convenience.

We argue that these findings can be explained by the changing dominance of two channels with a long tradition in the economic debate: the "money channel" and the "liquidity demand channel." The money channel encapsulates the monetarist perspective that the nominal rate of interest is the cost of holding money (Cagan, 1958; Tobin, 1969; Friedman, 1969), augmented with the view that Treasury bonds of all maturities have some money-like qualities (Friedman and Schwartz, 1982).[2] This channel generates a positive inflation-convenience relationship, as higher inflation

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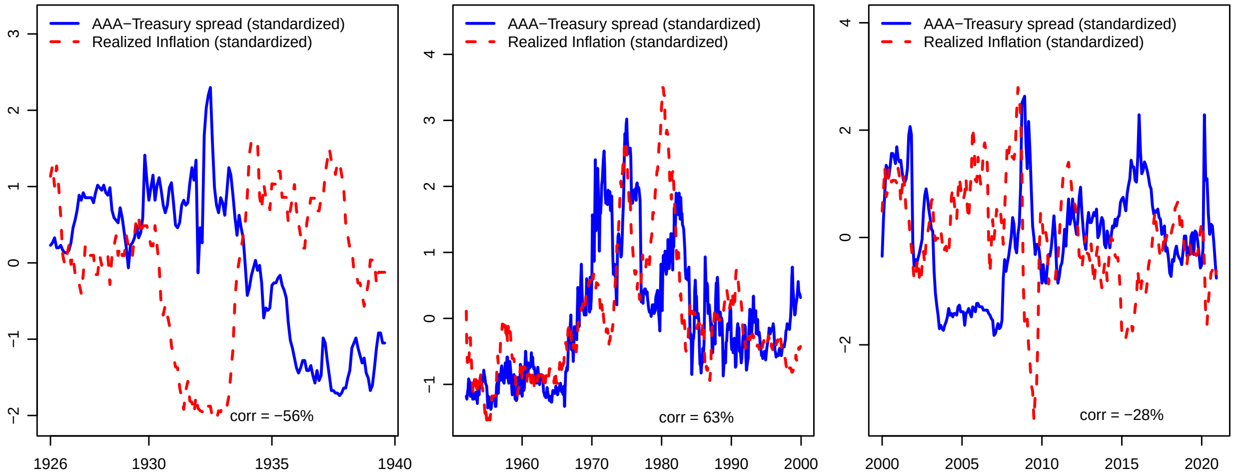
[1] We follow Krishnamurthy and Vissing-Jorgensen (2012) in measuring the convenience value of Treasury bonds with the spread between Aaa-rated corporate bond yields and long-term Treasury bond yields, consistent with the fact that Aaa-rated corporate bonds have never defaulted during our historical period. A higher Aaa-Treasury spread corresponds to a higher value of Treasury convenience.

[2] A long literature has argued that monetary aggregates include not only narrow money but also other liquid assets (Barnett et al., 1984; Lucas and Nicolini, 2015; Ireland, 2009), including Treasury securities that provide liquidity services (Friedman and Schwartz, 1982; Holmström and Tirole, 1998; Longstaff, 2004; Krishnamurthy and Vissing-Jorgensen, 2012; Nagel, 2016; Krishnamurthy and Li, 2023).

Figure 1: **Historical convenience yield and inflation (standardized).** We plot the Treasury convenience, measured as Aaa-Treasury spread (Krishnamurthy and Vissing-Jorgensen, 2012), and the 12-month change in CPI-U inflation. Monthly data runs from 1926:01 through 2020:12, excluding the WWII period 1939:09-1951:12. The three subperiods shown are 1926:01-1939:08, 1952:01-1999:12, and 2000:01-2020:12. In each subperiod, we normalize both measures to have mean zero and standard deviation of one.



expectations increase the cost of holding money and close money substitutes such as Treasuries, increasing the Treasury convenience premium that investors pay in equilibrium. On the other hand, Keynes (1937) considered exogenous variation in liquidity preference as the key determinant of interest rates, business cycles and inflation. Since then, liquidity demand shocks have been argued to be responsible for the Great Depression of the 1930s (Friedman and Schwartz, 1963) and have been incorporated into microfounded New Keynesian models of the Great Recession of 2008–2009 (e.g., Del Negro et al., 2017; Anzoategui et al., 2019). Intuitively, the liquidity demand channel views a shock to the demand for liquid stores of wealth as a causal driver of lower aggregate demand, spending and inflation, implying a negative inflation-convenience relationship. As such, the two views have distinct implications for the causal interpretation of the convenience-inflation relationship. In the money channel, higher inflation leads to higher convenience. In the liquidity demand channel, liquidity shocks, such as those originating from financial crises and panics, lead to disinflation.

We start our empirical analysis by estimating the relationship between the Treasury convenience spread and inflation across different historical regimes. Our baseline measure of Treasury convenience is the spread between yields on Aaa-rated corporate bond yields and long-term Treasury yields following Krishnamurthy and Vissing-Jorgensen (2012). Because yields are inversely related to prices, the Treasury-Aaa spread increases with the convenience value of Treasury bonds, or the value that investors attribute to Treasury bonds above and beyond less convenient assets with equivalent cash flows. Our analysis starts in 1926, dictated by data availability. We split the sample at WWII and in 2000, when inflation dynamics are broadly understood to have changed from supply to demand shocks (e.g., Justiniano and Primiceri, 2008; Stock and Watson, 2007; Bekaert et al., 2021; Pflueger, 2023).

We find that a one percentage point increase in inflation is associated with a convenience yield that is 13 bps higher in the second half of the 20th century (1952-1999) compared to the pre-WWII period, a magnitude that is large relative to an average convenience spread of 87 bps. In contrast, the coefficients on inflation in the pre-WWII and post-2000 periods are generally negative and typically not statistically significantly distinguishable from each other. These patterns hold while controlling for the federal funds rate, the quantity of Treasury debt as measured by the Debt/GDP ratio, equity volatility, and the credit spread between Baa and Aaa corporate bond yields. Controlling for the federal funds rate, in particular, ensures that our results do not simply reflect monetary policy surprises or the monetary policy response to non-liquidity demand shocks. Results for T-bill convenience, measured by the Repo-T-bill spread, display similar shifts, though the level of the federal funds rate now captures a bigger share of the T-bill convenience variation (Nagel (2016)). The results are robust to the exact timing of the start and end dates for the periods, as long as the first shift is dated in the 1950s or 1960s and the second one between 1995 and 2005.

We next present a series of empirical findings that, taken together, support a positive convenience-inflation relationship in the face of direct inflation shocks, but a negative relationship in response to increases in the demand for convenient assets. First, we analyze the lead and lag relationships between inflation and Treasury convenience using predictive regressions. We show that in the higher-inflation second half of the 20th century, higher inflation tends to be followed by higher Treasury convenience with a peak effect at roughly 24 months, coinciding with substantial supply-side disturbances during the 1970s and 1980s. This relationship is as expected if higher inflation expectations cause the cost of holding money and other convenient assets to rise via the money channel. However, these regressions also show that increases in convenience yield tend to be followed by lower inflation similarly across all our subperiods, with the effect peaking between 12 and 24 months. This fact is consistent with a liquidity shock interpretation, whereby a positive shock to the demand for convenient Treasuries reduces real consumption via the liquidity demand channel.

Those lead-lag relationships hence indicate that there are stable mechanisms flowing from inflation to liquidity and vice versa, and that the shifts in the contemporaneous inflation-convenience relationships occur because the composition of shock driving the economy – liquidity shocks to Treasury convenience versus direct shocks to inflation – has changed over the past 100 years.

We next explore the different components of inflation for the post-1959 sample. We find that long-term Treasury convenience exhibits a stable positive relationship with core inflation, supporting the notion that persistent inflation tends to raise convenience via the money channel. We similarly find stable positive relationships between Treasury convenience and survey inflation expectations and trend inflation (Stock and Watson, 2007) during the second half of the 20th century. The correlation between energy inflation and Treasury convenience is much weaker. As such, the money channel tends to manifest in our data when inflationary shocks are longer-lived and pass onto broad measures of core inflation.

To understand the link between convenience and macroeconomic drivers, we employ Shapiro (2024)'s decomposition of core PCE inflation into demand and supply drivers from disaggregated data, available starting in 1969.[3] We show that higher long-term Treasury convenience is associated with higher supply-driven inflation, but lower demand-driven inflation. The lead-lag relationships are also intuitive, with supply inflation leading Treasury convenience, but Treasury convenience leading lower demand inflation. Again, the decomposition into supply- and demand-driven inflation supports the notion that supply-type shocks increase inflation and Treasury convenience together, whereas shocks to liquidity demand tend to act on inflation similar to macroeconomic demand shocks.

Rather than splitting the sample according to a small number of break dates, we next analyze the Treasury convenience-inflation relationship in subsamples determined by the level of Treasury bond-stock betas. Positive bond-stock betas have often been regarded as real-time financial market proxies for the dominance of inflationary supply shocks (Campbell et al., 2020; Pflueger, 2023). The intuition is that supply shocks tend to drive up inflation and lower Treasury bond valuations just as stocks fall due to the impending recession, thereby leading to a positive correlation between bonds and stocks. Consistent with this notion, we find that Treasury convenience has a negative relationship with inflation when the bond-stock beta is negative, as measured from a regression of daily Treasury bond returns onto daily stock market returns over a rolling 120-day window.

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[3] Shapiro (2024) decomposes inflation into supply- and demand-driven inflation using data on prices and quantities at individual product category level.

Conversely, the convenience-inflation relationship is positive when the bond-stock beta is positive. At the same time, our baseline results are robust to controlling for bond-stock betas directly, which might matter if bond-stock betas have an effect on the hedging value of convenient Treasuries (Acharya and Laarits, 2023).

To understand the mechanisms behind our empirical findings, we build a framework that encompasses the money and liquidity demand channels. We combine a parsimonious three-equation New Keynesian model as in Galí (2008), Rotemberg and Woodford (1997), or Clarida et al. (1999), with a model of convenience yield following Nagel (2016).[4] Specifically, the money channel arises from the assumption that Treasuries are substitutes with deposits or even non-interest paying money. Higher inflation drives up the nominal interest rate and raises the opportunity cost of holding money, thus, also the opportunity cost of holding near-money assets, including Treasuries. Consequently, higher inflation leads to higher convenience yield via the money channel. We show in a standard calibration that the money channel is particularly prominent if the economy experiences supply cost-push shocks and average inflation is high, as in the 1970s and 1980s (middle panel of Figure 1), or the recent post-pandemic episode. The liquidity demand channel, instead, treats the convenience yield as a wedge in the household Euler equation between the risk-free discount rate and the Treasury yield. A positive shock to convenience yield suppresses aggregate demand, which decreases inflation and induces a negative inflation-convenience comovement.[5] This liquidity demand channel plays an important role when the economy experiences liquidity shocks, such as disruptions in the financial sector, and these are indeed more salient in the 1930s and post-2000 (left and right panel in Figure 1). Taken together, the changing preeminence of the money and the liquidity demand channels can explain the shifting comovement between Treasury convenience and inflation, as well as their lead-lag relationships.

The model also allows us to explore the hypothesis that high inflation directly depletes the Treasury convenience benefits. Such direct and negative effect of inflation on convenience could

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[4] For models of banking and money within a New Keynesian economy see also Curdia and Woodford (2010), Gertler and Karadi (2011a), Drechsler et al. (2018), Piazzesi et al. (2019) and Wang (2022). Caballero and Simsek (2020) and Caballero and Simsek (2022b) develop models of optimal monetary policy when broad asset prices matter for aggregate fluctuations, and both financial and non-financial demand shocks are present. Our focus is different, in that we seek to build the most basic model of monetary policy and Treasury convenience that can replicate the changing inflation-convenience relationship that we document in the data.

[5] Shocks to the convenience of Treasury bonds have been increasingly used to explain a wider range of empirical facts (Anzoategui et al. (2019), Jiang et al. (2023), Itskhoki and Mukhin (2021), Kekre and Lenel (2021), Fukui et al. (2023), Bianchi et al. (2022), Engel and Wu (2023), Abadi et al. (2023).

arise via several mechanisms highlighted in the literature: (a) Higher inflation means that the monetary authority has less capacity to monetize debt (Nagel, 2016; Krishnamurthy and Li, 2023). (b) When inflation is more volatile, Treasuries as safe assets have less stable valuation and therefore the safety premium declines (Krishnamurthy and Vissing-Jorgensen, 2012; Di Tella, 2020; Brunnermeier et al., 2022b; Liu et al., 2021). (c) Higher inflation increases the cost of financial intermediaries trading Treasury securities and thus reduces Treasury convenience.[6]

We capture this class of mechanisms in our model in reduced form by allowing Treasury convenience to decline directly with higher inflation. Contrary to the data, this assumption implies a more negative convenience-inflation relationship in the 1952–1999 period than during the pre-WWII and post-2000 periods. Intuitively, this alternative assumption implies that Treasuries have little convenience during the high-inflation 1970s and 1980s. Consequently, the money channel should have been especially weak during this period, leading to a less positive or even more negative Treasury convenience-inflation relationship. Our finding of a positive inflation-convenience relationship during the second half of the 20th century hence points to the persistent feature of US Treasuries as convenient assets at the historically experienced US inflation rates.

Finally, we confirm the model predictions for the post-COVID period, which featured global supply chain disruptions, labor market dislocations, trade frictions, etc. We find that the reemergence of the money channel explains a positive shift in the convenience-inflation comovement post-2020, which robustly appears across different measures of Treasury convenience, such as Agency-Treasury spreads, and different measures of inflation expectations.

Our work relates to the growing literature that studies the determinants and effects of Treasury convenience on the aggregate economy. Nagel (2016) shows that the US monetary policy drives the Treasury convenience yield by changing the opportunity cost of holding money and money-like assets, and Diamond and Van Tassel (2023) provide international evidence and link convenience demand shocks to financial crises. Duffee (2023) shows that bond yields do not comove with output growth expectations as predicted by a standard consumption Euler equation, suggesting the presence of a substantial shock. Our paper provides a potential resolution, showing that demand shocks to Treasury convenience can affect the macroeconomy and drive precisely such as wedge in the Euler equation. Du et al. (2018b) and Jiang et al. (2021) document that violations of the covered interest parity in foreign exchange markets are correlated with an international view of the

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[6] See Duffie et al. (2007) for a general theory of how intermediation frictions affect asset prices. Du et al. (2023) provide both theory and empirics on how intermediation costs affect Treasury pricing.

US Treasury convenience.Van Binsbergen et al. (2022) construct stock-option implied risk-free rates and find that monetary policy affects the convenience yield, consistent with the money channel. Hébert et al. (2023) provide complementary evidence that the gap between the stock market-implied risk-free rate and government rates acts as a shifter in the Euler equation akin to a demand shock. Brunnermeier et al. (2022b) show that the convenience yield is a component of fiscal capacity. Li (2024) presents the convenience yield as a channel of how quantitative easing policies affect the banking sector and financial crises. Complementary to our work, Acharya and Laarits (2023) argue that the hedging properties of Treasury bonds can explain their convenience, measuring covariances at monthly frequency. Our contribution lies in documenting important lower-frequency shifts since the 1920s. Fu et al. (2023) find a negative correlation between Treasury convenience and inflation expectations extracted from long-term Treasury yields. While the main sample of Fu et al. (2023) overlaps with the post-2000 period we consider in our analysis, we interpret the negative inflation-convenience comovement over this period as evidence for the dominant demand channel whereby liquidity shocks lead to lower inflation, in line with much recent research about the Great Recession.

We also contribute to the literature seeking to understand the financial drivers of business cycle, with implications for policy. Our evidence suggests that shocks to the demand for the convenience of Treasury bonds matter for the macroeconomy and act similarly to classic demand shocks, in line with Del Negro et al. (2017), Anzoategui et al. (2019), Bianchi and Lorenzoni (2021), Kekre and Lenel (2021), and Jiang et al. (2023). The classic prediction for a central bank minimizing deviations of inflation and the output gap from target is that it should raise interest rates one-for-one with demand shocks, and according to the certainty equivalent when observing a noisy signal about demand (Svensson and Woodford, 2003). To the extent that shocks to the demand for convenient Treasuries act as a standard demand shocks, such a central bank may hence find it optimal to respond to liquidity demand shocks in financial markets, just like it would to other demand shocks driving inflation and the output gap.

The remainder of the paper is structured as follows. Section 2 describes our empirical results, with data and measurement in Subsection 2.1, our baseline regressions and evidence on the break dates in Subsection 2.2, and a decomposition of the relationship into core versus energy and supply versus demand inflation in 2.4. Section 3 describes the model setup and the calibration, and compares the model results to the data. Finally, Section 5 concludes.

2 A Century of Evidence on Inflation and Treasury Convenience

In this section, we present our main empirical results on the changing relationship between inflation and Treasury convenience.

2.1 Data and Measurement

We use the consumer price index for all urban consumers from Shiller (2016), who reports the data starting from the late 1800s. We define the inflation rate as the annual percentage change in the consumer price index. As shown by Atkeson and Ohanian (2001) and Stock and Watson (2007), the four-quarter moving average of past inflation is one of the most robust predictors of future inflation, so our measure can also be thought of as a proxy for expected inflation, though we check robustness to other inflation expectations measures in Section 2.4.1. We avoid the Cleveland Fed measure of inflation expectations because it is based on a model that uses Treasury bond yields, and hence potentially directly reflects term premia and convenience yields (see Appendix A.3).

Previous literature has proposed two main proxies of the Treasury convenience yield that are available back to the 1920s. Our primary measure is the Aaa yield minus a maturity-matched Treasury bond yield, as in Krishnamurthy and Vissing-Jorgensen (2012).[7] We additionally construct the T-bill convenience following Nagel (2016) as the spread between 3-month banker acceptance rate and 3-month T-bill rate before 1990, and the spread between 3-month term repo rate collateralized by Treasuries and 3-month T-bill rate after 1990. The repo data in Nagel (2016) ended in 2011; we therefore rely on the 3-month commercial paper rates to supplement the recent period afterwards.[8] We refer to the concatenated series as the T-bill convenience yield. The Aaa-Treasury spread reflects the convenience of long-term Treasury bonds, and the T-bill convenience yield captures the convenience of short-term Treasury bills.

The Aaa-Treasury spread is commonly interpreted as reflecting the convenience yield of Treasuries, rather than default risks of Aaa bonds, because short- and long-term default rates for Aaa

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[7] Following Krishnamurthy and Vissing-Jorgensen (2012), we subtract a long-term government bond yield until 2000 and the yield on a 20-year Treasury bond afterwards to match the duration of the Moody's index, which contains corporate bonds with 20- to 30-years to maturity. See detailed construction in Appendix Section A.1.

[8] For the post-2011 sample, we cross-checked 3-month commercial paper rates against 3-month repo rates from JP-Morgan markets (proprietary data), and found that they are similar. For replicability, we use the publicly-available data on commercial paper rates.

bonds are zero or nearly indistinguishable from zero. As reported by Moody's (Emery et al., 2009), Aaa-rated bonds have never defaulted in history. Over longer horizons, Aaa-rated bonds may of course transition to lower rating categories, but even the 5-year cumulative credit loss rate for Aaa-rated bonds was only 0.02% for the period 1982-2008. By contrast, Baa-rated bonds have a cumulative credit loss rate of 1.1% at the 5-year horizon, corresponding to an annualized credit loss rate of 0.22%. To understand the credit risk of Aaa-rated bonds over the lifetime of the bond, we employ a simple calculation based on the rating migration rates, default rates, and loss rates reported by Emery et al. (2009). This calculation suggests that the annualized credit loss rate over a 20-year horizon for Aaa bonds is only 0.009%, but that of Baa is 0.36%, a 40-fold difference. Details are provided in Appendix A.2. Again, this suggests that credit risks are negligible for Aaa bonds but an important component for Baa bonds. Given the prominence of credit risk in the Baa-Aaa spread, in our regressions, we also control for the Baa-Aaa spread to further alleviate concerns about time-varying credit risk driving the Aaa-Treasury spread.

We control for other well-known drivers of Treasury convenience, in particular market volatility, the total government debt supply, and monetary policy. For market volatility, we use the VIX index. The VIX data are only available since 1990. For the period before 1990, we use a linear projection of VIX on realized volatility of the S&P 500 index, where the projection coefficients are estimated on the post-1990 data. For government debt supply, we use the total quantity of Treasury debt, at market value, excluding intra-governmental holdings and holdings by depository institutions and the Federal Reserve. The data construction follows Krishnamurthy and Li (2023). For monetary policy, we use the end-of-month effective federal funds rate, available from the flow of funds data. We also occasionally control for credit conditions using the difference between Moody's seasoned Aaa minus Aaa yields available from the St. Louis FRED.

Table 1 presents summary statistics for our key variables using monthly observations from 1926 to 2020, excluding the WWII period defined as September 1939 through December 1951. The start of our sample is determined by the availability of daily stock returns and a measure of stock return volatility. The end of our sample period is at the end of 2020, before the post-COVID inflation period, which we analyze separately in Section 4.

We consider three distinct periods for our empirical analysis: the pre-WWII period from 1926 through 1939, the second half of the 20th century from 1952 through 1999, and the post-2000 period until the start of the pandemic (2000 to 2020). We exclude the WWII period until 1951 due to interest rate controls, which were lifted by the Treasury-Fed accord in 1952. The table shows that

Table 1: **Summary statistics 1926–2020.** This table presents summary statistics for our full sample 1926:01–2020:12, excluding the WWII period 1939:09–1951:12. Note that although Aaa-Tsy spread and Baa-Aaa credit spread have similar magnitude, the credit risk component is negligible in Aaa-Tsy spread compared to the Baa-Aaa credit spread (See Appendix A.2 for details).

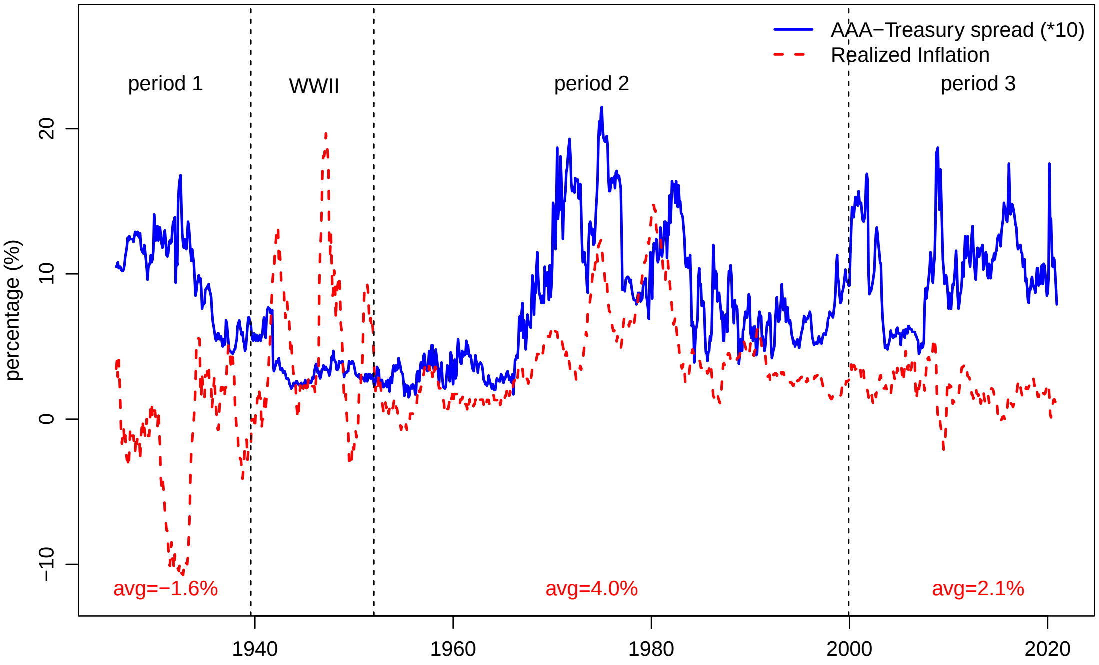
Variable	Obs	Mean	Std. Dev.	Mean (1926-1939)	Mean (1952-1999)	Mean (2000-2020)
Aaa-Tsy spread (%)	992	0.87	0.42	0.98	0.78	1.03
T-bill convenience yield (%)	992	0.43	0.46	0.28	0.56	0.23
Inflation (%)	992	2.60	3.64	-1.58	3.99	2.13
VIX	992	19.64	8.16	27.39	17.30	19.96
Baa-Aaa spread (%)	992	1.14	0.70	2.03	0.93	1.05
Debt/GDP	992	0.30	0.15	0.17	0.26	0.47

the Aaa-Treasury spread averaged around 87 bps, with similar means across subperiods. A simple calculation illustrates the relevance of convenience for fiscal policy. In 2024, U.S. government debt has a duration of around 5 years and total outstanding of 27 trillion, so the 87 bps translates into an extra fiscal capacity of more than 1 trillion dollars. While the magnitude for the Aaa-Treasury spread is comparable to that of the Baa-Aaa spread, recall that credit loss rates of Aaa bonds are negligible compared to the credit loss rates of Baa bonds, suggesting that the Aaa-Treasury spread mostly captures non-credit related Treasury convenience, while the Baa-Aaa spread is a useful control for credit risk. The summary statistics also show that our subperiods were marked by significantly different average levels of inflation.

