NBER WORKING PAPER SERIES

MONETARY POLICY WHEN THE CENTRAL BANK SHAPES FINANCIAL-MARKET SENTIMENT

Anil K Kashyap
Jeremy C. Stein

Working Paper 30751
http://www.nber.org/papers/w30751

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
December 2022

Paper in preparation for Journal of Economic Perspectives. We are grateful to Livia Amato and Zhi Zhang for outstanding research assistance, and to Michael Blank, Sam Hanson and Adi Sunderam for helpful comments. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

At least one co-author has disclosed additional relationships of potential relevance for this research. Further information is available online at http://www.nber.org/papers/w30751.ack

Monetary Policy When the Central Bank Shapes Financial-Market Sentiment
Anil K Kashyap and Jeremy C. Stein
NBER Working Paper No. 30751
December 2022
JEL No. E44,E52,E58

ABSTRACT

Recent research has found that monetary policy works in part by influencing the risk premiums on both traded financial-market securities and intermediated loans. Research has also shown that when risk premiums are compressed, there is an increased likelihood of a reversal that damages the credit-supply mechanism and the real economy. Together these effects create an intertemporal tradeoff for monetary policy, as stimulating the economy today can sow the seeds of a future downturn that might be difficult to offset. We introduce a simple model of this tradeoff and draw out its implications for the conduct of monetary policy.

Anil K Kashyap
Booth School of Business
University of Chicago
5807 S. Woodlawn Avenue
Chicago, IL 60637
and NBER
anil.kashyap@chicagobooth.edu

Jeremy C. Stein
Department of Economics
Harvard University
Littauer 219
Cambridge, MA 02138
and NBER
jeremy_stein@harvard.edu

In the years since the Global Financial Crisis of 2008-09, the conduct of monetary policy has changed markedly. As central banks bumped up against the zero lower bound (ZLB) on short-term policy rates, they began to experiment with other tools, including notably quantitative easing, or QE. Key to the effectiveness of QE is that central bank bond purchases influence the so-called term premium on Treasury securities, which can be thought of as the risk premium that investors expect to earn on a carry trade that borrows short-term to invest in long-term Treasury bonds.[1] Other unconventional central bank tools, such as the corporate credit facilities which the Federal Reserve unveiled in the spring of 2020 in response to COVID-19, also worked by compressing risk premiums, in this case the credit spreads (relative to safe Treasuries) on risky corporate bonds.[2]

While these asset-purchase facilities are designed to have a direct effect on financial-market risk premiums, a body of recent research has found that even conventional monetary policy—implemented via increases or decreases in the short-term rate—tends to have powerful effects on risk premiums in a range of financial markets, including those for stocks, Treasuries, corporate bonds, and foreign exchange. In a similar vein, changes in the stance of monetary policy have been found to influence banks' risk appetites and lending standards.

Moreover, it appears that these policy-induced movements in risk premiums, like other movements in risk premiums, tend to be temporary, meaning that an increase in asset prices spurred by central bank action is typically reversed in the months or years that follow. One way to summarize these findings is to say that central banks have a broad ability—via both their conventional and unconventional policies—to influence financial-market "sentiment", which we use as a synonym for the time-varying risk premiums on both traded securities and intermediated loans.[3] This is a very different channel of monetary-policy transmission than seen in traditional models, for example those in the New Keynesian genre.

The central thesis of this paper is that once one appreciates that monetary policy achieves much of its effectiveness through its impact on financial-market sentiment, one may think quite differently about a number of issues that arise in the conduct of policy. To see why, it helps to

[1] Bernanke (2020) surveys the large literature that studies the impact of QE on asset prices and the real economy.
[2] See e.g., D'Amico, Kurakula and Lee (2020), Clarida, Duygan-Bump and Scotti (2021) and Boyarchenko, Kovner and Shachar (2022) for analyses of the Fed's corporate credit facilities.
[3] For example, when credit spreads are compressed, and the objective expected return to bearing credit risk is unusually low, we will say that credit-market sentiment is elevated. In this usage, elevated sentiment can reflect either an increase in investors' effective risk tolerance that causes them to knowingly accept lower returns, or behavioral mistakes of various sorts that lead them to over-estimate future returns. For much of what follows, we can be agnostic as to which of these two mechanisms is at work.

connect to a second strand of recent work, which documents the importance of what we call a "credit-bites-back" effect, in homage to the seminal paper of Jordà, Schularick and Taylor (2013). In brief, this literature finds that following periods of rapid credit growth, and especially when asset prices are elevated and risk premiums are compressed (i.e. when sentiment is running high), the likelihood of a recession or a financial crisis is significantly increased.

Taken together, these two lines of research suggest an important tradeoff facing monetary policymakers. Accommodative policy can be quite powerful in raising aggregate demand when needed, even when the ZLB threatens to bind—this is the upside of the central bank's ability to stoke market sentiment. But this power comes with a potential downside as well, since elevated sentiment today may reverse, and increase the odds of a recession at some later date. And, as we argue below, this tension becomes all the more pronounced when financial regulation is by itself unable to fully contain the credit-bites-back risks put into play by monetary policy.

A related observation is that the so-called neutral real rate of interest, or r^*, may not be a function just of exogenous demographic and technological factors, as in standard accounts, but may also be endogenously related to the historical path of monetary policy. In particular, if policy has been highly accommodative in the recent past, it may have to continue to be more accommodative going forward, all else equal, to avoid sparking a reversal in financial conditions that leads to a downturn in activity.

Another implication of this general logic is that if financial-market risk premiums are determined in a partially integrated fashion across global markets—e.g. if the term premium on U.S. Treasuries is correlated with that on German bunds and U.K. gilts—then as Rey (2013) has emphasized, there may be less effective monetary-policy independence across countries than is generally appreciated, and the Federal Reserve, as the dominant-currency central bank, may exert more influence over global financial conditions than any of its peers.

New Theories and Evidence on Monetary Transmission

In the canonical New Keynesian account of monetary policy transmission (Woodford (2003), Galí (2008, 2018)), time-variation in financial-market risk premiums does not play a meaningful role. Rather, policy can be thought of as working through the expectations hypothesis and the term structure of safe (e.g. Treasury) interest rates. Given sticky prices, when the central bank cuts the short-term nominal rate, it also lowers the short-term real rate. And if policy changes are persistent, there will be an associated impact on longer-term real rates as well; these in turn will influence consumption and investment decisions. Again, this story can be largely told in a world where all risk premiums are constant over time.

A similar observation applies to other accounts of the monetary transmission mechanism, such as the bank lending channel (Kashyap and Stein (2000), Drechsler, Savov and Schnabl (2017)). Here, an easing of monetary policy effectively stimulates bank lending by generating an inflow of cheap deposit funding into the banking system. In other words, what changes for banks as monetary policy varies is not their risk tolerance, but rather their liquidity position, and hence their ability to finance their lending activity. The broader macro literature on the financial accelerator, as summarized by Bernanke, Gertler and Gilchrist (1999), also does not emphasize time-varying risk premiums as a central factor in policy effectiveness.

By contrast, a body of recent work has put changes in investor and intermediary risk tolerance front and center in its account of monetary policy. We begin with a brief discussion of the underlying theories, and then survey some of the most relevant evidence.

Why might monetary policy affect investor and intermediary risk tolerance?

