Treasury Buybacks, the Fed's Portfolio, and Local Supply

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October 2023

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Abstract

The U.S. Department of Treasury has announced plans to revive its buyback program after more than two decades. We estimate the effects of the 2000-2002 Treasury Buyback program on Treasury returns and the Federal Reserve's System Open Market Account (SOMA) portfolio. The reduction in supply from the buybacks had significant effects on both the bonds purchased by the buybacks and bonds with similar remaining maturity. Changes in supply contributed about 90 basis points to price returns over the course of the program – nearly 1/5 of the overall change in prices. At a higher frequency, prices of purchased bonds and their near substitutes tended to change on settlement dates, not auction dates. We find that the Fed's holdings of individual securities were largely unaffected over the course of the buyback program. This is consistent with the Fed attempting to avoid exacerbating supply shortages in Treasury markets.

*Connolly: Fannie Mae. Struby: Carleton College Department of Economics. This paper was written before Michael Connolly was working at Fannie Mae, while he was affiliated with Colgate University and Boston College. The views represented here are those of the authors alone and not of their respective employers. Thanks to Joshua Gallin, Brent Bundick, Nathan Grawe, our discussants Manuela Pedio and Vitaliy Strohush, and audiences at Carleton College, the Western Economic Association International meetings, and the Liberal Arts Macroeconomics conference for helpful suggestions and feedback. Any mistakes are our own.

1 Introduction

In its May 3, 2023 quarterly refunding statement, the United States Department of Treasury announced plans to begin a "regular buyback program" in calendar year 2024. If adopted, this program would revive a policy last conducted at scale more than two decades prior. The stated aim of reviving the program is to improve both Treasury's cash management and liquidity support (U.S. Department of Treasury (2023)). However, as the Treasury Borrowing Advisory Committee (TBAC) noted in its October 2022 meeting, a potential limitation of buybacks is their potential to impact prices, which may result in greater costs of debt issuance.[1] While some assessments of the 2000-2002 buybacks concluded they had relatively minor impacts on Treasury yields and liquidity around the time of the auctions (Han et al. (2007)), the buyback episode has also been used as evidence for the efficacy of Treasury purchases as a policy tool (Bernanke et al. (2004)).

In this paper, we revisit the 2000-2002 buyback policy, particularly in light of recent work on "local supply" channels of Treasury purchases (e.g. D'Amico and King (2012); Vayanos and Vila (2021)). Particularly, we investigate both the direct effects of buyback purchases on the prices of securities, and the spillovers of those purchases to substitute securities of similar maturity. Unlike previous research on the buyback policy, we are able to control for the Federal Reserve's presence in the Treasury market through its holdings in the System Open Market Account (SOMA) portfolio using data obtained through a Freedom of Information Act (FOIA) request. Our data allows us to also examine how the Federal Reserve reacted to changes in Treasury markets induced by buybacks. This local supply lens is important for the design of policy – understanding how large and distributed purchases should be across maturities.More broadly, this paper also contributes to the literature on the supply of safe assets and its effects on investor behavior and monetary policy.

We examine both the "stock" and "flow" effects of Treasury buybacks for the 2000-2002 period.[2] We find that the buyback program had statistically significant and economically

[1] https://home.treasury.gov/system/files/221/TBACCharge2Q32022.pdf

[2] We borrow this terminology from D'Amico and King (2012), who distinguished between examining the the cumulative effect over the course of a policy (the stock effect) versus the change calculated around a particular event associated with the policy (the flow effect).

sizable impacts. This includes both the direct effects of reduction in available supply of repurchased bonds as well as changes in the prices of bonds that had a similar maturity and were thus close substitutes (the "local supply" channel). Our point estimates imply that about 90 basis points (bp) of returns on bonds exposed to the buybacks can be attributed to changes in the supply of Treasuries. This effect is approximately 18.6% of the price change for exposed bonds during the period we examine. The estimated effects are conditional on the bond's characteristics, the characteristics of close substitutes, and on the holdings in the SOMA portfolio. We show that failing to control for the characteristics of close substitutes (e.g., spillovers from changes in local supply) understates the effects of buybacks by about 40%, and failing to control for the SOMA portfolio composition understates the effect of buybacks by about 15%. This implies that assessments of local supply channels in the Treasury market must take into account effective local supply outside of the Fed's portfolio, not simply the remaining issue of individual bonds.

In addition to examining the cross-section of returns, we conduct an event study to identify the flow effects of purchases – the size and timing of return changes around individual buyback auctions. The advantage of the event study approach is that we can incorporate fixed effects for individual securities and auctions, unlike in the cross sectional regression. Interestingly, we find that 1 day returns on securities eligible for repurchase are not impacted until settlement. Our interpretation is that this is consistent with hedging strategies by primary dealers insuring themselves against the "winner's curse" effects of their buyback auction sales.

We then ask whether the Fed's management of its balance sheet was impacted by these purchases. Although the Fed did not participate in the buyback auctions, we may have expected it to adjust its holdings either to help reduce price or liquidity impacts, or to avoid holding "too large" a fraction of the remaining bonds. As we discuss in the next section, evidence from FOMC meeting transcripts suggests that these issues were front-of-mind for the SOMA managers. Despite this, we find no evidence to reject the null of zero direct effect of Treasury buybacks on the holdings of individual securities in the SOMA portfolio over the course of the program, We do find precisely estimated, but quite small, negative effects from the purchase of close substitutes: purchases of 1% of an outstanding substitute security are associated with the Fed reducing its holdings by 0.45% of the amount outstanding (relative to the counterfactual where no purchases occurred). Since the average cumulative near purchase for any given security was about 4.5% of the outstanding amount, this amounts to a relatively small overall impact on the Fed's portfolio holdings due to buyback-induced changes in supply.

At a higher frequency, evidence is more mixed, but the balance points to the Fed generally not increasing holdings in weeks following buyback auctions for "treated" securities. In our preferred specification, we find zero evidence that the Fed's probability of purchasing a security was impacted by whether the security had been bought back recently. Some alternative specifications suggest the Fed was less likely to purchase a security that was included in a buyback in the week of that buyback. These results are broadly consistent with the Fed attempting to avoid impacting markets by further limiting the tradeable supply of Treasury bonds during the buyback period.

Although Treasury's outlined plans for new buybacks are still developing, we use our estimated stock effects results to examine the possible impact of buyback programs on Treasury yields. Based on the estimates from the previous buyback program, any given quarter's worth of buybacks will have limited effects on yields (on the order of a third of a basis point), although the effects are larger for bonds closest to maturity. The difference between the new program and the old is mainly driven by differences in scale, and because our baseline scenario assumes that a relatively small level of purchases will be spread out over a large set of Treasury bonds of different tenors which limits spillovers. If buybacks were more concentrated in a particular maturity bucket, the results could differ, although buying back long-time-to-maturity bonds is predicted to have very limited impacts on yields overall. Overall, our analysis suggests that the proposed buyback revival will have limited impact on Treasury yields.

The next section reviews some of the institutional details of the buyback episode, particularly how it featured in contemporary discussions in FOMC meetings and in the media. Following that, we examine the impacts of the buybacks on returns, and then the SOMA portfolio holdings. We then quantify possible price impacts of the Treasury's proposed buyback program revival before concluding.

2 Institutional Background

2.1 The 2000-2002 Treasury Buyback program

On August 4, 1999, U.S. Treasury officials announced a draft set of regulations allowing the Treasury to conduct reverse auctions (buybacks) of Treasury debt.[3] This development followed years of declining Treasury issuance which created concerns about the available supply of securities and increasing average duration of Treasury debt (Garbade and Rutherford (2007)). The rules were finalized in early 2000, and the first buyback auction took place on March 9, 2000. Ultimately, 45 buyback auctions took place from 2000-2002.[4] Treasury bought back $67.5 billion of 42 different securities, including 9 callable securities and two Treasury Inflation Protected Securities (TIPS).

The typical auction was announced 1-2 days in advance, and auctions usually occurred about twice a month, one week apart. Usually, 10-12 securities were eligible for repurchase, and an average of $1.5 billion in securities were bought back per auction. For context, primary dealers reported an average of $4.1 billion in transactions of coupon securities with maturity greater than 5 years per week in 1999, so a given auction represented a significant volume of Treasury purchases relative to the usual flow at the time. On average, 3 securities included in the auction would receive offers but not be bought back.

Discussions raising the possibility of a buyback program of some type had been raised at quarterly meetings of the TBAC starting in February 1998. TBAC urged the Treasury to develop rules for buybacks in May 1999, although Treasury did not commit to doing so, apparently cautious of how buybacks would affect budget negotiations with Congress (Pulizzi (1999)). Initial rules were released for comment in August, and final rules (largely unchanged) were published January 13, 2000. Alongside the announcement of the final rule, then-Treasury Secretary Lawrence Summers announced that up to $30 billion in debt would be bought back that year (U.S. Department of Treasury (2000)).

[3] A timeline of key dates in the policy is found in appendix A. More extensive reviews of the buyback program are found in Garbade and Rutherford (2007) and Merrick (2005).

[4] Qualitatively speaking, the last three auctions were presented as a way of managing stronger-than-expected tax receipts. After the invasion of Afghanistan in 2001, Treasury had paused on conducting buybacks in the first quarter of 2002 and said it would announce any future buybacks at subsequent quarterly refunding announcements (U.S. Department of Treasury (2001).

Despite the fact that the adoption of buybacks had been anticipated by markets, their size and composition was not known in advance. For example, the initially announced total was larger than anticipated by market participants (Dreazen and Zuckerman (2000)). Which securities, and even which types of securities, would be eligible was not obvious when the buyback program was initially discussed. Contemporary media accounts suggested that it would mainly be securities with single-digit coupon rates and bonds with 15-25 years left to maturity (Hershey (1999)). Ex-post, bonds with as few as 25 (and as much as 27) years left to maturity, and coupons as high as 14% were purchased at auction. Furthermore, between Secretary Summers's announcement and the actual commencement of auctions, there was still considerable uncertainty about what the buyback program would actually look like.[5]

The Department of the Treasury announced which CUSIPs it would potentially purchase at the time of the auction announcement, and the total amount it would purchase, but not amount per security. This gave the Treasury some flexibility about which bids to accept. On auction days, bids were accepted until 11 AM and then results were announced two hours later (Han et al. (2007)). The auctions were oversubscribed, but not every security that was eligible for buyback or received bids at a given reverse auction was actually purchased. The Federal Reserve did not participate in buyback auctions, unlike standard debt issuance auctions.

The exact strategy of which offers to accept was not announced, and the individual offers are not publicly available. However, Han et al. (2007) document that a greater quantity of offers were accepted by Treasury when the coupon rate of the debt higher and when remaining maturity was greater, among other features. They suggest that the Treasury was accepting offers partially to reduce their interest expense rather than lowering the net present value of debt.

In summary, Treasury progressively revealed its intention to introduce a buyback program of some type. However, the details of its size and pace were not known even after the terms of the buyback process were finalized. For a given auction, whether a particular CUSIP would be purchased (much less the quantity or price) was not known until the results were

[5]For example, the Wall Street Journal reported on February 28, 2000 "Last week, demand shifted, as traders and investors decided that the Treasury buyback may not be as big as expected. Investors began selling 30-year bonds while buying shorter maturities." (Parry (2000))

announced.

Treasury buybacks and the SOMA portfolio The buyback auctions, and the broader issue of declining Treasury issuance, lead to some difficulty for the management of the Federal Reserve's System Open Market Account (SOMA) portfolio. The inversion of the yield curve in early 2000 was attributed, at the time, to the perceived shortage in long-term Treasury debt and lead to speculation that the Fed might have to tighten further to slow down the economy.[6] The Treasury's official releases in August 1999 and January 2000 announcing terms of the buybacks are mentioned in the FOMC transcripts. By March, SOMA manager Peter Fisher suggested that the FOMC "continue to roll over existing holdings at auction but monitor the impact of the Treasury's buyback program and the changes in note and bond sizes on our percentage holdings of individual coupon issues. [...] I don't think that is an immediate concern, but it is something that we need to keep an eye on."[7] In May, Fisher noted the ongoing difficulty in managing the SOMA portfolio, in part due to buybacks:

> [...] with over $3 trillion in marketable Treasury debt outstanding it seems clear that we ought to be able to find sufficient assets to grow the SOMA balance sheet from the existing stock. However, the amount of marketable Treasury securities outstanding with remaining maturities of more than 10 years, exclusive of SOMA holdings, totals only $433 billion. And that amount will decline as a consequence of both Treasury buybacks and System purchases. [...] investors perceive few acceptable long-term substitutes for Treasury securities. Thus the stock of such Treasury issues is not large relative to apparent demand and that stock is expected to decline. (Peter Fisher, May 16, 2000 FOMC meeting)

Fisher also noted at that meeting that "most knowledgeable observers" in bond markets

[6]The New York Times reported in early February 2000 that

> "[...]the Fed has tried to slow things a bit by raising short-term interest rates three times and signaling that further increases were likely. Even as they have done so, yields on long-term bonds have fallen [...] Behind this oddity is the Treasury's aggressive plan to reduce the nation's debt. [...] the perception that there is going to be a shortage of long-term United States Treasuries has brought these investors into the market with a vengeance, causing yields on long-term bonds to plunge. What worries some bond market participants is that this plunge in yields will blunt the impact that the Fed's interest rate increases will have on the economy." (Morgenson (2000))

[7]March 21, 2000 FOMC meeting transcript.

anticipated further purchases in 2001.