2.2 The Changing Treasury Convenience-Inflation Relationship

In this section, we show that the relation between inflation and the Treasury convenience spread has changed in a quantitative and statistically significant manner over the three periods we consider. To visualize these shifts, Figure 2 juxtaposes the Aaa-Treasury spread against the realized inflation over the past century. The correlation between inflation and the spread changes from negative -0.56 pre-WWII to positive 0.63 in the second half of the 20th century, and back to negative -0.28 post-2000. The average inflation is 4% in the middle period which encompasses the high-inflation 1970s and 1980s, but much lower in the other periods (the period averages of inflation are marked on the graph).

Figure 2: **Time series of Aaa-Treasury spread and inflation.** This figure shows the measures of inflation and the Aaa-Treasury spread used for our main analysis. Vertical lines indicate the subperiods used, with the WWII period excluded from our analysis. The three subperiods shown are 1926:01–1939:08, 1952:01–1999:12, and 2000:01–2020:12.



To assess the statistical and economic significance of those changes, we estimate the following baseline regression at a monthly frequency:

$$spread_t^{Aaa} = b_0 + b_1\pi_t + b_2\pi_t \times I_{\text{1952-1999},t} + b_3\pi_t \times I_{\geq 2000,t} + \Gamma X_t + \varepsilon_t, \tag{1}$$

where we interact inflation with period-specific dummy variables. The interaction coefficients are interpreted relative to the pre-WWII period 1926–1939 (the omitted category). π_t is the inflation rate over the 12 months prior to time t. The vector X_t captures controls.

Table 2 shows a consistently negative baseline coefficient on inflation, a positive interaction coefficient on $\pi_t \times I_{\text{1952-1999},t}$, and a negative though not always significant interaction coefficient on $\pi_t \times I_{\geq 2000,t}$. The positive interaction with the 1952–1999 dummy is particularly revealing, as it indicates that the relationship between inflation the Aaa-Treasury spread is significantly more

Table 2: **Shifts in long-term Treasury convenience-inflation relationship.** Monthly data runs from 1926:01 through 2020:12, excluding the WWII period 1939:09–1951:12. The three subperiods shown are 1926:01–1939:08, 1952:01–1999:12, and 2000:01–2020:12, with the first period being the omitted period. Newey-West t-statistics with 12 lags are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	AAA-Tsy spread				
	(1)	(2)	(3)	(4)	(5)
Inflation	-0.038***	-0.038***	-0.022**	-0.013	-0.034***
	(-5.15)	(-5.31)	(-2.40)	(-1.00)	(-4.61)
Inflation x $I_{1952-1999}$	0.13***	0.12***	0.094***	0.078***	0.12***
	(6.45)	(3.87)	(3.29)	(2.64)	(5.28)
Inflation x $I_{\geq 2000}$	-0.034	-0.049	-0.083**	-0.083*	-0.072*
	(-0.93)	(-1.33)	(-2.02)	(-1.96)	(-1.81)
FFR		0.017	0.0096	0.0085	
		(0.86)	(0.50)	(0.46)	
Debt/GDP			-0.57	-0.58	-0.60
			(-1.43)	(-1.48)	(-1.61)
VIX			0.0093***	0.0058	
			(2.88)	(1.64)	
BAA spread				0.10	
				(1.59)	
$I_{1952-1999}$	-0.52***	-0.51***	-0.34***	-0.25	-0.42***
	(-5.12)	(-5.30)	(-2.72)	(-1.57)	(-3.41)
$I_{\geq 2000}$	0.27***	0.31***	0.56***	0.60***	0.51***
	(2.71)	(2.89)	(2.92)	(2.96)	(2.71)
Constant	0.92***	0.88***	0.76***	0.67***	1.03***
	(13.20)	(10.56)	(4.90)	(3.85)	(11.48)
$\bar{R}^2$	0.39	0.39	0.43	0.44	0.41
N	992	992	992	992	992

positive over this period – which includes the Great Inflation of the 1970s and 1980s – than over other periods. The coefficients in column (1) imply that a one percentage point increase in inflation is associated with a 13 bps higher Aaa-Treasury spread in the 1952–1999 period compared to pre-WWII. This magnitude is large compared to an average Aaa-spread of 87 bps reported in Table 1. In particular, scaling the magnitude to standard deviation terms, we find a one standard deviation increase in inflation is associated with a one standard deviation greater Aaa-Treasury spread in the 1952–1999 period.

The negative baseline coefficient on inflation means that a one percentage point increase in inflation tends to be associated with a four bps *de*crease in the Aaa-Treasury spread before WWII. The relationship is similar or even more negative during the 2000s. These results hold controlling for potential other drivers of the Treasury convenience, such as the government debt/GDP ratio, equity volatility, and even the credit spread, underscoring that the switch in the inflation-spread relationship is specific to the liquidity premium in Treasuries, as distinct from how inflation affects credit risk (e.g. Kang and Pflueger (2015), Brunnermeier et al. (2023), Bhamra et al. (2023)).

Controlling for Debt/GDP is important, as prior research has found that an increase in the quantity of Treasury debt tends to reduce the convenience of Treasury bonds (Krishnamurthy and Vissing-Jorgensen, 2012; Krishnamurthy and Li, 2023). We find that Debt/GDP enters negatively with a quantitatively meaningful coefficient of around -0.60, similar to the magnitude reported by Krishnamurthy and Vissing-Jorgensen (2012). At the same time, the time-varying relationship between convenience and inflation is little affected by controlling for Debt/GDP. However, the significance of the Debt/GDP variable is reduced because inflation and Debt/GDP are negatively correlated in our sample. Debt/GDP is also a simple proxy for fiscal channels driving inflation, though the relationship between fiscal channels and inflation may be complicated by endogenous debt issuance and term premia (Cochrane, 2001; Corhay et al., 2023). To understand why Debt/GDP does not drive the inflation-convenience relationship in our sample, consider the financial crisis of 2008-2009. Treasury convenience spiked, just as aggregate demand and inflation plummeted, and government debt issuance accelerated. However, inflation fell during this period – plausibly triggered by the disruptions in financial markets – rather than rising. Of course, this does not mean that debt issuance may not be highly consequential for inflation going forward. Overall, while fiscal considerations may have explanatory power for Treasury convenience and inflation separately, they do not appear to be the primary driver of the changing convenience-inflation comovement that is our main focus.

Table 3: **Shifts in T-bill convenience–inflation relationship.** Monthly data runs from 1926:01 through 2020:12, excluding the WWII period 1939:09–1951:12. The three subperiods shown are 1929:01–1939:08, 1952:01–1999:12, and 2000:01–2020:12, with the first period being the omitted period. The T-bill convenience yield measure extends Nagel (2016)'s measure after 2011 using the spread between 3-month commercial paper rate and 3-month T-bill yield. Newey-West t-statistics with 12 lags are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	T-bill convenience				
	(1)	(2)	(3)	(4)	(5)
Inflation	-0.029***	-0.027***	-0.016***	-0.021***	-0.029***
	(-4.69)	(-5.95)	(-2.83)	(-2.99)	(-4.52)
Inflation x $I_{1952-1999}$	0.15***	0.082***	0.071***	0.078***	0.15***
	(9.04)	(3.95)	(3.69)	(3.37)	(9.22)
Inflation x $I_{\geq 2000}$	0.070***	0.0040	0.013	0.013	0.063***
	(4.30)	(0.16)	(0.49)	(0.51)	(3.18)
FFR		0.075***	0.076***	0.076***	
		(6.00)	(6.10)	(6.18)	
Debt/GDP			0.22	0.22	-0.11
			(0.99)	(1.01)	(-0.50)
VIX			0.0092***	0.011***	
			(3.77)	(3.23)	
BAA spread				-0.048	
				(-0.87)	
$I_{1952-1999}$	-0.15**	-0.15**	-0.093	-0.14	-0.14*
	(-2.12)	(-2.15)	(-1.23)	(-1.38)	(-1.90)
$I_{\geq 2000}$	-0.091	0.11	0.051	0.030	-0.046
	(-1.48)	(1.48)	(0.46)	(0.27)	(-0.44)
Constant	0.24***	0.046	-0.23**	-0.19*	0.25***
	(4.87)	(0.90)	(-2.41)	(-1.87)	(4.07)
$\bar{R}^2$	0.49	0.58	0.60	0.60	0.49
N	992	992	992	992	992

Table 3 estimates analogous regressions with the T-bill convenience as the dependent variable. Column (1) indicates that secular shifts have also occurred in the relationship between inflation and short-term Treasury convenience, with a positive coefficient on inflation interaction with the 1952–1999 period dummy. However, different from the long-term spread, columns (2) through (4) of Table 3 show that the fed funds rate enters significantly, reducing the strength of the relationship between short-term convenience and inflation. This difference between long-term and short-term convenience suggests that while the inflation-convenience relationship exhibits common patterns across Treasury maturities, the role of monetary policy in the transmission differs.[9] We explain these differences in our model in Section 3, where the money channel links short-term convenience to the short-term nominal interest rate, but long-term convenience to the persistent component in inflation and nominal rates.

When exactly did the inflation-convenience relationship shift? Our main results are robust to varying the cutoff dates that define our subperiods. Figure 3 plots the t-statistics for the interaction coefficients from the baseline regression (1) over a range of dates demarcating the starts of the second and third periods. The specification is identical to column (1) of Table 2, except that we vary the start of the second period between 1952 and 1975 and the start of the third period between 1990 and 2005. The left panel shows that the $\pi_t \times I_{1952-2000,t}$ loading is positive and significant for a broad range of start dates for the second period, and almost completely insensitive to the start of the third period. The right panel shows that the $\pi_t \times I_{\geq 2000,t}$ loading is negative with a t-statistic exceeding -2 in absolute value if we allow the second period to start in the 1950s or 1960s and the third period to start any time between 1995 and 2005. We conclude that the economic mechanism driving the inflation-convenience relationship changed once sometime in the middle of the 20th century, and then again around 2000.

A particularly informative period for the potential channels constitutes the phase of binding deposit rate caps during part of the mid 20th century in the United States. Drechsler et al. (2023) argue powerfully that interest rate caps on deposit rates, mandated by regulation, imposed an important constraint and amplification mechanism for monetary policy during the 1970s, before 1982 when MMDAs were introduced. In Appendix A.4, we show that the positive inflation-convenience relationship of the second half of the 20th century is indeed amplified by an additional 6 bps during the period when regulation Q was binding (1966-1982), but that the significance and magnitude

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[9] Controlling for the fed funds rate also uncovers the negative relationship between inflation and T-bill convenience in the post-2000 period (not significantly different from the baseline pre-WWII period).

of all other inflation interactions in Table 2 remain virtually unchanged. It therefore appears that periods of binding constraints on deposit rates featured a somewhat stronger money channel, in line with Drechsler et al. (2023), but that the positive relationship between inflation and long-term Treasury convenience is not confined to this period.

Figure 3: **T-statistics for different period start dates.** This figure reports results for the baseline regression in column (1) of Table 2 using different start dates for periods 2 and 3. The first break date (period 2 start) ranges from 1952 to 1975 and is shown on the x-axis. The second break date (period 3 start) ranges from 1990 to 2005 and is shown on the y-axis. Our baseline break dates – 1st break in 1952 and 2nd break in 2000– are indicated with black squares. The t-statistics for the interaction coefficients between period dummies with inflation are shown on the z-axis and are based on Newey-West standard errors with 12 lags.


t-stat on Inflation x period 2

t-stat on inflation x period 3

2.3 Lead-Lag Relationships Between Inflation and Treasury Bond Convenience

To better understand these distinct regimes, we investigate the lead-lag relationship between inflation and convenience. We predict future changes in the annual inflation rate from month t to $t + h$ with a one-month change in the Aaa-Treasury spread from month $t - 1$ to t, and vice versa.

We interpret the results in the spirit of Granger causality. Specifically, we estimate forecasting regressions of the form:

$$\pi_{t+h} - \pi_t = a_h + b_h \Delta spread_t^{Aaa} + \gamma_h \Delta FFR_t + \varepsilon_{t+h} \tag{2}$$

$$spread_{t+h}^{Aaa} - spread_t^{Aaa} = c_h + d_h \Delta \pi_t + \delta_h \Delta FFR_t + \epsilon_{t+h} \tag{3}$$

and plot the coefficients b_h and d_h for different h up to 60 months in Figure 4. Since we have already seen that the inflation-convenience relationship was different during the half of the 20th century than either before or after, we estimate the predictive regressions separately for the second half of the 20th century (1952–1999) and for a sample combining the pre-WWII and post-2000 periods.[10] We include the change in the fed funds rate to control for the direct effect of the short rate on inflation and the spread.

Figure 4 shows intuitive lead-lag patterns. The right panels in Figure 4 suggest that increases in the Aaa-Treasury spread tend to be followed by inflation declines, which are statistically significant across subsamples. In terms of economic magnitudes, a 10 bps innovation in the convenience spread in a given month (about one standard deviation) is associated with a future decline in annual inflation of about 30 to 40 bps in either sample over the next 24 months. In contrast, the left panels show that inflation tends to be followed by an increase in the Aaa-Treasury spread only in the 1952–1999 sample. In that period, a 40 bps innovation in the annual inflation rate in a given month (one standard deviation) predicts an increase in the spread of about 12 bps over the next 24 months. Thus, to the extent that a positive inflation-convenience relationship is present, it tends to run from inflation to Treasury convenience. By contrast, a negative relationship tends to run from convenience spreads to inflation.

To interpret these lead-lag relationships causally, it would be necessary to assume that inflation does not respond immediately to the convenience yield and vice versa, in the spirit of Sims (1980). One threat to this interpretation would arise if spreads are forward-looking and inflation expectations respond instantaneously. In that case, inflation or any other predictor of future inflation should not be able to predict changes in spreads, in line with our empirical evidence for the 1926–1939 and 2000–2020 sample in Panel B of Figure 4, but in contrast to the evidence for the 1952–1999 period in Panel A. Another concern might arise when spreads simply anticipate lower inflation but do not cause it. However, such an alternative story could not explain why higher

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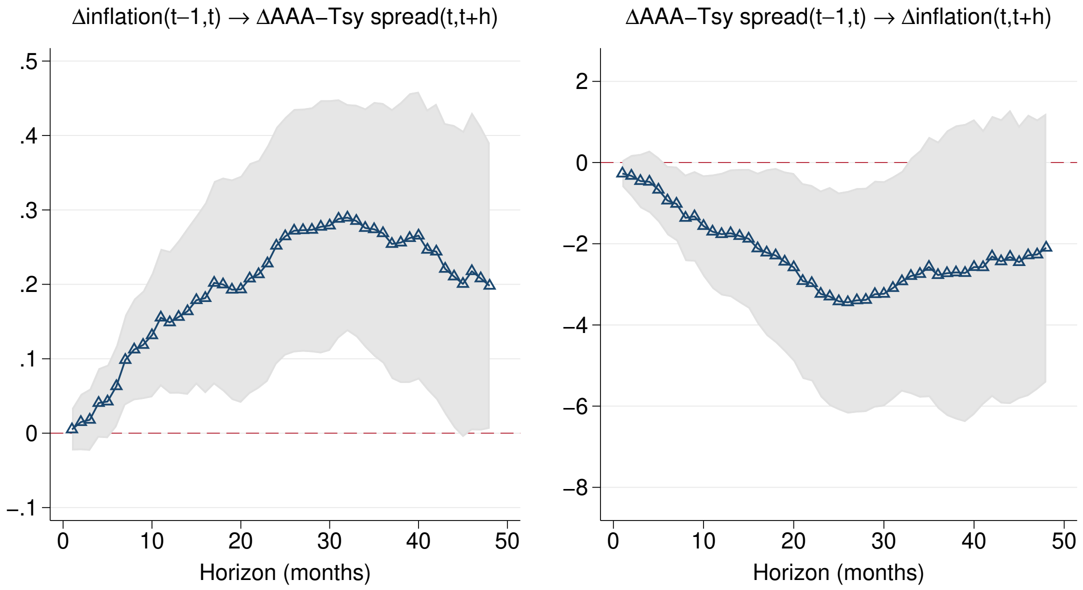
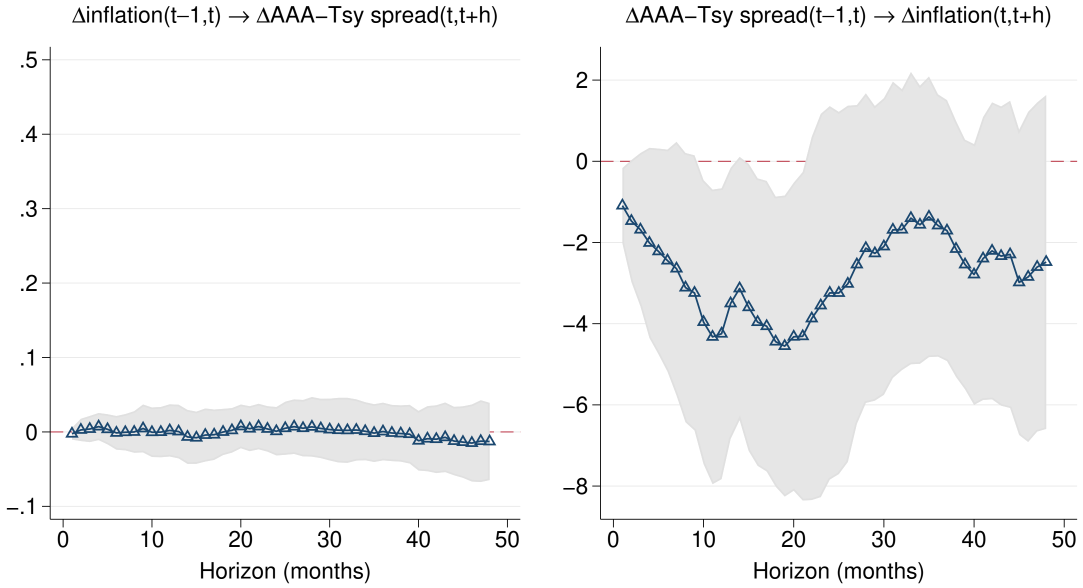
[10] Formally, the estimates in Panel A treat the observations between 1939.09 and 1999.12 as missing.

Figure 4: **Predictive regressions.** This figure presents coefficients from regressions (2) and (3). The left panels plot b_h as a function of horizon h. The right panels plot d_h as a function of horizon h. The top panels use the post-WWII sample (1952–1999). The bottom two panels use the combined sample of the pre-WWII and post-2000 periods (1926–1939 and 2000–2020). The gray shading indicates 95% confidence intervals based on Newey-West standard errors with h lags.

Panel A: 1952–1999



Panel B: 1926–1929 and 2000-2020



convenience spreads predicted lower inflation during the 1952–1999 period even though they were positively contemporaneously correlated with the best-known inflation predictor, namely inflation itself. While the evidence in the left panels is therefore potentially subject to different interpretations and might require some sluggishness in the updating of inflation expectations, the results in the right panels are indicative of the NK liquidity demand channel whereby shocks to the demand for Treasury convenience cause lower inflation. In the appendix, we further confirm that these lead-lag relationships are robust to estimating local projection impulse responses in a VAR to identify inflation shocks and convenience shocks.

Overall, the evidence suggests distinct mechanisms at play generating positive versus negative inflation-convenience relationships. Forces that move inflation first tend to induce a positive inflation-convenience relationship, dominating the relationship in the 1952–1999 period. Conversely, forces that move convenience first tend to induce a negative inflation-convenience spread relationship, dominating the overall relationship pre-WWII and again during the post-2000 period.

2.4 Inflation Components and Treasury Bond Convenience

So far, evidence from headline inflation and its leads and lags points to secular changes in the inflation-Treasury convenience relationship. To understand these patterns in the context of underlying economic forces, we decompose inflation into components and link those to the underlying structural shocks driving aggregate demand and supply in the economy. Table 4 reports the relationships of Treasury convenience with different measures of expected headline inflation in Panel A, and separately for core and energy inflation in Panel B. Table 5 decomposes inflation into supply- and demand-driven components using Shapiro (2024)'s measure from disaggregated product data.

2.4.1 Different measures of expected headline inflation

Panel A of Table 4 starts with a regression of headline inflation onto inflation, and the interaction of inflation with a post-2000 dummy. For comparability with Panel B, the sample starts in 1959 when core and energy inflation become available. The first two columns show that our baseline result – a positive inflation-convenience relationship in the second half of the 20th century vs. a negative relationship post-2000 – carries over to this slightly shorter sample. Columns (3) and (4) use a different, more sophisticated, measure of trend inflation from the inflation forecasting literature (Stock and Watson, 2007), computed following Chan (2018). This measure can be thought of as filtering out a time-varying amount of short-term noise in realized inflation. We see that the baseline result continues to hold for trend headline inflation, and the coefficient on inflation interacted with the post-2000 dummy becomes even more negative and more strongly statistically significant.

If the headline inflation-Treasury convenience relationship changed because the dominant drivers of inflation changed, we would expect more stable relationships between Treasury convenience and inflation components. The last two columns in Panel A use the 4-quarter forecast for real GDP inflation from the Survey of Professional Forecasters (SPF), which is however only available for a somewhat shorter sample starting in the second quarter of 1970. Here, we see that the positive relationship between inflation expectations and Treasury convenience in the second half of the 20th century continues to hold, but the interaction with the post-2000 dummy becomes insignificant. One possible reason for the somewhat different results for the post-2000 period could be that survey inflation expectations were extremely stable during this period, while actual and trend inflation did exhibit some variation due to demand-driven inflation.[11] Overall, we find a robustly positive relationship between headline inflation and Treasury convenience in the second half of the 20th century, which appears to be driven by the trend or slow-moving components of inflation, while the negative relationship post-2000 appears to be related to cyclical inflation factors.