There are several channels through which changes in central-bank policy rates might affect the risk tolerance of investors and intermediaries, and hence the risk premiums on a range of financial assets. Campbell and Sigalov (2022) tell a particularly straightforward story: they begin with an otherwise completely neoclassical model of consumption and portfolio choice featuring an infinitely lived investor with power utility. They then add one wrinkle: the investor faces what they call a sustainable spending constraint and can only consume the expected return on her wealth; she is not allowed to run down her wealth over time. This assumption, which would seem to capture accurately the behavior of endowments and sovereign wealth funds, as well as perhaps that of some individual retirees, naturally generates "reaching for yield" behavior: as the real interest rate falls, the investor increases her allocation to risky assets, in an effort to partially insulate her level of current consumption.

Other theories, in the spirit of Rajan (2005), and Borio and Zhu (2012), emphasize agency or regulatory frictions that distort intermediary behavior. For example, Hanson and Stein (2015) build a model in which a set of intermediaries such as commercial banks care about maintaining their accounting income in the face of interest-rate cuts. This leads them to take on more duration risk at such times, which in their model puts downwards pressure on the term premium. Chodorow-

Reich (2014) and Di Maggio and Kacperczyk (2017) argue that low interest rates may lead money-market funds to take more risk in order to cover their fixed costs and sustain their profit margins.

Drechsler, Savov and Schnabl (2018), and Acharya and Naqvi (2019) take a somewhat different route, noting that accommodative monetary policy gives banks easier access to cheap liquidity, which serves an insurance role: they can afford to take on more risk without worrying as much about this risk causing a disruptive liquidity shortfall.

All of these stories are rooted in the constraints and frictions facing intermediaries. Kekre and Lenel (2022) instead focus on heterogeneity in households' risk tolerance and argue that an interest-rate cut redistributes wealth towards more risk-tolerant households, thereby increasing aggregate risk appetite. And Lian, Ma and Wang (2019) adopt a behavioral perspective: in randomized experiments, they find that people exhibit a stronger preference for risky assets when the risk-free rate is lower. They interpret this as evidence that psychological mechanisms, such as reference points and salience, affect investor risk-taking in an important way. Another behavioral story is due to Fontanier (2022). In his model, a rate cut that initially raises asset values for purely fundamental discounted-cashflow reasons causes price-extrapolative investors to become overly enthusiastic about future prospects, thereby causing an eventual overshoot of valuations.

The stock market

Bernanke and Kuttner (2005) examine the stock market's response to monetary policy surprises. Using an event-study approach, they find that a surprise 25-basis-point cut in the federal funds rate target is associated with a contemporaneous increase in the value of the stock market of about one percent. Perhaps more interestingly for our purposes, they show that the vast majority of the stock-price increase—on the order of 80%—is due to a change in the expected excess return, or risk premium, in the stock market. Concretely, they accomplish this by documenting that the initial upward spike in stock returns is followed by a long period of abnormally low returns. That is, the boost to stock prices associated with a surprise monetary easing is in large part transitory and is eventually mostly reversed. This is exactly what one would expect to find if the monetary-policy innovation led to an increase in investor risk tolerance.[4]

Treasury term premiums

Hanson and Stein (2015) study the high-frequency reaction of real interest rates—those on Treasury Inflation Protected Securities, or TIPS—to monetary policy announcements. They find

[4] See also Cieslak and Pang (2021).

that monetary innovations have a surprisingly large impact on even very far forward real rates. For example, if the two-year nominal Treasury yield goes up by 25 basis points in the immediate wake of an FOMC announcement, this is associated with a 11 basis-point increase in the ten-year forward real rate. Hanson and Stein (2015) argue that this increase in the distant-forward real rate is unlikely to reflect a change in the expected path of short-term real rates at such a long horizon—which would require prices to be counterfactually sticky for an extremely long time—but rather a change in the Treasury term premium. In support of this point, they demonstrate that the movements in forward rates that occur on FOMC announcement dates tend to largely mean revert over the next 12 months. As with Bernanke and Kuttner's (2005) evidence for the stock market, this reversal effect is suggestive of a change in risk premiums.

In a similar vein, Hanson, Lucca and Wright (2021) find that since 2000, increases in short-term Treasury rates are associated with strong, yet temporary upwards pressure on term premiums. They build a model in which changes in short rates trigger "rate-amplifying" shifts in the demand for long-term bonds, which might come from investors who either extrapolate recent changes in short rates, or who reach for yield when short rates fall.

Credit spreads and bank lending terms

The risk premium on corporate credit—i.e., the expected return differential between risky corporate bonds and safe Treasuries—is one of the most important risk premiums that monetary policy can affect, given its documented powerful effects on real economic activity. (Gilchrist and Zakrajšek (2012), Lopez-Salido, Stein and Zakrajšek (2017)). However, inference in this case is somewhat trickier than for the stock market and the Treasury market. Corporate bonds are less liquid, and less actively traded, and so may reprice less promptly in the immediate hours after an FOMC meeting than do Treasury bonds. If so, one would be mechanically biased away from finding an effect of monetary policy on credit spreads in a high-frequency event study, especially if these spreads are measured directly based on the difference in corporate and Treasury yields.

One response to this challenge is to look at longer-horizon effects. This is the approach taken by Gertler and Karadi (2015), who use a vector-autoregression to estimate the dynamic impact, at monthly frequency, of monetary-policy surprises on the excess bond premium (EBP) of Gilchrist and Zakrajšek (2012). The EBP is, heuristically, that portion of the credit spread that is not accounted for by expected default losses, and hence maps very closely into the concept of a credit-risk premium. Gertler and Karadi (2015) find that a monetary innovation that reduces the one-year Treasury bill rate by 25 basis points compresses the EBP by 10 basis points in the first month. This effect persists for about eight months, and then is gradually reverted away, again consistent with the behavior of a transitory risk premium.

By its nature, however, this longer-horizon approach is inevitably more sensitive to the precise details of the econometric specification and the identifying assumptions used; as such, it lacks the appealing transparency and robustness of a high-frequency event study. Bauer and Swanson (2022) provide a detailed treatment of these issues. Interestingly, with their preferred approach to identification they find an even stronger effect of monetary policy surprises on the EBP than do Gertler and Karadi (2015). At the same time, they are careful to highlight the sensitivity of these results to alternative specifications.

An alternative approach to address how monetary policy affects the pricing of credit risk is to revert back to the high-frequency event-study methodology, but to look at the spreads on credit default swaps (CDS) instead of corporate bonds. CDS tend to be more liquid than the underlying bonds, and to have prices that adjust more rapidly, so they may be better suited for this approach. And indeed, using a methodology similar to Hanson and Stein (2015), Palazzo and Yamarthy (2022) find that a 25 basis-point increase in the 2-year Treasury yield in the short window around an FOMC announcement is associated with a 7 basis-point average increase in firm-level CDS spreads. They also uncover noteworthy heterogeneity in the response, with a larger effect being seen in the set of riskier firms with higher ex-ante CDS spreads.

Of course, when one thinks about the pricing of credit risk, it is important to go beyond the corporate bond market and to think also about bank lending. *A priori*, one might naturally expect there to be some integration between the pricing of credit risk across corporate bonds and loans; this conjecture is superficially consistent with the relatively high correlation between corporate credit spreads and bank lending terms as reported in the Federal Reserve's Senior Loan Officer Opinion Survey (SLOOS).[5]

In this vein, there is a recent body of work that suggests that an easing of monetary policy does in fact lead banks to loosen their credit standards and take on more credit risk. For example, Paligorova and Santos (2017) use data on syndicated corporate loans from Dealscan to show that

[5] For example, over the period 1996:4-2022:2, the correlation in levels between the high-yield credit spread and a measure of easing of credit terms from the SLOOS is -0.51. There is also a strong correlation between the SLOOS and corporate bond issuer quality, as noted by Greenwood and Hanson (2013).

when short-term rates are low, there is a reduced sensitivity of the spread that a firm is charged on its loans to a measure of its fundamental credit risk; in other words, there is a lower cross-sectional price of credit risk. In a similar vein, Dell'Ariccia, Laeven and Suarez (2017) exploit supervisory data from the Fed to look at how banks' internal risk ratings on newly originated loans vary with the stance of monetary policy. They find that when the policy rate declines, banks extend more credit to riskier borrowers. This is true even when they restrict the set of loans to be only those that are new and not made under commitment, so that this is clearly a discretionary choice. And Maddaloni and Peydró (2011) use loan officer survey data from both the U.S. and the euro area to document that times of low policy rates are associated with generally laxer lending standards.