The FOMC transcripts also suggest that the Fed was primarily reacting to changes in Treasury supply in an attempt to not disrupt markets:

> "[...] at present we're dancing as fast as we can to try to redistribute our holdings more smoothly across the entire yield curve to prevent our pace of accumulation of Treasuries from disrupting the markets.[...] Yes, buying more Treasuries solves our asset accumulation problem for now, but the very act of doing so diminishes the liquidity of the market on which we rely. **In effect, recently we have been setting the pace of outright purchases of Treasuries at a rate that we think will not disrupt the market. We adjust it gradually in an effort to keep out of the way of the Treasury's buyback operation–it's sort of an intramural courtesy–and we alter the size of our 28-day repo book to meet our reserve needs.**" (Peter Fisher, January 30 2001 FOMC meeting, emphasis added)

In short, contemporary media coverage and FOMC transcripts suggest that the Federal Reserve was essentially reacting to Treasury's debt issuance and buyback policy, insofar as its management of the SOMA portfolio was concerned, and that they were trying to avoid moves that would potentially "disrupt" the market for Treasuries.

2.2 Related literature on Treasury buybacks

Our paper contributes to a literature that has explored the price impacts of the 2000-2002 Treasury buyback auctions. Using an event-study approach, Bernanke et al. (2004) discuss the buybacks as evidence that purchasing quantities of Treasuries affects their prices. Longstaff (2004) finds that the liquidity premium is positively related to the amount of Treasury buybacks. Merrick (2005) argues that the cost of buybacks to the Treasury was generally low, but they still bought back some moderately rich securities. He finds that the buybacks did not affect secondary market liquidity for coupon-bearing securities, but did have spillovers to STRIPS securities. Han et al. (2007) conclude that the Treasury was motivated to buy back high-coupon, long-maturity bonds in order to reduce interest expense. These purchases resulted in a fairly small market impairment cost and minimal disruption to Treasury market liquidity. Relative to these papers, we go beyond quantifying the direct impact of buybacks on particular Treasury securities by demonstrating local-supply effects. Furthermore, we consider cumulative effects of purchases over time as well as in the window surrounding auctions. Importantly, we show that relative changes in Treasury supply feed back into prices of *ineligible* near-neighbor securities. Furthermore, we also illuminate an additional feedback effect of reductions in local Treasury supply on the Fed's management of its SOMA portfolio. Our study of the effects of supply changes in Treasury markets is also related to the more recent literature documenting direct impacts of Fed purchases of Treasury securities (D'Amico and King (2013), Huther et al. (2017), Song and Zhu (2018)); we discuss similarities and differences relative to the Fed's policies in section 3.

2.3 Data

SOMA holdings Using data obtained via Freedom of Information Act (FOIA) request, we construct a weekly panel of Treasury securities held inside by the public and by the Federal Reserve from September 1997-2003 at the individual CUSIP level.[8] This data set considerably extends the available sample of security-level data at the weekly level. The use of this data allows us to understand the publicly available supply of Treasuries during the Treasury buyback program we examine. To our knowledge, this data was not publicly available at a weekly frequency for the pre-2003 period prior to the FOIA request, and it may be of some independent interest.

The Federal Reserve's SOMA portfolio has internal limits on the fraction of any given issue it holds. These limits have changed over time. We construct the share held by SOMA and within particular maturity buckets and plot them for the buyback period, alongside the SOMA limit, in figure 1. Prior to July 2000, there was an informal limit of 35% of the total issue of any particular non-TIPS security in the SOMA portfolio. On July 5, 2000, a graduated limit on the percentage held at different maturities was announced, with the SOMA portfolio holding up to 35% of bills and securities with maturity of 1 year or less, 35-declining to 25% between 1-2 years, 25-20% for 2-5, 20-15% for 5-10 year securities and

[8] Securities are identified by codes assigned by the Committee on Uniform Security Identification Procedures (CUSIP)). We thank the FOMC FOIA office for handling the request. According to their response, weekly data prior to mid-1997 is not available at the CUSIP level.

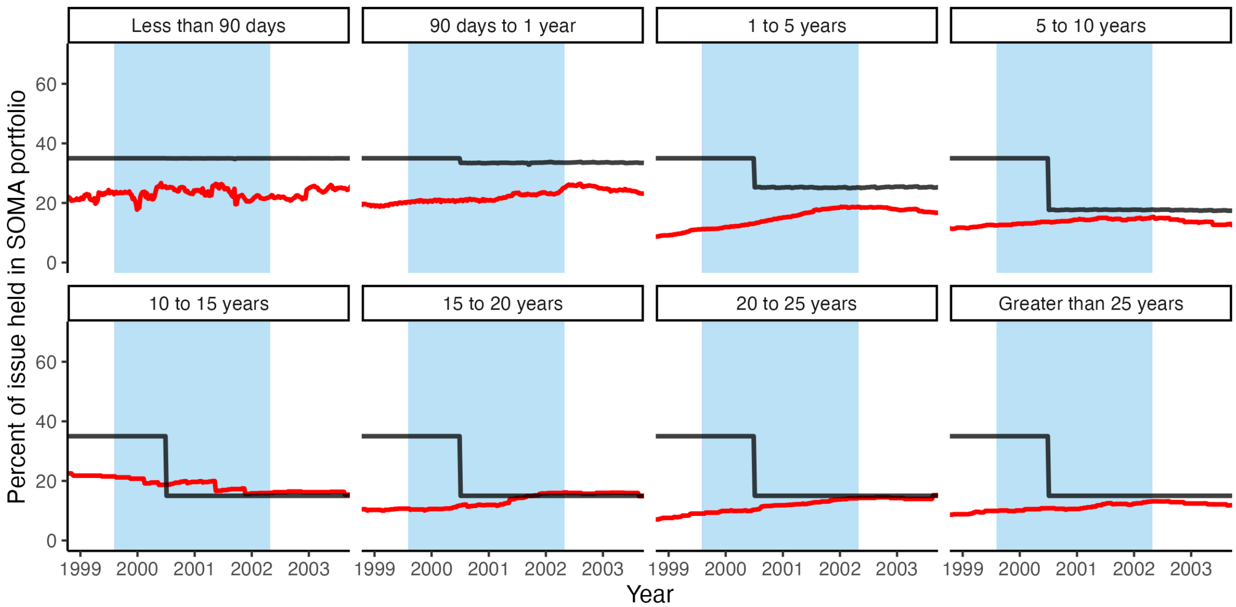

Figure 1: Plot of weighted average share of nominal Treasury securities held in SOMA portfolio, by maturity bucket. Red bars indicate weighted average, where weights are calculated by the share of that security relative to total debt outstanding. Black lines indicate self-imposed limits on quantity of holdings. Shaded area indicates the dates between the announcement of the buyback program (August 1999) and the settlement of the final buyback auction (April 2002)). Units are percentage points.

15% for 30 year securities.[9] In our reconstruction of limits for individual securities shown in figure 1, we assume that the change in the limits are linear within these maturity buckets, which appears to be consistent with the briefing materials presented to the FOMC by the SOMA manager at the May 16, 2000 FOMC meeting,[10] and with the amended limits after the introduction of 3-year notes.[11] Notably, these ceilings were apparently "soft" and sometimes adjusted following their occasional violation as Treasury market conditions warranted.

Other data We use data on prices and bond characteristics from the Center for Research in Security Prices (CRSP) US Treasury Database. The CRSP daily supply measure is that month's observation from the Monthly Statement on the Public Debt; we convert this to daily by adding in new issuance from Treasury auctions, and decreases from buybacks and redemptions (the latter taken from the Monthly Statement of the Public Debt).

[9] https://www.newyorkfed.org/newsevents/news/markets/2000/an000705.html
[10] https://www.federalreserve.gov/monetarypolicy/files/FOMC20000516material.pdf
[11] https://www.newyorkfed.org/newsevents/news/markets/2003/an030501.html

3 Buyback effects on the price of Treasuries

In this section, we investigate the effects of buybacks on the prices of Treasury bonds. We focus on two types of effects – the "stock" effect, looking at the complete cross-section of returns over the course of the buyback program, and the "flow" effects of purchases at particular auctions. We adopt this terminology, and methodology, from D'Amico and King (2012), who studied the effects of the first round of Large Scale Asset Purchases (LSAPs). We argue their methodology is appropriate for a number of reasons. Like the LSAPs, the buybacks represented a sizable shift in the supply of Treasuries outstanding. While the absolute scale in dollar terms of LSAP purchases was about four and a half times larger than the Treasury buyback program ($300 billion versus $67.5 billion), they were more similar as a percentage of outstanding debt. (2.7% for LSAPs versus 1.2% for the buybacks). Second, like LSAPs, the buybacks represented a change in *local* supply, because they were concentrated among a particular set of long-maturity-at-issue securities with varying times left to maturity. Hence, like D'Amico and King (2012) we can examine how otherwise similar securities were impacted. Finally, like the LSAP purchases, there was uncertainty about which Treasuries would be purchased (or be eligible for purchase) which gives us cross-sectional and time-series variation to exploit when estimating these effects.

At the same time, we do not necessarily expect that the effects of buybacks will be identical to the LSAPs. First, the fiscal environment of the (majority) of the buybacks was during a period of declining deficits and smaller Treasury issuance. Moreover, short term rates were far from the effective lower bound during the buyback period, which meant that the nature of interest rate risk might also have been different at the time. In a no-arbitrage model with local demand risks, Vayanos and Vila (2021) note that the transmission of local demand shocks is more localized when there is short rate risk as well as interest rate risk. With short rates constrained on the downside during the ZLB period, we might anticipate that the preferred habitats-driven effects of LSAPs would be different than buybacks. Hence, our estimates may give a better sense of the transmission of local supply shocks away from the ZLB. Finally, the Treasury may have been trying to avoid price impact during the buyback period and was not attempting to influence market participants' beliefs about the macroeconomy. On the other hand, the Federal Reserve's LSAP program was intended to have significant price impacts, and its communications may have contained information about its forecasts or future policy actions. Hence, it makes sense to examine how they buybacks actually impacted prices directly, rather than trying to extrapolate the experience from the LSAPs to future buybacks.

3.1 Stock effects

3.1.1 Methodology

We begin our analysis of the Treasury's buybacks by investigating stock effects on prices: whether changes in local supply of a given security affected cumulative price returns over the length of the buyback program. Our main hypothesis is that a decrease in the local supply of a given Treasury security increased its price and subsequent return. The starting point for this analysis is August 3, 1999, which is the day before the U.S. Treasury announced its plans to conduct buybacks. We view this initial date as conservative, as the plans were only finalized in early 2000 and media accounts suggested there was still uncertainty about what would be bought back even after the final rule was announced.[12] An earlier start date seems appropriate to capture any anticipation effects – to the extent that the effects of buybacks were potentially "priced in" by the time the purchases actually occurred, a somewhat earlier start date than the actual start of the auctions is needed to capture the full effect on prices. Since Treasury officials were clear about the program winding down in in late 2001, it is likely the case that the anticipation (or changes in beliefs about the scope or size of the program) was essentially resolved by our end date.

Let n denote a particular Treasury security, t is August 4, 1999, and $t+h$ is April 30, 2002. $R_{n,t,t+h}$ is the cumulative percent return of Treasury security n from just before the buyback announcement to the last settlement date of the program. We estimate the following

[12] The fact that Treasury would buy back up to $30 billion was announced in January 2000. On February 28 of that year, the Wall Street Journal reported that market participants were still not sure what was going to happen and some had pared back their expectations of the scale of the program: "Some people have been wagering on what the buyback might mean for the market, whereas many others have cautiously retreated to the sidelines. [...]Last week, demand shifted, as traders and investors decided that the Treasury buyback may not be as big as expected. Investors began selling 30-year bonds while buying shorter maturities" (Parry (2000)).

Ordinary Least Squares (OLS) regression:

$$R_{n,t,t+h} = \alpha^{OLS} + \beta_0^{OLS} q_{n,0,t,t+h} + \beta_1^{OLS} q_{n,1,t,t+h} + \delta_0^{OLS} X_{n,0,t} + \epsilon_{n,t,t+h}^{OLS} \quad (1)$$

$q_{n,0,t,t+h}$ (Own Purchases) equals the amount of security n purchased between dates t and $t+h$ as a fraction of the total amount of all Treasury securities outstanding that are maturing within 3 years of security n (in absolute value). $q_{n,1,t,t+h}$ (Near Purchases) equals the fraction of all securities bought back that mature within 3 years of security n (excluding n itself) repurchased between dates t and $t+h$ divided by the total amount of all Treasury securities outstanding that are maturing within 3 years of security n (in absolute value).

We include a set of security-level characteristics ($X_{n,0,t}$) as control variables measured on August 3, 1999, the date before the Treasury buyback announcement. Motivated by Han et al. (2007) and Garbade and Rutherford (2007) we include the remaining maturity (and its square) and the coupon rate. The stated purpose of the program was to decrease the average maturity and interest costs of Treasury debt (U.S. Department of Treasury (2000)).[13] Furthermore, the security's remaining maturity (and its square) control for duration and convexity effects that might differentially affect bonds over our sample period. We also control for the share outstanding of each security in the SOMA portfolio and the pricing error relative to the Svensson-implied price of the bond as proxies for liquidity.[14] Lastly, similar to D'Amico and King (2012) we include the natural logarithm of price to adjust for differential expectations of returns being captured by initial prices.