2.4.2 Headline vs. core inflation

Table 4 Panel B decomposes inflation into its most basic fundamentals: core and energy inflation. Although simple, this decomposition has the advantage of being available in real-time without the forward-looking bias of most econometric models. It also reflects the way the Federal Reserve thinks about inflation, where core inflation is viewed to capture the more persistent component whereas fluctuations around core, driven by food and energy prices, are viewed as more transitory.[12] If core inflation reveals the relatively more persistent supply shocks, it should raise the

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[11] Over the post-2000 period, the standard deviation of 12-month headline inflation was 1.24, of trend inflation was 0.56, but of 4-quarter GDP inflation forecasts was only 0.22 (all in annualized percent).

[12] For example, Fed Chair Jerome Powell stated in his 2023 Jackson Hole speech “Food and energy prices are influenced by global factors that remain volatile, and can provide a misleading signal of where inflation is headed. In my remaining comments, I will focus on core inflation, which omits the food and energy components.” (August 25, 2023, speech by Fed Chair Jerome Powell). While it is well known that energy inflation can reflect both supply and demand shocks, demand shocks have been important for energy prices since at least the early 1990s. For prominent decompositions of energy prices see Kilian (2009) and Baumeister et al. (2022).

long-term convenience via the "money channel," i.e., higher future monetary policy rate, and we would thus expect a consistently positive core inflation-convenience relationship across periods.

This is indeed what we find in Panel B, which separates headline inflation into core and energy. It shows that these components have more stable relationships with Treasury convenience, as indicated by the insignificant interaction coefficients with the post-2000 dummy. Treasury convenience is consistently positively related to core inflation, for both the pre- and post-2000 samples. Energy inflation enters with a coefficient that is significantly smaller than the coefficient on core inflation for both the Aaa-Treasury spread and the T-bill spread. For the Aaa-Treasury spread, the relationship with energy inflation is statistically indistinguishable from zero.[13] The results from this decomposition therefore deepen the puzzle if one expected higher long-term inflation to diminish the value of Treasury convenience. Instead, the results in Table 4 are in line with an interpretation where the inflation-Treasury convenience relationship reflects changing dominant components, each of which has a stable inflation-Treasury convenience relationship.

2.4.3 Demand- and supply-driven inflation components

We next show results for an explicit decomposition of inflation into its demand- versus supply-driven components from Shapiro (2024). Shapiro (2024) uses monthly price, quantity, and expenditure data for more than 100 goods and services categories in the personal consumption expenditures (PCE)[14] to separate demand from supply shocks at an individual product category level. The shocks are then aggregated to obtain demand- and supply-driven PCE inflation. The decomposition is available starting from 1969:12, thus covering the key part of the high inflation period and the 2000s.

Table 5 reports our baseline contemporaneous regressions of Aaa-Treasury spreads on supply and demand components of PCE inflation, with the decomposition for core PCE (which the Fed mostly focuses on) in the first three columns, and headline PCE in the subsequent three columns. The full sample regressions of the Aaa-Treasury spread onto supply and demand components of inflation in columns (1) and (4) show that Treasury convenience has a positive relationship with

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[13] In column (4), the federal funds rate subsumes the otherwise positive coefficient on the core inflation. This relationship is captured in our model if the money channel at the short end is intermediated by monetary policy, but long-term convenience is more closely linked to long-term inflation expectations.

[14] The PCE and the CPI inflation (which we used so far) trace each other relatively closely. However, the construction of the two indices differs in the scope of the consumption basket, the weights of individual items, and how the basket changes are accounted for. Since 2000, the Federal Reserve has used PCE inflation as the preferred inflation measure.

Table 4: **Convenience yield onto core vs. headline inflation measures.** The sample period is 1959:01–2020:12 for headline, trend, core and energy inflation. The 4-quarter GDP inflator forecast from the Survey of Professional Forecasters and trend inflation are the for the current quarter. Survey forecasts start in 1970:04. Trend inflation is based on the decomposition of Stock and Watson (2007), computed following Chan (2018).

Panel A: Headline inflation measures

	Headline		Trend		Survey	
	(1)	(2)	(3)	(4)	(5)	(6)
Infl	0.089***	0.081***	0.081***	0.057**	0.079***	0.071**
	(4.24)	(3.21)	(3.93)	(2.37)	(2.85)	(2.13)
Infl x $I_{\geq 2000}$	-0.16***	-0.099**	-0.32***	-0.38***	-0.29	-0.011
	(-3.87)	(-2.26)	(-3.30)	(-4.56)	(-1.17)	(-0.05)
FFR		-0.032*		-0.018		-0.047**
		(-1.76)		(-0.93)		(-2.40)
VIX		0.0075		0.0086**		0.0075
		(1.62)		(1.96)		(1.51)
Debt/GDP		-0.32		-0.72*		-0.68
		(-0.88)		(-1.90)		(-1.55)
BAA spread		0.33***		0.36***		0.29***
		(3.76)		(3.73)		(3.08)
$I_{\geq 2000}$	0.71***	0.43***	1.07***	1.18***	0.81	0.12
	(6.29)	(2.88)	(5.14)	(5.98)	(1.61)	(0.25)
Constant	0.48***	0.34*	0.51***	0.40**	0.64***	0.73***
	(5.33)	(1.72)	(5.45)	(2.01)	(4.74)	(2.60)
$\bar{R}^2$	0.31	0.45	0.28	0.48	0.097	0.31
N	744	744	744	744	606	606

Panel B: Core vs. energy inflation

	AAA-Tsy spread		T-bill convenience	
	(1)	(2)	(3)	(4)
Infl (core)	0.12***	0.12***	0.095***	0.017
	(5.81)	(4.09)	(4.01)	(0.67)
Infl (eng)	-0.0076	-0.0044	0.015*	0.014**
	(-1.18)	(-0.70)	(1.67)	(2.32)
Infl (core) x $I_{\geq 2000}$	0.021	0.092	0.041	-0.088
	(0.16)	(0.79)	(0.82)	(-1.16)
Infl (eng) x $I_{\geq 2000}$	-0.0027	-0.00038	-0.013	-0.015**
	(-0.39)	(-0.05)	(-1.43)	(-2.30)
FFR		-0.039**		0.091***
		(-2.35)		(5.94)
VIX		0.011**		0.013***
		(2.37)		(2.78)
Debt/GDP		-0.31		0.20
		(-0.87)		(0.85)
BAA spread		0.21**		-0.063
		(2.13)		(-0.60)
$I_{\geq 2000}$	0.43*	0.12	-0.20*	0.24
	(1.74)	(0.46)	(-1.85)	(1.27)
Constant	0.35***	0.29	0.15**	-0.31**
	(3.81)	(1.47)	(1.98)	(-2.57)
$\bar{R}^2$	0.38	0.48	0.46	0.60
N	744	744	744	744

supply-driven inflation, but a negative relationship with demand-driven inflation. The next columns add interactions between the inflation components and a post-2000 dummy and add controls. This analysis shows that the positive association with supply inflation is predominantly driven by the pre-2000 period, as one might expect if there were few supply shocks post-2000. The post-2000 relationship between supply inflation and the Aaa-Treasury spread is statistically indistinguishable from zero. While the relationship between Treasury convenience and demand inflation is loses power for the shorter subsamples, the point estimates are consistently negative for each subperiod, supporting that demand-driven inflation has a negative relationship with Treasury convenience. These relationships between Treasury convenience and the components of inflation are similar without and with our full set of controls.

The different-signed relationships between Treasury convenience with supply- vs. demand-inflation are even clearer when we analyze lead-lag patterns. We extend the predictive lead-lag regressions (2) and (3) to separately consider demand- and supply-drivers of core PCE inflation:

$$\pi_{t+h}^{core,j} - \pi_t^{core,j} = a_h + b_h \Delta spread_t^{Aaa} + \gamma_h X_t + \varepsilon_{t+h} \tag{4}$$

$$spread_{t+h}^{Aaa} - spread_t^{Aaa} = c_h + d_h \Delta \pi_t^{core,j} + \delta_h X_t + \epsilon_{t+h}, \tag{5}$$

where inflation is split into demand- and supply-driven components, $j = \{dem, sup\}$. We augment these regressions with additional controls, X_t, using the first differences of the variables included in Table 5. Figure 5 summarizes the main findings. During the 1969–1999 period, an increase supply-driven inflation predicts a significant increase in the Aaa-Treasury spread with a peak effect at about 20 months ahead (Panel A). In contrast, in the post-2000s period, a higher spread predicts a lower demand-driven inflation, with a maximum effect at around 24 months ahead (Panel B). We also find no evidence of spreads significantly leading supply inflation or demand inflation leading spreads, as shown in Appendix Figure A6. While these results are not a direct test of causality, they indicate that supply vs. demand-driven fluctuations fundamentally alter the causal interpretation of the convenience-inflation relationship.

2.4.4 Bond-stock beta as indicator of supply and demand shocks

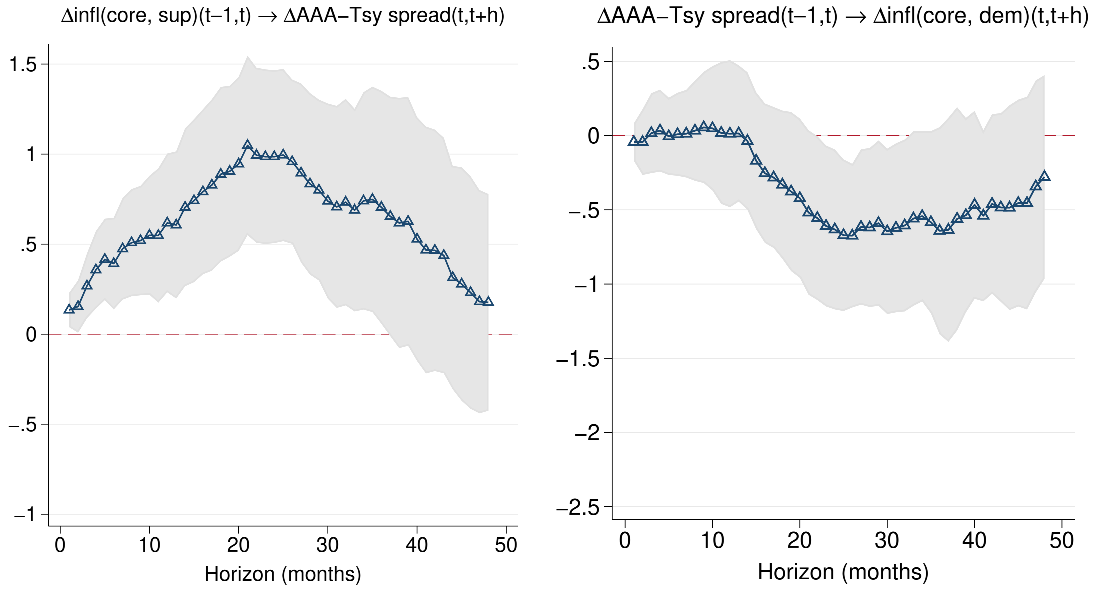
So far we have divided different historical episodes based on narratives about underlying shocks, and we have shown that results are robust to shifting around the cutoffs. If the changing Treasury convenience-inflation relationship over broad historical periods is indeed due to the changing

Table 5: **Convenience yield onto demand and supply inflation components.** The table reports regressions of convenience spreads on demand and supply components inflation for core inflation the first three columns, and for headline inflation in the last three columns. $I_{\geq 2000}$ is a dummy variable equal to one from 2000 onward. The sample period is 1969:12–2020:12. Newey-West t-statistics with 12 lags are shown in parentheses. * p <0.10, ** p <0.05, *** p <0.01.

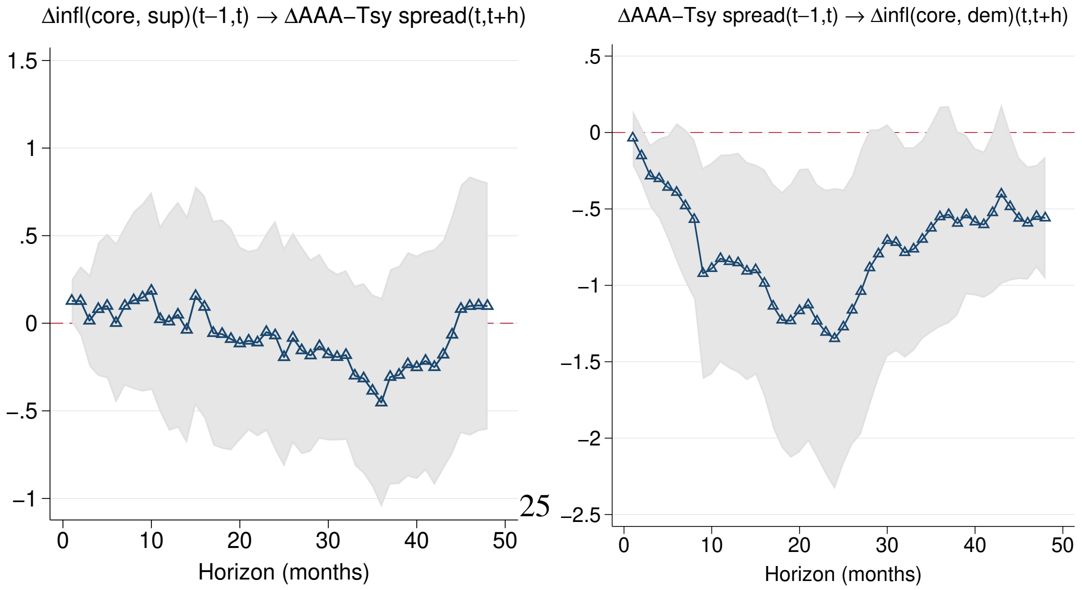
	(1)	(2)	(3)	(4)	(5)	(6)
	Core decomposition			Headline decomposition		
Infl (sup)	0.25***	0.24***	0.22***	0.15***	0.18***	0.18***
	(5.62)	(4.25)	(4.44)	(3.44)	(3.92)	(3.94)
Infl (dem)	-0.29***	-0.17	-0.11	-0.17**	-0.11	-0.076
	(-4.13)	(-1.12)	(-0.85)	(-2.18)	(-0.89)	(-0.77)
Infl (sup) x $I_{\geq 2000}$		-0.52***	-0.40*		-0.25**	-0.23***
		(-2.63)	(-1.88)		(-2.56)	(-2.76)
Infl (dem) x $I_{\geq 2000}$		-0.32	-0.085		-0.13	0.013
		(-1.51)	(-0.41)		(-0.88)	(0.10)
FFR			-0.041**			-0.049***
			(-2.56)			(-2.72)
VIX			0.0086**			0.0078*
			(2.13)			(1.96)
Debt/GDP			-0.48			-0.52
			(-1.13)			(-1.33)
BAA spread			0.16**			0.22***
			(2.05)			(2.93)
$I_{\geq 2000}$		0.81***	0.48*		0.51***	0.27
		(3.30)	(1.66)		(3.63)	(1.64)
Constant	0.90***	0.71***	0.77***	0.92***	0.71***	0.79***
	(13.26)	(4.59)	(2.91)	(12.86)	(6.15)	(3.32)
$\bar{R}^2$	0.26	0.35	0.45	0.16	0.28	0.42
N	613	613	613	613	613	613

Figure 5: **Predictive regressions with demand- vs. supply-driven inflation components** This figure presents coefficients from predictive regressions (4) and (5). The controls include the monthly changes from $t-1$ to t of FFR, VIX, Debt/GDP, and Aaa spread, i.e., first differences of controls in Table 5. Panel A displays the b_h coefficients predicting the demand component of core inflation with the Aaa-Treasury spread in the post-2000 sample. Panel B displays the d_h coefficients for predicting Aaa-Treasury spread with the supply-driven component of core inflation in the 1952–1999 sample. The gray shading indicates 95% confidence intervals based on Newey-West standard errors with h lags.

Panel A: 1969:12–1999:12



Panel B: 2000:01-2020:12



dominance of fundamental economic shocks, bond-stock betas should provide a good split for the changing convenience-inflation relationship. This approach builds on the literature characterizing comovements of stocks and bonds in supply- and demand-driven environments (e.g., Campbell et al., 2017, 2020; Ermolov, 2022; Pflueger, 2023), whereby supply shocks induce a positive stock-bond beta and demand shocks induce a negative stock-bond beta. In particular, we would expect to see a positive Treasury convenience inflation relationship when supply shocks are dominant, as indicated by a higher bond-stock beta, and vice versa.

Table 6 reports the loadings of the Aaa-Treasury spread on inflation for the full sample and in subsamples split by the stock-bond beta. It shows that the overall inflation-convenience relationship in the full post-1960 sample is positive, and it strengthens as the stock-bond beta increases. Notably, when we condition on the negative beta, the relationship becomes negative. This fact aligns with the interpretation that a negative inflation-convenience relationship arises when demand shocks are especially prominent. The magnitude in the convenience-inflation coefficient between the lowest beta and highest beta observations is substantially different. When the bond-stock beta is above 0.3, a one percentage point increase in inflation leads to a 11 bps higher convenience spread than when the bond-stock beta is below -0.1, roughly in line with our baseline magnitudes.

Table 6: **Aaa-Treasury spread inflation for subsamples split by Treasury bond-stock beta.** The bond-stock beta is the 120-day rolling beta of daily returns for a nominal zero-coupon Treasury bond with seven years to maturity onto daily stock returns. Daily nominal Treasury bond returns are computed from zero-coupon bond yields (Gürkaynak et al., 2007). Daily stock market index returns are from Ken French's website. The sample period is from 1961:11–2020:12. Robust Newey-West t-statistics (column (1)) and robust t-statistics (all other columns) in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	(1) 1961-2020	(2) beta≤ -0.1	(3) beta≤ 0	(4) beta> 0.1	(5) beta> 0.2	(6) beta> 0.3
Inflation	0.043***	-0.064***	-0.0032	0.045***	0.052***	0.052***
	(2.48)	(-3.91)	(-0.20)	(9.61)	(7.12)	(5.93)
Constant	0.78***	1.19***	0.96***	0.64***	0.61***	0.62***
	(30.51)	(30.67)	(22.88)	(21.51)	(15.67)	(12.88)
$\bar{R}^2$	0.092	0.090	0.000	0.16	0.18	0.21
N	710	152	284	261	165	105

The bond-stock beta could also directly affect the convenience yield by changing the hedging

Table 7: **Aaa-Treasury spread onto inflation controlling for bond-stock beta.** This table presents regressions of Aaa-Treasury spread onto inflation and bond-stock beta. 120-day rolling Treasury bond-stock betas are constructed as described in Table 6. The sample period is from 1961:11–2020:12. Newey-West t-statistics with 12 lags are shown in parentheses. * p <0.10, ** p <0.05, *** p <0.01.

	(1) 1961-2020	(2) 1961-1999	(3) 2000-2020	(4) 1961-2020	(5) 1961-1999	(6) 2000-2020
Inflation	0.043**	0.078***	-0.072**	0.059***	0.079***	-0.070**
	(2.48)	(3.73)	(-2.01)	(3.47)	(3.83)	(-2.15)
Bond-stock beta				-0.63***	-0.19	-0.76
				(-3.68)	(-0.71)	(-1.48)
Constant	0.78***	0.53***	1.19***	0.76***	0.56***	1.09***
	(9.48)	(5.35)	(17.07)	(9.95)	(4.94)	(14.34)
$\bar{R}^2$	0.092	0.29	0.080	0.17	0.30	0.12
N	710	458	252	710	458	252

properties of Treasuries, as argued by Acharya and Laarits (2023). Or negative bond-stock betas might reflect a positive shock to liquidity demand, thereby driving convenience yield spreads up and inflation down. In this second case, controlling for bond-stock betas might soak up some of the variation in liquidity demand shocks, and help isolate the role of inflation shocks for Treasury convenience. In Table 7, we project the Aaa-Treasury spread on inflation in the full sample as well as pre-/post-2000 subsamples, with and without stock-bond betas as controls. While the bond-stock beta enters with a negative sign in the full sample (confirming the results in Acharya and Laarits (2023)), its inclusion further strengthens the significantly positive coefficient on inflation (column (4)). As such, in the full sample, the stock-bond serves to control for confounding factors that attenuate the positive inflation-convenience relationship. In subperiods, the coefficient on inflation is positive and significant for the 1961-1999 period, but negative and significant in the 2000-2020 period, both consistent with our main findings. Neither its value nor significance are affected by the inclusion of the bond-stock beta, which itself becomes insignificant. This suggests that the changing inflation-convenience relationship is informative about the types of shocks affecting the economy.

To summarize, the evidence shows that higher inflation has generally been with associated with an increase, not decrease, in Treasury convenience, while higher Treasury convenience has predicted lower future inflation. Further, the relative contributions of these mechanisms for the macroeconomy and Treasury convenience appear to have shifted over time, implying a positive inflation-convenience relationship during the high inflation in the second half of the 20th century, but a negative inflation-convenience relationship pre-WWII and post-2000. To understand the mechanisms and potential causal links behind the empirical patterns, we next turn to a New Keynesian model of monetary policy with Treasury convenience.

3 Model of Convenience Yields and Inflation Drivers

This section provides a simple formalization of the two channel of Treasury convenience, i.e., the "money channel" and the "liquidity demand channel." Our model combines two standard components – a simple three-equation New Keynesian model of inflation and monetary policy (e.g., Galí (2008)) and block with money-like assets in the utility and Treasury bonds and money-like assets being substitutes (Sidrauski (1967), Friedman (1969), Nagel (2016)). We focus on the new implications for the changing relationship between inflation and convenience yields.[15] We solve for log-linear dynamics for inflation, the output gap, interest rates, and importantly the convenience spread between illiquid loans and liquid bond rates in the model. We illustrate the effects of cost-push and liquidity shocks on convenience yields and inflation via impulse responses.

There are three different short-term interest rates in our model, that correspond to different rates in practice. We use I_t^l to denote the interest rate on illiquid loans. In practice, households and firms cannot directly borrow and lend at T-bill rates, instead relying on less liquid bank loans, credit cards, student loans, mortgages etc. In order to capture lower liquidity inherent in these markets we proxy for I_t^l using high-grade corporate bond yields or commercial paper rates in our empirical analysis. We denote I_t^b as the interest rate on liquid Treasury bonds, such as T-bills and Treasury bonds that are highly liquid and that have many regulatory and liquidity benefits. Finally, I_t^d denotes the interest rate on liquid deposits, representing the interest rate that consumers and households can earn by depositing their money with a bank, i.e. the most liquid and money-like asset in this model. Deposits collapse to cash in the special case where the deposit rate is set to zero. Each of these interest rates are available at various maturities and we denote the n-period zero-coupon interest rates by $I_{n,t}^l$, $I_{n,t}^b$, $I_{n,t}^b$. Log interest rates are related to level interest rates via

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[15] Bianchi et al. (2022) also feature a convenience yield shock as a driver of business cycles and asset prices but do not focus on the changing inflation-convenience relationship, which we have documented in Section 2.

$i_t^l = \log\left(1 + I_t^l\right)$ etc. We use lowercase letters to denote logs throughout.