These sorts of results appear to hold up across a range of other countries. Using credit registry data from Spain, Jimenez, Ongena, Peydró, and Saurina (2014) find that when interest rates drop, the amount of lending to firms with bad credit histories (or future impending losses) rises relative to loans made to more creditworthy firms. They also show that this effect is more pronounced for loans made by weakly-capitalized banks than for those made by well-capitalized ones. And Ioannidou, Ongena and Peydró (2015) work with data from Bolivia—a largely dollarized economy where monetary policy changes are exogenously transmitted from the U.S—to show that a lower fed funds rate leads to relatively more bank lending to borrowers with worse credit histories, lower internal credit ratings, and poorer ex-post performance.

Thus, whether through banks or via capital markets, it seems that an important part of what happens when the central bank cuts interest rates is that the risk premium on corporate credit declines. Thus, holding borrowers' creditworthiness and loan demand fixed, we would expect to see an expansion in overall credit creation, and one that is tilted towards higher-risk firms.

Foreign exchange

Greenwood, Hanson, Stein and Sunderam (2022) and Gourinchas, Ray and Vayanos (2022) argue that there is likely to be a close correlation between bond market term premium differentials across countries on the one hand, and exchange-rate risk premiums on the other. This is because both long-term bonds and currencies are exposed to the same primary risk factor, namely changes in the stance of monetary policy. Greenwood et al. (2022) provide supporting evidence, showing for example that if the Fed undertakes a round of QE, this will not only reduce the term premium on U.S Treasury securities relative to those in other countries, but it will also weaken the dollar by more than can be accounted for by the standard uncovered-interest-parity channel—so that the dollar subsequently tends to appreciate by an abnormal amount going forward against other currencies. This is yet another example of central-bank policy gaining additional traction to stimulate output in the short term by virtue of its ability to influence risk premiums.

Evidence on the Credit-Bites-Back Mechanism

We now turn to the body of work that studies the credit-bites-back mechanism. Broadly speaking, this work highlights two sets of stylized facts. The first is that if one looks at quantity data that captures the growth of aggregate credit, then at relatively low frequencies rapid growth in credit tends to portend adverse macroeconomic outcomes, be it a financial crisis or some kind of more modest slowdown in activity. The second is that elevated levels of financial-market sentiment—especially indicators which signal that the expected returns to bearing credit risk are low—also tend to carry negative information about future economic growth, above and beyond that impounded in credit-quantity variables. Thus the overall picture is that credit booms, especially those associated not just with rapid increases in the quantity of credit, but also with aggressive pricing of credit risk, tend to end badly.

With respect to the quantity-oriented evidence, some of the most influential research is by Schularick and Taylor (2012), and Jordà, Schularick and Taylor (2013). In the former, they study 14 developed countries over the period 1870-2008, and find that the growth of bank loans in the preceding five years is associated with a significantly increased probability of a financial crisis.

In a similar spirit is the work by Mian, Sufi, and Verner (2017). Like Schularick and Taylor (2012), and Jordà, Schularick and Taylor (2013), they focus on a quantitative measure of credit expansion, in this case the growth of household credit to GDP. Using a sample of 30 mostly advanced economies, and a panel running from 1960-2012, they find large negative effects of credit booms on future output: a one-standard-deviation increase in household debt to GDP over a three-year interval leads to a 2.1 percent decline in GDP over the following three years. Notably, these results reflect not just the consequences of extreme financial crises but are also driven by more moderate non-crisis recessions and slowdowns.

Turning to the role of credit-market sentiment, López-Salido, Stein, and Zakrajšek (2017) investigate the role of sentiment in a U.S. sample running from 1929 to 2015. To do so, they build on the work of Greenwood and Hanson (2013), who show that when credit spreads are narrow, and when the share of high-yield (or "junk bond") issuance in total corporate bond issuance is high, the expected returns to bearing credit risk are predictably low, and sometimes even negative—in other words, narrow credit spreads and an above-average high-yield share are indicative of elevated credit-market sentiment. López-Salido et al (2017) then show that exuberant credit-market sentiment in a given year *t* is also associated with a decline in economic activity in years *t + 2* and *t + 3*. Underlying this result is the existence of predictable mean reversion in market conditions. When credit risk is aggressively priced, spreads subsequently widen. The timing of this widening is closely tied to the onset of a contraction in economic activity, one in which the pain is felt disproportionately by firms with lower credit ratings. Exploring the mechanism, they find that buoyant credit-market sentiment in year *t* also forecasts a change in the composition of external finance: net debt issuance falls in year *t + 2*, while net equity issuance increases, consistent with the reversal in credit-market conditions leading to an inward shift in credit supply.

This focus on sentiment is extended by Kirti (2020), who examines a sample encompassing 38 countries. His key finding concerns the *interaction* of growth in the quantity of credit with credit-market sentiment, where he follows Greenwood and Hanson (2013) and proxies for the latter with the high-yield share. In particular, following strong credit growth, economic growth in the following three years is roughly 1.10 percent a year slower. However if this increase in the quantity of credit is accompanied by a two-standard-deviation increase in the high-yield share, growth over the next three years slips by a further 0.80 percent per year.[6]

Greenwood, Hanson, Shleifer and Sorensen (2022) also focus on the interaction between credit growth and asset prices and give a sense of just how strong the economic effects can be. In a panel of 42 countries over the period 1950 to 2016, they find that the probability of a financial crisis rises dramatically—from a normal-times value of 7% to over 40% at a 3-year horizon—when a country is in what they call a "Red Zone", characterized by business credit growth over the prior three years in the top quintile of the distribution, and stock returns over the same window in the top tercile.

A related set of papers uses quantile regressions to explore how changing financial conditions affect not just mean or median outcomes, but the *full distribution* of real activity. Important contributions here include Adrian, Boyarchenko and Giannone (2019) and Adrian, Grinberg, Liang, Malik and Yu (2022). The former focuses on the U.S, while the latter also looks

[6] Krishnamurthy and Muir (2020) present related findings, using a panel that goes back 150 years and covers 19 countries.

at data from Australia, Canada, Switzerland, Germany, Spain, France, Great Britain, Italy, Japan, and Sweden. The general picture that emerges in both studies is that it is the lower tail of GDP growth—e.g. the 5th percentile—that is especially vulnerable in the two to three years following an easing of financial conditions. In other words, loose financial conditions seem to particularly raise the downside risks to real activity, while they have weaker effect on the upper tail of the distribution.

Carpenter, Harris, Hooper, Kashyap and West (2022) report similar findings for the U.S. but clarify which are the most relevant factors for assessing the role of financial conditions in this sort of predictive exercise: it turns out that proxies for credit supply such as loan spreads or debt levels are more informative for downside risks to the economy than variables relating to equity markets or exchange rates. The idea that tracking the pricing of credit risk is especially important in this context echoes the findings of Lopez-Salido, Stein and Zakrajšek (2017), among others.