In all regressions, bond characteristics of security n are scaled by the par value outstanding in the "local supply" bucket around security n (the par value of all securities maturing within 3 years of the security in our baseline specification). We also include the weighted average characteristics of near neighbors that are particularly salient for returns, $X_{n,1,t}$: averages of the Svensson pricing errors and SOMA share for all securities maturing within 3 years of security n. Weights in these weighted average terms are the share of the par value

[13] Han et al. (2007) show that the Treasury was motivated to lower its interest cost by repurchasing relatively illiquid, off-the-run securities.

[14] The Svensson pricing error is calculated using the smooth discount function estimates from Gürkaynak et al. (2007). Pricing errors of this type have been used as a proxy for liquidity by Hu et al. (2013) and Duffie and Keane (2023).

Table 1: Summary statistics for stock regressions

Variable	Range	Mean	Median	SD	IQR
100 × Cumulative return	[-9.84, 9.59]	3.19	5.07	4.59	[-0.09, 6.79]
100 × Cumulative own purchases	[0, 2.6]	0.38	0.00	0.61	[0, 0.67]
100 × Cumulative near purchases	[0, 17.05]	4.82	0.68	5.94	[0, 11.78]
100 × scaled Maturity remaining (own)	[0.01, 4.28]	0.76	0.26	0.94	[0.06, 1.22]
100 × scaled Maturity remaining (average near)	[0, 4.14]	0.75	0.24	0.93	[0.04, 1.2]
Log price (own)	[0.01, 0.74]	0.20	0.16	0.18	[0.05, 0.32]
Log price (average near)	[0.01, 0.62]	0.19	0.15	0.16	[0.05, 0.3]
100 × Coupon rate (own)	[0.01, 0.81]	0.17	0.12	0.15	[0.04, 0.25]
100 × Coupon rate (average near)	[0, 0.65]	0.15	0.12	0.14	[0.03, 0.21]
100 × Pricing error (own)	[-0.04, 0]	0.00	0.00	0.01	[0, 0]
100 × Pricing error (average near)	[-0.02, 0]	0.00	0.00	0.00	[0, 0]
100 × SOMA share (own)	[0, 0.03]	0.01	0.00	0.00	[0, 0.01]
100 × SOMA share (average near)	[0, 0.03]	0.01	0.00	0.01	[0, 0.01]
Maturity at issue (percent of total):	5 years	17.6%	-	-	-
	10 years	22.5%			
	20 years	10.8%			
	30 years	49.0%			

Note:

For ease of interpretation, returns, own purchases, scaled maturity remaining coupon rates, pricing errors, and SOMA shares are all multiplied by 100 to report them in percentage points. All variables other than returns are divided by the total quantity of securities in the three-year maturity bucket around each security. Maturity, log price, pricing error, SOMA shares are all as of August 3, 1999. (average near) indicates a variable is the weighted average of securities within the three-year maturity bucket of that security, excluding the security itself.

outstanding within the bucket. These variables capture the relative cheapness (or richness) of different regions of the yield curve and differences in the shares of privately held securities. Together, both sets of characteristics are meant to capture idiosyncratic and relatively systematic changes in supply and demand. Summary statistics of the data used in the stock regressions are shown in table 1.

Our main objective is to quantify the overall impact of buybacks on Treasury returns, while allowing for substitution effects motivated by preferred habitats. We focus on the set of securities with original maturity over 5 years that do not mature during prior to April 30, 2002. Analysis of stock effects is impacted by a simultaneity problem. Returns are a function of the price of the underlying security. If (own and near) buybacks were a truly exogenous shift in available supply, then the regression coefficient of returns on buybacks could be interpreted as the estimated price elasticity of demand. However, we may be concerned that the quantity of buybacks was driven, in part, by prices; for example, the Treasury may have chosen to repurchase relatively cheap securities. A similar issue affects the stock effect regressions in D'Amico and King (2012) and we adopt a similar instrumental variables strategy.

To partially address concerns of simultaneity, we adopt $X_{n,0,t}$ and $X_{n,1,t}$ as a set of internal instruments reflecting the conditions in the market for a particular security the day prior to the August 4, 1999 announcement. We also incorporate a set of external instruments as well: an indicator variable for whether a security's maturity at issue was originally 30 years or not, and the average maturity (and its square), log bond price, and coupon rate for near securities n.[15]

Table 2 presents results of regressing Own and Near purchases on the set of included and external instruments. We argue that these factors are also correctly excluded from the returns stock regression, conditional on the set of included instruments. They capture information about the outstanding supply of the existing security and its close substitutes, as well as equilibrium prices of those substitutes. To the extent that this information is otherwise relevant for returns, it should be reflected in pricing prior to the buyback announcement. They are, however, relevant to the Treasury's decision about what to subsequently buy back. Characteristics of close substitutes may have informed the Treasury's strategy in any given auction. The indicator variables for the original issue should not affect the returns conditional on remaining maturity and coupon rates, but may have impacted the choice of securities to include in the auction by Treasury for other reasons (since longer term securities were further off the run).

We estimate the following Instrumental Variables (IV) regression:

$$R_{n,t,t+h} = \alpha^{IV} + \beta_0^{IV} \hat{q}_{n,0,t,t+h} + \beta_1^{IV} \hat{q}_{n,1,t,t+h} + \delta_0^{IV} X_{n,0,t} + \delta_1^{IV} X_{n,1,t} + \epsilon_{n,t,t+h}^{IV}. \quad (2)$$

The main coefficients of interest from this analysis are β_0^{OLS}, β_1^{OLS}, β_0^{IV}, and β_1^{IV}. Under a local-supply explanation of the buybacks, we would expect these coefficients to be positive.

[15]All instruments are scaled by the amount outstanding of security n divided by the total amount outstanding for all near neighbors (within 3 years). This ensures that the second-stage estimates for Treasury purchases are consistently scaled.

Table 2: First stage: Regression of Own and Near Purchases on prebuyback characteristcs

	Own Purchases	Near Purchases
Average maturity (Near)	0.178**	1.141***
	(0.072)	(0.322)
Average maturity sq. (Near)	−0.003*	−0.029***
	(0.002)	(0.008)
Average log price (Near)	−0.145	0.485
	(0.129)	(1.063)
Average coupon (Near)	−0.162	−0.338
	(0.128)	(0.478)
30 year issue	−0.002	0.025*
	(0.001)	(0.013)
Average SOMA share (Near)	−1.074	−11.983***
	(0.978)	(3.862)
Remaining maturity	−0.123**	−0.678**
	(0.056)	(0.287)
Remaining maturity sq.	0.002	0.015**
	(0.001)	(0.006)
SOMA share	0.366	−0.903
	(0.239)	(1.454)
log(Price)	0.211	−0.217
	(0.135)	(1.008)
Coupon rate	0.032	−0.131
	(0.030)	(0.192)
Svennson pricing error	0.123	−0.337
	(0.190)	(1.201)
Average pricing error (Near)	−1.057	−8.661
	(1.554)	(5.510)
Num.Obs.	102	102
R2 Adj.	0.725	0.923
F	37.809	184.333

Note:

This table reports the first stage of the IV regressions (regressing own and near purchases on the set of excluded instruments). Near substitutes are defined as all non-TIPS Treasury securities maturing within 3 years of the security n. Own Purchases equals the amount of security n purchased between dates t and $t+h$ as a fraction of the total amount of all Treasury securities outstanding within three years of security n. Near Purchases equals the fraction of all buybacks of near substitutes of n (excluding n itself) repurchased between dates t and $t+h$ divided by the total amount of all Treasury securities maturing within 3 years of n. In all regressions, all security-level variables are weighted by the amount outstanding of security n divided by total amount of all Treasury securities outstanding maturing within 3 years of that security. Heteroskedasticity-robust standard errors reported below coefficient estimates. ***, **, and * denote significance at the 1, 5, and 10 percent levels.

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

3.1.2 Results

Table 3 presents coefficient estimates from the stock effects regressions on price returns. We find positive and significant coefficients of both Own and Near Purchases. Column 1 reports OLS estimates from equation 1. To interpret the coefficient estimates, repurchasing 1% of the outstanding supply of a security (its near substitute) resulted in a 2.48% (0.59%) relative increase in the price over the period of August 1999-April 2002. These price changes are consistent with yield changes of -25.20 and -6.08 bp for Own and Near purchases, respectively, given an average duration of 9.85 years for eventually repurchased securities. While these magnitudes are larger than findings in D'Amico and King (2012), we note that the on-the-run 30-year Treasury security yielded approximately 6% in August 1999 versus 3.5% in March 2009. Nevertheless, scaling for the overall levels of yields, we find individual security effects that are larger than the first round of LSAP purchases. Column 2 reports second-stage results from the IV regressions of equation 2. Consistent with the OLS estimates, we find that changes in buybacks positively affected security-level cumulative returns. The estimated magnitudes of the effects are somewhat larger for the IV regressions than for OLS. This difference could be consistent with simultaneity bias; if Treasury concentrated its purchases among securities with low returns, than the reduced form regression of returns on buybacks would be downwardly biased. However, the results are quite similar across both methods. Overall, the results from this section suggest that the local supply channel of buybacks had a quantitatively significant effect on returns during this period.

3.1.3 Counterfactual returns and the contribution of local supply

Using the estimated coefficients from the IV regression, we are able to net out the impacts of supply changes across the yield curve. This is the difference between actual yields at the conclusion of the program versus the yields implied by the counterfactual price returns net of purchases ($R_{n,t,t+h} - \widehat{\beta_0^{IV}} \hat{q}_{n,0,t,t+h} - \widehat{\beta_1^{IV}} \hat{q}_{n,1,t,t+h}$). The implied difference in yields is displayed in figure 2. The contribution of supply effects is concentrated in securities with 10-20 years left to maturity, but spill over to securities with less than 10 years and as much as 30 years remaining.

On average of all off the run Treasuries, our IV estimates imply the changes in supply

Table 3: Stock Effects of Treasury Buybacks

Dependent variable:	Price return	
	OLS	IV
Own purchases	2.482***	3.006**
	(0.495)	(1.390)
Near purchases	0.599***	0.692***
	(0.082)	(0.157)
Remaining maturity	−0.620***	−0.686***
	(0.100)	(0.125)
Remaining maturity sq.	0.015***	0.016***
	(0.003)	(0.003)
SOMA share	−3.332***	−3.573**
	(1.231)	(1.376)
log(Price)	2.261***	2.424***
	(0.235)	(0.250)
Coupon rate	−0.784***	−0.852***
	(0.138)	(0.185)
Svennson pricing error	−1.234	−1.452
	(0.990)	(1.137)
Average pricing error (Near)	−4.373***	−4.715***
	(1.591)	(1.764)
Average SOMA share (Near)	−15.192***	−15.498***
	(3.423)	(3.764)
Num.Obs.	102	102
R2 Adj.	0.704	0.698
F	54.754	
First stage Wald statistic:		30.972
Wu-Hausman test p-value:		0.286

Note:

This table reports results of "stock effect regressions". The dependent variable is measured as the price return for a particular security n between t and $t+h$ where t is August 3, 1999, and $t+h$ is April 30, 2002. Own Purchases equals the amount of security n purchased between dates t and $t+h$ as a fraction of the total amount of all Treasury securities outstanding within three years of security n. Near Purchases equals the fraction of all buybacks of near substitutes of n (excluding n itself) repurchased between dates t and $t+h$ divided by the total amount of all Treasury securities maturing within 3 years of n. In all regressions, all security-level variables are weighted by the amount outstanding of security n divided by total amount of all Treasury securities outstanding maturing within 3 years of that security. Column 2 reports estimates using two stage least squares, instrumenting for Own and Near Purchases. Excluded instruments from the first-stage regressions include: an indicator variable for whether the original maturity of security n 30 years and averages of remaining maturity, remaining maturity squared, log(bond price), current yield, and coupon rate for all securities that are near substitutes of security n. Heteroskedasticity-robust standard errors reported below coefficient estimates. ***, **, and * denote significance at the 1, 5, and 10 percent levels. Near substitutes are defined as all non-TIPS Treasury securities maturing within 3 years of the security n.