3.1 Preferences, Consumption, and Liquidity

A representative household has preferences over consumption, leisure, and liquidity services and maximizes

$$E_0 \sum_{t=0}^{\infty} \beta^t U\left(C_t, Q_t, H_t, N_t, \Theta_t\right), \tag{6}$$

$$\tag{7}$$

where

$$U\left(C_t, Q_t, H_t, N_t, \Theta_t\right) = \frac{\Theta_t \left(C_t - H_t\right)^{1-\gamma}}{1-\gamma} + \alpha \log Q_t - \chi \frac{N_t^{1+\eta}}{1+\eta}. \tag{8}$$

Different from the basic New Keynesian model, households have direct preferences over liquidity, similar to money in the utility function (Sidrauski (1967)) and the seminal work by Krishnamurthy and Vissing-Jorgensen (2012). We assume that Q_t is a composite of deposits and convenient government bonds

$$Q_t = D_t + \frac{\lambda_t}{1-\lambda_t} B_t. \tag{9}$$

Here, $D_t = D_{1,t} + D_{2,t} + ...$ and $B_t = B_{1,t} + B_{2,t} + B_{3,t} + ...$ denote real balances of zero-coupon bank deposits and Treasury bonds of various maturities. While we consider the case of perfect substitutability between Treasury bonds and deposits for our calibration, this assumption is not crucial and the qualitative results are similar if Treasuries and deposits are not perfect substitutes.[16] The parameter λ_t controls the relative contribution of government bonds to the liquidity aggregate. A spike in λ_t can be interpreted as heightened uncertainty in the economy (Caballero and Krishnamurthy (2008)), tightened collateral constraints (Del Negro et al. (2017)), or a liquidity shock in

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[16] The assumption of perfect substitutability makes the model as simple as possible while illustrating our main points. Appendix B.3 considers an extension to imperfect substitutability, and shows that in that case liquidity demand shocks need to be interpreted more broadly as incorporating shocks to the quantity of Treasury bonds. We include measures of Treasury debt quantities, which tend to mostly move at lower frequency than inflation, to control for this possibility throughout our empirical analysis.

the financial sector (Li (2024)), all of which would increase the preference for government debt. We refer to λ_t as Treasury liquidity.

The rest of the household specification is standard. Here, N_t denotes market labor supplied outside the home, and $H_t = hC_{t-1}$ denotes external consumption habit (Fuhrer (2000), Christiano et al. (2005)), i.e., consumers do not internalize the effects of their choices on future habit. External habit H_t serves to generate a backward-looking term in the Euler equation and slows down the output response to monetary policy.[17] The shifter Θ_t represents a taste shock that increases the utility that households derive from consumption today vs. tomorrow.

The representative household's budget constraint can then be written as

$$\begin{aligned} & D_t + B_t - L_t + C_t \\ = \; & \frac{W_t}{P_t} N_t + \Pi_t + \frac{P_{t-1}}{P_t} D_{1,t-1}(1 + I^d_{t-1}) + \frac{P_{t-1}}{P_t} B_{1,t-1}(1 + I^b_{t-1}) - \frac{P_{t-1}}{P_t} L_{1,t-1}(1 + I^l_{t-1}) \\ & + \frac{P_{t-1}}{P_t} \sum_{i=2}^{\infty} \left(B_{i,t-1}(1 + R^b_{i,t}) + D_{i,t-1}(1 + R^d_{i,t}) - L_{i,t-1}(1 + R^l_{i,t})] \right), \end{aligned} \tag{10}$$

where P_t is the aggregate price level in the economy at time t, $L_{i,t}$ denotes the real quantity of zero-coupon loans of maturity i, $L_t = \sum_{i=1}^{\infty} L_{i,t}$ is the total real quantity of loans, Π_t is the sum of firm and bank profits remitted to the household sector, and $R^b_{i,t}$, $R^d_{i,t}$ and $R^l_{i,t}$ denote the nominal returns from buying an i-period bond, deposit or loan at time $t-1$ and selling it again at time t.

3.2 Deposits and Monetary Policy

We assume that the deposit rate I^d_t equals a fraction of the illiquid loan rate I^l_t:

$$I^d_t = \delta I^l_t, \tag{11}$$

where the constant δ is generally less than 1 to reflect banks' market power and ability to keep raise deposit rates less than one-for-one with market rates.[18] In the corner case where $\delta = 0$, deposits

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[17] We follow the macroeconomics literature in our specification of habit because we are not solving for risk premia here. Campbell et al. (2020) show that a somewhat more complicated habit specification can also explain salient features of asset prices while preserving the same macroeconomic equilibrium.

[18] A long-standing and growing literature has documented the role of bank market power, see e.g. Barro and Santomero (1972); Startz (1979); Drechsler et al. (2017, 2021); Egan et al. (2022); Wang et al. (2022). The same functional form is endogenously generated in the model of Drechsler et al. (2017) and also assumed by Nagel (2016).

in the model can be interpreted as cash that carries a liquid benefit but earns no interest. The Fed implements policy by affecting the liquid bond rate, I_t^b. Intuitively, the Fed is not allowed to operate directly through private loan markets, as deciding which borrower is creditworthy would be considered fiscal policy and hence outside the purview of the central bank. We assume that the target policy rate follows a log-linear Taylor (1993)-type rule. Theoretical and empirical research has documented the relevance of interest-rate smoothing and policy inertia (Woodford (2003b), Taylor and Williams (2010), Bernanke (2004), Stein and Sunderam (2018)). Therefore, we include an inertial term in the policy rule:

$$i_t^b = (1-\rho^i)\left(\gamma^x x_t + \gamma^\pi \pi_t\right) + \rho^i i_{t-1}^b + v_{i,t}, \tag{12}$$

where the monetary policy shock $v_{i,t}$ is assumed to be iid, i_t^b is the one-period log liquid bond rate, π_t is log inflation, and x_t is the log output gap, or the difference between log real output and its natural level in the absence of price-setting frictions. Specifying monetary policy in terms of an interest rate target is consistent with how monetary policy was conducted throughout almost all of our sample.[19] We assume that the central bank conducts monetary policy by choosing an interest rate target and then setting the amount of deposits to the implicit value satisfying households' money demand function to ensure the interest rate target is met.[20] The rule (12) says that the central bank raises the policy rate when the output gap or inflation are higher, though it does so gradually over time as captured by the parameter ρ^i. A higher inertia parameter ρ^i also implies that monetary policy may raise interest rates slowly in response to an increase in inflation, as the short-term response to inflation $(1-\rho^i)\gamma^\pi$ may be substantially smaller than the long-term response γ^π.

3.3 Firms

The supply side of the economy is standard and we relegate the details to the Appendix. Partially monopolistic firms are assumed set product prices but can adjust their product prices only in some periods according to Calvo (1983) with inflation indexation (Christiano et al., 2005). Such a setup

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[19] The short 1979-1982 monetarist experiment provides an exception, though interest rates featured prominently in the Federal Reserve's considerations even during this episode.

[20] If banks face a constant reserve requirement, the implicit rule for deposits can then be met by increasing or decreasing the amount of federal funds in the system, similarly to how the Fed operated for much of our sample period until the global financial crisis of 2008-2009.

generates a standard log-linearized Phillips curve with an extra backward-looking term. Since the model does not have real investment, the aggregate resource constraint implies that consumption equals output, $C_t = Y_t$. Details are in Appendix B.

3.4 Shock Processes

In our baseline model, we assume that the liquidity shock λ_t follows a simple AR(1) process, similar to Anzoategui et al. (2019). We also consider an extension where Treasury liquidity is allowed to depend directly on inflation. Encompassing both of these cases, liquidity dynamics can be written as:

$$\lambda_t = \bar{u} - b\pi_t + u_t \tag{13}$$

$$u_t = \rho^\lambda u_{t-1} + v_{\lambda,t}. \tag{14}$$

Here, ρ^λ is the persistence of Treasury liquidity. Our baseline analysis sets $b = 0$, so inflation does not have a direct effect on Treasury liquidity. We also consider the case with $b > 0$, which captures the intuition that low and stable inflation may be important for the safety and convenience of nominal Treasury bonds as discussed in the introduction.[21] The steady-state Treasury bond liquidity weight equals $\bar{\lambda} = \bar{u} - b\bar{\pi}$, where $\bar{\pi}$ is steady-state log inflation. To allow for a clear comparison between liquidity and taste shocks, we assume that the log taste shifter $\theta_t \equiv \log \Theta_t$ is also normally distributed and follows and AR(1) process with the same autocorrelation coefficient ρ^λ. The cost-push shock, which formally arises as a markup shock to firms' market power over the variety they produce, is assumed to be log-normal and iid.

3.5 Asset Pricing Euler Equations

Let the nominal consumption-based stochastic discount factor be denoted by

$$M_{t+1}^{\$} = \beta \frac{U_c\left(C_{t+1}, Q_{t+1}, H_{t+1}, N_{t+1}, \Theta_{t+1}\right)}{U_c\left(C_t, Q_t, H_t, N_t, \Theta_t\right)} \frac{P_t}{P_{t+1}}, \tag{15}$$

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[21] Appendix B.4 shows that shocks to α cannot be interpreted as a meaningful shock to the overall demand for liquidity as long as assumption (11) is unchanged. However, any additional shocks that also enter the deposit rate pass-through (11) would act analogously to λ_t. We therefore refer to λ_t broadly as liquidity demand shocks.

where β is the time discount rate. This stochastic discount factor prices all nominal assets that have no special liquidity benefits, such as illiquid loans, giving the standard asset pricing Euler equation for the one-period loan rate

$$E_t\left[M_{t+1}^{\$}\left(1+I_t^l\right)\right] \;=\; 1. \tag{16}$$

In equilibrium, the representative household must be indifferent between marginally increasing Treasury bond holdings while decreasing consumption subject to the budget constraint (10), giving the Treasury bond Euler equation

$$E_t\left[M_{t+1}^{\$}\left(1+I_t^b\right)\right] \;=\; 1-\underbrace{\frac{\frac{\alpha}{Q_t}\frac{\lambda_t}{1-\lambda_t}}{U_c\left(C_t,Q_t,H_t,N_t,\Theta_t\right)}}_{\zeta_t^b}. \tag{17}$$

Note that the Euler equation (17) for liquid Treasury bonds takes exactly the form as in models with a reduced-form Treasury convenience benefit ζ_t^b, which has proven useful in understanding global currency fluctuations (Jiang et al. (2021)) and international business cycles (Jiang et al. (2023), Kekre and Lenel (2021)). Bianchi et al. (2022) introduce a similar wedge between the household and financial market Euler equations in their model of high-frequency market responses to monetary policy. We provide a new connection between this increasingly successful financial market shock and the real economy.

The analogous Euler equation for deposits is given by

$$E_t\left[M_{t+1}^{\$}\left(1+I_t^d\right)\right] \;=\; 1-\underbrace{\frac{\frac{\alpha}{Q_t}}{U_c\left(C_t,Q_t,H_t,N_t,\Theta_t\right)}}_{\zeta_t^d}. \tag{18}$$

Equation (17) shows that Treasury bond convenience ζ_t^b increases with the liquidity weight of Treasury bonds, $\lambda_t/(1-\lambda_t)$, and decreases with the marginal consumption value of liquidity $\frac{\alpha/Q_t}{U_{c,t}}$. Equation (18) shows that the convenience of deposits ζ_t^d increases with the liquidity value of deposits measured in marginal consumption units. Combining the first-order conditions for Treasury bonds (17) and deposits (18) with assumption (11), linking the deposit and loan rates, delivers the central equation for the Treasury bond convenience spread:

$$I_t^l - I_t^b = \frac{\lambda_t}{1-\lambda_t}(1-\delta)I_t^l. \tag{19}$$

To interpret equation (19) note that in the special case where deposits are simply liquid cash ($\delta = 0$) the nominal loan rate I_t^l is the cost of holding non-interest bearing cash, and $\lambda_t/(1-\lambda_t)$ is the liquidity value of Treasuries relative to cash.

3.6 Log-Linearized Model Dynamics

We log-linearize the model around the flexible-price steady-state $\bar{c} = \bar{y}$, $\bar{\pi}$, $\bar{i}^l$, $\bar{i}^b$, $\bar{\theta}$, and $\bar{\lambda}$. For ease of notation, we use c_t, y_t, π_t, i_t^l, i_t^b, and i_t^d to denote log deviations from these steady-state values. Because potential output is constant, the log output gap x_t equals log output up to a constant, i.e., $x_t = y_t = c_t$. A first-order approximation abstracts from second-order terms, such as liquidity risk premia, which are treated in complementary papers by Du et al. (2023) and Acharya and Laarits (2023), instead focusing on the first-order effects of liquidity.

We start with the log-linearized expressions for bond yields and convenience spreads. Log-linearizing the expression (19) gives the following log-linear expression for the illiquid loan rate

$$i_t^l \;=\; f^i i_t^b + f^\lambda \lambda_t, \tag{20}$$

where the log-linearization constant

$$f^i \;=\; \frac{1}{1-\frac{\bar{\lambda}}{1-\bar{\lambda}}(1-\delta)}\frac{1+\bar{I}^b}{1+\bar{I}^l}, \tag{21}$$

can be shown to be strictly greater than one, provided that $\bar{\lambda} > 0$ and $\delta < 1$, as in that case the illiquid loan rate increases more than one-for-one with the liquid Treasury bill rate. The intuition for $f^i > 1$ is that a higher policy rate i_t^b also increases the convenience yield $i_t^l - i_t^b$ via the money channel, and therefore, i_t^l increases with i_t^b more than one-for-one. The constant f^λ is a log-linearization constant linking the magnitude of the liquidity shock λ_t to its impact on illiquid loan rates.

The log-linearized convenience yield spread then equals

$$\underbrace{i_t^l - i_t^b}_{\text{Convenience yield}} = \underbrace{\left(f^i - 1\right) i_t^b}_{\text{Money channel}} + \underbrace{f^\lambda \lambda_t}_{\text{Liquidity demand channel}} . \tag{22}$$

Long-term Treasury convenience, to first order, is given by the expected short-term Treasury convenience over the lifetime of the bond

$$\begin{aligned} i_{n,t}^l - i_{n,t}^b &= \frac{1}{n} E_t \left[\sum_{h=0}^{n-1} \left(i_{t+h}^l - i_{t+h}^b \right) \right], \\ &= \underbrace{\left(f^i - 1\right) \frac{1}{n} E_t \sum_{h=0}^{n-1} \pi_{t+h+1}}_{\text{Money channel}} + \left(f^i - 1\right) \frac{1}{n} E_t \sum_{h=0}^{n-1} r_{t+h}^b + \underbrace{f^\lambda \frac{1}{n} E_t \sum_{h=0}^{n-1} \lambda_{t+h}}_{\text{Liquidity demand channel}} . \end{aligned} \tag{23}$$

The two different channels of Treasury convenience are visible in equations (22) and (23). Since equilibrium real rates are pinned down by productive capacity in the long term and outside the traditional scope of monetary policy (Fisher, 1930; Friedman, 1968), at the long end of the term structure the money channel drives a positive relationship between long-term inflation and long-term Treasury bond convenience. For short-term bonds, the convenience spread between illiquid loans and liquid Treasury bonds rises with the nominal Treasury bond rate provided that Treasury bonds have positive steady-state convenience ($\bar{\lambda} > 0$) and there is incomplete interest rate pass-through to deposits ($\delta < 1$). As expected inflation and the nominal bond rate rise, it becomes more expensive to hold money-like assets such as deposits. Because Treasury bonds and deposits are substitutes, the Treasury bond convenience yield increases as well.

The liquidity demand channel is captured by the last term in (23). A widening gap between the liquidity value of Treasury bonds relative to deposits, captured by an exogenously given λ_t, drives up the convenience spread between illiquid loans and liquid government bonds. As such, rising Treasury convenience in itself acts as a shock in the economy, and as we argue below, has the usual properties associated with a demand shock, depressing household spending and reducing inflation.

The representative household's log-linearized intertemporal first-order condition takes the standard form

$$x_t = \rho^x x_{t-1} + (1 - \rho^x) E_t x_{t+1} - \psi \left(i_t^l - E_t \pi_{t+1} \right) + v_{x,t}, \tag{24}$$

where the backward-looking coefficient equals $\rho^x = \frac{h}{1+h}$, and the elasticity of intertemporal substitution is given by $\psi = \gamma^{-1}\frac{1-h}{1+h}$. The demand shock equals $v_{x,t} = \psi\left(\theta_t - E_t\theta_{t+1}\right)$ and captures the typical New-Keynesian demand shifter arising from preference or taste shocks, unrelated to Treasury liquidity (e.g., Galí, 2008).

Substituting the log-linearized convenience yield (20) into the macroeconomic Euler equation yields the Euler equation with liquidity:

$$x_t = \rho^x x_{t-1} + (1-\rho^x)E_t x_{t+1} - \psi(\underbrace{f^i i_t^b}_{\text{money channel}} - E_t\pi_{t+1}) - \psi \underbrace{f^\lambda \lambda_t}_{\text{liquidity demand}} + v_{x,t}. \tag{25}$$

Demand for liquid assets enters the macroeconomic Euler equation (25) in two ways. First, an increase in government bond convenience acts just like a negative demand shock via the $f^\lambda\lambda_t$ term, reflecting the liquidity demand channel, and thereby provides an alternative microfoundation for demand shocks. When the Treasury bond convenience increases due to a shift in λ_t, households face a higher loan rate for a given Treasury bond rate, increasing their incentive to save and decreasing the incentive to consume this period. Second, the effect of the nominal rate on consumption and output is amplified by a factor f^i, which arises from the money channel of bond convenience. This amplification implies that a rise in inflation that is accompanied by the same rise in the nominal rate is contractionary, as $f^i > 1$.[22] S

Because utility is separable in consumption, leisure, and liquidity, the standard log-linearization of the firm's optimal price setting problem gives the log-linearized Phillips curve

$$\pi_t \;\; = \;\; \rho^\pi \pi_{t-1} + (1-\rho^\pi)E_t\pi_{t+1} + \kappa x_t + v_{\pi_t}, \tag{26}$$

where ρ^π and κ are log-linearization constants, and the cost-push shock $v_{\pi,t}$ arises from deviations in the markup from its steady-state value (see Appendix B for details). The slope parameter κ reflects the rise in marginal costs of production when output is running above potential, leading firms to optimally raise prices.

We use Blanchard and Kahn (1980) algorithm to solve the equilibrium dynamics (25) , (26)

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[22] This channel is complementary to Drechsler et al. (2023), who argue that an increase in inflation affects firms directly, thereby amplifying the increase in inflation. We abstract from that channel, which would tend to amplify but not change the sign of the inflation-convenience relationship.

and (12) for an equilibrium of the form

$$Z_t = BZ_{t-1} + \Sigma v_t, \tag{27}$$

where the state vector equals $Z_t = [x_t, \pi_t, i_t^b, u_t]$ and the vector of exogenous iid shocks is given by $v_t = [v_{\lambda,t}, v_{\pi,t}, v_{i,t}]$. In the baseline calibration, we focus on the Treasury liquidity λ_t as the only source of demand shocks, $v_{\lambda,t}$. To compare the effects of the convenience-driven demand, we also consider a standard New-Keynesian benchmark without Treasury convenience where demand shocks originate solely from preference shocks, $v_{x,t}$. Our calibration features a single non-explosive equilibrium of the form (27). The short- and long-term convenience spreads can then be solved by substituting (13) into the log-linear expressions (20) and (23).

3.7 Quantitative Illustration

We illustrate the properties of the model using standard parameter values, with parameters listed in Appendix Table A3. The backward-looking component of the Euler equation (ρ^x) and the slope of the Euler equation (ψ) follow Pflueger and Rinaldi (2022), who show that these values match the empirical output response to identified monetary policy shocks. The Phillips curve has a substantial backward-looking component, which Fuhrer (1997) found necessary to explain the empirical persistence of inflation. The slope of the Phillips curve is set following Rotemberg and Woodford (1997).[23] The monetary policy rule has a long-term inflation weight greater than one, ensuring that the Taylor principle holds, and a moderate amount of inertia or gradualism. We consider versions of the model with only one shock switched on at a time, so the impulse responses and regression results are invariant to the magnitude of the shock volatilities. We hence need to specify which shock is active and the size of the impulse, but not the equilibrium volatilities of shocks.

We choose to set the pass-through of loan rates to deposit rates to $\delta = 0.34$, within the range of $1/3$ to $1/2$ suggested by Nagel (2016). The steady-state liquidity weight of government bonds and the autocorrelation coefficient of this liquidity weight are set to match summary statistics in our data, where the average Aaa-Treasury spread over the sample period 1926–2020 has a mean of 87 bps with a quarterly AR(1) coefficient of 0.91. The average long-term government bond yield over

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[23] The somewhat higher Phillips curve slope compared to Hazell et al. (2022) generates a slightly larger inflation response to liquidity shocks in the model but leaves the qualitative model properties unchanged.

the same sample period equals 5.28%. Setting $\bar{\lambda} = 0.20$ and substituting into equation (19) then implies a steady-state Treasury liquidity spread of $\bar{i}^l - \bar{i}^b = \frac{0.2}{1-0.2} \times (1 - 0.34) \times 5.29\% = 87$ bps in the model. The steady-state discount rate is set to $\beta = 0.98$ and inflation to $\bar{\Pi} = 2\%$ in annual units, so the steady-state illiquid loan rate equals 4.03% annualized. These values imply an interest rate multiplier of $f^i = 1.20$. Thus, a 100 bps increase in inflation expectations that is accompanied by a one-for-one increase in the policy rate i_t^b has the same macroeconomic impact as a 120 bps increase in the illiquid loan rate i_t^l. Our baseline scenario treats liquidity shocks λ_t as completely exogenous and, thus, sets $b = 0$ in equation (13). Later, we consider an extension where we allow inflation to directly negatively affect the liquidity value of Treasuries via $b > 0$.

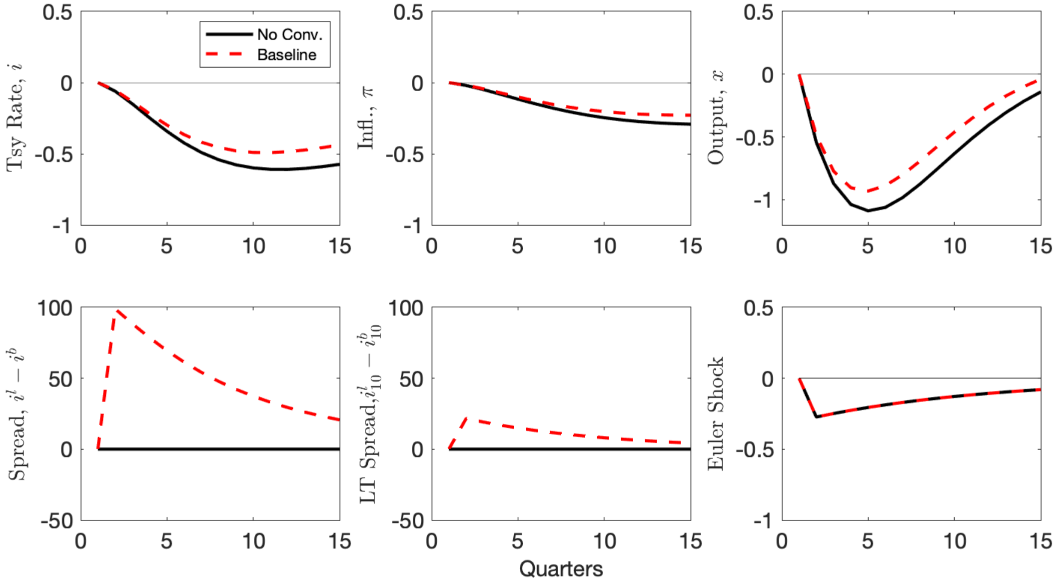
3.8 Baseline Model Impulse Responses

We illustrate the economic mechanism through model impulse responses. Figure 6 traces out the effects of negative liquidity shock $v_{\lambda,t}$ for inflation, convenience spreads, the Treasury bond yield, and the output gap. The $v_{\lambda,t}$ shock is scaled so that its on-impact effect on the convenience spread is 100 bps, implying a negative effect on aggregate demand in equation (25). For comparison, we report the responses to the same size of shock to the Euler equation (24) in a model without Treasury convenience.