For the purposes of using the above findings to draw implications for the conduct of monetary policy, it is important to note two caveats. First, we believe that the above-discussed evidence is quite compelling in establishing two propositions: (i) accommodative monetary policy leads to reductions in risk premiums generally, and in credit risk premiums in particular; and (ii) rapid credit growth and compressed credit risk premiums increase the odds of adverse economic outcomes at a horizon of between two to five years. However, as noted by Boyarchenko, Favara and Schularick (2022), there is limited evidence that it is specifically *monetary-policy induced changes* in credit growth and risk premiums—as opposed to changes driven by other factors—that create this economic vulnerability. As they note, establishing such a link is challenging, and more research would be welcome. We are going to make the leap and assume that the link is operative in what follows, but the reader should be aware that this connection is not yet firmly established.

Secondly, any normative implications for monetary policy hinge on the extent to which one believes that the credit-bites-back risks that we have identified can be mitigated by financial regulation. A traditional argument, made e.g. by Bernanke (2015), is that financial regulation should be the first line of defense against these risks. While agreeing on the importance of robust financial regulation, Stein (2021) expresses skepticism about its ability to serve as a panacea. He notes that the limitations of regulation are likely to vary by jurisdiction, but are particularly acute in countries like the U.S., where the majority of corporate credit creation now takes place outside of the easier-to-regulate banking sector, and where various political-economy constraints have left policymakers with essentially nothing in the way of time-varying macroprudential tools. With this line of argument in mind, our implicit assumption in the remainder of the paper is that even after doing the best that one can with regulatory tools, there still remains in equilibrium—as in the historical data—a meaningful credit-bites-back effect.

A Simple Model of Monetary Transmission via Credit Risk Premiums

In what follows, we develop a bare-bones framework in which one can examine the intertemporal tradeoff that arises when monetary policy influences credit risk premiums and when there is a credit-bites-back effect of the sort documented in the work discussed above.[7]

Baseline setup

To keep things as simple as possible, we assume that the central bank has no inflation mandate, so that its only responsibility is output stabilization; this can be thought of as capturing a "divine coincidence" world where shocks only come from the demand side of the economy, and so stabilizing output also amounts to stabilizing inflation. The IS curve is given by:

$$y_t = y^* - \gamma(r_t - r^*) + \epsilon_t, \tag{1}$$

where y_t is output at time *t*, y^* is potential output, r_t is the real interest rate, r^* is the natural rate of interest, and ϵ_t is an aggregate demand shock.

The central bank chooses r_t to minimize squared deviations of output from potential:

$$min \sum_{t=0}^{\infty} E\,(y_t - y^*)^2 \tag{2}$$

The solution is given by:

$$r_t = r^* + \frac{\epsilon_t}{\gamma} \tag{3}$$

Thus in this simple case, the central bank is able to perfectly stabilize output period-by-period, by raising rates to offset demand shocks.

[7] See Caballero and Simsek (2020, 2022) and Fontanier (2022) for more fully-developed models that investigate similar issues.

Adding credit spreads

We now add credit spreads to the model and allow monetary policy to influence these spreads.[8] In particular, the IS curve is modified as follows:

$$y_t = y^* - \gamma((r_t + s_t) - (r^* + s^*)) - \beta(s_t - s_{t-1}) + \epsilon_t, \qquad (4)$$

where s_t is the credit spread at time *t*, and $s^*$is the steady-state value of the credit spread. There are two changes to note here: first, what matters for aggregate output now is not the real interest rate set by the central bank, but a broader notion of financial conditions, given by $(r_t + s_t)$. Second, and crucially, there is a "credit bites back" term, given by $-\beta(s_t - s_{t-1})$: output is reduced, all else equal, when credit spreads *increase* from the prior period. This might be because an increase in credit spreads impairs the health of financial intermediaries, and financial regulation is inadequate to fully prevent this damage. For example, a bank's capital might be reduced by an erosion of the perceived credit quality of its loan book, and this might in turn compromise its ability to make new loans. Or alternatively, a corporate bond fund that experiences mark-to-market losses might see substantial outflows of money under management, which would dampen its demand for new bonds.

The time-*t* credit spread is in turn determined by:

$$s_t = s^* + \theta(r_t - r^*) \ + \upsilon_t, \qquad (5)$$

where the $\theta(r_t - r^*)$ term captures what can be thought of as a reaching-for-yield effect—easy monetary policy tends to depress credit spreads—and υ_t is an exogenous credit-supply shock.

The parameter β is key to creating an intertemporal tradeoff for policy. To see why, let's begin by setting $\beta = 0$, so there is no credit-bites-back effect. In this case, (4) simplifies to:

$$y_t = y^* - \gamma((r_t + s_t) - (r^* + s^*)) + \epsilon_t. \qquad (4')$$

[8] To be clear, although we use the terms "credit" and "credit spreads" for concreteness in what follows, our analysis would apply equally to other risk premiums that are influenced by monetary policy, such as the stock market risk premium, bank lending spreads, or term premiums in the Treasury market.

It is straightforward to show that output can again be perfectly stabilized in every period with a simple modification of the interest-rate rule:

$$r_t = r^* + \frac{\epsilon_t}{\gamma(1+\theta)} - \frac{\upsilon_t}{(1+\theta)}. \tag{6}$$

Relative to (3), the interest-rate rule is changed in two ways: first, the policy rate is less responsive to demand shocks, by a factor of $(1+\theta)$. This is because changes in the policy rate have an amplified impact on output, due to the reaching-for-yield effect. Second, policy leans against exogenous movements in financial conditions, as given by υ_t. When credit spreads are relatively low, the policy rate is higher, and vice-versa.

Thus in this limiting case where $\beta = 0$, and there is no credit-bites-back effect, optimal monetary policy takes account of both exogenous changes in financial conditions, as well as its own impact on these conditions. Note, however, that to do so we now require the central bank to be able to observe υ_t precisely, which amounts to being able to separate these temporary shocks to credit conditions from more permanent shifts in $s*$. This is a potentially challenging informational requirement, whose implications we discuss in more detail below. Nevertheless, if we provisionally assume that υ_t can be well measured, monetary policy faces no compromises or tradeoffs, and is still able to perfectly stabilize output in every period.

This version of the model might be thought of as roughly in line with contemporary central-bank practice, whereby a good deal of attention is paid to financial conditions—and where evidence suggests that the policy rate is indeed set at a lower value, all else equal, when conditions are tight, and vice-versa (Peek, Rosengren and Tootell (2016), Razzak (2022))—but where the intertemporal tradeoffs associated with policy-induced changes in financial conditions are generally not given explicit consideration, at least not in the formal models used to guide policy.

An intertemporal tradeoff

We now return to the case where $\beta > 0$. To simplify the exposition, we focus on the optimal choice of policy rates r_1 and r_2 at times 1 and 2, respectively, and the tradeoffs these choices entail. Moreover, we assume that at an earlier time 0, the economy was in steady state, with $r_0 = r^*$, and with $s_0 = s^*$. To simplify even more, we further assume that there are no credit supply shocks at either time 1 or time 2, so that $\upsilon_1 = \upsilon_2 = 0$. And finally, as will become clear, the most interesting scenario arises when there are persistent recessionary pressures—i.e., negative demand shocks—at both dates, and there is a possibility that things may get worse at time 2, to the point that the zero lower bound (ZLB) may bind.