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

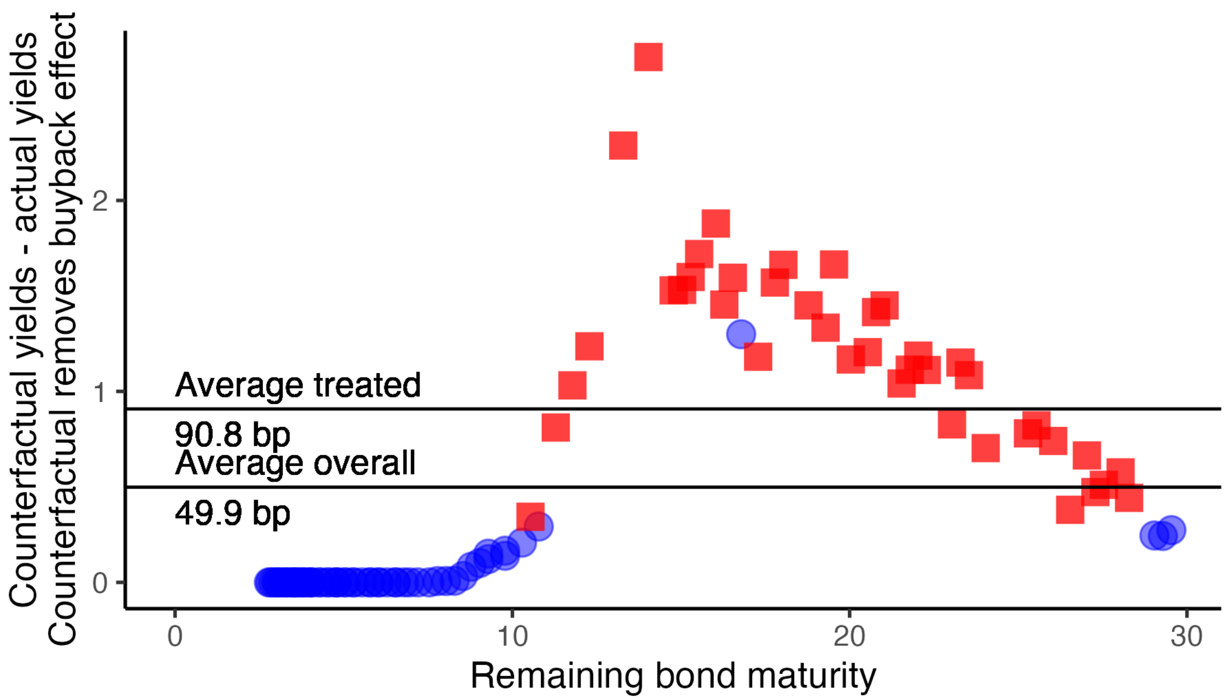

Figure 2: Difference in yields attributable to direct and local changes in supply. Counterfactual price changes are actual price returns minus counterfactual returns predicted by equation (2): $R_{n,t,t+h} - \widehat{\beta_0^{IV}} \hat{q}_{n,0,t,t+h} - \widehat{\beta_1^{IV}} \hat{q}_{n,1,t,t+h}$. Counterfactual prices are subsequently converted to yields Red squares indicate securities that were directly bought back.

from the buyback program elevated returns. Among "treated" securities (those bought back or their near neighbors), the mean contribution of supply changes was about 91 basis points. Since the overall price return for treated securities was about 4.88%, this implies that about 18.6% of the change in returns on treated securities is explained by supply changes during this time period.

In appendix B, we quantify the effects of two possible omitted variables: ignoring local supply effects (i.e., not controlling for spillovers) and omitted SOMA holdings. We show that both of these introduce quantitatively meaningful omitted variable bias. Ignoring local supply neglects one channel by which buybacks affected prices and the estimated price impact of the program. More subtly, including local supply but ignoring SOMA holdings biases the estimated direct effects upward and leads to a downward bias of estimated spillover effects. The overall effect of the bias is smaller estimated effects of the buyback program on returns. Hence, the evidence in the appendix demonstrates the importance of accounting for local supply channels *and* SOMA holdings when predicting the effects of buybacks. Previous studies of the buybacks which ignored these effects may have under-estimated their price impact as a result of these omissions.

Appendix C.1 investigates the robustness of these results to a number of reasonable permutations of our strategy, particularly (1) defining near-substitutes as being within two years or four years (2) Excluding the 2002 rounds of buybacks and (3) using a less conservative start date (January 2000, when the actual buyback programs were announced). Qualitatively, the signs and significance of most coefficients are similar across these changes. When we change the definition of near substitute, own purchases occasionally drops in significance in the IV regressions, but near purchases are always significant and the magnitudes of effects are also similar. Own-security SOMA share's significance is also somewhat sensitive to choices in sample construction, but has a consistent sign; near-substitute SOMA share is always significant. Overall, the robustness exercises broadly support that (1) buybacks had direct and indirect effects that were both significant and consistent with a local supply channel and (2) the effects of purchases were likely impacted by the relative holdings in the SOMA portfolio of own and near substitutes.

Finally, appendix D contains plots that compare the low-frequency change in holdings of

Treasuries as assets by sector of the economy in the quarter the buybacks were announced, the quarter they were terminated, and the most recent data available. We use this data to examine whether the nature of "final demand" for Treasuries as assets dramatically changed over the course of the buyback period, a casual version of the exercise in Carpenter et al. (2015). In terms of percentage outstanding, the largest shifts between the start and end of the buyback program appear to be a decrease in the household sector (which includes hedge funds) and banks and banklike institutions, offset by relatively larger quantities held by the Federal Reserve, other private financial firms, and federal and state pension funds. This could be consistent with the buybacks ultimately purchasing from households and hedge funds (via primary dealers) and the Fed also increasing its relative holdings (both because they did not adjust holdings overall and because of a change in the stance of monetary policy from tightening to easing). Although this exercise is informal, we do not think that large shifts in the nature of demand for Treasuries dramatically impact our results over this period.

3.2 Flow effects

3.2.1 Methodology

In this section, we examine the "flow effects" of buyback purchases. That is, to what extent did the shift in supply caused by buybacks lead to immediate changes in returns? And to what extent are those changes in returns attributable to changes in the duration of Treasury debt versus changes in local supply along the lines of Vayanos and Vila (2021)?

We examine this question in the context of a panel event study. Here, we are able to take advantage of a number of features of the buyback auctions. First, the exact securities included in auctions were only disclosed a day or two in advance of the actual auction. Second, auction participants did not know whether Treasury would, in fact, accept bids on any particular security; on average, three of the securities included in any given auction would receive bids, but not be bought back. Moreover, Treasury did not seem to pursue an obvious rule (such as accepting a constant fraction of bids) which would have allowed auction participants to easily anticipate what *quantity* of a security would be bought back at a given auction (Han et al. (2007)). These features support the argument that the buybacks represented exogenous shifts in the supply of individual securities in the window we examine. Furthermore, because bonds were included in auctions more than once, we are able to include CUSIP fixed effects, reducing concerns about omitted variables. The limitation relative to the stock effects approach is that the window may be too small to capture the full effects of purchases.

We first focus our analysis on the set of securities that were eligible for repurchase. We estimate the following regression using this set of securities:

$$R_{n,t} = \alpha_t + \alpha_n + \beta_0 q_{n,0,t} + \beta_1 q_{n,1,t} + \epsilon_{n,t} \tag{3}$$

In this equation, $q_{n,0,t}$ (Own Purchases) equals the amount of security n purchased on auction date t as a fraction of the total amount of all Treasury securities outstanding that are maturing within 3 years of security n (in absolute value terms). $q_{n,1,t}$ (Near Purchases) equals the fraction of all buybacks maturing within 3 years of security n (excluding n) repurchased on auction date t divided by the total amount of all Treasury securities outstanding that are maturing within 3 years of security n (in absolute value terms). The inclusion of CUSIP fixed effects, α_n, necessitates that each security appears at least twice in the sample period of March 9, 2000 (first auction) to April 25, 2002 (the last auction). α_t denote buyback date fixed effects.

In order to determine whether flow effects of buybacks affected a broader class of securities, we subsequently consider all off-the-run Treasury CUSIPs with original maturities of 5-30 years that were ineligible for purchase in a given buyback operation. This allows us to isolate the strength of local supply effects (and how "local" they were). We estimate the following regression using the set of ineligible securities:

$$R_{n,t} = \alpha_t + \alpha_n + \beta_1 q_{n,1,t} + \beta_2 q_{n,2,t} + \epsilon_{n,t} \tag{4}$$

In this regression, $q_{n,2,t}$ ("Far Purchases") equals total purchases maturing within 3-6 years divided by the total amount of all Treasury securities outstanding that are maturing within 3 years of security n.[16]

[16]There is a small difference in specification relative to D'Amico and King (2012) and to the stock re-

3.2.2 Results

We consider three one-day windows for our analysis: buyback announcement, auction, and settlement dates. Table 4 reports results from regressions 3 and 4. Standard errors reported below coefficient estimates are clustered at the CUSIP level. We find strong evidence of flow effects among eligible securities on buyback settlement dates, but not on announcement or auction dates. To interpret the coefficient estimates, repurchasing 1% of a security (or its near substitute) resulted in a 0.1% (0.04%) increase in 1-day returns on the settlement date. For an average duration of 9.88 years in the sample used for the these regressions, flow effects resulted in yield changes of -0.01 and -0.004 bp for Own and Near purchases, respectively. Even among ineligible securities, we find sizable flow effects on settlement dates. In appendix C.2, we show that these results are largely robust to changes in the definition of "near neighbor" and to excluding the 2002 round of buybacks. The magnitudes and coefficients shift as we change the definition of "near" and "far" neighbor, but in general price changes have are consistently positive on settlement dates, usually significant, and of similar magnitudes across specifications.

The dynamic effects of Treasury buybacks seems to suggest that most of the price movements occurred on settlement dates. To illustrate this point, we plot the *cumulative* returns on eligible securities relative to three days before each Treasury buyback auction in figure 3. As the figures demonstrate, for both Own and Near purchases, there was statistically significant and positive cumulative returns on day $T + 2$, the buyback settlement date, but not on other dates.

If the quantity of securities purchased had been fully anticipated prior to the announcement, then we would not see a change in returns across the window. It is possible that the absence of effects for eligible and ineligible securities on announcement dates is consistent with some anticipation of which securities would be included at auctions – there was no "news" in the auction announcement. However, we might have expected news from the *out-*

gression. We use slightly larger groupings than D'Amico and King (2012) because of multicollinearity in purchases. We also drop the control for the SOMA portfolio from this regression. Although the response of the SOMA is important for the stock returns, around the window of auctions the overall change in SOMA appears to be close to zero. This is consistent with the "intramural courtesy" the SOMA desk extended to Treasury, and the null effects of auctions on changes in SOMA holdings that we find in the next section.

Table 4: Flow effects of buybacks on bond returns

Dependent variable:	1 day price return					
Date:	Announcement		Auction		Settlement	
Securities:	Eligible	Ineligible	Eligible	Ineligible	Eligible	Ineligible
	(1)	(2)	(3)	(4)	(5)	(6)
Own Purchases	−0.025		0.028		0.103***	
	(0.041)		(0.072)		(0.027)	
Near Purchases	−0.010	0.044	0.022	0.047	0.036**	0.057
	(0.013)	(0.063)	(0.040)	(0.062)	(0.014)	(0.038)
Far Purchases		−0.022		0.086*		0.081***
		(0.039)		(0.051)		(0.029)
Num.Obs.	513	5898	513	5900	513	5900
R2 Adj.	0.989	0.524	0.990	0.561	0.986	0.530
No. CUSIPS:	45	168	45	168	45	168
Cluster:	CUSIP	CUSIP	CUSIP	CUSIP	CUSIP	CUSIP

Note:

This table reports results of "flow effect regressions". The dependent variable is measured as the price return for a particular security from close of the day before the indicated date to close of the indicated debt. Each regression uses CUSIP and auction fixed effects. Own purchases equals the amount of security n purchased between dates t and $t+h$ as a fraction of the total amount of all Treasury securities outstanding within three years of security n. Near Purchases equals the fraction of all buybacks of near substitutes of n (excluding n itself) repurchased between dates t and $t+h$ divided by the total amount of all Treasury securities maturing within 3 years of n. Near Purchases equals the fraction of all buybacks of near substitutes of n (excluding n itself) repurchased between dates t and $t+h$ divided by the total amount of all Treasury securities maturing within 3 years of n. Standard errors are clustered by CUSIP. ***, **, and * denote significance at the 1, 5, and 10 percent levels. Near Purchases and Far purchases are scaled purchases of securities maturing within 3 years and from 3-6 years of the security n, respectively.