Figure 6 shows that the liquidity demand channel provides an explanation for our main empirical finding for periods 1 and 3 in the data, as inflation and convenience move against each other following a liquidity shock, $v_{\lambda,t}$. This arises because a positive convenience shock acts similarly to a negative demand shock to the Euler equation, decreasing the output gap, inflation and the Treasury bond rate. The intuition follows directly from equation (20): households face a higher illiquid loan rate i_t^l at a given policy rate i_t^b, decreasing their demand to borrow and consume. Firms reduce production to meet this weaker demand, which also means that firms optimally decrease prices through the Phillips curve (26). The macroeconomic responses to a liquidity demand shock are qualitatively similar to a standard New Keynesian demand shock (denoted by "No Conv."). There is a slight amplification when Treasury bonds have convenience because private sector loan rates rise more than one-for-one with the liquid bond rate.

Figure 7 shows that the money channel explains the empirical evidence for the 1952–1999 period (period 2), as a cost-push shock moves inflation and convenience – especially long-term convenience – in the same direction. The impulse response for the long-term convenience spread

Figure 6: **Baseline model responses to liquidity shock** This figure shows impulse responses to a liquidity shock to $v_{\lambda,t}$ for our baseline model with $b = 0$. The shock is scaled so that in the model with convenience it corresponds to a 100bps increase in the convenience yield spread $i_t^l - i_t^b$. The black line reports the impulse response to a demand shock to the Euler equation, $v_{x,t}$, with identical AR(1) coefficient as the liquidity shock while setting Treasury convenience to zero ($\bar{\lambda} = 0$). Responses for inflation, π and the Treasury rate i^b are in annualized percent units. The response for the convenience spread $i^l - i^b$ is in annualized basis points units. The response for the output gap x is in percent units. Quarters are shown on the x-axis.



follows most closely the inflation response, while the short-term convenience spread follows most closely the policy rate response to a cost-push shock. The intuition is that due to its persistence, inflation is a better indicator of high nominal interest rates in the future than the current policy rate, thereby driving long-term convenience through the expectation of the future convenience benefit of Treasury bonds. Monetary policy is amplified in the presence of Treasury convenience, deepening the recession but mitigating inflation in response to a positive cost-push shock compared to a New Keynesian model without Treasury convenience.

Table 8 summarizes the switch in the model convenience-inflation relationship when changing the dominance of liquidity vs. inflationary cost-push shocks. For clarity, we switch on one shock at a time in model simulations. The first column in Panel A shows that when the economy is hit

Table 8: **Model convenience, inflation, and policy rate relationships.** The table reports model correlations between ST and LT convenience spreads with contemporaneous inflation (Panel A) and with the contemporaneous policy rate i_t (Panel B). All correlations are from a simulation of the model of length 500. Columns labeled "Liquidity Shock" use a model simulation with only the liquidity shock $v_{\lambda,t}$ switched on, and all other shocks set to zero. Columns labeled "Supply Shock" use a model simulation with only the supply shock $v_{\pi,t}$ switched on and all other shocks set to zero. Columns labeled "MP Shock" use a model simulation with only the monetary policy shock $v_{i,t}$ switched on and all other shocks set to zero. Panel C shows model correlations between inflation and the long-term convenience spread 8 quarters before and after.

Panel A: Inflation-Convenience Correlation

Corr(Convenience spread, Inflation)	Liquidity Shock	Cost-Push Shock	MP Shock
ST Convenience	-0.43	0.98	0.07
LT Convenience	-0.40	1.00	0.99

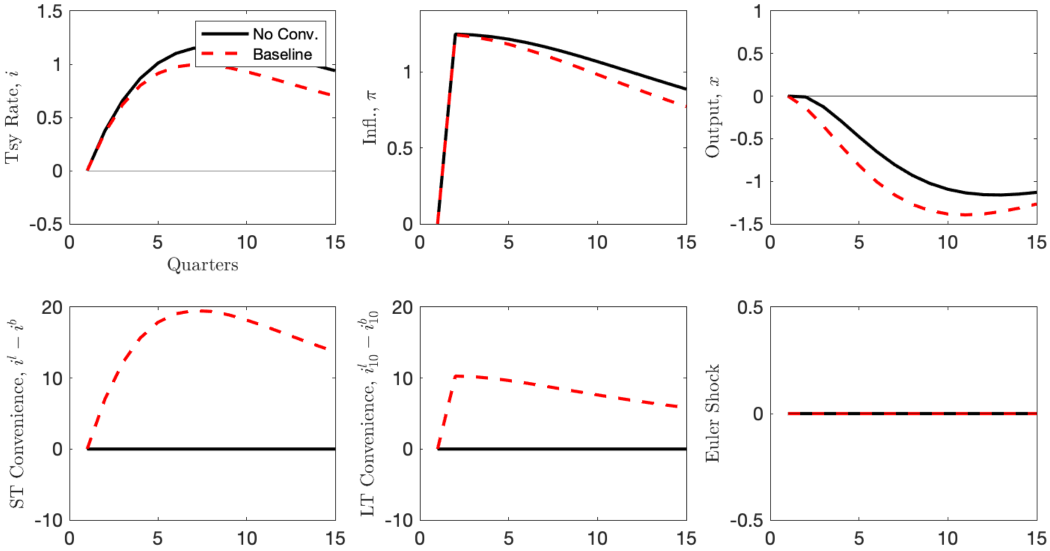
Panel B: Policy Rate-Convenience Correlation

Corr(Convenience Spread, Policy Rate)	Liquidity Shock	Cost-Push Shock	MP Shock
ST Convenience	-0.59	1.00	1.00
LT Convenience	-0.57	0.97	0.09

Panel C: Leads and Lags

Corr(LT Convenience Spread$_{q\pm h}$, Inflation$_q$)	Liquidity Shock	Cost-Push Shock	MP Shock
LT Convenience $(q-8)$	-0.67	0.76	0.88
LT Convenience	-0.40	1.00	0.99
LT Convenience $(q+8)$	-0.07	0.74	0.82

Figure 7: **Baseline model impulse responses to cost-push shock** This figure shows impulse responses to a cost-push (supply) shock for our baseline model. The supply shock is a positive 100 bps shock to the Phillips curve. Responses for inflation, π and the Treasury rate i^b are in annualized percent units. The response for the convenience spread $i^l - i^b$ is in annualized basis points units. The response for the output gap x is in percent units. Quarters are shown on the x-axis.



repeatedly by liquidity shocks, as in Figure 6, inflation-convenience correlation is negative. On the other hand, the second column in Panel A shows that the correlation is strongly positive if the economy is exposed to inflationary cost-push shocks, as in Figure 7. Panel C shows correlations of inflation with leads and lags of long-term Treasury convenience 8 quarters after and 8 quarters ahead. When the liquidity shock is switched on, the negative inflation-convenience correlation is strongest between convenience 8 quarters prior, i.e. convenience leads inflation as in the right panels of Figure 4, further supporting the interpretation that the liquidity demand channel was dominant pre-WWII and during the pre-Covid 2000s. When the cost-push shock is switched on, the model does not generate a clear lead-lag pattern between inflation and convenience, in line with the somewhat more mixed evidence of inflation leading convenience in Figure 4. The reason for this model implication is that agents' expectations in this model are perfectly rational and long-term convenience is forward-looking, so convenience moves immediately when long-term inflation expectations increase, such as after an inflationary cost-push shock. A plausible model extension where inflation expectations move slowly (Malmendier and Nagel (2016)) would easily generate a pattern whereby inflation leads convenience spreads when cost-push shocks are present, and thereby generate the lead-lag pattern in the bottom-left of Figure 4, but we do not pursue this extension here for simplicity.

Comparing the final column across Panels A and B shows that when there are monetary policy shocks, short-term convenience is strongly connected to the policy rate, while long-term convenience is hardly related to the policy rate.[24] This suggests that when there are both cost-push and monetary policy shocks, a regression of long-term convenience onto inflation and the policy rate will mainly load onto inflation. The policy rate, in this case, captures unrelated monetary policy shocks. Conversely, for short-term convenience, both cost-push and monetary policy shocks influence it through the policy rate. Thus, the model helps explain the contrasting finding that the fed funds rate partly drives out inflation in the short-term convenience regressions in Table 3, but that inflation enters separately and positively for long-term convenience in the second half of the 20th century even when controlling for the fed funds rate in Table 2.

3.9 Alternative Model Impulse Responses with Direct Inflation-Convenience Link

Finally, we investigate the implications of an alternative model allowing for a direct inflation-Treasury liquidity link, and show that it cannot explain our empirical findings. Specifically, by setting $b > 0$ in equation (13), we assume that inflation can directly undermine the liquidity benefits of the Treasuries. We keep all other parameters unchanged, and calibrate $b = 0.02$. This value means that at an annualized steady-state inflation rate of 10% the liquidity value of Treasury bonds would be eliminated because $\bar{\lambda} - 10 \times b = 0.2 - 10 \times 0.02 = 0$. To illustrate the implications of the inflation-liquidity link in a low- vs. high-inflation environment we consider two levels for steady-state inflation, with $\bar{\Pi}^{high} = 4.01\%$ corresponding to the empirical average in our period 2 and $\bar{\Pi}^{low} = 0.65\%$ corresponding to empirical inflation averaged across our periods 1 and 3. For simplicity we assume a constant discount rate $\beta = 0.98$ across the two calibrations, so the real risk-free rate is held constant.

Figure 8 shows that this alternative model implies a *more negative* convenience-inflation re-

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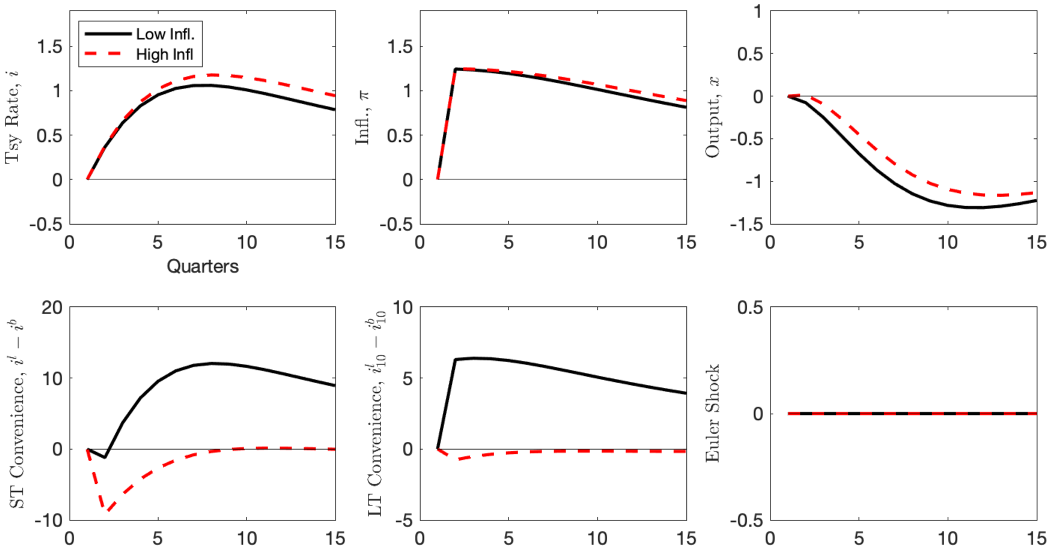
[24] The corresponding impulse responses are shown in Appendix Figure A7.

Figure 8: **Alternative model impulse responses to cost-push shock.** This figure shows impulse responses to a cost-push (supply) shock for the model with a direct inflation-convenience link ($b = 0.02$ in equation (13)). The high-inflation equilibrium assumes $\bar{\Pi}^{high} = 4.01\%$ and the low-inflation equilibrium assumes $\bar{\Pi}^{low} = 0.65\%$. The supply shock is a positive 100 bps shock to the Phillips curve. Responses for inflation, π and the Treasury rate i^b are in annualized percent units. The response for the convenience spread $i^l - i^b$ is in annualized basis points units. The response for the output gap x is in percent units. Quarters are shown on the x-axis.



lationship when steady-state inflation is high than when it is low. This is in stark contrast to the data where we found a *more positive* inflation-convenience relationship during the high-inflation 1970s and 1980s than during the low-inflation pre-WWII and 2000s periods in the data. Figure 8 focuses on the cost-push impulse responses for the alternative model, as impulse responses to the other two shocks are very similar to our baseline model.[25] To the extent that higher cost-push inflation reduces the attractiveness of Treasury bonds as a convenient asset, one might expect a decrease in convenience spreads following an inflationary cost-push shock. The bottom panels of Figure 8 show that this pattern emerges only for the high-inflation equilibrium. In the data, the inflation-convenience relationship is instead more positive during the high-inflation 1970s and

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[25] We show that these implications are robust to alternative parameter values in the Appendix.

1980s.

Why does the alternative model imply a more negative relationship between Treasury convenience and inflation when inflation is high? The intuition is simply that with higher steady-state inflation, Treasuries have less steady-state convenience $\bar{\lambda}$, which implies that the convenience response to inflation is weaker according to equation (23). The money channel is hence weaker. In this case, the response of Treasury convenience is dominated by the direct effect on λ_t as in the liquidity demand channel. By contrast, when steady-state inflation is low, the money channel is more important and a cost-push shock that leads to higher nominal rates has a pronounced positive effect on Treasury convenience.

Overall, the simple New Keynesian model with Treasury convenience shows that low-frequency shifts between the liquidity demand channel and the money channel of Treasury convenience can explain patterns documented in our empirical analysis, while a direct link between inflation and Treasury convenience cannot.

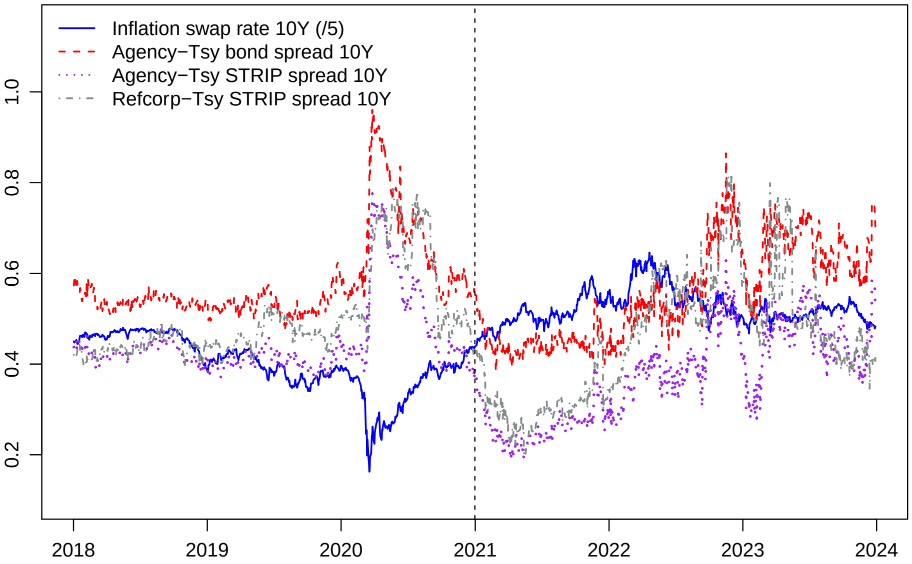
4 Evidence from the Post-Covid Period

Our main analysis uses a century of historical data and reveals structural shifts in the relation between inflation and the Treasury convenience yield. These shifts are not isolated to historical episodes but remain relevant in today's world.

Figure 9 shows that while the correlation between Treasury convenience and market-implied inflation was strongly negative before the bout of post-pandemic inflation, it turned slightly positive just as inflationary pressures reemerged. This fact is robust to using various measures of convenience yields available in the post-2000 sample, including the agency-Treasury bond spread, agency-Treasury STRIPs spread, and the Refcorp-Treasury STRIPs spread. All of these alternative measures have exactly-matched maturities and involve no credit risk (agency bonds and refcorp bonds are guaranteed by the U.S. government). We use inflation swap rates to obtain high-frequency measures of inflation expectations, but due to concerns about inflation risk premia supplement our analysis with direct measures of inflation expectations. .

This change of correlation provides an out-of-sample test of one of the key model predictions. The year of 2020 witnessed a sharp drop of inflation due to the negative demand shock, and then a gradual recovery. Meanwhile, different measures of convenience yields spiked at the onset of the pandemic and then recovered during the rest of 2020. We note that the spike of convenience yield does not conflict with the literature that documents a spike of long-term Treasury yield at the onset of the pandemic (He et al., 2022), because despite an increase of Treasury yield during that time, yields of relatively less liquid safe bonds such as agency bonds increased by more, reflecting a scarcity of liquidity. Starting from 2021, inflation shocks pushed the inflation rate to be more than 2% and that is when the inflation-convenience correlation turns from negative to positive.

Figure 9: **Daily time series of various convenience yield measures and the 10-year breakeven inflation after 2018.** We plot various Treasury convenience yield measures and 10-year inflation swap rates from Bloomberg (USSWIT10) 2018:01 to 2023:12. All convenience yield measures are maturity-matched spreads of 10-year maturity. In particular, Agency-Tsy spread is the yield spread between 10-year agency bonds and 10-year Treasury notes. Agency-Tsy STRIP spread is the yield spread between 10-year agency STRIPs (zero coupon) and 10-year Treasury STRIPs (zero coupon). Refcorp represents 10-year Refcorp STRIPs (zero coupon). The vertical dashed line marks the end of 2020.



In Table 9, we implement a formal analysis on the relation between convenience yield and inflation for the recent period. Our measures of convenience yields not only include the Aaa-Treasury spread, but also agency-Treasury bond spread, agency-Treasury STRIPs spread, and the Refcorp-Treasury STRIPs spread. The latter measures are ideal for the purpose of capturing Treasury convenience, because agency bonds and Refcorp bonds are guaranteed by the U.S. government and hence eliminate concerns about credit risk, but they are only avaialble for a shorter sample not for our long sample.

In Panel A, we use realized inflation. In panel B, we use expected inflation, measured as the four-quarter forecast of CPI inflation from the survey of professional forecasters. In panel C, we use inflation swap rates. The common pattern across all different measures of inflation and convenience yields is that the inflation-convenience correlation is negative before the end of 2020, but positive after 2021. In all regressions, we control for the federal funds rate, because there are changes in monetary policy stance that confound the inflation-convenience relationship. Since we use long-term convenience yield measures, we are still able to recover the underlying inflation-convenience relationship after controlling for monetary policy.

Table 9: **Post-COVID inflation shocks and convenience yields.** The table presents estimates that regress various convenience-yield measures on realized inflation, expected inflation, and inflation swap rates. The pre sample is monthly from 2018:01 to 2020:12, which captures the demand shock during COVID-19 crisis, and the post sample is monthly from 2021:01 to 2023:12, which captures the post-COVID inflation. Realized inflation is the lagged 12-month CPI inflation rate. Expected inflation is the forecast of next four-quarter inflation from the Survey of Professional Forecasters. Agency-Tsy spread is the yield spread between 10-year agency bonds and 10-year Treasury notes. Agency-Tsy STRIP spread is the yield spread between 10-year agency STRIPs (zero coupon) and 10-year Treasury STRIPs (zero coupon). Refcorp represents 10-year Refcorp STRIPs (zero coupon). Newey-West t-statistics with 12 lags are reported in parentheses. Constant terms are included in regressions but not reported for conciseness. * p <0.10, ** p <0.05, *** p <0.01.

	Aaa-Tsy		Agency-Tsy		Agency-Tsy STRIP		Refcorp-Tsy STRIP	
	(1) pre	(2) post	(3) pre	(4) post	(5) pre	(6) post	(7) pre	(8) post
Panel A: 12-Month Inflation								
Inflation	-0.15***	0.016	-0.047**	0.012***	-0.041	0.015***	-0.075***	0.043***
	(-4.15)	(1.62)	(-2.19)	(7.27)	(-1.41)	(4.97)	(-4.19)	(5.30)
FFR	-0.0055	-0.037***	-0.051*	0.047***	-0.034	0.045***	-0.037*	0.043***
	(-0.15)	(-4.69)	(-2.01)	(20.75)	(-1.36)	(14.86)	(-1.80)	(5.94)
$\bar{R}^2$	0.28	0.58	0.47	0.80	0.33	0.72	0.53	0.60
N	36	36	36	36	36	36	36	36
Panel B: SPF Inflation Expectations								
$\mathbb{E}$[Inflation]	-0.42**	0.12***	-0.087	0.086***	-0.078	0.11***	-0.27**	0.32***
	(-2.31)	(3.54)	(-1.30)	(4.48)	(-1.22)	(4.57)	(-2.43)	(9.29)
FFR	-0.060	-0.045***	-0.070***	0.041***	-0.050**	0.037***	-0.062***	0.022***
	(-1.35)	(-6.11)	(-2.91)	(12.97)	(-2.11)	(9.45)	(-3.05)	(2.80)
$\bar{R}^2$	0.17	0.57	0.42	0.79	0.28	0.72	0.48	0.59
N	36	36	36	36	36	36	36	36
Panel C: Zero-Coupon 10YR Inflation Swap								
Inflation Swap 10Y	-0.37***	0.080	-0.14***	0.10***	-0.12**	0.13***	-0.13***	0.27***
	(-6.02)	(1.52)	(-2.92)	(8.87)	(-2.20)	(9.20)	(-6.78)	(9.44)
FFR	-0.0052	-0.036***	-0.045***	0.051***	-0.030*	0.050***	-0.048***	0.050***
	(-0.31)	(-3.86)	(-2.80)	(15.00)	(-1.70)	(13.46)	(-2.99)	(4.02)
$\bar{R}^2$	0.69	0.54	0.71	0.81	0.56	0.74	0.61	0.46
N	36	36	36	36	36	36	36	36

5 Conclusion

This paper argues that two different mechanisms driving Treasury bond convenience – the "money channel" and the "liquidity demand channel" – have dominated over distinct historical periods, leading to sign changes in the comovement between Treasury convenience and inflation. We show that during the 1970s and 1980s, Treasury convenience was robustly positively correlated with inflation. however, Treasury convenience tended to fall with higher inflation in the first half of the 20th century and again during the post-2000 period. An empirical decomposition of inflation into components reveals that the positive correlation during the 1970s and 1980s was due to the persistent component of inflation, largely driven by supply shocks.

We explain these findings in a New Keynesian model that embeds the money channel of Treasury convenience along with liquidity-driven demand shocks. In the model, a higher liquidity value of Treasuries increases the incentive to save and reduces consumption, lowering demand and hence inflation via the standard liquidity demand channel. A negative inflation-convenience relationship ensues, similar to the experience of the early 20th century and the 2000s. In contrast, an inflationary cost-push shock raises expectations of future inflation and nominal interest rates, the opportunity cost of holding money, and by extension, the cost of holding convenient money-like assets. Because cost-push shocks lead to persistent inflation in standard New Keynesian models, the positive inflation-convenience relationship is most pronounced for long-term convenience and not absorbed by the current policy rate, consistent with our empirical evidence from the 1970s and 1980s.

While intuition might suggest that episodes of high inflation deplete the convenience benefits of Treasuries, this intuition does not accurately describe the historical experience to date. Our results highlight a more complex link between Treasury convenience and the macroeconomy through the interplay of money and liquidity demand channels, with substantial periods dominated by a positive inflation-convenience relationship through the money channel.

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Online Appendix to
“Inflation and Treasury Convenience”

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A Data and Robustness of Empirical Results

In this section, we provide details on dataset construction and robustness checks of our main results.

A.1 Data Sources

Our main measure of inflation is the annual change in the consumer price index (CPI) for all urban consumers. Data after 1947 can be easily downloaded from FRED. Since we need a longer horizon, we use CPI data from Shiller (2016), who reports the data starting from the late 1800s. Data are downloaded using *“ie_data”* link on the website https://shillerdata.com/.