In a more elaborate model, we would allow for these demand shocks to be stochastic, but here we just assume that they are deterministic, that $\varepsilon_2 < \varepsilon_1 < 0$, and that this is all fully known as of time 1. A richer model could also allow for other reasons, besides the ZLB, why policy might be unable to fully neutralize all relevant shocks to the economy. This could be, for example, because the rapid unwinding of a financial bubble has an especially damaging effect on the credit-allocation mechanism. However, to make our points as simply as possible we set aside these considerations and use the ZLB as a catch-all for the idea that there may be times when monetary policy cannot perfectly offset all potential damage to the real economy.

In order for the central bank to fully stabilize output at y^* at both time 1 and time 2, it is easy to show that it would have to set the following policy rates:

$$r_1^S = r^* + \frac{\varepsilon_1}{\gamma(1+\theta)+\beta\theta} \tag{7}$$

$$r_2^S = \frac{r^*\gamma(1+\theta)+r_1^S\beta\theta+\varepsilon_2}{\gamma(1+\theta)+\beta\theta} = r^* + \frac{\varepsilon_2}{\gamma(1+\theta)+\beta\theta} + \frac{\beta\theta(r_1^S-r^*)}{\gamma(1+\theta)+\beta\theta} \tag{8}$$

There are two important points to take away from (8). First, r_2^S now depends on r_1^S. In other words, there is hysteresis in the policy rate, and a lower rate at time 1 now requires the central bank to set a lower rate at time 2, all else equal, in order to stabilize output. This is because of the credit-bites-back effect. By cutting rates at time 1, the central bank compresses credit spreads, and if it backs away from this policy at time 2, credit spreads will widen, which—by damaging the balance sheets of intermediaries, will exert a drag on output.

Second, if ε_2 is sufficiently negative, the ZLB will bind at time 2, even if it was not binding at time 1. We assume that this is the case in what follows; in a more realistic stochastic setting it would suffice to simply assume that there is a non-zero probability of the ZLB binding at time 2. When the ZLB binds at time 2, the central bank will be unable to fully stabilize output by cutting rates as far as it needs to. Moreover, the lower the policy rate at time 1, the more tightly binding the ZLB will be at time 2, and the lower will be realized output.

When the ZLB binds at time 2 and not at time 1, we can write output at the two dates as:

$$y_1 = y^* - \gamma(1+\theta)(r_1 - r^*) - \beta\theta(r_1 - r^*) + \epsilon_1 \tag{9}$$

$$y_2(ZLB) = y^* + \gamma(1+\theta)r^* + \beta\theta r_1 + \epsilon_2 \tag{10}$$

Given these expressions, we can then ask what the central bank's optimal choice of r_1 is, given its quadratic loss function in (2). Note the intertemporal tradeoff: cutting r_1 is helpful in offsetting a negative demand shock at time 1, but when $\beta > 0$ and the ZLB binds at time 2, such a time-1 rate cut reduces output further below potential at time 2. We can solve for the optimal value of r_1 in this case as:

$$r_1(ZLB) = \frac{r^*\left[(\gamma(1+\theta)+\beta\theta)^2 - \beta\theta\gamma(1+\theta)\right] + \varepsilon_1(\gamma(1+\theta)+\beta\theta) - \varepsilon_2\beta\theta}{(\gamma(1+\theta)+\beta\theta)^2 + (\beta\theta)^2} \tag{11}$$

Based on (11), we can establish the following proposition (see the appendix for details):

Proposition 1: If the ZLB binds at time 2, then: (i) the optimal policy rate at time 1 is higher than it would be if the ZLB were not binding at time 2, i.e., $r_1(ZLB) > r_1^s$; (ii) output at time 1 is lower than it would be if the ZLB were not binding at time 2; and (iii) $\frac{dr_1(ZLB)}{d\varepsilon_1} < \frac{1}{\gamma(1+\theta)+\beta\theta} = \frac{dr_1^s}{d\varepsilon_1}$, so that it is no longer optimal for the central bank to fully offset negative time-1 demand shocks.

Intuitively, the central bank fears that if it cuts rates at time 1 enough to fully offset a negative demand shock, it will overheat credit conditions, and this overheating will create a drag on time-2 output that cannot be offset if the ZLB binds at time 2. This is the core intertemporal tradeoff that arises in our setting. Moreover, this time-1 timidity in providing accommodation is more pronounced when the anticipated negative demand shock at time 2 is larger in absolute magnitude—or, in a richer setting, when the likelihood of a severe ZLB episode is greater.

It is worth noting that in many discussions of the role of monetary policy in safeguarding financial stability, the question is framed as asking whether monetary policy should proactively "lean against the wind" of changes in financial-market sentiment (e.g. Svensson (2017)). This formulation would seem to suggest that fluctuations in asset prices are an exogenous source of variation—a "wind" blowing in from outside the model, as might be associated say, with a late 1990s-style stock-market bubble driven by enthusiasm over a new technology. However, as our framework underscores, sometimes the central bank is itself the driver of movements in asset prices. In this case, the question is not whether it should lean against an external shock, but rather how aggressively it should deploy a tool that itself can lead to overly compressed risk premiums.

Implications for the Conduct of Monetary Policy

Incorporating insights from the model into the policy process

How might central banks adapt their monetary-policy processes to explicitly take account of the intertemporal tradeoff we have identified? One suggestion is that there should be additional attention given to developing summary measures of financial conditions that are most useful for capturing the kind of credit-bites-back risk we have highlighted. Many central banks now produce financial stability reports that track a wide variety of indicators in financial markets and typically also identify some imbalances. This is admirable and represents progress relative to the situation before the GFC. But most of these reports stop short of making an overall judgment about the level of risk to the macroeconomy, and its implications, if any, for monetary policy. This approach stands in stark contrast to the treatment given to factors that feature in other, more conventional models. For example, it is hard to imagine a central-bank seeking to pursue inflation targeting without a commonly agreed-to measure of inflation.

Such a lack of consensus as to the nature of the problem can create a situation where, so long as a large number of indicators are not flashing red, the default presumption is that monetary policymakers can simply ignore credit-bites-back effects when they go about setting their target for short-term rates. Such a default setting may be especially problematic when, as argued by Fontanier (2022), extrapolative behavior on the part of market participants implies that the right time to begin leaning against financial imbalances is relatively early in the cycle—not when these imbalances have reached a critical level, and when inadvertently popping a bubble may do more harm than good.

A related challenge is to integrate the analysis of financial risk more fully into monetary policy decision-making. For instance, the Federal Reserve currently does deep dives on financial risk four times a year and publishes much of the work in two financial stability reports. The Fed should consider discussing these risks, and their implication for policy, at every meeting, much as they currently do with inflation, the other major source of tradeoff they face in stabilizing real activity. Strikingly, nobody thinks that the right way to deal with the risk of accelerating inflation is to have a default presumption that it is not a problem until the situation is indisputably critical. Careful ongoing monitoring, and a willingness to take early action if needed, are core to the policy process for dealing with inflation. We would argue that the intertemporal tradeoff associated with credit-bites-back risk should be managed analogously.

Ultimately, these changes to the policy process should be reflected in how central banks communicate with the public and the elected representatives to whom they are accountable. For example, the Fed's annual "Statement on Longer-Run Goals and Monetary Policy Strategy" mentions the importance of financial stability as a precursor for achieving its other objectives. This framing could be adjusted to recognize that threats to these objectives can come not just from exogenous developments in financial markets, but also from the Fed's own aggressive attempts to support the economy.

Relatedly, in its monetary policy reports to Congress, the Fed shows five interest-rate rules that are used as points of reference in policy deliberations. None of these rules take account of financial conditions. This should probably be changed, and the committee could presumably then experiment with alternatives that make different judgments about how to weigh the circumstances of the moment against potential constraints on future policy.