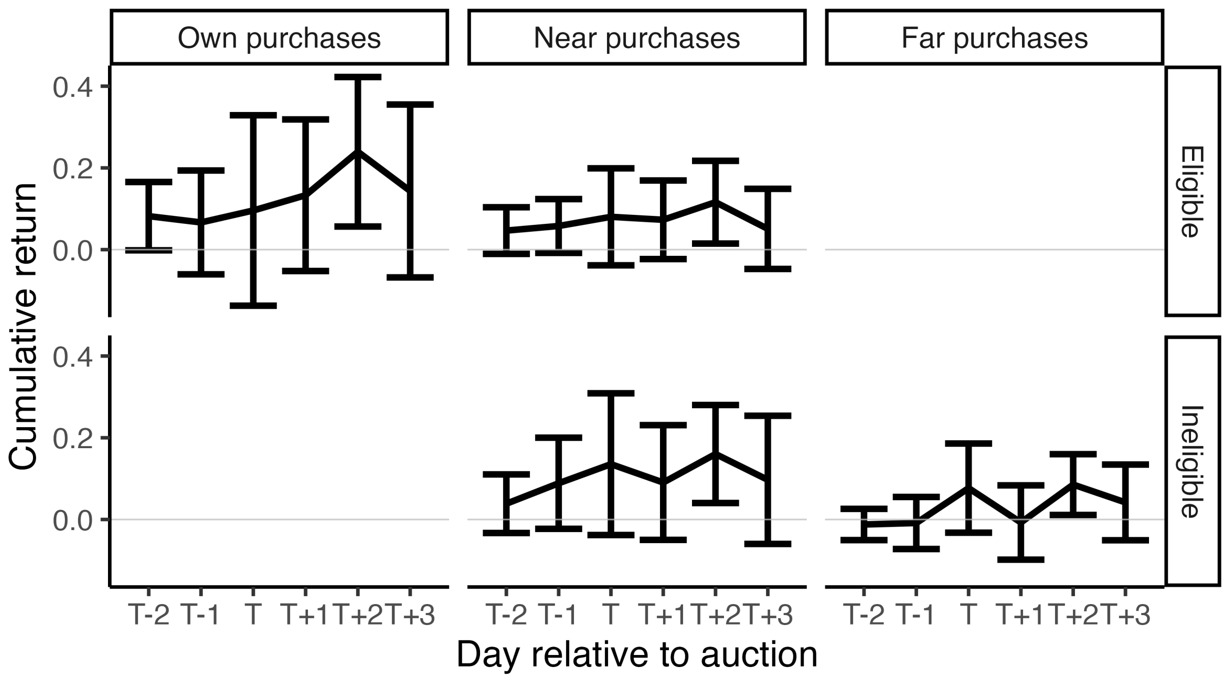

Figure 3: Plot of coefficients of Own, Near, and Far purchases from flow regressions. The dependent variables in the regressions are the cumulative returns on Treasury securities relative to three days before each buyback auction. The top row is the subsample of eligible securities, and the bottom row the subsample of ineligible securities. The plot shows coefficient estimates (solid lines) with 90% confidence intervals. Units are percentage points.

come of the auction to impact returns that day rather than on the settlement date. Instead, prices change once settlement occurs. One possible interpretation of the timing of returns is that it reflects inventory risks by primary dealers (Lou et al. (2013); Fleming et al. (2022); Smales (2021); Herb (2022)).[17] Auction participants (particularly, primary dealers) faced a risk of a winners curse. If they chose to bid too high on a security, then the Treasury might not have accepted their offer. If they bid too low, they faced the risk of acquiring the security at too high of a price and selling it back for a net loss. To the extent that the primary dealers acquired securities in advance of the auctions, they might have hedged by going long on other securities not included in that auction. After auction results were announced, the primary dealers could have unwound those positions on the settlement date. This change in hedging demand could have increased returns in the Treasury cash and repo

[17]There is debate about whether inventory risk is priced. Lou et al. (2013) do not find evidence of priced inventory risk, but Herb (2022) does.

markets until the settlement date.

3.3 Fed SOMA Portfolio

In the previous section, we showed economically and statistically significant evidence that the Treasury buyback program increased the prices of Treasury securities, and that some of this increase was due to local supply effects. In this section, we investigate the effects of these changes on the SOMA portfolio. As discussed in section 2, the Federal Reserve was forced to adjust its SOMA management strategy at the same time buybacks were occurring in light of the broad trend towards less issuance (leading it to adopt more formal limits on its acquisition of any given issue) and because of the "intramural courtesy" they extended to Treasury (trying to limit acting in markets around buyback auctions). These adjustments may have affected both the composition of the SOMA portfolio and the returns earned by the Fed (relative to its costs). Since the Fed's profits are ultimately remanded to the Treasury, understanding how the impacts of buybacks affected the SOMA portfolio is important to quantify the ultimate benefit (or cost) to the taxpayer of the buyback program.

We estimate stock effect regressions of the same form as equations (1) and (2) but with the change in SOMA share as the dependent variable. To the extent that we are concerned about simultaneity bias among changes in SOMA purchases and buybacks by Treasury, we also adopt the same IV strategy as when examining returns.

3.3.1 Results

The results of the stock regressions on the SOMA portfolio are reported in table 5. We focus on the OLS results, because the case for simultaneity bias here is somewhat weaker and we have less (statistical) evidence that the IV regression is likely to be an improvement over the OLS estimates. Notably, there were not significant reactions in the total holdings of securities that were bought back – a 1 percent own purchase (relative to the amount of near-Treasury maturities available) lead to a statistically insignificant change in the SOMA portfolio. However, near purchases did lead to precisely estimated (but similarly small) adjustments in holdings. This is clear from figure 4 where we plot the cumulative change in SOMA holdings as a function of the bond's maturity and the size of own purchases; There are larger changes in holdings for bonds with short times to maturity, and these bonds were

Table 5: Stock effects of Treasury buybacks on SOMA portfolio

Dependent variable:	Change in SOMA share	
	OLS	IV
Own purchases	0.716	5.998***
	(0.655)	(2.161)
Near purchases	−0.451***	−0.939***
	(0.141)	(0.284)
Remaining maturity	−0.044	0.169
	(0.167)	(0.215)
Remaining maturity sq.	0.001	−0.004
	(0.004)	(0.005)
SOMA share	−7.617***	−8.095***
	(1.859)	(2.135)
log(Price)	0.188	−0.007
	(0.430)	(0.466)
Coupon rate	0.110	−0.274
	(0.186)	(0.241)
Svennson pricing error	0.751	0.249
	(1.517)	(1.530)
Average SOMA share (Near)	−6.247	−3.244
	(5.763)	(5.763)
Num.Obs.	102	102
R2 Adj.	0.180	0.038
F	6.956	
First stage Wald statistic:		5.756
Wu-Hausman test p-value:		0.058

Note:

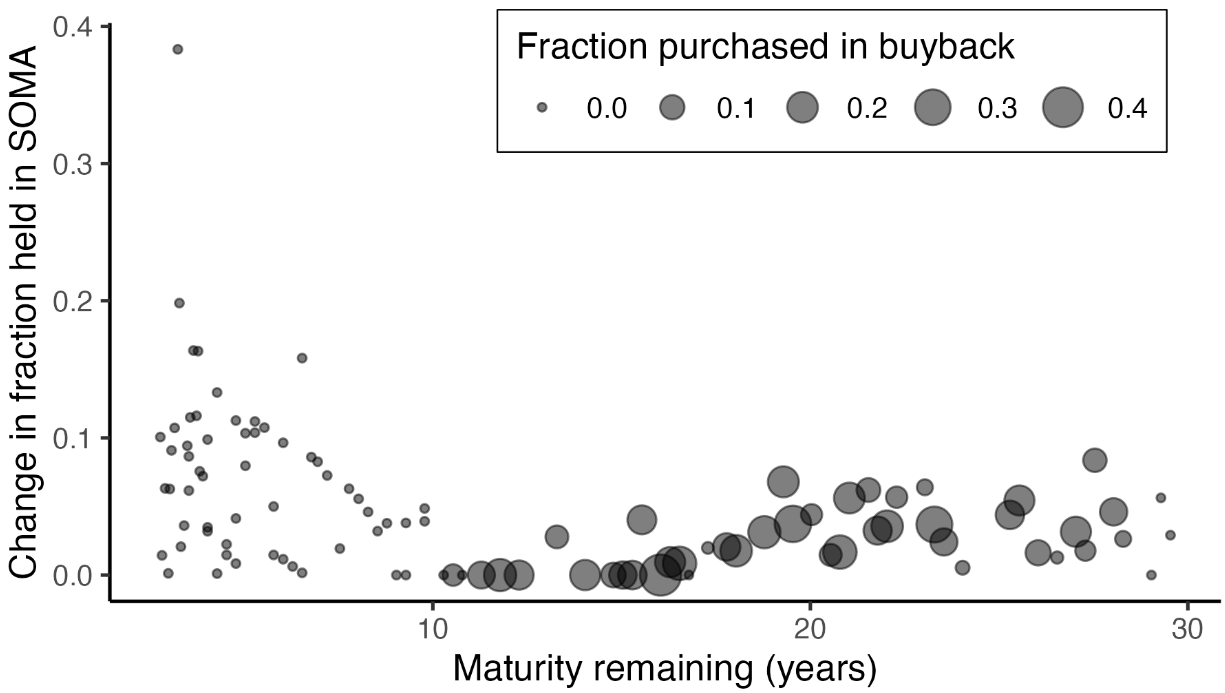

Figure 4: Cumulative change in the fraction of bonds outstanding held in the SOMA portfolio (vertical axis) as a function of the maturity structure (horizontal axis) and the size of the overall buyback (dot size). Securities are included if they were exposed to treatment (e.g., if there were own or near purchases for that security during the buyback program)
.

purchased less in the buybacks (if at all). The negative point estimate for near purchases implies that purchases of a security's neighbors lead to a decline in holdings of that security by a small magnitude. One possibility is that the SOMA managers perceived excess demand for neighboring maturities over the course of the buyback program and decreased their holdings to mitigate the market impact of buybacks on related securities.

It is also possible that the stock effect regressions mask higher-frequency changes – perhaps the Fed made immediate moves following auctions to help offset price changes, but reversed them over time. Unfortunately, the SOMA portfolio data is not available at less than a weekly frequency, so we cannot pursue an exact analog of the flow regressions for SOMA changes. In fact, in most weeks, SOMA holdings for most individual securities do not change during this period, except for bonds that are very close to maturity.

In figure 5 we plot the change in SOMA holdings for bonds that were bought back directly, or whose near substitutes were bought back against the change in SOMA holdings (vertical

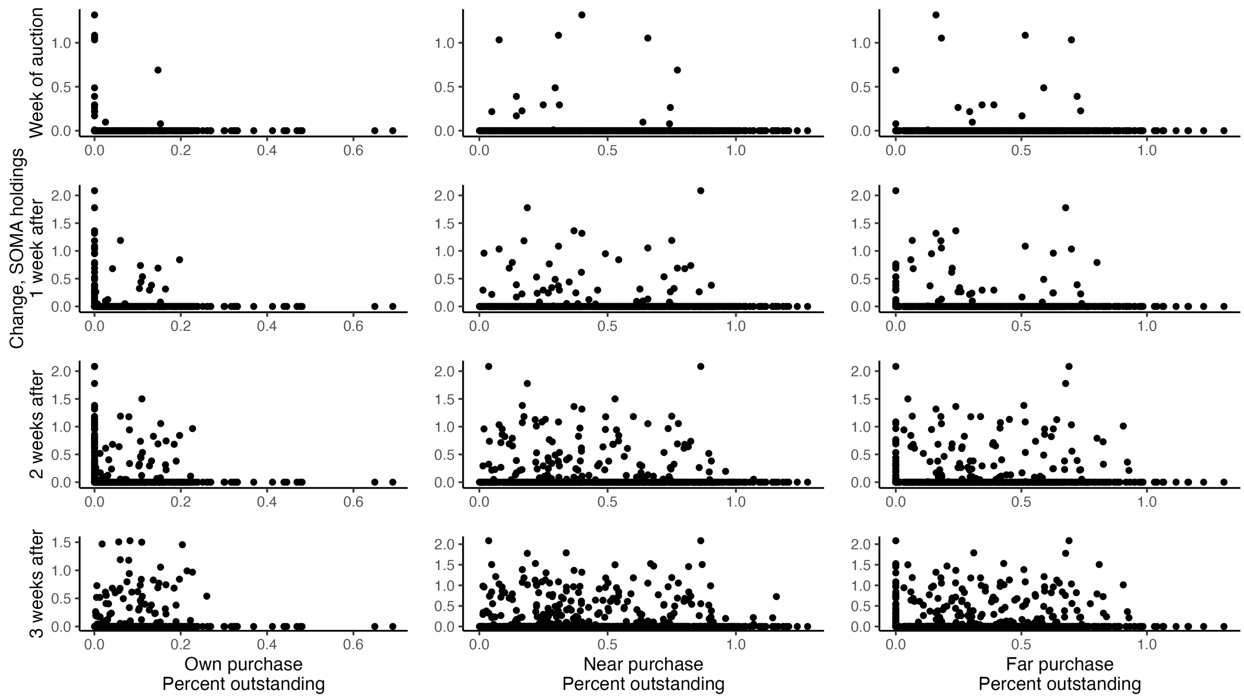

Figure 5: Percentage change in SOMA holdings (vertical axis) as a function of the size of the "treatment" (horizontal axis). The columns (left to right) are own, near and far purchases as a fraction of the outstanding quantity prior to the start of the buyback. The rows represent weeks relative to the buyback; the first row is the week of the buyback itself. Dots are shown in the panel conditional on having been exposed to treatment in a given auction (that is, either having own or near purchases).

axis). The columns show the quantity of the purchase, quantity of near purchases, and quantity of far purchases (between 3 and 6 years of the maturity of the bond). The top row of the figure represents the change in the week of a buyback auction, and subsequent rows show subsequent weeks. We note that the Fed did not decrease its holdings of *any* of these bonds.[18] Moreover, we see very little change in SOMA holdings for this group of securities the week of buyback auctions, and increases in holdings were more focused on the set of bonds that were bought back in smaller quantities.

More formally,we estimate a logistic regression model where the outcome of interest is *increasing* holdings of a given security.We include the same set of fixed effects and controls as in the flow effects regressions for returns. The results are shown in table 6.

Each column of the table shows the odds ratio for increasing holdings of a security in the

[18]In fact, SOMA holdings of securities with original maturities of 5 years or greater did not decrease in our sample period.