Our measure of Aaa-Treasury spread directly replicates Krishnamurthy and Vissing-Jorgensen (2012). From 1924 until 1999, we use the average yield on long-term government bonds (LTGVTBD) from the St. Louis Fed’s FRED. From 2000 onwards, we use the yield on 20-year maturity Treasury bonds (GS20) from FRED. The monthly Moody’s seasoned Aaa corporate bond index (Aaa) is also from FRED. Similarly, we obtain Moody’s seasoned Baa corporate bond index from FRED.

We additionally construct the T-bill convenience following Nagel (2016). Specifically, we directly use the main T-bill convenience series in Nagel (2016), downloaded from Stefan Nagel’s website, https://voices.uchicago.edu/stefannagel/code-and-data/, link *“Time-Series of Liquidity Premia ...”*. This series is constructed as the spread between 3-month banker acceptance rate and 3-month T-bill rate before 1990, and the spread between 3-month term repo rate collateralized by Treasuries and 3-month T-bill rate after 1990. This repo series ends in 2011. Therefore, we rely on the 3-month commercial paper rates to supplement the recent period afterward, which is ticker “RIFSPPAAAD90NB” in FRED. For the post-2011 data, we cross-check the 3-month commercial paper rates with 3-month repo rates from JP-Morgan markets (proprietary data), and find they are similar. For replicability, we use the publicly-available data on commercial paper rates.

For the decomposition of inflation into supply and demand components, we rely on the data constructed by Adam Shapiro, downloaded from https://www.frbsf.org/research-and-insights/data-and-indicators/supply-and-demand-driven-pce-inflation/. This data is available at monthly frequency from 1969 onwards.

For the analysis in Section 4, we also use many other measures of convenience yields, including agency-Treasury spread, agency-Treasury STRIP spread, and Refcorp-Treasury STRIP spread. Agency-Treasury spread is the yield spread between matched-maturity agency bonds and Treasuries. Data are from Bloomberg, with tickers “H15T[maturity]” for Treasuries and “C090[maturity]” for agency bonds, where “[maturity]” can be “3M”, “6M”, “1Y”, “5Y”, etc. Agency-Treasury STRIP spread is the yield spread between matched-maturity agency-bond STRIPs and Treasury STRIPs (STRIPs are zero-coupon bonds derived stripped from principal and coupon payments), with tickers “C094[maturity]” for agency-bond STRIPs and “C079[maturity]” for Treasury STRIPs. Refcorp-Treasury STRIP spread is the yield spread between Refcorp STRIPs and Treasury STRIPs. Refcorp STRIPs are zero-coupon bonds stripped from Refcorp bonds, which are issued by Resolution Funding Corporation (Refcorp), a government agency created in 1989 to resolve the savings and loan crisis of the 1980s. Refcorp is explicitly guaranteed by the US government, and thus, the Refcorp-Treasury STRIP spread is free from default risks. Tickers for Refcorp STRIPs are “C091[maturity]”.

We also use both survey-based inflation measures and inflation-swap rates in Section 4. The survey inflation expectation, denoted by $\mathbf{E}$[inflation], is the one-year (four quarters) forecast of inflation from the Survey of Professional Forecasters. This expectation data are available at Philadelphia Fed, https://www.philadelphiafed.org/surveys-and-data/data-files. Inflation swap rates are available from Bloomberg, tickers ”USSWIT[maturity]”.

We control for other well-known drivers of Treasury convenience, in particular, market volatility, the total government debt supply, and monetary policy. For market volatility, we use the VIX index. The VIX data are only available since 1990 (ticker “VIXCLS” on FRED). For the period before 1990, we use a linear projection of VIX on monthly realized volatility of the S&P 500 index returns (calculated as the standard deviation of daily index returns at each month), where the projection coefficients are estimated on the post-1990 data. S&P 500 index return data can be obtained from WRDS. We use the variable “VW_return”, which is value-weighted return including dividends.

For government debt supply, we use the total quantity of Treasury debt held by the public, at market value, minus intra-governmental holdings and holdings by depository institutions and the Federal Reserve. The data construction follows Krishnamurthy and Li (2023). Total debt held by the public can be obtained from FRED, ticker "FYGFDPUN", from 1970 to 2016. Before 1970, we use the total debt measure in Nagel (2016) (the same data source as T-bill convenience), which originally come from Bohn (2008). Next, we calculate net debt supply as the book value of total debt held by the public minus financial sector holding and Federal Reserve holdings of Treasuries, which leads to a measure of non-bank private sector holding of Treasuries. Then we translate the book value into market values using the market-to-book ratio of all marketable Treasury securities. Data on market and book values are provided by the Federal Reserve Bank of Dallas, https://www.dallasfed.org/research/econdata/govdebt.

For monetary policy, we use the end-of-month effective federal funds rate, downloaded from FRED with ticker "EFFR".

A.2 Expected Credit Risks in Aaa and Baa Corporate Bonds

The Aaa- and Baa-corporate bonds in Moody's index have long maturities around 20 years. One concern about the Aaa index is that it contains non-negligible credit risks over that longer horizon. In this subsection, we provide a way to quantify that risks and we show that even at 20-year horizon, after accounting for transition dynamics across different ratings, the credit risk in Aaa index is still negligible compared to the Baa index.

Denote the one-year default probability for various credit ratings as π^d and loss given default as L_{loss}, which are both column vectors. We assume that the expectation of default probability at any future year is still π^d.

Let the one-year transition probability across ratings be Q. Then the probability of not defaulting in the next year is simply $1 - \pi^d$ for the vector of ratings. The probability of not defaulting in the next two years for rating bucket i is

$$(1 - \pi^d(i)) \sum_j Q_{i,j}(1 - \pi^d(j)).$$

Denote $\odot$ as element-wise multiplication and $*$ as matrix multiplication. In matrix form, the vector of probabilities for not defaulting in the next two years is

$$(1-\pi^d)\odot Q*(1-\pi^d)$$

Similarly, the probability of not defaulting in the next three years for rating bucket i is

$$(1-\pi^d(i))\sum_j Q_{i,j}(1-\pi^d(j))\sum_k Q_{j,k}(1-\pi^d(k)),$$

To generalize the matrix notation, we denote the transition probability accounting for not defaulting as $\hat{Q}$, defined as

$$\hat{Q}_{i,j}\equiv q_{i,j}(1-\pi^d(j)).$$

Then the probability of not defaulting in the next three years in matrix notation is

$$(1-\pi^d)\odot\hat{Q}*Q*(1-\pi^d).$$

More generally, the probability of not defaulting in n year is

$$(1-\pi^d)\odot\underbrace{\hat{Q}*\cdots*\hat{Q}}_{n-2}*Q*(1-\pi^d).$$

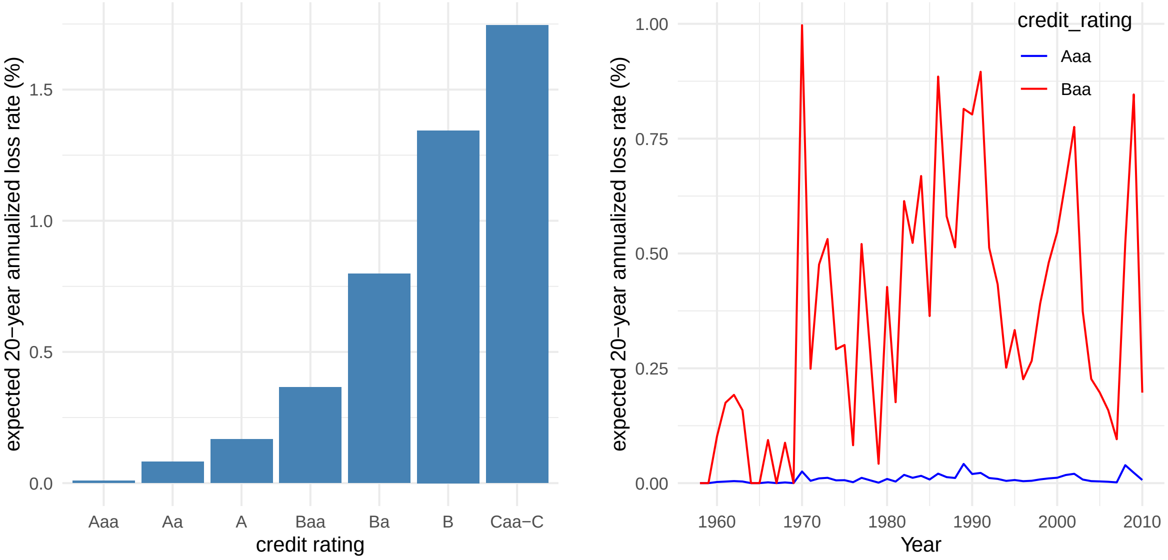
Then the annualized loss rate in a 20-year horizon is

$$\frac{1}{20}\left(1-(1-\pi^d)\odot\underbrace{\hat{Q}*\cdots*\hat{Q}}_{18}*Q*(1-\pi^d)\right)\odot L_{\text{loss}}. \tag{A1}$$

In the data, the realized default rate varies a lot across different years, while loss given default and the transition probabilities across ratings are more stable. The change in realized default rate could influence the market perception of default risks. To reflect such dynamics, we use the realized default rate in each year as an approximation for expected default rates π_d, so we can uncover dynamics of the expected long-term credit loss rate for each year in the data. We use Moody's Default & Recovery Database for this purpose, and our sample are from 1959 to 2010.

To calculate the expected loss rate in the data, we use the average credit migration matrix Q reported by Exhibit 31 in Moody's investor service report (Emery et al., 2009). This migration matrix is estimated on data from 1920–2008. We extract the transition-without-default probabilities by conditioning the transition on no default, since the model deals with default separately. Then we use the recovery rates L_{loss} reported by the last column of Exhibit 27 in the same report.

Figure A1: **Expected Annualized Credit Loss for a 20-year Horizon.** The graphs present the expected annualized credit loss rate for a 20-year horizon, calculated using equation (A1). To reflect the dynamics of belief updating, we use the realized default ratio in each year from 1959 to 2010 for each credit rating, i.e., π_d is updated each year. In panel (a), we illustrate the average expected loss rate by credit rating over the whole sample. In panel (b), we plot the dynamics of expected loss for Aaa- and Baa-rated bonds.



(a) Average expected credit loss rate (b) Dynamics of expected credit loss rate

In Figure A1, we illustrate both the dynamics of the expected loss rate (only for Aaa and Baa) and the average loss rate across ratings. In panel (a), we find an extremely low average of the expected 20-year annualized loss rate for Aaa-rated bonds, which is 0.009%. In contrast, the number for Baa-rated bonds is 0.36%, which is about 40 times that of the Aaa-rated bonds. We therefore conclude that for a 20-year horizon, on average, the credit risk of Aaa-rated bonds is negligible. In panel (b), we further probe if the fluctuations of the expected credit loss rate are of concern. We find that the maximum expected credit loss rate for Aaa-rated bonds is 0.04% over the entire sample, but the maximum expected credit loss rate for Baa-rated bonds is 1%. Again, we find that fluctuations of the expected loss rate are negligible for Aaa-rated bonds but not the case for Baa-rated bonds.

A.3 The Cleveland Fed index, inflation expectations, and term premia

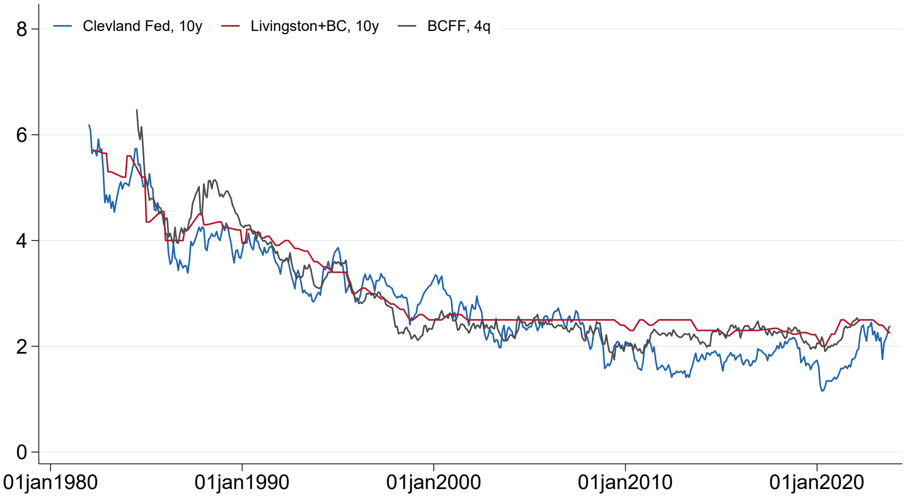
We next investigate the suitability of the popular Cleveland Fed inflation expectations measures for analyzing convenience yields. This index is used for example in Acharya and Laarits (2023) and Fu et al. (2023). As stated by the Cleveland Fed "Our estimates are calculated with a model that uses Treasury yields, inflation data, inflation swaps, and survey-based measures of inflation expectations." While the Cleveland Fed uses a model that aims to separate term premia from expectations, such decompositions are somewhat reliant on the specific modeling choices and there is no guarantee that the resulting inflation expectations measure is really free of term premia.

Panel A of Figure A2 shows 10-year inflation expectations from the Cleveland Fed against long-term and 4-quarter consensus inflation expectations from surveys. It is clear that the Cleveland Fed inflation expectations roughly move similarly at lower frequencies, but are substantially more volatile, raising the question whether being derived from bond yields they still contain a measure of time-varying term premia or even Treasury convenience yields.

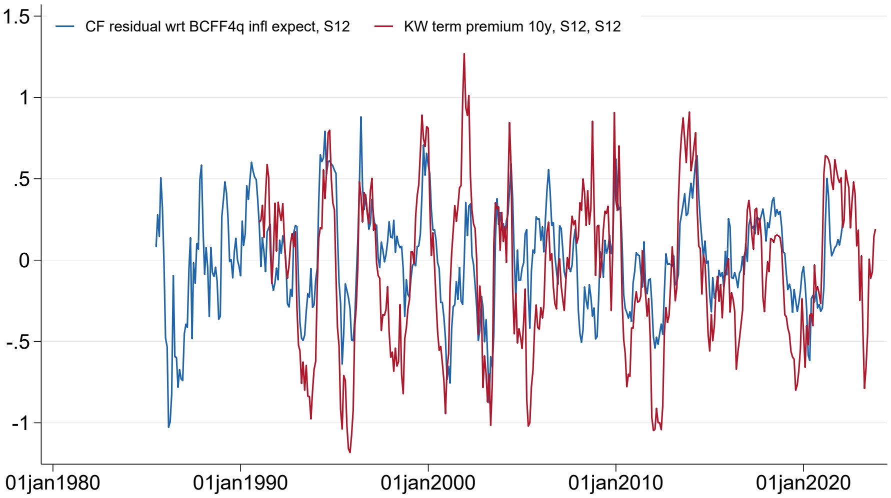
Panel B of Figure A2 shows 12-quarter changes in the 10-year Cleveland Fed inflation forecast, residualized against survey expectations, together with a measure of contemporaneous changes in 10-year term premia from Kim and Wright (2005). The correlation is very high at 60%, further confirming the likely presence of term premia or even convenience yields in the Cleveland Fed inflation expectations. While this presence may not be an issue if the objective is merely to obtain an unbiased forecast of long-term inflation, in a regression of a Treasury convenience spread on the left-hand side and the Cleveland Fed inflation expectations on the right-hand-side it is likely to bias the results towards finding a negative regression coefficient. The intuition is simply that a shock that lowers the 10-year Treasury bond yield due to term premia or increased convenience, is likely to lower the Cleveland Fed measure even if inflation expectations truly did not move.

Long-term CPI inflation forecasts from Blue Chip and Livingston surveys are available via the website of the Philadelphia Fed: https://www.philadelphiafed.org/surveys-and-data/real-time-data-research/inflation-forecasts.

Figure A2: **Cleveland Fed inflation expectations vs. inflation expectations and term premia.** Panel A shows the 10-year inflation forecast from the Cleveland Fed model against 10-year inflation expectations from Blue Chip and Livingston surveys, and the 4-quarter consensus CPI inflation forecast from the Blue Chip Financial Forecasts. Cleveland Fed inflation expectations start in 1982:Q1, Livingston/Blue Chip forecasts start in 1982:Q1, and BCFF 4-quarter forecasts start in 1984:Q3. The sample ends in 2023:Q4. Panel B plots the residual from a regression of 12-month changes in Cleveland Fed inflation expectations onto BCFF 4-quarter inflation expectations against 12-month changes in the 10-year term premium from Kim and Wright (2005).



(a) Cleveland Fed inflation expectations vs. surveys



(b) Cleveland Fed inflation expectations vs. term premia

A.4 Interaction with Regulation Q period (1966-1982)

Drechsler et al. (2023) argue powerfully that interest rate caps on deposit rates, mandated by regulation, imposed an important constraint and amplification mechanism for monetary policy during the 1970s, before 1982 when MMDAs were introduced. A deposit cap mandated by law might act to lower the pass-through from loan rates to deposit rates, δ, in our model, and thereby be expected to strengthen the money channel. We would therefore expect to find an even stronger positive relationship between inflation and convenience yields during the period when regulation Q was binding, which Drechsler et al. (2023) date from January 1966 through December 1982.

Table A1 confirms this prediction in the data. Column (1) shows that inflation interacted with the regulation-Q period (1966-1982) enters positively and significantly, even when the inflation interaction with the longer post-war period (1952-1999) is already included. The magnitude on $InflationxI_{1966-198}$ is economically meaningful, suggesting that a one percentage point increase in inflation was associated with 6 bps higher convenience, on top of the positive inflation-convenience relationship during the longer 1952-1999 period.

At the same time, the baseline coefficient on inflation and on the interaction $InflationxI_{1952-1999}$ remain significant and are quantitatively virtually unchanged relative to our baseline result in Table 2. These patterns continue to hold as we include our battery of controls. Columns (2) through (5) show that inflation in the 1952-1999 period has a quantitatively and statistically significantly more positive relationship with long-term Treasury convenience than either before or after, confirming our baseline results. The interaction $InflationxI_{1966-198}$ remains positive but becomes insignificant once we control for the federal funds rate. This is not surprising, if one expects that regulation Q acted particularly on the rates of short-term bonds and short-term deposit rates. Particularly if there was an anticipation that regulation Q might eventually be phased out, it is reasonable that it would have acted through short-term expectations of the policy rate and less through long-term expected inflation.

Overall, we therefore confirm that the period with binding caps on deposit rates strengthened the money channel. However, we also find that the money channel is strong during the inflationary episode of the second half of the 20th century more broadly and is not just confined to the period of 1966-1982, as one might expect if competitive forces in the banking sector provide an additional longer-term force depressing the pass through from loan to deposit rates.

Table A1: **Baseline results with regulation Q period.** Monthly data runs from 1926:01 through 2020:12, excluding the WWII period 1939:09–1951:12. Inflation is interacted with the following three subperiod dummies: 1952:01–1999:12, 1966:01-1982:12, and 2000:01–2020:12. The period 1926:01–1939:08 acts as the omitted period. Newey-West t-statistics with 12 lags are shown in parentheses. * p <0.10, ** p <0.05, *** p <0.01.

	AAA-Tsy spread				
	(1)	(2)	(3)	(4)	(5)
Inflation	-0.038***	-0.037***	-0.025**	-0.017	-0.038***
	(-5.15)	(-5.36)	(-2.48)	(-1.28)	(-5.00)
Inflation x $I_{1952-1999}$	0.12***	0.094***	0.069**	0.054*	0.12***
	(6.20)	(3.20)	(2.30)	(1.80)	(6.21)
Inflation x $I_{1966-1982}$	0.064**	0.044	0.024	0.013	0.064**
	(2.08)	(1.15)	(0.64)	(0.34)	(2.07)
Inflation x $I_{\geq 2000}$	-0.034	-0.054	-0.047	-0.048	-0.034
	(-0.93)	(-1.49)	(-1.50)	(-1.47)	(-1.07)
FFR		0.022	0.025	0.024	
		(1.27)	(1.39)	(1.38)	
Debt/GDP			0.21	0.20	0.00077
			(0.70)	(0.64)	(0.00)
VIX			0.011***	0.0081**	
			(3.39)	(2.47)	
BAA spread				0.083	
				(1.43)	
$I_{1952-1999}$	-0.59***	-0.57***	-0.48***	-0.40***	-0.59***
	(-6.51)	(-6.56)	(-4.77)	(-3.00)	(-5.87)
$I_{1966-1982}$	0.11	0.12	0.25	0.31	0.11
	(0.44)	(0.47)	(0.96)	(1.19)	(0.44)
$I_{\geq 2000}$	0.27***	0.33***	0.28*	0.32*	0.27
	(2.71)	(3.10)	(1.83)	(1.95)	(1.61)
Constant	0.92***	0.86***	0.54***	0.47***	0.92***
	(13.18)	(10.82)	(3.88)	(2.81)	(10.47)
$\bar{R}^2$	0.49	0.50	0.53	0.54	0.49
N	992	992	992	992	992

A.5 Robustness on the Regimes of Inflation and Treasury Convenience

In this subsection, we present regressions that separately deal with three periods to account for potential structural changes in the economy, and full plots of the moving averages of Treasury convenience and inflation.

In Table A2, we show the subsample regression results for both Treasury convenience and T-bill convenience. We find that results are broadly consistent with the main settings shown in Table 2 and Table 3. The only exception is column (6), where the coefficient on inflation is insignificant and positive. In Panel B, we control for lagged inflation and we find that the sign is negative on lagged inflation. A plausible explanation is that aggregate demand response to liquidity shocks is sluggish. This explanation predicts that short-term convenience does not immediately correlates to current inflation, but responds to lagged inflation. On the other hand, since long-term convenience reflects the expectation of future short-term convenience (see equation (22)), it has a stronger response.

Finally, in Figure A3, we plot the moving averages of Treasury convenience and inflation to better understand the frequency of the relationship. We use both the headline inflation (two upper panels) and the core inflation (two lower panels). The dramatic regime shifts across three periods are more prominent at the 60-month moving average than 12-month moving average. As a result, the relation between inflation and Treasury convenience is stronger at lower frequency, indicating that they are more likely related to macroeconomic changes rather than having a direct linage through the financial market.