Given the current state of research, which does not provide decisive guidance on how to best measure credit-bites-back risk, moving in these directions would initially be challenging. But our view is that having even an imperfect measure and starting to take it into account in a disciplined way is better than ignoring the tradeoff. Moreover, doing so is likely to give useful impetus to the research agenda that is needed to improve measurement. It is also possible that confronting these issues head on and talking publicly about them might spur Congress to take steps to improve the macroprudential tools that are available to regulators. Any progress on that front would be highly desirable in its own right.

Exogenous and endogenous determinants of r*

A central concept in the conduct of monetary policy is the neutral real rate of interest, or *r**. This is the level of the short-term real rate at which output equals potential and policy is neither inflationary nor deflationary. A large body of research, summarized in e.g., Holston, Laubach and Williams (2017), has found that *r** declined significantly, in the U.S., as well as in several other advanced economies, in the years leading up to the onset of the COVID-19 pandemic in 2020. Common explanations for this decline focus on *exogenous* demographic and technological factors, such as increased savings by an aging population, a slowdown in trend productivity growth, and increased income inequality (Straub 2019).

More recently, several papers have argued that part of the decline in *r** could instead be *endogenously* related to the prior conduct of monetary policy, via a hysteresis effect whereby low rates today beget the need for continued low rates in the future.[9] One mechanism that generates such an effect works through durable goods—for example, if low rates today lead consumers to buy a lot of new cars, there will be less demand for cars going forward, and the policy rate will have to be lower all else equal to sustain enough aggregate demand to keep the economy at full employment (McKay and Wieland 2021). Other mechanisms that can have similar consequences work through mortgage refinancing decisions and indebted households.[10]

Our model offers another reason why there can be history-dependence of this sort in *r**: easy monetary policy creates a boom in asset prices, but then effectively corners policymakers into keeping policy easy, for fear of creating an asset-price reversal that damages the economy.

The distinction between the exogenous/demographic/technological and the endogenous/ history-dependent accounts of *r** is of practical importance, for a couple of reasons. First, in the

---

[9] In a related vein, Acharya and Rajan (2022) and Acharya, Chauhan, Rajan and Steffen (2022) emphasize a potentially history-dependent impact of QE-driven increases in bank reserves. They observe that as reserves grow, intermediaries create additional short-term deposits and expand credit lines to match the increase in reserves. They argue that the presence of these claims can lock the central bank into needing to keep reserves high in order for the intermediaries to be able to honor these claims.

[10] Berger, Milbradt, Tourre and Vavra (2021) argue that a period of low rates encourages mortgage borrowers to refinance, which is stimulative, but which exhausts the pool of future refinancers and hence weakens the power of this channel going forward. See also Greenwald (2018), Wong (2021), and Beraja, Fuster, Hurst and Vavra (2019). Mian, Straub and Sufi (2021) make the point that easy monetary policy causes households to become more highly indebted, which in turn makes further stimulus less effective.

former case, the central bank's job is effectively to come up with its best empirical estimate of the current (exogenous) value of r^*, and then set policy rates accordingly. By contrast, in the latter case, there is a looking-in-the-mirror problem: simply knowing that it will take a low policy rate today to maintain full employment is insufficient for making good decisions over time, since this observation muddles together exogenous factors and the history of past policy choices. And it ignores the fact that low rates today may have repercussions for the future policy opportunity set.

Second, the exogenous/demographic/technological view suggests that movements in r^* are likely to be highly persistent, given that the underlying driving factors themselves are so slow-moving. Such a view seems to have informed the Fed's framework review of August 2020, which unequivocally endorsed the proposition that r^* would continue to remain low for the foreseeable future, and which adopted a "lower for longer" philosophy—one that arguably proved problematic when inflation began to rise sharply in the following year.[11] By contrast, an endogenous/history-dependent interpretation of the history of r^* would have presumably given one less confidence as to its stability over the coming years.

International considerations

Our discussion has thus far taken a largely closed-economy perspective. But there are important international implications associated with the observation that monetary policy works by influencing risk premiums. In influential work, Rey (2013) and Miranda-Agrippino and Rey (2020) argue that if monetary-policy-induced changes in risk premiums are highly correlated across countries—as one might expect if the arbitrageurs who police these risk premiums are global financial players—then individual central banks will have less policy independence than is normally envisioned in flexible-exchange-rate open-economy macro models.

Table 1 provides a simple illustration of this point, focusing on data from the period January 1998 to December 2021. The left column of the table shows the correlation of one-month changes in one-year yields—a natural proxy for the expected short-term path of monetary policy—between U.S. government bonds and those from six other advanced economies: Australia, Canada, Switzerland, Germany, Great Britain, and Japan. The right column repeats the exercise for ten-

[11] In a speech accompanying the revised 2020 Statement on Longer-Run Goals and Monetary Policy Strategy, Chair Powell (August 27, 2020) said: "This decline in assessments of the neutral federal funds rate has profound implications for monetary policy…..going forward, employment can run at or above real-time estimates of its maximum level without causing concern, unless accompanied by signs of unwanted increases in inflation or the emergence of other risks that could impede the attainment of our goals."

year yields, which one can think of as capturing both the expected path of monetary policy, as well as a term premium. As can be seen, in all cases, the correlation of changes in long-term yields is higher than the correlation of changes in short-term yields. And in several cases, most notably Australia, Germany and Great Britain, this differential is strikingly large. For example, the correlation of changes in Australian one-year yields with changes in U.S. one-year yields is 0.42, while for ten-year yields the corresponding correlation is 0.73.

This suggests that term premiums across countries are more tightly correlated than short-term policy rates, and underscores the point raised by Rey (2013) and Miranda-Agrippino and Rey (2020): even if one country's central bank attempts to set its monetary policy in a way that is independent of that in other countries, it may not fully succeed in doing so, particularly if what ultimately matters for economic activity are risk-premium-inclusive financial conditions such as longer-term rates. Moreover, if one believes that the Fed has a special role in determining these risk premiums due to the dominant role of the dollar in international finance, then this mechanism has the potential to significantly increase the Fed's influence over other economies.

Conclusions

Our analysis is built on two findings that have been well-documented in recent research, namely that: (i) monetary policy operates in significant part by influencing financial-market sentiment; and (ii) these sentiment shifts are prone to reversals, which can impair the credit-supply mechanism and ultimately damage the real economy. We have developed a simple model to show that taking account of these effects overturns some basic presumptions about how monetary policy should be conducted. Perhaps most importantly, the risk of reversals means that optimal policy no longer always completely offsets even pure negative demand shocks. Instead, policy may in some cases need to trade off the benefits of supporting the economy now against the possibility that an unwinding of financial-market sentiment could lead to worse outcomes in the future.

As we have seen, the analytics of this tradeoff are relatively straightforward. However, the practical implications are not. Addressing the tradeoff raises serious measurement challenges with respect to gauging the credit-bites-back risk. It will also require standard central-bank operating practices and communication policies to be adapted in a variety of ways. We have highlighted a number of areas where further research along these lines would be especially valuable and look forward to seeing this work develop.

References

Acharya, Viral V., and Hassan Naqvi. 2019. "On Reaching for Yield and the Coexistence of Bubbles and Negative Bubbles." *Journal of Financial Intermediation* 38 (C): 1–10.

Acharya Viral V., Rahul S. Chauhan, Raghuram G. Rajan, and Sascha Steffen. 2022. "Liquidity Dependence: Why Shrinking Central Bank Balance Sheets is an Uphill Task." paper prepared for the Federal Reserve Bank of Kansas City Jackson Hole Symposium.