Table 6: Flow effects of buybacks on SOMA portfolio

Dependent Variable:	Cumulative Change in SOMA			
Number of Weeks:	0	1	2	3
	(1)	(2)	(3)	(4)
Own Purchases	0.40	1.01	7.52	12.28
	(2.41)	(2.66)	(13.84)	(19.38)
Near Purchases (<3yr)	1.88	0.56	0.64	1.38
	(1.53)	(0.24)	(0.20)	(0.37)
Far Purchases (3-6yr)	2.32	0.58	1.00	1.72**
	(1.47)	(0.23)	(0.31)	(0.45)
Observations	3,974	4,919	5,480	5,567
CUSIPs	97	120	135	136
Pseudo R-squared	0.16	0.13	0.09	0.07
CUSIP Fixed Effects	Y	Y	Y	Y
Auction Date Fixed Effects	Y	Y	Y	Y

This table reports results of where n denotes a particular Treasury security. The estimating equation is: $Pr((S_{n,t,t+h} > 0)|q_{n,0,t}, q_{n,1,t}) = F(\alpha_t + \alpha_n + \beta_0 q_{n,0,t} + \beta_1 q_{n,1,t})$, where F is the cumulative logistic distribution function. $S_{n,t-1,t+h}$ is the change in the amount of security n held in Fed's SOMA account between weeks t and $t+h$ divided by the total amount outstanding in week t. $q_{n,0,t}$ (Own Purchases) equals the amount of security n purchased in auction week t as a fraction of the total amount of all Treasury securities outstanding that are maturing within 3 years of security n (in absolute value terms). $q_{n,1,t}$ (Near Purchases) equals the fraction of all buybacks maturing within 3 years of security n (excluding n) repurchased in auction week t divided by the total amount of all Treasury securities outstanding that are maturing within 3 years of security n (in absolute value terms). $q_{n,2,t}$ (Far Purchases) equals total purchases maturing within 3-6 years divided by the total amount of all Treasury securities outstanding that are maturing within 3 years of security n. The sample includes all off-the-run Treasury securities with an original maturity greater than 5 years that were both eligible and ineligible to be repurchased on a given buyback date. The inclusion of CUSIP fixed effects necessitates that each security appears at least twice in the sample period of March 9, 2000 (first auction) to April 25, 2002 (last auction) and has at least one positive observation of $S_{n,t-1,t+h}$. Standard errors reported below coefficient estimates are clustered at the CUSIP level. ***, **, and * denote significance at the 1, 5, and 10% levels.

week of an auction (first column) and subsequent weeks (columns 2-4). There are two key takeaways from this exercise. First, we do not find evidence that the SOMA manager reacted to buybacks by purchasing more of that security the week of the auction or in subsequent weeks. We also do not find any significant effects on purchases of near neighbors. The absence of significant changes in purchasing behavior is consistent with SOMA managers trying to avoid contributing to reducing liquidity by restricting the supply of assets.

In appendix E, we examine the robustness of these results to changes in definition of neighbor, changing the start date of the analysis, and excluding the 2002 buybacks. The results of the stock effect regressions are somewhat inconsistent, but in general the fit is very low (with negative adjusted R^2 in some specifications), which is likely a product of the fact that holdings, by and large, do not change. The flow effects, however, do exhibit some changes in significance, in that a few coefficient estimates are significant. When significant, the estimated odds ratios are less than 1, and often close to zero, which implies that the Fed was much *less* likely to make purchases the week of auctions to exposed securities. Overall, the robustness results are broadly consistent with economically tiny effects on the SOMA portfolio holdings as a result of the buybacks, and with reduced purchases of securities affected by auctions. This latter is consistent with "intramural courtesy" extended by the SOMA manager as mentioned in section 2.

4 Some implications for future buybacks

Our results show the 2000-2002 Treasury buyback program impacted the prices of Treasury bonds through their effects on the available supply of assets. This is consistent with the predictions of models that emphasize the interaction of preferred habitat investors with arbitrageurs in determining Treasury yields. The cumulative effect we estimate is modest relative to estimates of the effects of LSAPs, but our evidence this suggests that this is attributable to the overall size of the program; our estimated yield elasticities of supply changes for both own- and near-purchases are somewhat larger than those found by D'Amico and King (2012).

The new Treasury buyback program is still in the process of being finalized, but our results have bearing on several features of the "current views" on the design of the policy as of August 2023 (as articulated in Office of Debt Management (2023)). In particular, the Department of Treasury has stated that its new buyback policy will be organized around a set of nine buckets of uneven size. Our results suggest that purchases are likely to spill over across these "nearby" buckets; we find significant spillover effects for securities within four years of bought back securities. The articulated framework indicates that Treasury will select quantities of securities to buy back with an eye to leaving some quantity outstanding and in the hands of the public (outside of the SOMA portfolio). Our results suggest that buybacks are likely to also affect the demand for bonds of "nearby" CUSIPs. This is not necessarily a negative; to the extent that increased demand for nearby CUSIPs reduces the on-the-run premium for those issues, buybacks may be able to achieve the stated goal of liquidity support at a lower cost than anticipated.

Policy experiments As a back of the envelope demonstration, we conduct a similar exercise as the counterfactual in section 3. We take the quantity outstanding and time remaining to maturity for all nominal Treasury notes and bonds from the September 2023 Monthly Statement of the Public Debt and closing prices as of September 29, 2023. We then estimate the implied effect on bond yields as if the Treasury had conducted buybacks on on that date.

We conduct three experiments, "as if" the buybacks for a given quarter occur on that date. Office of Debt Management (2023) indicates that Treasury has identified 9 unevenly sized buckets, 7 of which are nominal bonds (Maturities of 0 to 2 years, 2 to 3 years, 3 to 5, 5 to 7, 7 to 10, 10 to 20, and 20 to 30) and 2 of which are buckets of TIPS.[19] It has also indicated it intends to buy no more than $4 billion from any of the nominal buckets, and no more than $30 billion total. Our three experiments are

- **Baseline:** Assume that Treasury buys back $4 billion from each of the seven nominal buckets.
- **Short end:** Assume the Treasury buys back $28 billion from the 2-3 year bucket
- **Long end:** Assume Treasury buys back $28 billion from the 10-20 year bucket.

Within the bucket, we assume the purchases of individual CUSIPs are in proportion to each security's amount outstanding within the bucket. The latter two scenarios admittedly do not fully conform to Treasury's design principle of spreading purchases across bond tenors. However, they are selected to illustrate the possible pricing effects of more concentrated buybacks within a set of bonds. We re-scale the purchases using the same method as for the stock effect regressions in section 3

We show the raw size of purchases and near purchases by maturity remaining for each scenario in figure 6. The red dots indicate the actual purchases, while the blue dots indicate the sum of "nearby" purchases (within a window of three years of remaining maturity) for each individual bond. The horizontal lines indicate the cutoffs for the buckets indicated in Office of Debt Management (2023). For the Baseline scenario, this implies that bonds with maturties of 0-10 years end up relatively highly exposed to nearby purchases because of spillovers from adjacent buckets. In the Short scenario, the near-purchases effects are more

[19] We ignore TIPS, because they were excluded from our sample from the previous buyback.

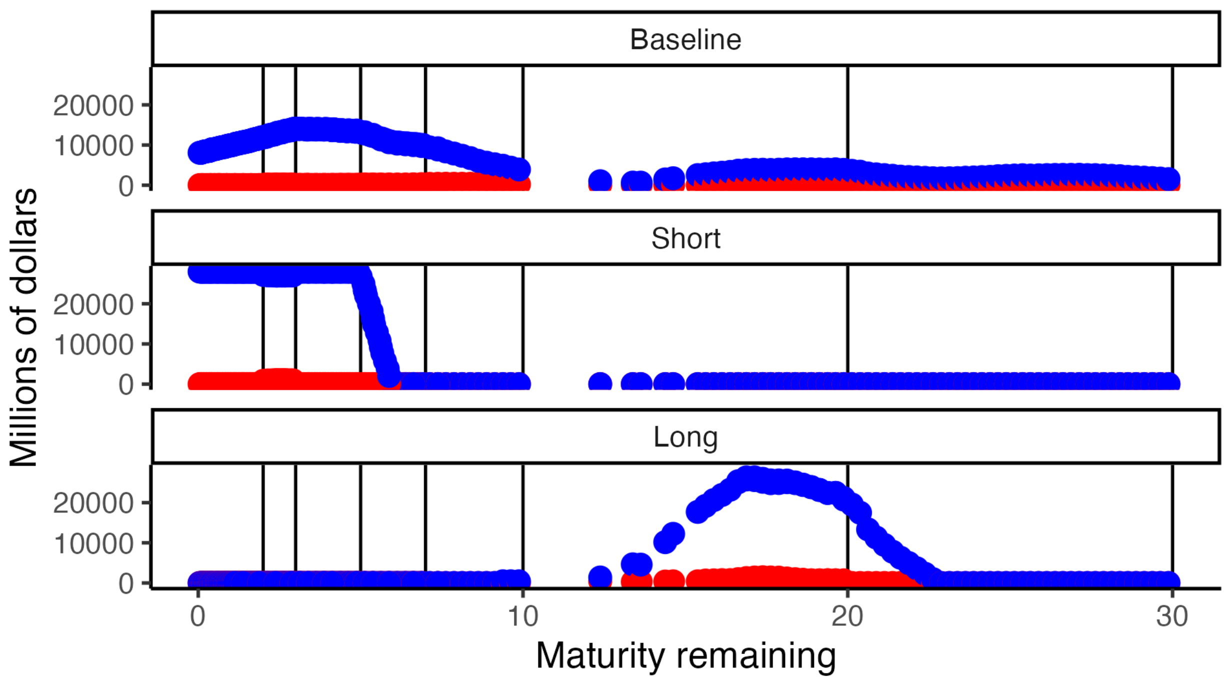

Figure 6: Dollars of own (red) and near-substitute (blue) purchases under three different policy scenarios. Baseline assumes $4 billion in purchases across maturity buckets, Short assumes $28 billion in purchases from bonds with tenors between 2 and 3 years, and Long assumes $28 billion in purchases for bonds with tenor of 10 to 20 years. Vertical lines indicate boundaries of maturity buckets outlined in Office of Debt Management (2023).

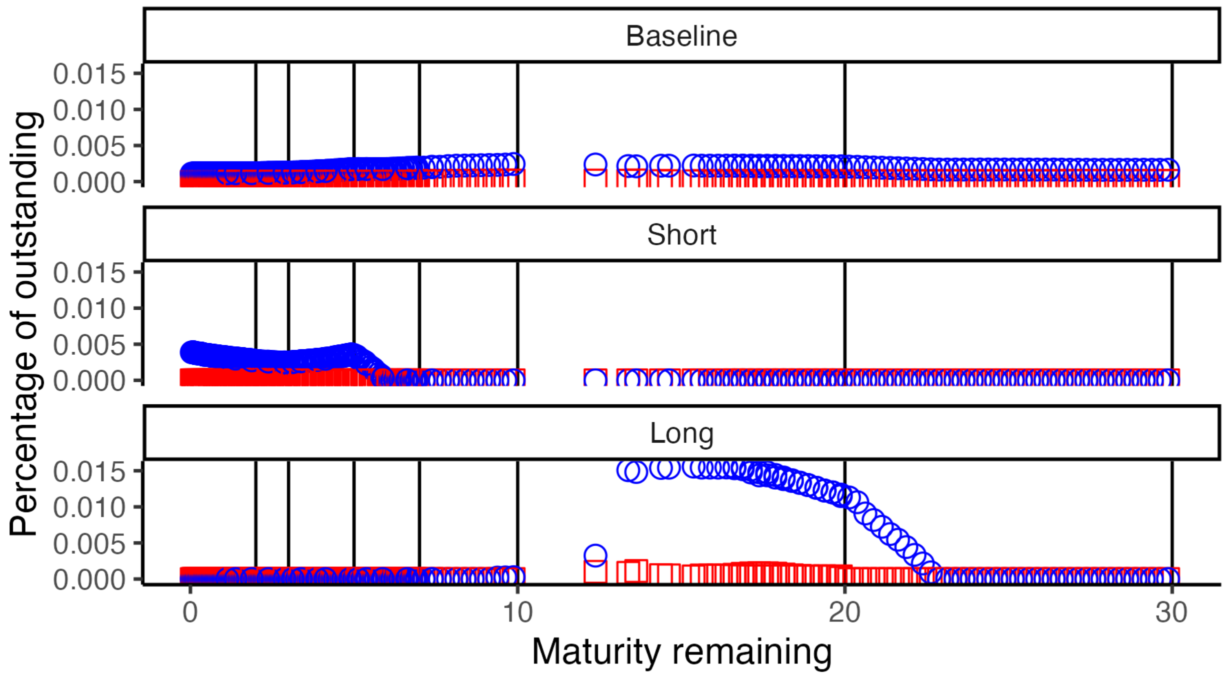

Figure 7: Percentage of outstanding issue repurchased of own (red) and near-substitute (blue) securities under three different policy scenarios. Baseline assumes $4 billion in purchases across maturity buckets, Short assumes $28 billion in purchases from bonds with tenors between 2 and 3 years, and Long assumes $28 billion in purchases for bonds with tenor of 10 to 20 years. Vertical lines indicate boundaries of maturity buckets outlined in Office of Debt Management (2023).

concentrated on the 0-5 year range, and for Long it is mainly contained in the 10-20 bucket with some exposure in the 20-30 bucket. Figure 6 rescales this to the size of the purchase as a fraction of all securities in the near-substitute bucket (within 3 years of maturity, in absolute value terms). This intermediate step reflects the same rescaling of the data as used in the stock regressions. The scale of the figure, in comparison to the cumulative purchases noted in 1, reveals that the size of the buybacks proposed by Treasury (at least, for a given quarter) are several orders of magnitude smaller than the (cumulative) buyback program from 2000-2002. Using the IV estimates from table 3, we translate purchases into predicted price impacts and then changes in yield. This is analogous to the exercise used to construct figure 2, except presented as the predicted *decrease* in yield due to additional purchases.[20] Our estimates suggest that the effects of the proposed buyback program, at least within a

[20]In 2, the counterfactual exercise was the absence of buybacks; here, the counterfactual is the new round.