Table A2: **Robustness: Estimates by subsample.**

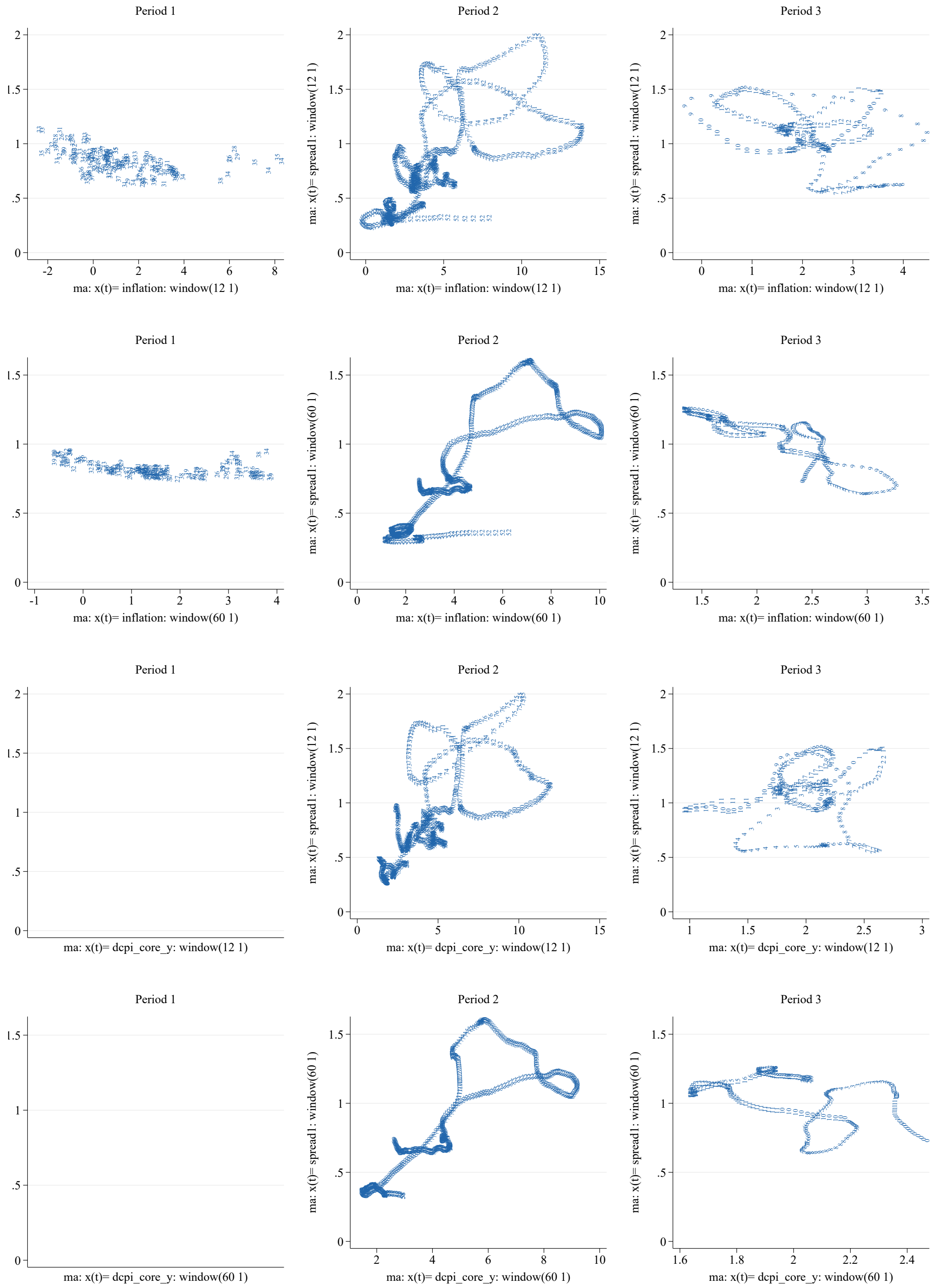
Panel A. Estimates by subsample

	Aaa-Tsy spread			T-bill convenience		
	(1) 1926-1939	(2) 1952-1999	(3) 2000-2020	(4) 1926-1939	(5) 1952-1999	(6) 2000-2020
Inflation	-0.032***	0.041	-0.053**	-0.011**	0.027	0.015
	(-4.55)	(1.51)	(-2.24)	(-2.39)	(1.36)	(0.90)
FFR	0.14***	-0.000053	0.031	0.064**	0.080***	0.056***
	(4.63)	(-0.00)	(0.70)	(2.15)	(5.07)	(6.09)
Debt/GDP	0.46	-2.54***	0.87**	-2.48*	-0.81**	0.22*
	(0.31)	(-3.60)	(2.11)	(-1.89)	(-2.27)	(1.67)
VIX	0.0017	0.019***	0.022***	0.0085***	0.026***	0.0065**
	(0.79)	(2.76)	(5.31)	(4.25)	(4.63)	(2.40)
Constant	0.47**	0.90***	0.28	0.13	-0.27*	-0.20**
	(2.09)	(3.43)	(1.05)	(0.63)	(-1.69)	(-2.04)
$\bar{R}^2$	0.66	0.55	0.37	0.45	0.62	0.46
N	164	576	247	164	576	247

Panel B. Estimates by subsample with lagged inflation

	Aaa-Tsy spread			T-bill convenience		
	(1) 1926-1939	(2) 1952-1999	(3) 2000-2020	(4) 1926-1939	(5) 1952-1999	(6) 2000-2020
Inflation	-0.027***	0.014	-0.080**	-0.011**	0.038*	0.0093
	(-6.23)	(0.59)	(-2.41)	(-2.00)	(1.74)	(0.40)
L12.Inflation	-0.012**	0.037**	-0.046	0.0010	-0.013	-0.015
	(-2.31)	(2.21)	(-1.24)	(0.15)	(-0.84)	(-1.03)
L24.Inflation	-0.021***	0.038***	-0.049	0.0073	-0.038***	-0.0015
	(-3.55)	(2.76)	(-1.51)	(1.23)	(-2.81)	(-0.10)
FFR	0.11***	-0.020	0.040	0.072**	0.097***	0.059***
	(3.92)	(-1.36)	(0.99)	(2.44)	(6.92)	(5.33)
Debt/GDP	-2.47*	-2.26***	0.56	-1.68	-1.07***	0.17
	(-1.88)	(-3.73)	(1.13)	(-0.97)	(-3.57)	(1.20)
VIX	-0.0022	0.022***	0.022***	0.0094***	0.024***	0.0067**
	(-1.40)	(3.32)	(5.34)	(5.12)	(4.62)	(2.41)
Constant	0.94***	0.70***	0.65*	0.010	-0.11	-0.14
	(4.86)	(3.28)	(1.67)	(0.04)	(-0.87)	(-0.86)
$\bar{R}^2$	0.76	0.65	0.40	0.45	0.66	0.46
N	164	576	247	164	576	247

Figure A3: **Low frequency relationship between inflation and convenience yield.**



A.6 Impulse Responses and Supply/Demand Decompositions

To gain better identification, we apply the standard VAR local projection method and show the impulse responses of core inflation and headline inflation in in Figure A4 and A5. Results are generally similar to Figure 4.

We also show the full set of estimates on predictive regressions between Treasury convenience yield and the supply and demand components of inflation in Figure A6.

Figure A4: **VAR local projection impulse responses: core inflation.** The graphs present orthogonalized impulse-responses obtained from a local projections VAR. The VAR is estimated separately for each subperiod, using monthly data with 12 lags. The following variables are included and ordered as Debt/GDP, energy CPI inflation, core CPI inflation, unemployment, FFR, and Aaa-Treasury spread. We report 90% confidence intervals using robust standard errors.

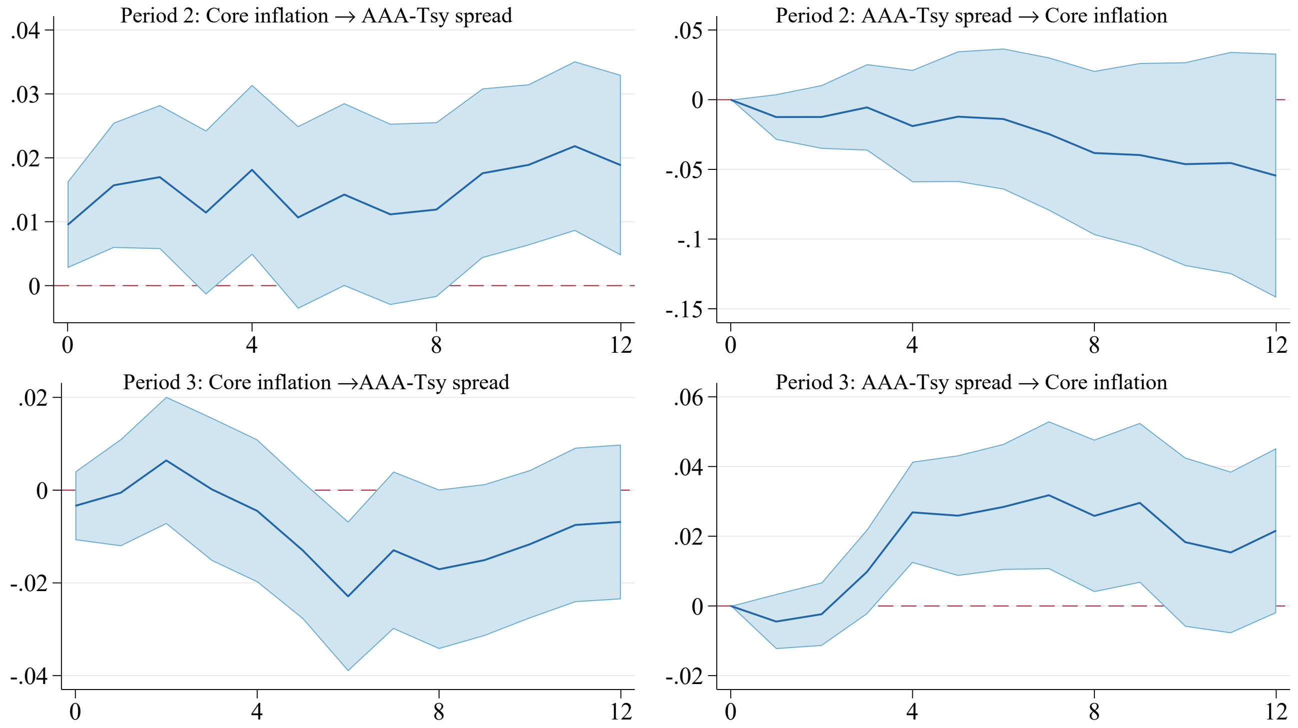


Figure A5: **VAR local projection impulse responses: headline inflation.** The graphs present orthogonalized impulse-responses obtained from a local projections VAR. The VAR is estimated separately for each subperiod, using monthly data with 12 lags. The following variables are included and ordered as Debt/GDP, headline CPI inflation, unemployment, FFR, and Aaa-Treasury spread. We report 90% confidence intervals using robust standard errors.

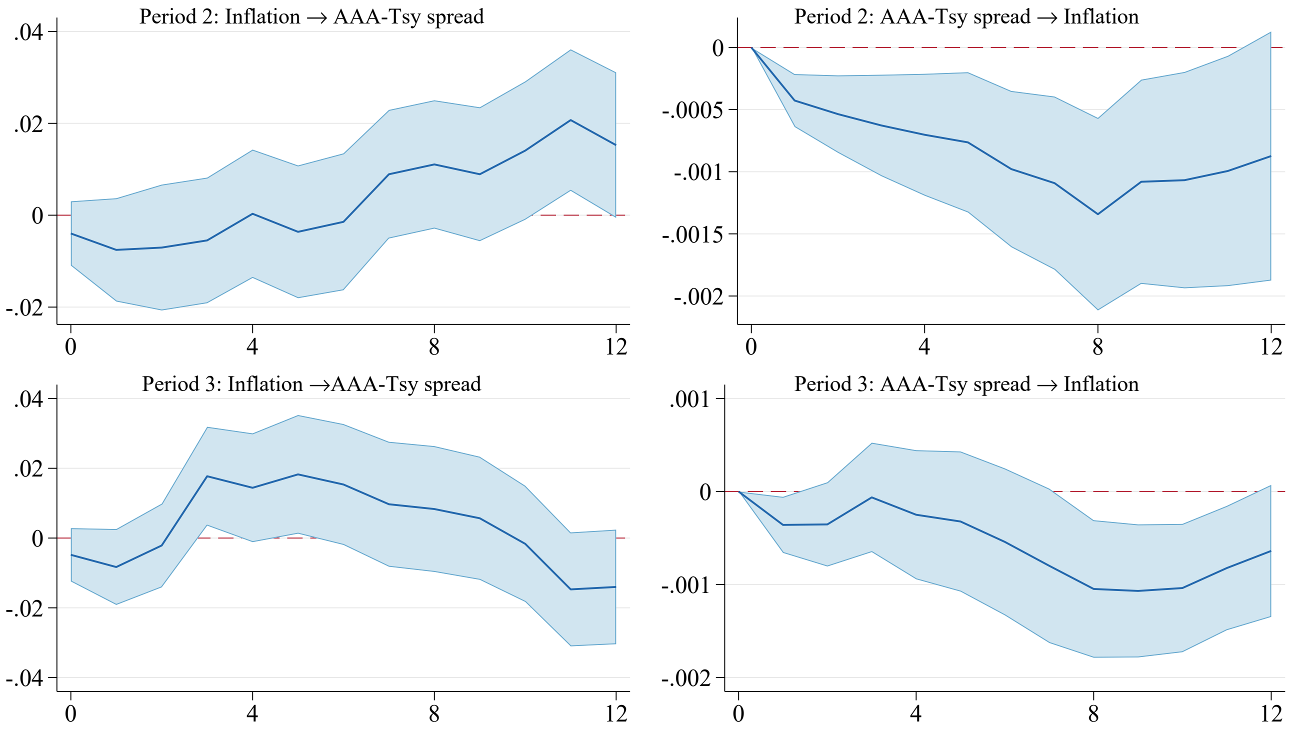
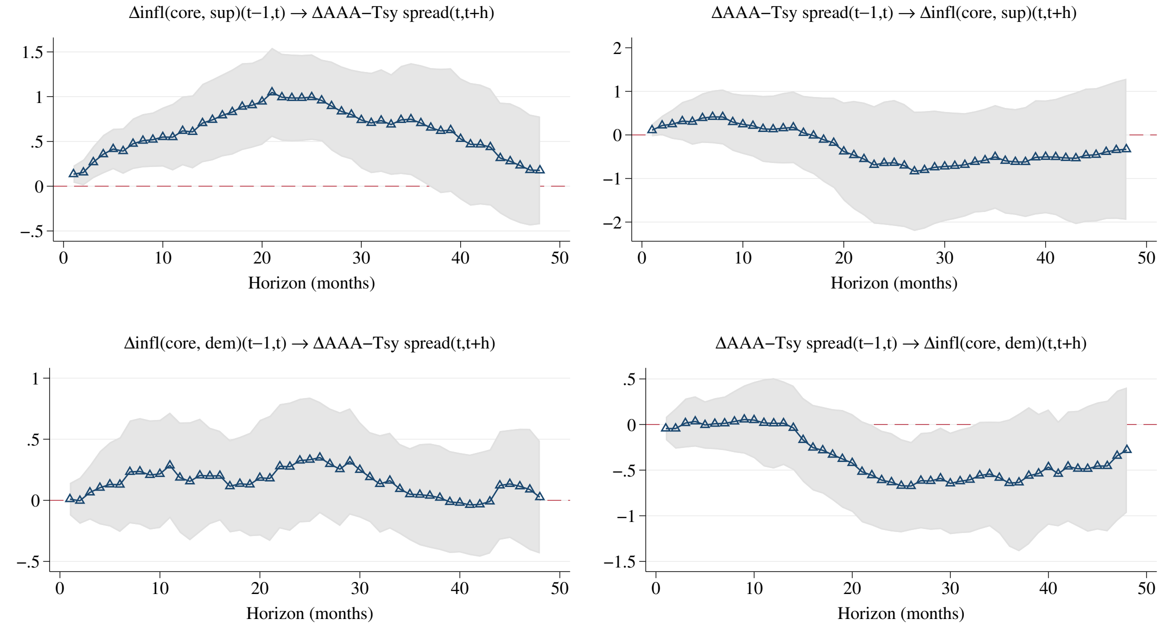


Figure A6: **Predictive regressions with demand- vs. supply-driven inflation components**. This figure presents the full set of estimates to accompany results in Figure 5 in the main text.

Panel A: 1969–1999

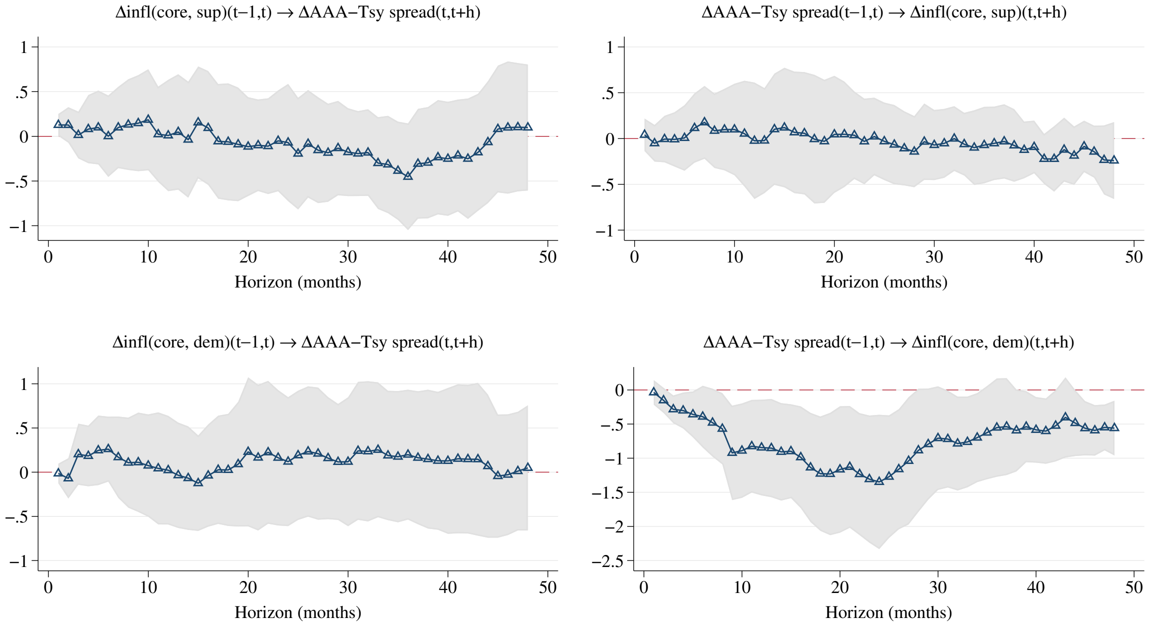

Δinfl(core, sup)(t−1,t) → ΔAAA−Tsy spread(t,t+h)

ΔAAA−Tsy spread(t−1,t) → Δinfl(core, sup)(t,t+h)

Δinfl(core, dem)(t−1,t) → ΔAAA−Tsy spread(t,t+h)

ΔAAA−Tsy spread(t−1,t) → Δinfl(core, dem)(t,t+h)

Panel B: 2000-2020


Δinfl(core, sup)(t−1,t) → ΔAAA−Tsy spread(t,t+h)

ΔAAA−Tsy spread(t−1,t) → Δinfl(core, sup)(t,t+h)

Δinfl(core, dem)(t−1,t) → ΔAAA−Tsy spread(t,t+h)

ΔAAA−Tsy spread(t−1,t) → Δinfl(core, dem)(t,t+h)

B Model Appendix

In this appendix, we provide detailed model solutions. We start the baseline model, and then provide details on the extension model that directly introduces the inflation-convenience linkage.

B.1 Supply Side and Price-Setting Frictions

The consumption aggregate is given by

$$C_t = \left(\int_0^1 C_{jt}^{(\sigma_t-1)/\sigma_t}\right)^{\frac{\sigma_t}{\sigma_t-1}}, \tag{A2}$$

where C_{jt} denotes the quantity consumed of consumption good of variety j, and σ_t is the potentially time-varying elasticity of substitution across varieties, which will give rise to supply-type shocks in the log-linearized Phillips curve (Woodford (2003a), p. 451). Household optimization then implies that demand for variety j is downward-sloping in its price P_{jt}

$$C_{jt} = \left(\frac{P_{jt}}{P_t}\right)^{-\sigma} C_t, P_t = \left(\int_0^1 P_{jt}^{1-\sigma_t}\right)^{1/(1-\sigma_t)}. \tag{A3}$$

We set up the firm's problem as simple and standard as possible. Firms face price-setting frictions in the manner of Calvo (1983). We assume that there is a unit mass of firms producing consumption good j. Firms of type j have a constant returns to scale production technology and use labor as their only input

$$Y_{jt} = N_{jt}. \tag{A4}$$

Each period a random fraction $1-\omega$ of firms is allowed to adjust prices, while the remaining fraction ω of firms have a price that is automatically indexed to lagged inflation. That is, the time $t+\tau$ price of a firm that last re-set its product price to P_t^* at time t equals $P_t^*\left(\frac{P_{t-1+\tau}}{P_{t-1}}\right)^{\zeta}$, where ζ is an indexation parameter as in Christiano et al. (2005) and leads to a backward-looking term in the Phillips curve. There is no real investment in the model, so consumption must equal output for each variety

$$C_{jt} = Y_{jt}. \tag{A5}$$

B.2 Model Derivations

B.2.1 Liquidity Spread

Taking the difference between (17) vs. (16) and (18) vs. (16) gives the following expressions

$$\frac{I_t^l - I_t^b}{1 + I_t^l} = \frac{\frac{\alpha}{Q_t}\lambda_t}{U_c\left(C_t, H_t\right)} \tag{A6}$$

$$\frac{I_t^l - I_t^d}{1 + I_t^l} = \frac{\frac{\alpha}{Q_t}(1-\lambda_t)}{U_c\left(C_t, H_t\right)}. \tag{A7}$$

Substituting in (11) into (A7) then gives (19) in the main text. A simple rearrangement gives that

$$I_t^l = \frac{1}{1 - \frac{\lambda_t}{1-\lambda_t}(1-\delta)} I_t^b \tag{A8}$$

B.2.2 Flexible Price Steady-State

We log-linearize the model around the flexible-price steady-state values $\bar{c}$, $\bar{\pi}$, $\bar{i}^l$, $\bar{i}^b$, $\bar{\theta}$, and $\bar{\lambda}$ with deviations c_t, π_t, i_t^l, i_t^b, θ_t, and λ_t. Before we can log-linearize we need to solve for the flexible-price steady-state. With flexible prices, profit-maximization implies all firms optimally choose to charge a constant markup

$$\frac{P_t^*}{P_t} = \frac{\sigma}{\sigma - 1}\frac{W_t}{P_t}. \tag{A9}$$

The representative household's optimal labor-leisure choice implies that the real wage must satisfy

$$\frac{\chi N_t^\eta}{(C_t - hC_{t-1})^{-\gamma}} = \frac{W_t}{P_t}. \tag{A10}$$

In the flexible-price equilibrium, we must have $P_t^* = P_t$. Substituting in good markets clearing ($Y_t = C_t$) implies that the steady-state flexible price output is constant and equals

$$\bar{Y}_t = \left(\frac{(1-h)^\gamma(\sigma - 1)}{\chi\sigma}\right)^{1/(\gamma+\eta)}. \tag{A11}$$

In the steady-state interest rates must satisfy:

$$\left(1+\bar{I}^l\right)\beta E\left[\frac{U_c(C_{t+1})}{U_c(C_t)}\frac{P_t}{P_{t+1}}\right] \;=\; 1, \tag{A12}$$

where we suppress the non-consumption arguments in the utility function to sav on notation. In the nonstochastic steady-state consumption and habit are constant, so:

$$1+\bar{I}^l \;=\; \frac{1+\bar{\Pi}}{\beta}. \tag{A13}$$

The steady-state government bond yield (in levels) then satisfies

$$\bar{I}^b \;=\; \bar{I}^l\left(1-\frac{\bar{\lambda}}{1-\bar{\lambda}}(1-\delta)\right). \tag{A14}$$

B.2.3 Log-Linearization

We define the log steady-state interest rates by $\bar{i}^l = \log(1+\bar{I}^l)$, and $\bar{i}^b = \log(1+\bar{I}^b)$. For conciseness we define the function

$$\phi\left(\lambda_t\right) \;=\; \frac{1}{1-\frac{\lambda_t}{1-\lambda_t}(1-\delta)}. \tag{A15}$$

The function ϕ has the first-order Taylor approximation around $\bar{\lambda}$ in terms of $\hat{\lambda}_t \equiv \lambda_t - \bar{\lambda}$:

$$\phi(\lambda_t) \;\approx\; \phi\left(\bar{\lambda}\right)+\phi'\left(\bar{\lambda}\right)\hat{\lambda}_t, \tag{A16}$$

$$\phi\left(\bar{\lambda}\right) \;=\; \frac{1}{1-\frac{\bar{\lambda}}{1-\bar{\lambda}}(1-\delta)}, \tag{A17}$$

$$\phi'\left(\bar{\lambda}\right) \;=\; \left(\frac{1}{1-\frac{\bar{\lambda}}{1-\bar{\lambda}}(1-\delta)}\right)^2(1-\delta)\frac{1}{\left(1-\bar{\lambda}\right)^2} \tag{A18}$$

We can then re-write expression (A8)

$$\exp(\hat{i}_t^l+\bar{i}^l)-1 \;=\; \phi\left(\lambda_t\right)\left(\exp(\hat{i}_t^b+\bar{i}^b)-1\right) \tag{A19}$$

Substituting in the log-linear approximation for ϕ,

$$(1+\bar{I}^l)\hat{i}^l_t + \bar{I}^l \approx \Big(\phi(\bar{\lambda}) + \phi'(\bar{\lambda})\hat{\lambda}_t\Big)\Big((1+\bar{I}^b)\hat{i}^b_t + \bar{I}^b\Big) \tag{A20}$$

Solving out for $\hat{i}^l_t$ and dropping second-order terms gives the first-order Taylor expansion

$$\begin{aligned} \hat{i}^l_t &\approx \phi(\bar{\lambda})\frac{1+\bar{I}^b}{1+\bar{I}^l}\hat{i}^b_t + \phi'(\bar{\lambda})\frac{\bar{I}^b}{1+\bar{I}^l}\hat{\lambda}_t, && \text{(A21)} \\ &= f^i\hat{i}^b_t + f^\lambda\hat{\lambda}_t, && \text{(A22)} \end{aligned}$$

where the coefficients are given by

$$\begin{aligned} f^i &= \phi(\bar{\lambda})\frac{1+\bar{I}^b}{1+\bar{I}^l}, && \text{(A23)} \\ &= \frac{1}{1-\left(\frac{\bar{\lambda}}{1-\lambda}(1-\delta)\right)}\frac{1+\bar{I}^l\left(1-\left(\frac{\bar{\lambda}}{1-\lambda}(1-\delta)\right)\right)}{1+\bar{I}^l} && \text{(A24)} \\ &= \frac{1}{1-\left(\frac{\bar{\lambda}}{1-\lambda}(1-\delta)\right)}\left(1-\frac{\bar{I}^l}{1+\bar{I}^l}\left(\frac{\bar{\lambda}}{1-\lambda}(1-\delta)\right)\right), && \text{(A25)} \\ f^\lambda &= \phi'(\bar{\lambda})\frac{\bar{I}^b}{1+\bar{I}^l}. && \text{(A26)} \end{aligned}$$

As long as $\frac{\bar{I}^l}{1+\bar{I}^l} < 1$, $\bar{\lambda} > 0$ and $\delta < 1$ the second expression for f^i makes clear that $f^i > 1$. Alternatively, f^i can be written as $f^i = \phi(\bar{\lambda})\frac{1+\bar{I}^b}{1+\bar{I}^l} = \frac{\phi(\bar{\lambda})+\bar{I}^l}{1+\bar{I}^l}$, which can be easily used to see that $f^i > 1$.