Acharya Viral V., and Raghuram G. Rajan. 2022, "Liquidity, Liquidity Everywhere, Not a Drop to Use: Why Flooding Banks with Central Bank Reserves May Not Expand Liquidity." National Bureau of Economic Research Working Paper 29680.

Adrian, Tobias, Nina Boyarchenko, and Domenico Giannone. 2019. "Vulnerable Growth." *American Economic Review* 109 (4): 1263–89.

Adrian, Tobias, Federico Grinberg, Nellie Liang, Sheheryar Malik, and Eva Yu. 2022. "The Term Structure of Growth-at-Risk." *American Economic Journal: Macroeconomics* 14 (3): 283–323.

Bauer, Michael D., and Eric T. Swanson. 2022. "A Reassessment of Monetary Policy Surprises and High-Frequency Identification." *NBER Macroeconomics Annual* Vol. 37, M. Eichenbaum, E. Hurst, and V. A. Ramey eds.

Beraja, Martin, Andreas Fuster, Erik Hurst, and Joseph Vavra. 2019. "Regional Heterogeneity and the Refinancing Channel of Monetary Policy." *Quarterly Journal of Economics*, 134 (1): 109–183.

Berger, David, Konstantin Milbradt, Fabrice Tourre, and Joseph Vavra. 2021. "Mortgage Prepayment and Path-Dependent Effects of Monetary Policy." *American Economic Review* 111 (9): 2829–2878.

Bernanke, Ben S. 2015. "Federal Reserve Policy in an International Context." Paper presented at the 16th Jacques Polak Annual Research Conference Hosted by the International Monetary Fund. Washington, DC, November 5–6.

Bernanke, Ben S. 2020. "The New Tools of Monetary Policy." *American Economic Review* 110 (4): 943–83.

Bernanke Ben S., Mark Gertler, and Simon Gilchrist. 1999. "The Financial Accelerator in a Quantitative Business Cycle Framework." *Handbook of Macroeconomics*, Elsevier, Volume 1, Part C: 1341-1393.

Bernanke, Ben S, and Kenneth N Kuttner. 2005. "What Explains the Stock Market's Reaction to Federal Reserve Policy?" *Journal of Finance* 60 (3): 1221–1257.

Borio, Claudio, and Haibin Zhu. 2012. "Capital Regulation, Risk-Taking and Monetary Policy: A Missing Link in the Transmission Mechanism?" *Journal of Financial Stability* 8 (4): 236–251.

Boyarchenko, Nina, Giovanni Favara, and Moritz Schularick. 2022. "Financial Stability Considerations for Monetary Policy: Empirical Evidence and Challenges." Federal Reserve Bank of New York Staff Report 1003, February.

Boyarchenko, Nina, Anna Kovner, and Or Schachar. 2022. "It's What You Say and What You Buy: A Holistic Evaluation of the Corporate Credit Facilities." Federal Reserve Bank of New York Staff Report 935, January.

Caballero, Ricardo J, and Alp Simsek. 2020. "Prudential Monetary Policy." NBER Working Paper 25977, June.

Caballero, Ricardo J, and Alp Simsek. 2022. "A Monetary Policy Asset Pricing Model." NBER Working Paper 30132, June.

Campbell, John, and Roman Sigalov. 2022. "Portfolio Choice with Sustainable Spending: A model of Reaching for Yield." *Journal of Financial Economics* 143 (1): 188–206.

Carpenter, Seth, Ethan Harris, Peter Hooper, Anil Kashyap, and Kenneth West. 2022. "Some Benefits and Risks of a Hot Economy." U.S. Monetary Policy Forum 2022 Report.

Chodorow-Reich, Gabriel. 2014. "Effects of Unconventional Monetary Policy on Financial Institutions." *Brookings Papers on Economic Activity* (Spring): 155-204.

Cieslak, Anna, and Hao Pang. 2021. "Common Shocks in Stocks and Bonds." *Journal of Financial Economics* 142(2): 880-904.

Clarida, Richard H., Burcu Duygan-Bump, and Chiara Scotti. 2021. "The COVID-19 Crisis and the Federal Reserve's Policy Response." Washington: Board of Governors of the Federal Reserve System Finance and Economics Discussion Series 2021-035, June.

D'Amico, Stefania, Vamsi Kurakula, and Stephen M. Lee. 2020. "Impacts of the Fed Corporate Credit Facilities through the Lenses of ETFs and CDX." Federal Reserve Bank of Chicago Working Paper WP-2020-14, May.

Dell'Ariccia, Giovanni, Luc Laeven, and Gustavo Suarez. 2017. “Bank Leverage and Monetary Policy’s Risk-Taking Channel: Evidence from the United States.” *Journal of Finance* 72 (2): 613–654.

Di Maggio, Marco, and Marcin Kacperczyk. 2017. “The Unintended Consequences of the Zero Lower Bound Policy.” *Journal of Financial Economics* 123 (1): 59–80.

Drechsler, Itamar, Alexi Savov, and Philipp Schnabl. 2017. “The Deposits Channel of Monetary Policy.” *The Quarterly Journal of Economics* 132 (4): 1819–1876.

Drechsler, Itamar, Alexi Savov, and Philipp Schnabl. 2018. “A Model of Monetary Policy and Risk Premia.” *Journal of Finance* 73 (1): 317–373.

Fontanier, Paul. 2022. “Optimal Policy for Behavioral Financial Crises.” Working Paper, January.

Galí, Jordi. 2008. “Introduction to Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework.” Princeton University Press.

Galí, Jordi. 2018. “The State of New Keynesian Economics: A Partial Assessment.” *Journal of Economic Perspectives* 32 (3): 87–112.

Gertler, Mark, and Peter Karadi. 2015. “Monetary Policy Surprises, Credit Costs, and Economic Activity.” *American Economic Journal: Macroeconomics* 7 (1): 44–76.

Gilchrist, Simon, and Egon Zakrajšek. 2012. “Credit Spreads and Business Cycle Fluctuations.” *American Economic Review* 102 (4): 1692–1720.

Gourinchas, Pierre-Olivier, Walker D. Ray, and Dimitri Vayanos. 2022. “A Preferred-Habitat Model of Term Premia, Exchange Rates, and Monetary Policy Spillovers.” NBER Working Paper 29875, March.

Greenwald, Daniel. 2018. “The Mortgage Credit Channel of Macroeconomic Transmission.” MIT Sloan Research Paper 5184-16, January.

Greenwood, Robin, and Samuel G. Hanson. 2013. “Issuer Quality and Corporate Bond Returns.” *Review of Financial Studies* 26 (6): 1483–1525.

Greenwood, Robin, Samuel G. Hanson, Andrei Shleifer, and Jakob A. Sørensen. 2022. “Predictable Financial Crises.” *Journal of Finance* (77) 2: 863–921.

Greenwood, Robin, Samuel G. Hanson, Jeremy C. Stein, and Adi Sunderam. 2022. “A Quantity-Driven Theory of Term Premia and Exchange Rates.” *Quarterly Journal of Economics*, forthcoming.

Hanson, Samuel G., and Jeremy C. Stein. 2015. “Monetary Policy and Long-term Real Rates.” *Journal of Financial Economics* 115 (3): 429–448.

Hanson, Samuel G., David O. Lucca, and Jonathan H. Wright. 2021. “Rate-Amplifying Demand and the Excess Sensitivity of Long-Term Rates.” *Quarterly Journal of Economics* 136 (3): 1719–1781.

Holston, Kathryn, Thomas Laubach, and John C. Williams. 2017. “Measuring the Natural Rate of Interest: International Trends and Determinants.” *Journal of International Economics* 108 (1): S59–S75.