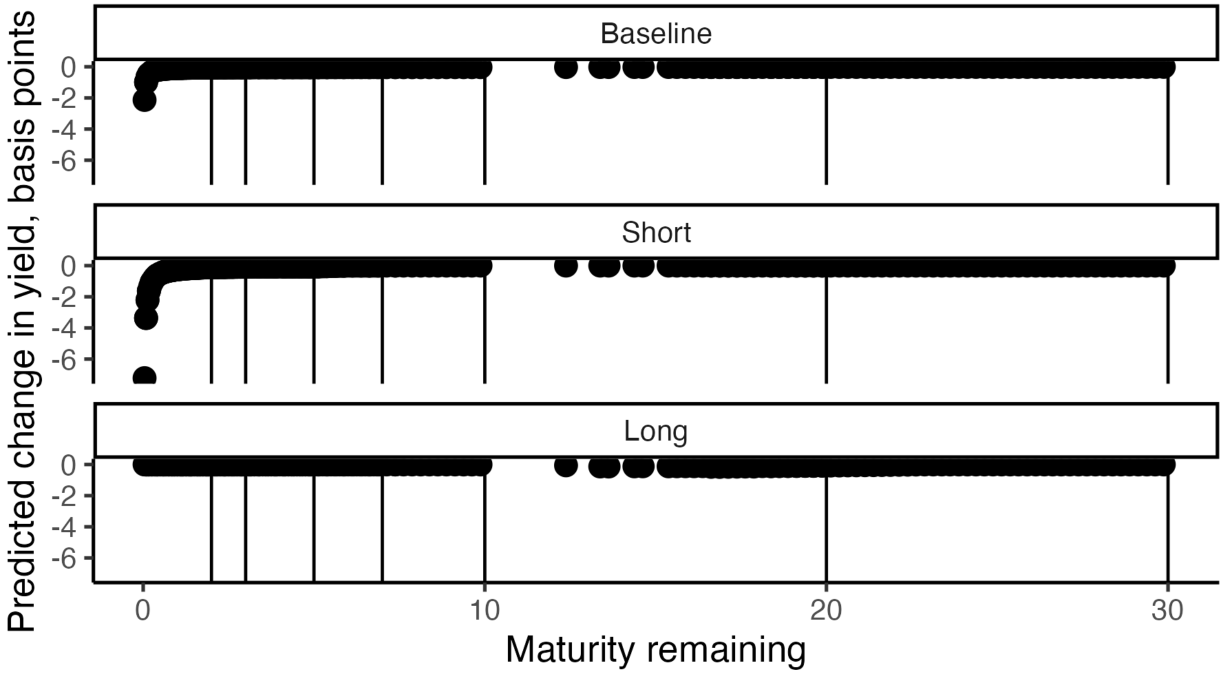

Figure 8: Predicted change in yield due to supply changes. The difference is calculated as yields with no repurchases minus predicted yields after repuchases under the three different scenarios outlined in the text: Baseline assumes $4 billion in purchases across maturity buckets, Short assumes $28 billion in purchases from bonds with tenors between 2 and 3 years, and Long assumes $28 billion in purchases for bonds with tenor of 10 to 20 years. Office of Debt Management (2023).

given quarter, will be economically modest and skewed towards the short end of the yield curve under the Baseline scenario. Summary statistics for the yield changes are in table 7. Under the Baseline scenario, the median change in yield is approximately a 0.3 bp decrease, with a maximum decrease of 2.13 bp at the short end. The other two scenarios outline the effects of buybacks that are concentrated in a short-term debt bucket of 2-3 years maturity remaining versus a 10-20 year bucket. In the Short scenario, yield decreases are larger for the bonds closest to maturity, even though they are not bought back directly, because they are near-substitutes of what is repurchased. The maximum effect is a more than 7 basis point decrese in yields. For the Long scenario, yield changes are quite small and concentrated in the 10-20 and 20-30 year buckets. This is despite a larger intensity of treatment (in terms of purchase outstanding) for many of the securities; the change in price is larger in absolute terms, but not large enough to impact yields to maturity. Overall, the exercise suggests that

Scenario	Mean	Median	Std. Deviation	Range
Baseline	-0.72	-0.31	0.17	(-2.13, -0.01)
Short	-0.19	-0.06	0.57	(-7.22, 0)
Long	-0.014	0	0.37	(-0.16, 0)

Table 7: Summary statistics of predicted change in yields for three different policy scenarios, relative to no buybacks. Baseline assumes $4 billion in purchases across maturity buckets, Short assumes $28 billion in purchases from bonds with tenors between 2 and 3 years, and Long assumes $28 billion in purchases for bonds with tenor of 10 to 20 years. Reported numbers are in basis points.

buybacks are not likely to have substantive impacts on the costs of financing Treasury debt.

There are two caveats to these estimates. First, we are essentially assuming that estimated price elasticity in response to supply changes are unchanged from the 2000-02 round of buybacks, an assumption we fully acknowledge may be questionable. Appendix section D compares the percentage (and level) of holdings of Treasuries from the Flow of Funds in the most recent data available compared to the start and the end of the previous buyback period. Relative to 2002, the Federal Reserve and financial institutions currently hold a larger fraction of Treasuries, and Federal and State pension funds hold a smaller fraction. To the extent that pension funds are "preferred habitat" investors, the shift in composition of demand may imply supply changes will transmit differently than in the past. Second, we ignore how the buybacks are financed. To the extent that Treasury plans on issuing new debt (of some maturity) in order to finance retirement of old debt, there would be offsetting increases in supply within or across maturity buckets, which could shift yield impacts.

Other policy considerations The results in section 3.2 suggest that the effects of buybacks on returns mainly occur on settlement dates, rather than auction dates, which we speculate points to hedging behavior. This is potentially an important facet to consider when choosing the timing of buybacks. Market participants appear to hedge the risk of a winner's curse, and this hedging activity may have consequences for repo and futures markets. Barth and Kahn (2021) and Barth et al. (2023) note that the "basis trade" – an investment strategy where hedge funds go long on cash Treasuries and short futures, financing their long position through the repo market – has grown significantly since 2017. As a result, hedge funds play a larger role in intermediating Treasury transactions. Since hedge funds both face risks associated with repo rollover and face margin requirements, changes in Treasury prices associated with Treasury buybacks could create risks for hedge funds and spill over to the futures and repo markets. We emphasize that these effects are not limited to bonds that are included in buybacks.

Finally, we note that the lack of SOMA response to the previous set of buybacks was a policy decision, and that future SOMA managers may make different decisions. Figure 9 plots the complete SOMA share of outstanding treasuries in the maturity "buckets" proposed in Office of Debt Management (2023). Although SOMA has increased its internal limits for maximum share of outstanding bonds since the last buyback program, it has, at times, been quite close to those limits (most recently in 2020, when the SOMA portfolio contained more than 60% of all outstanding debt in the 10-20 year bucket). Buybacks may occasionally push SOMA closer to those limits, particularly in the event of future LSAPs, and leave the Federal Reserve close to once again holding the majority of long-term US Treasury debt. Recent "Quantitative Tightening" policies have given SOMA more room to maneuver in this respect.

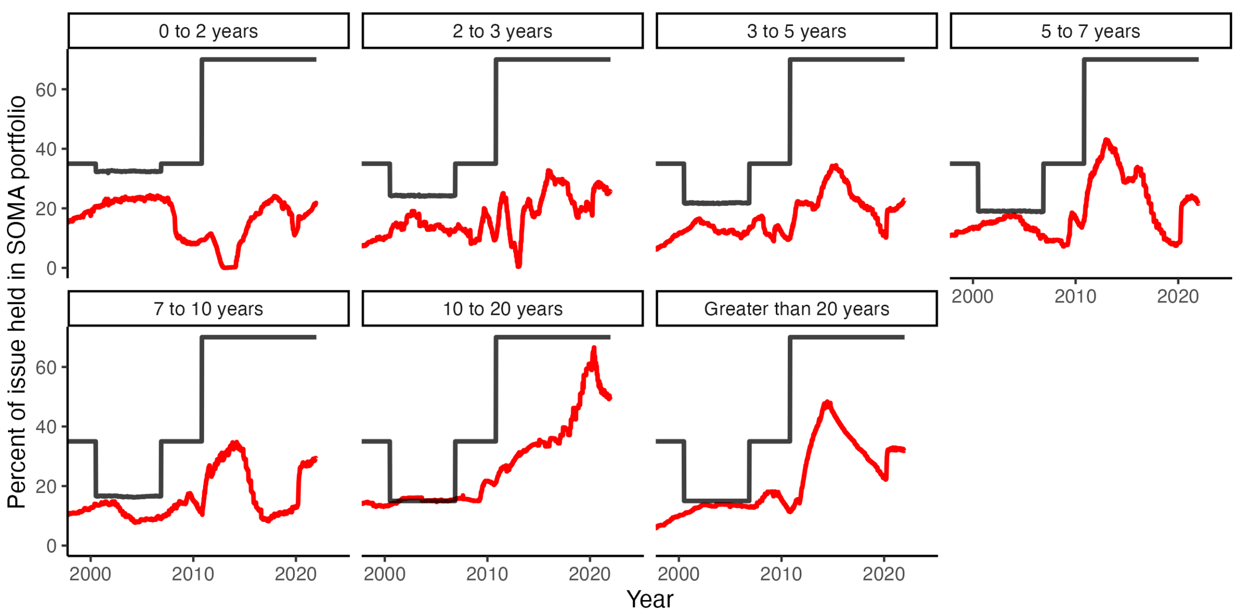

Figure 9: Plot of weighted average share of nominal Treasury securities held in SOMA portfolio, by maturity bucket. Buckets chosen to match maturity groupings in Office of Debt Management (2023). Red bars indicate weighted average, where weights are calculated by the share of that security relative to total debt outstanding. Black lines indicate self-imposed limits on quantity of holdings. Units are percentage points.

5 Conclusion

We examine the effects of the 2000-2002 Treasury buyback program on the prices of Treasuries at a low- and high-frequency, and the reaction of SOMA managers to these purchases. We find that the effects of the reduction in supply explain slightly less than 1/5 of the change in prices over the course of the program. We document spillover effects at a high frequency and cumulatively over the course of the program – purchases of bonds lead to substitution in the demand for other bonds with similar time to maturity. We also find, consistent with statements in FOMC transcripts, that the SOMA managers largely avoided changing their holdings of securities around the time of buyback purchases. In addition, SOMA managers did not systematically change holdings of bonds that were bought back over the life of the program. Using our estimates, we perform a back of the envelope analysis of the stock effects of Treasury's proposed buyback program revival. We find that the effects in any given quarter are likely to be quite small, on the order of fractions of a basis point; this is largely because the size of the program (in any quarter) is much smaller than the cumulative buybacks in earlier years.

There are a number of interesting questions about the buybacks (past and future) that deserve further study. Our effects point to a delay between auctions and settlement, which we speculate is due to hedging. It would be interesting to study the behavior of primary dealers and other market participants at a higher frequency around buybacks to understand how they insure themselves against risk of the winner's curse and how buyback auctions spill over into other related markets, such as repo and futures markets. Since 2019, the Office of Financial Research in the Dept of Treasury has begun collecting data on centrally cleared repo markets and in 2023 proposed rules for bilateral repo data collection. This data may be useful for understanding how market participants react to semi-predictable changes in supply such as regular buyback auctions.

Moreover, our results suggest that the Federal Reserve was essentially passive during the buyback period. It would be interesting for theoretical work to examine whether this passiveness is optimal from the perspective of ensuring smooth Treasury market functioning, or if more coordination between Treasury and the New York Fed's trading desk is warranted.

Existing theoretical work that incorporates supply (e.g. Vayanos and Vila (2021)) is silent on the role of the central bank in Treasury markets. However, given the large share of Treasury holdings by the Federal Reserve, it would be interesting to study how their presence (and overall changes in balance sheet size) impacts the incentives of market participants. Furthermore, we have mainly focused on the price of Treasuries and the extent to which one significant player – the Federal Reserve – reacted to the buyback program. It would also be interesting to more formally examine who the Treasury ultimately bought from, as in Carpenter et al. (2015)'s study of the Large Scale Asset Purchase program.