We then derive the relationship between convenience spreads across the term structure. Investing one dollar into an n-period zero coupon government bonds at time t and selling it at time $t+1$ generates a return $R_{n,t+1} = \frac{\exp\left(-(n-1)i^b_{n-1,t+1}\right)}{\exp\left(-ni^b_{n,t}\right)}$. Since government bonds are assumed to provide the same liquidity services at time t irrespective of bond maturity, the first-order condition between investing in an n-period vs. 1-period bond becomes

$$0 = \beta E_t\left[U_c\left(C_{t+1}\right)\left(\exp(i^b_t) - \frac{\exp\left(-(n-1)i^b_{n-1,t+1}\right)}{\exp\left(-ni^b_{n,t}\right)}\right)\right]. \tag{A27}$$

Log-linearizing gives the long-term liquid government bond yield in terms of the expected short-term government bond yields according to the expectations hypothesis:

$$i_{n,t}^{b} = \frac{1}{n} E_t \left[\sum_{i=0}^{n-1} i_{t+i}^{b} \right]. \tag{A28}$$

Since short- and long-term illiquid loans also generate the same liquidity value at time t, their yields up to first-order also satisfy an expectations hypothesis:

$$i_{n,t}^{l} = \frac{1}{n} E_t \left[\sum_{i=0}^{n-1} i_{t+i}^{l} \right]. \tag{A29}$$

We derive log-linearized Euler equation (24) following standard steps. The representative household's intertemporal first-order condition is

$$\Theta_t \left(C_t - hC_{t-1}\right)^{-\gamma} = \beta \left(1 + I_t^l\right) E_t \left[\Theta_{t+1} \frac{P_t}{P_{t+1}} \left(C_{t+1} - hC_t\right)^{-\gamma} \right] \tag{A30}$$

Log-linearizing around the flexible-price steady-state $\bar{C}$ gives up to a constant

$$\log\left(C_t - hC_{t-1}\right) \approx \frac{1}{1-h}(c_t - hc_{t-1}) \tag{A31}$$

The log-linearized consumption Euler equation then equals (up to constant)

$$(\theta_t - E_t\theta_{t+1}) - \frac{\gamma}{1-h}\left(c_t - hc_{t-1}\right) = i_t^l - E_t\pi_{t+1} - \frac{\gamma}{1-h}\left(E_t c_{t+1} - hc_t\right). \tag{A32}$$

A simple re-arrangement then gives

$$c_t = \frac{1}{1+h} E_t c_{t+1} + \frac{h}{1+h} c_{t-1} - \gamma^{-1} \frac{1-h}{1+h} \left(i_t^l - E_t \pi_{t+1}\right) + \gamma^{-1} \frac{1-h}{1+h} \left(\theta_t - E_t\theta_{t+1}\right) \tag{A33}$$

Equation (24) then follows from $x_t = c_t$ with the demand shock taking the form $v_{x,t} = \gamma^{-1}\frac{1-h}{1+h}\left(\theta_t - E_t\theta_{t+1}\right)$.

Because the labor-leisure trade-off is standard, the firm's problem is also entirely standard. Walsh (2017) provides a detailed derivation of the log-linearized New Keynesian Phillips curve (26).

The standard textbook treatment of firm decision problem will give rise to the log-linearized

Phillips curve,

$$\pi_t = \rho^\pi \pi_{t-1} + (1-\rho^\pi)E_t\pi_{t+1} + \kappa x_t + v_{\pi_t}.$$

B.2.4 Solution Details

Denote scaled liquidity shock by $\xi_t \equiv -\psi f^\lambda u_t$, so that

$$\xi_t \quad = \quad \rho^\xi \xi_{t-1} + v_{\xi,t}, \tag{A34}$$

with $v_{\xi,t} = -\psi f^\lambda v_{\lambda,t}$ iid and serially uncorrelated and $\rho^\xi = \rho^\lambda$.

The log-linearized dynamics for the state vector $Y_t = [x_t, \pi_t, i_t, \xi_t]$ can then be summarized

$$\begin{aligned}
x_t &= (1-\rho^x)E_t x_{t+1} + \rho^x x_{t-1} - \psi f^i i_t + \psi E_t \pi_{t+1} + \psi b f^\lambda \pi_t + \xi_t + v_{x,t}, && \text{(A35)}\\
\pi_t &= (1-\rho^\pi)E_t\pi_{t+1} + \rho^\pi \pi_{t-1} + \kappa x_t + v_{\pi,t}, && \text{(A36)}\\
i_t &= (1-\rho^i)\left(\gamma^x x_t + \gamma^\pi \pi_t\right) + \rho^i i_{t-1} + v_{i,t}, && \text{(A37)}\\
\xi_t &= \rho^\xi \xi_{t-1} + v_{\xi,t}. && \text{(A38)}
\end{aligned}$$

We only need to solve the model with either the liquidity shock ξ_t or the demand shock $v_{x,t}$. We start with the solution for the model liquidity shock ξ_t, setting the demand shock to zero. In matrix form, the model can be written as

$$0 \quad = \quad F E_t Y_{t+1} + G Y_t + H Y_{t-1} + M v_t, \tag{A39}$$

where the matrices are given by

$$F \quad = \quad \begin{bmatrix} 1-\rho^x & \psi & 0 & 0 \\ 0 & 1-\rho^\pi & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \tag{A40}$$

$$G = \begin{bmatrix} -1 & \psi b f^{\lambda} & -\psi f^{i} & 1 \\ \kappa & -1 & 0 & 0 \\ (1-\rho^{i})\gamma^{x} & (1-\rho^{i})\gamma^{\pi} & -1 & 0 \\ 0 & 0 & 0 & -1 \end{bmatrix} \tag{A41}$$

$$H = \begin{bmatrix} \rho^{x} & 0 & 0 & 0 \\ 0 & \rho^{\pi} & 0 & 0 \\ 0 & 0 & \rho^{i} & 0 \\ 0 & 0 & 0 & \rho^{\xi} \end{bmatrix} \tag{A42}$$

$$M = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix} \tag{A43}$$

and the vector of exogenous shocks is given by

$$v_t = [v_{\xi,t}, v_{\pi,t}, v_{i,t}]. \tag{A44}$$

We use Uhlig (1999)'s formulation of Blanchard and Kahn (1980) to solve for an equilibrium of the form (27).

The convenience spread of maturity then has the following log-linearized expression:

$$spread_{n,t} \equiv i^{l}_{n,t} - i^{b}_{n,t} = \frac{1}{n}\left(\left(f^{i}-1\right)e_3 - \psi^{-1}e_4 - bf^{\lambda}e_2\right)(I-B)^{-1}(I-B^{n})\,Y_t \tag{A45}$$

We then show impulse responses to shocks of the size $v_{\xi,t} = \frac{\psi}{400}$, $v_{\pi,t} = \frac{1}{400}$, and $v_{i,t} = \frac{1}{400}$ in natural units.

To solve the model with a generic demand shock but no liquidity shocks, note that if θ_t follows an AR(1) with autoregression coefficient ρ^{ξ} then $\theta_t - E_t\theta_{t+1} = (1-\rho^{\xi})\theta_t$ also follows an AR(1) process with the same AR(1) coefficient. The same solution then goes through, except we need to set $f^i = 1$ and $b = 0$ to obtain the impulse responses to a generic demand shock when Treasury bonds yield no liquidity.

B.3 Extension to Imperfect Substitutability

While our baseline model treats Treasuries and deposits as perfect substitutes, this assumption is made merely for simplicity. To see how the framework generalizes, assume that the liquidity aggregate is given as in Fu et al. (2023)

$$Q_t = ((1-\lambda_t)D_t^{\rho} + \lambda_t B_t^{\rho})^{1/\rho}\,, \tag{A46}$$

where the substitutability parameter ρ can be between zero and one. The case with $\rho = 1$ corresponds to perfect substitutability. For general ρ the liquidity premium becomes

$$I_t^l - I_t^b = \frac{\lambda_t}{1-\lambda_t}\left(\frac{B_t}{D_t}\right)^{\rho-1}(1-\delta)I_t^l, \tag{A47}$$

showing that if $\rho < 1$ an increase in the quantity of bonds outstanding now acts similarly to a decrease in the preference for bonds, λ_t.

Log-linearizing the liquidity spread now gives an additional term depending on the log quantity of debt $\hat{b}_t \equiv \log B_t - \log \bar{B}$ relative to the log quantity of deposits $\hat{d}_t \equiv \log D_t - \log \bar{D}$

$$\hat{i}_t^l \approx f^i \hat{i}_t^b + f^{\lambda}\hat{\lambda}_t - f^b\left(\hat{b}_t - \hat{d}_t\right), \tag{A48}$$

$$f^b = \frac{1}{\left(1 - \frac{\bar{\lambda}}{1-\bar{\lambda}}(1-\delta)\left(\bar{B}/\bar{D}\right)^{\rho-1}\right)^2}(1-\rho)(1-\delta)\frac{\bar{\lambda}}{1-\bar{\lambda}}\left(\bar{B}/\bar{D}\right)^{\rho-1}\frac{\bar{I}_b}{1+\bar{I}_l} \geq 0, \tag{A49}$$

$$f^i = \frac{1}{1 - \left(\frac{\bar{\lambda}}{1-\bar{\lambda}}(1-\delta)\left(\bar{B}/\bar{D}\right)^{\rho-1}\right)}\left(1 - \frac{\bar{I}^l}{1+\bar{I}^l}\left(\frac{\bar{\lambda}}{1-\bar{\lambda}}(1-\delta)\left(\bar{B}/\bar{D}\right)^{\rho-1}\right)\right), \tag{A50}$$

$$f^{\lambda} = \left(\frac{1}{1 - \frac{\bar{\lambda}}{1-\bar{\lambda}}(1-\delta)\left(\bar{B}/\bar{D}\right)^{\rho-1}}\right)^2(1-\delta)\left(\bar{B}/\bar{D}\right)^{\rho-1}\frac{1}{\left(1-\bar{\lambda}\right)^2}\frac{\bar{I}^b}{1+\bar{I}^l} \tag{A51}$$

Here, the log-linearization coefficient on $(\hat{b}_t - \hat{d}_t)+$ is zero in the perfect substitutes case $\rho = 1$ but strictly negative otherwise.

Substituting into the Euler equation (24) gives

$$x_t = \rho^x x_{t-1} + (1-\rho^x)E_t x_{t+1} - \psi\left(f^i i_t^b - E_t\pi_{t+1}\right) - \psi\left(f^\lambda \hat{\lambda}_t - f^b\left(\hat{b}_t - \hat{d}_t\right)\right) + v_{x,t} \quad \text{(A52)}$$

Since $\hat{b}_t$ does not enter the Phillips curve or monetary policy rule, this shows that when deposits and Treasury bonds are imperfect substitutes, shocks to the log ratio of Treasury bonds to deposits $\hat{b}_t - \hat{d}_t$ act on the economy analogously to a negative demand shock for Treasuries. Intuitively, when $\rho < 1$, an increase in the amount of Treasuries outstanding relative to Treasuries lowers the marginal utility from holding another Treasury bond. This lowers the convenience yield on Treasuries, and compresses private borrowing rates relative to the monetary policy rate, acting to increase demand just like a negative liquidity demand shock, i.e. $\hat{b}_t \uparrow$ acts analogously to $\hat{\lambda}_t \downarrow$. The inflation-convenience relationship is therefore affected similarly by Treasury supply shocks and liquidity demand shocks, and we focus on the latter throughout the paper for simplicity.

B.4 Shocks to Overall Liquidity Demand

A simple extension considers shocks to the overall liquidity weight in the utility function, α. Combining equations (16) and (17) gives

$$E_t\left[M_{t+1}^{\$}\right]\left(I_t^l - I_t^b\right) = \frac{\alpha_t/Q_t\lambda_t}{U_c\left(C_t, Q_t, H_t, N_t, \Theta_t\right)}. \quad \text{(A53)}$$

Combining equations (16) and (18) gives

$$E_t\left[M_{t+1}^{\$}\right]\left(I_t^l - I_t^d\right) = \frac{\alpha_t/Q_t(1-\lambda_t)}{U_c\left(C_t, Q_t, H_t, N_t, \Theta_t\right)}. \quad \text{(A54)}$$

In these equations, it appears that an increase in α_t raises the convenience yield on both deposits and Treasury bonds. However, as long as we maintain assumption (11) this possibility is precluded, as α_t is not allowed to enter into the deposit spread by assumption in equilibrium. Substituting (A53) into (A54) then gives equation (19) and the Treasury convenience yield is not affected by α_t. Changes in α_t can therefore not be regarded as a shock to the overall demand for liquidity, as long as assumption (11) is assumed to hold.

Different assumptions are of course possible. For example, one could replace (11) by a relationship that depends on both I_t^l and on α_t to reflect the notion that α_t is a shock that affects the overall demand for liquidity, and lowers the deposit rates that households require. In that case, combining this alternative relationship with (A53) and (A54) makes it straightforward to see that α_t enters the Treasury convenience spread similarly to the deposit spread. By lowering the Treasury convenience yield, shocks to the overall liquidity preference α_t would then enter the log-linearized Euler equation analogously to λ_t, and affect the convenience-inflation relationship similarly to $\hat{\lambda}_t$ in our main model.

B.5 Details on Model Calibration

Details about model calibration are shown in Table A3.

B.6 Additional Model Results

Figure A7 shows the impulse responses to a monetary policy shock in our baseline model. We see that long-term convenience and inflation both decline in response to a monetary policy shock, whereas short-term convenience and the nominal policy rate increase. This happens because the monetary policy shock first drives up the policy rate, but then eventually causes overshooting in the policy rate, as inflation declines following the contractionary shock. The short-term spread increases, similarly to the increase in the policy rate. The long-term spread, which is forward-looking declines similarly to inflation.

We also provide robustness for the alternative model, varying the magnitude of the direct inflation-liquidity link. Figures A8 and A9 report alternative versions of Figure 8 in the main paper. We see that the black convenience spread responses are robustly above the red dashed convenience spread responses, implying that the alternative model with a direct inflation-convenience link implies a *more negative* inflation-convenience relationship when inflation is high in steady-state, regardless of the strength of the direct inflation-convenience link parameter b. Of course, a stronger direct inflation-convenience link as in Figure A9 leads to a more negative inflation-convenience spread regardless of steady-state inflation, but the gap between the red dashed and black convenience impulse responses are consistent across different values of b. Our key empirical result is about the change in the the inflation-convenience relationship during the high-inflation 1970s and 1980s vs. the low-inflation pref-WWII and 2000s periods, and of the opposite sign as implied by the alternative model across these different values for b.

Table A3: **Model Calibration.** This table contains the calibration parameters for the New Keynesian model with convenience yields. Parameters are reported in units corresponding to inflation and interest rates in annualized percent, and output gap in percent, that is we report $\frac{\psi}{4}$, 4κ and $4\gamma^x$ compared to natural quarterly units. The values for δ and ρ^λ in the extension with direct liquidity-inflation link are identical to the baseline model and therefore not repeated.

Panel A: Inflation and Monetary Policy			
Euler equation			Target
Interest rate slope	ψ	0.07	Pflueger and Rinaldi (2022)
Backward-looking component	ρ^x	0.45	Pflueger and Rinaldi (2022)
PC Parameters			
Slope	κ	0.019	Rotemberg and Woodford (1997)
Backward-looking PC	ρ^π	0.80	Fuhrer (1997)
Monetary Policy			
MP inertia	ρ^i	0.8	Clarida et al. (2000)
Output gap weight	γ^x	0.5	Taylor (1993)
Inflation weight	γ^π	1.5	Taylor (1993)
Panel B: Interest Rates and Liquidity			
Discount rate	β	0.98	Average nominal policy rate = 4%
Steady-state inflation	$\bar{\Pi}$	2%	Fed inflation target
Deposit rate pass-through	δ	0.34	Nagel (2016)
Bond liquidity weight	$\bar{\lambda}$	0.20	Level Aaa-Tsy Spread
Persistence liquidity	ρ^λ	0.91	AR(1) Aaa-Tsy Spread

Figure A7: **Baseline Model Responses to a Monetary Shock.** This figure shows impulse responses to a monetary policy shock for our baseline model. The monetary policy shock is a positive 100 bps shock to the 3-month T-bill. Responses for inflation, π and the Treasury rate i^b are in annualized percent units. The response for the convenience spread $i^l - i^b$ is in annualized basis points units.The response for the output gap x is in percent units. Quarters are shown on the x-axis.

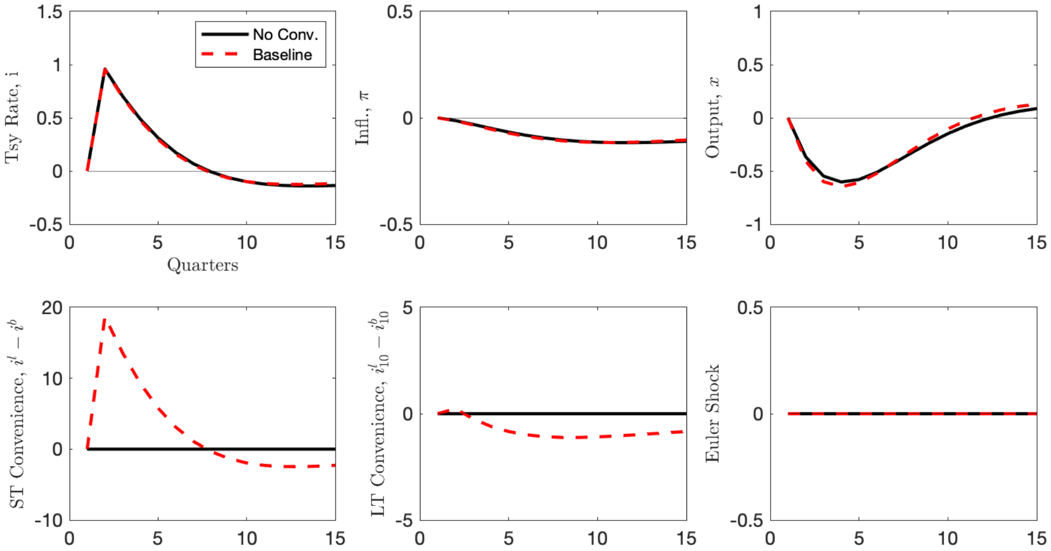


Figure A8: **Alternative Model Responses to Cost-Push Shock with $b = 0.01$.** This figure is identical to Figure 8 in the main paper but sets $b = 0.01$ instead of $b = 0.02$.

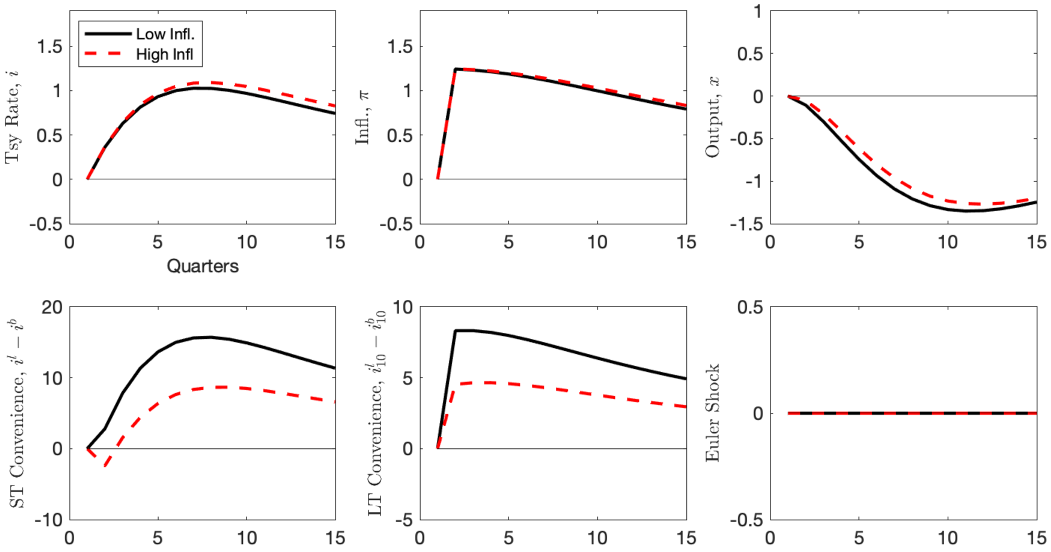


Figure A9: **Alternative Model Responses to Cost-Push Shock with $b = 0.04$.** This figure is identical to Figure 8 in the main paper but sets $b = 0.04$ instead of $b = 0.02$.