Ioannidou, Vasso, Steven Ongena, and José-Luis Peydró. 2015. “Monetary Policy, Risk-Taking, and Pricing: Evidence from a Quasi-Natural Experiment.” *Review of Finance* 19 (1): 95–144.

Jiménez, Gabriel, Steven Ongena, José-Luis Peydró, and Jesús Saurina. 2014. “Hazardous Times for Monetary Policy: What Do Twenty-Three Million Bank Loans Say About the Effects of Monetary Policy on Credit Risk-Taking?” *Econometrica* 82 (2): 463–505.

Jordà, Òscar, Moritz Schularick, and Alan M. Taylor. 2013. “When Credit Bites Back: Leverage, Business Cycles, and Crises.” *Journal of Money, Credit and Banking* 45 (S2): 3–28.

Kashyap, Anil, K., and Jeremy C. Stein. 2000. “What Do a Million Observations on Banks Say about the Transmission of Monetary Policy?” *American Economic Review* 90 (3): 407–428.

Kekre, Rohan, and Moritz Lenel. 2022. “Monetary Policy, Redistribution, and Risk Premia.” Becker Friedman Institute for Economics Working Paper 2020-02, May.

Kirti, Divya. 2020. “Lending Standards and Output Growth.” IMF Working Paper 18, January.

Krishnamurthy, Arvind, and Tyler Muir. 2020. “How Credit Cycles across a Financial Crisis.” Stanford Graduate School of Business Working Paper 3579, September.

Lian, Chen, Yueran Ma, and Carmen Wang. 2019. “Low Interest Rates and Risk-Taking: Evidence from Individual Investment Decisions.” *Review of Financial Studies* 32 (6): 2107–2148.

Lopez-Salido, David, Jeremy C. Stein, and Egon Zakrajšek. 2017. "Credit-Market Sentiment and the Business Cycle." *Quarterly Journal of Economics* 132 (3): 1373–1426.

Maddaloni, Angela, and José-Luis Peydró. 2011. "Bank Risk-taking, Securitization, Supervision, and Low Interest Rates: Evidence from the Euro-area and the U.S. Lending Standards." *Review of Financial Studies* 24 (6): 2121–2165.

McKay, A., and Johannes F. Wieland. 2021. "Lumpy Durable Consumption Demand and the Limited Ammunition of Monetary Policy." *Econometrica* 89 (6): 2717–2749.

Mian, Atif, Ludwig Straub, and Amir Sufi. 2021. "Indebted Demand." *Quarterly Journal of Economics* 136 (4): 2243–2307.

Mian, Atif, Amir Sufi, and Emil Verner. 2017. "Household debt and Business Cycles Worldwide." *Quarterly Journal of Economics* 132 (4): 1755–1817.

Miranda-Agrippino, Silvia, and Hélène Rey. 2020. "U.S. Monetary Policy and the Global Financial Cycle." *Review of Economic Studies* 87 (6): 2754–2776.

Palazzo, Berardino, and Ram Yamarthy. 2022. "Credit Risk and the Transmission of Interest Rate Shocks." *Journal of Monetary Economics*, forthcoming.

Paligorova, Teodora, and João A.C. Santos. 2017. "Monetary Policy and Bank Risk-taking: Evidence from the Corporate Loan Market." *Journal of Financial Intermediation* 30 (C): 35–49.

Peek, Joe, Eric S. Rosengren, and Geoffrey M. B. Tootell. 2016. "Does Fed Policy Reveal a Ternary Mandate?" Federal Reserve Bank of Boston Working Paper 16-11, September.

Rajan, Raghuram G. 2005. "Has Financial Development Made the World Riskier?" Federal Reserve Bank of Kansas City Economic Policy Symposium: 313–369.

Razzak, Ramiz Aziz. 2022. "Leaning Against Credit? Evidence that the Fed Incorporates Financial Stability Considerations into Monetary Policy." Bachelor's thesis, Harvard College.

Rey, Hélène. 2013. "Dilemma not Trilemma: The Global Financial Cycle and Monetary Policy Independence." Federal Reserve Bank of Kansas City Economic Policy Symposium: 285-333.

Schularick, Moritz, and Alan Taylor. 2012. "Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870–2008." *American Economic Review* 102 (2): 1029–1061.

Stein, Jeremy C. 2021. "Can Policy Tame the Credit Cycle?" IMF Economic Review 69 (1): 5–22.

Straub, Ludwig. 2019. "Consumption, Savings, and the Distribution of Permanent Income." Harvard Working Paper, June.

Svensson, Lars E.O. 2017. "Cost-benefit Analysis of Leaning against the Wind." *Journal of Monetary Economics* 90: 193–213.

Wong, Arlene. 2021. "Refinancing and the Transmission of Monetary Policy to Consumption." Princeton Economics Working Paper, March.

Woodford, Michael. 2003. *Interest and Prices: Foundations of a Theory of Monetary Policy*. Princeton University Press.

Table 1. Correlations between one-month changes in one-year and ten-year U.S. and advanced economy government bond yields.

The left column shows the correlation of one-month changes in one-year yields between U.S. government bonds and those from, respectively: Australia, Canada, Switzerland, Germany, Great Britain, and Japan. The right column repeats the exercise for ten-year yields. The sample period runs from January 1998 to December 2021.

Country	ΔUSD 1Y	ΔUSD 10Y
ΔAUD	0.4248	0.7256
ΔCAD	0.7129	0.8371
ΔCHF	0.4250	0.5934
ΔEUR	0.5266	0.7339
ΔGBP	0.5587	0.7682
ΔJPY	0.1776	0.3258

Appendix: proof of part (i) of Proposition 1

By rearranging equation (8) in the text, it follows that a binding ZLB at time 2 (i.e. $r_2^s < 0$) implies that

$$\varepsilon_2 < -r^*[\gamma(1+\theta)+\beta\theta] - \frac{\varepsilon_1\beta\theta}{\gamma(1+\theta)+\beta\theta} \quad \text{(A.1)}$$

Next, we show that if (A.1) is satisfied, then $r_1(ZLB) > r_1^s$. To do so, let $D = r_1(ZLB) - r_1^s$. Using equations (7) and (11) from the text, a series of straightforward calculations yields:

$$D = \frac{r^*[(\gamma(1+\theta)+\beta\theta)^2 - \beta\theta\gamma(1+\theta)] + \epsilon_1[\gamma(1+\theta)+\beta\theta] - \epsilon_2\beta\theta}{[\gamma(1+\theta)+\beta\theta]^2 + (\beta\theta)^2} - \frac{r^*(\gamma(1+\theta)+\beta\theta)+\epsilon_1}{\gamma(1+\theta)+\beta\theta}$$

$$= -\beta\theta\frac{r^*[\gamma(1+\theta)+\beta\theta]+\epsilon_2+\frac{\epsilon_1\beta\theta}{\gamma(1+\theta)+\beta\theta}}{[\gamma(1+\theta)+\beta\theta]^2+(\beta\theta)^2} \quad \text{(A.2)}$$

Therefore, since $\beta, \theta > 0$, we have that:

$$D > 0 \Leftrightarrow r^*[\gamma(1+\theta)+\beta\theta] + \epsilon_2 + \frac{\epsilon_1\beta\theta}{\gamma(1+\theta)+\beta\theta} < 0, \quad \text{(A.3)}$$

that is, we will have $D > 0$ if $\varepsilon_2 < -r^*[\gamma(1+\theta)+\beta\theta] - \frac{\varepsilon_1\beta\theta}{\gamma(1+\theta)+\beta\theta}$. This is exactly the condition in (A.1) that holds if the ZLB binds at time 2.