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A Timeline of the 2000-2002 Buyback program

Date	Event
8/4/99	Draft regulations announced, coinciding with 3rd quarter Quarterly Refunding Statement.
1/13/00	Treasury Dept. announces introduction of buyback and intention to conduct "several" buyback operations in the "first half" of 2000, buying back as much as 30 billion dollars of debt in 2000.
1/19/00	Final rules for buybacks issued
3/9/00	First buyback operation conducted
5/3/00	Treasury announces that buybacks will continue at approximately same size (1-3 billion), on the 3rd and 4th week of every month, and future notice period to will be shortened to 1 day.
8/2/00	At quarterly refunding statement, Treasury announces intention to buy back securities of maturity of 10 years or more in subsequent quarter, including callable securities.
10/31/01	As a result of increased spending and weakening of tax receipts after the September 11 attacks, Treasury announces (1) Buybacks will continue in 2001 (2) There will be no buybacks in January 2002 (3) Subsequent buybacks will be announced at future quarterly refunding meetings.
1/30/02	Treasury announces 3 planned buybacks "in order to lower high seasonal cash balances" and intending to "repurchase a total of 3 billion to 5 billion in long-dated securities."
4/25/02	Final buyback operation
5/1/02	Treasury announces it will not be conducting buybacks in subsequent months. "No buyback" announcements are included at quarterly refunding statements for several quarters before being dropped.

B Omitted variable bias in the stock regression

To illustrate the importance of accounting both local supply and for SOMA holdings, we calculate misspecified regressions where (1) We do not include local supply effects in the second stage regression (although we allow characteristics of nearby bonds to be an excluded instrument) and (2) we allow for local supply effects but do not control for SOMA holdings. Unsurprisingly, omitting the possibility of spillovers in the stock regressions drastically underestimates the impacts of buybacks on prices; part of this is because of bias in the estimated effect of own purchases, with the rest coming from omission of local supply entirely. Implied returns for individual securities are shown in the top panel of 10; the gray dots indicate the contribution of supply to returns implied by the misspecified regressions, and arrows indicate the change from the full specification to the misspecified. The omitted variable bias induced by ignoring the SOMA portfolio leads to an overestimate of the direct effects and an underestimate of spillover effects. The total effect, however, is an understatement of the importance of local supply for explaining returns, as shown in the bottom panel of 10.

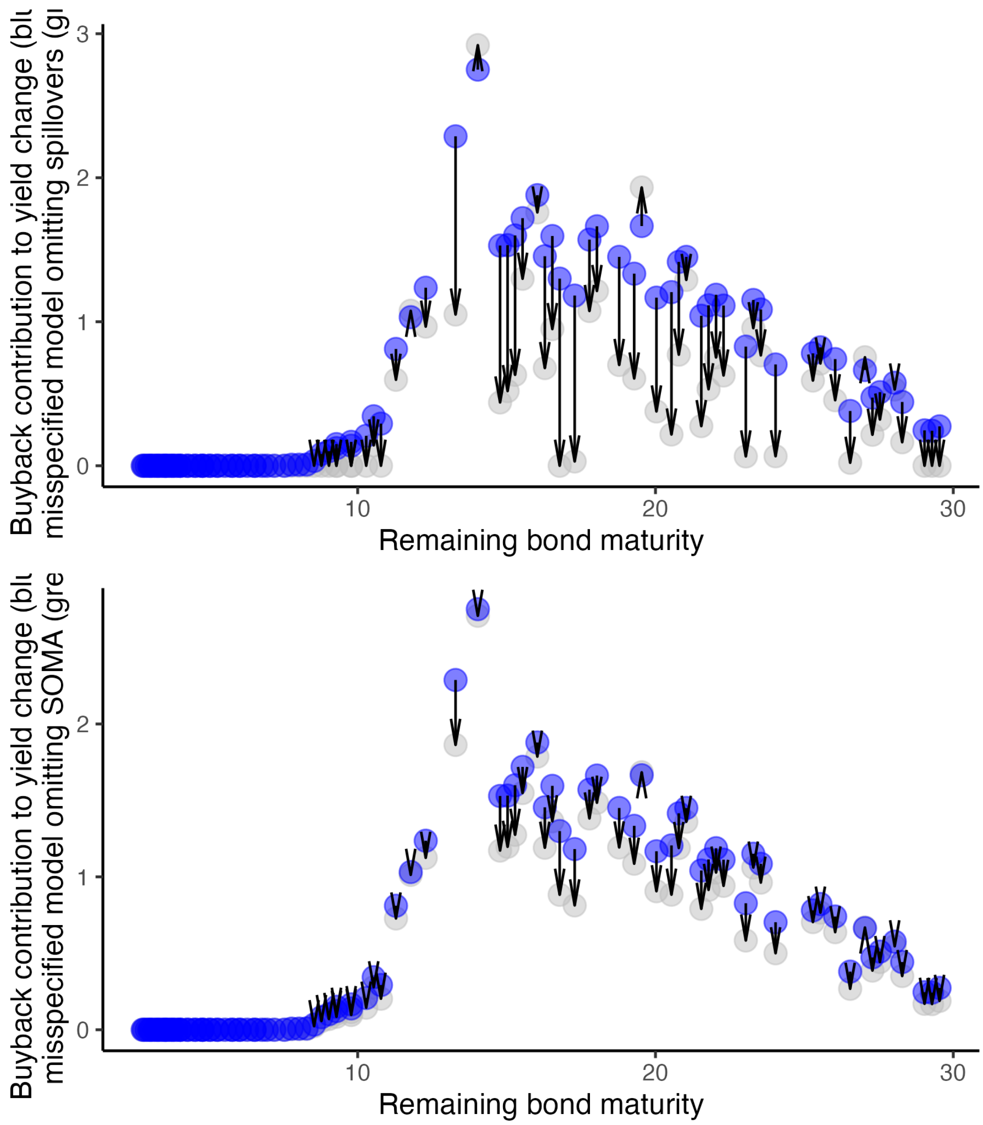

Figure 10: Differences in implied contribution from supply changes when near purchases are omitted as a control in the second stage regression (top), and when SOMA share is omitted as a control (bottom) Calculated by subtracting the fitted contributions of own and near purchases using (2), re-estimated to omit the relevant controls. Gray dots indicate the returns calculated using the model omitting controls, with arrows indicating the change from those calculated using the full version of (2).

C Robustness: Treasury prices

C.1 Stock effects

Table 8: Stock regression: alternative near substitute definitions

Near substitute:	Within 2 years		Within 4 years	
Dependent variable:	Price return			
	OLS	IV	OLS	IV
Own purchases	1.355***	0.252	2.499***	2.090
	(0.422)	(1.189)	(0.780)	(1.850)
Near purchases	0.545***	0.852***	0.475***	0.655***
	(0.099)	(0.188)	(0.100)	(0.197)
Remaining maturity	−0.368***	−0.471***	−0.757***	−0.886***
	(0.072)	(0.095)	(0.154)	(0.188)
Remaining maturity sq.	0.009***	0.012***	0.018***	0.021***
	(0.002)	(0.002)	(0.004)	(0.005)
SOMA share	−1.469*	−1.165	−4.650***	−5.098***
	(0.783)	(0.918)	(1.618)	(1.835)
log(Price)	1.237***	1.414***	2.936***	3.196***
	(0.151)	(0.180)	(0.452)	(0.496)
Coupon rate	−0.411***	−0.374***	−1.034***	−1.046***
	(0.087)	(0.136)	(0.195)	(0.285)
Svennson pricing error	−0.475	−0.384	−3.076**	−3.307*
	(0.632)	(0.762)	(1.497)	(1.902)
Average SOMA share (Near)	−6.253***	−7.670***	−23.824***	−24.630***
	(1.827)	(2.501)	(7.481)	(7.918)
Num.Obs.	109	109	109	109
R2 Adj.	0.636	0.586	0.528	0.516
F	31.374		22.715	
First stage Wald statistic:		20.019		10.660
Wu-Hausman test p-value:		0.004		0.320

Note:

This table reports results of "stock effect regressions". In columns 1 and 2, the definition of "near substitute" is all securities maturing within two years (in absolute value) of a given security. In columns 3 and 4, the definition of "near substitute" is all securities maturing within four years (in absolute value) of a given security. Own Purchases equals the amount of security n purchased between dates t and $t+h$ as a fraction of the total amount of all Treasury securities outstanding within three years of security n. Near Purchases equals the fraction of all buybacks of near substitutes of n (excluding n itself) repurchased between dates t and $t+h$ divided by the total amount of all Treasury securities that are near substitutes of n. In all regressions, all security-level variables are weighted by the amount outstanding of security n divided by total amount of all Treasury securities that are near substitutes of security n. Columns 2 and 4 reports estimates using two stage least squares, instrumenting for Own and Near Purchases. Excluded instruments from the first-stage regressions include: an indicator variable for whether the original maturity of security n 30 years and averages of remaining maturity, remaining maturity squared, log(bond price), current yield, and coupon rate for all securities that are near substitutes of security n. Heteroskedasticity-robust standard errors reported below coefficient estimates. ***, **, and * denote significance at the 1, 5, and 10 percent levels.

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

Table 9: Stock regression: alternative dates

Dates:	Jan 12, 2000 – Apr 30, 2002		Aug 3, 1999 – Dec 24, 2001	
Dependent variable:	Price return			
	OLS	IV	OLS	IV
Own purchases	3.145***	4.924***	2.035***	1.955
	(0.561)	(1.523)	(0.468)	(1.527)
Near purchases	0.798***	0.909***	0.556***	0.654***
	(0.082)	(0.172)	(0.089)	(0.162)
Remaining maturity	−0.612***	−0.722***	−0.630***	−0.685***
	(0.105)	(0.133)	(0.109)	(0.129)
Remaining maturity sq.	0.015***	0.018***	0.015***	0.017***
	(0.003)	(0.004)	(0.003)	(0.003)
SOMA share	−2.501	−3.490*	−3.250***	−3.344***
	(1.544)	(1.924)	(1.165)	(1.241)
log(Price)	2.289***	2.614***	2.138***	2.251***
	(0.251)	(0.289)	(0.245)	(0.247)
Coupon rate	−0.887***	−1.072***	−0.649***	−0.665***
	(0.170)	(0.213)	(0.124)	(0.181)
Svennson pricing error	−1.407	−2.042	−1.194	−1.296
	(1.318)	(1.632)	(0.914)	(1.025)
Average SOMA share (Near)	−13.846***	−14.305***	−14.339***	−14.791***
	(4.459)	(4.841)	(3.149)	(3.476)
Num.Obs.	106	106	109	109
R2 Adj.	0.803	0.785	0.619	0.615
F	74.875		50.555	
First stage Wald statistic:		35.162		23.452
Wu-Hausman test p-value:		0.020		0.536

Note:

This table reports results of "stock effect regressions". The dependent variable is measured as the price return for a particular security n between t and $t+h$. In columns 1 and 2, the start date is January 12, 2000, the day prior to the announcement of final rules for the Treasury buyback program. In columns 3 and 4, the end date is December 24, 2001, the day after the settlment date of the last buyback in 2001. Own Purchases equals the amount of security n purchased between dates t and $t+h$ as a fraction of the total amount of all Treasury securities outstanding within three years of security n. Near Purchases equals the fraction of all buybacks of near substitutes of n (excluding n itself) repurchased between dates t and $t+h$ divided by the total amount of all Treasury securities maturing within 3 years of n. In all regressions, all security-level variables are weighted by the amount outstanding of security n divided by total amount of all Treasury securities outstanding maturing within 3 years of that security. Column 2 reports estimates using two stage least squares, instrumenting for Own and Near Purchases. Excluded instruments from the first-stage regressions include: an indicator variable for whether the original maturity of security n 30 years and averages of remaining maturity, remaining maturity squared, log(bond price), current yield, and coupon rate for all securities that are near substitutes of security n. Heteroskedasticity-robust standard errors reported below coefficient estimates. ***, **, and * denote significance at the 1, 5, and 10 percent levels. Near substitutes are defined as all non-TIPS Treasury securities maturing within 3 years of the security n.

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

Table 10: Stock regression, dropping securities with less than 1 year to maturity on start date

Dependent variable:	Price return	
	OLS	IV
Own purchases	2.443***	2.970**
	(0.489)	(1.418)
Near purchases	0.588***	0.700***
	(0.089)	(0.178)
Remaining maturity	−0.526***	−0.603***
	(0.113)	(0.147)
Remaining maturity sq.	0.012***	0.014***
	(0.003)	(0.004)
SOMA share	−2.736**	−2.967**
	(1.215)	(1.363)
log(Price)	1.990***	2.171***
	(0.266)	(0.295)
Coupon rate	−0.755***	−0.823***
	(0.143)	(0.189)
Svennson pricing error	−1.121	−1.336
	(0.997)	(1.152)
Average SOMA share (Near)	−11.091***	−11.347***
	(3.694)	(4.130)
Num.Obs.	102	102
R2 Adj.	0.677	0.670
F	55.152	
First stage Wald statistic:		30.972
Wu-Hausman test p-value:		0.286

Note:

This table reports results of "stock effect regressions". The dependent variable is measured as the price return for a particular security n between t and $t+h$ where t is August 3, 1999, and $t+h$ is April 30, 2002. Own Purchases equals the amount of security n purchased between dates t and $t+h$ as a fraction of the total amount of all Treasury securities outstanding within three years of security n. Near Purchases equals the fraction of all buybacks of near substitutes of n (excluding n itself) repurchased between dates t and $t+h$ divided by the total amount of all Treasury securities maturing within 3 years of n. In all regressions, all security-level variables are weighted by the amount outstanding of security n divided by total amount of all Treasury securities outstanding maturing within 3 years of that security. Column 2 reports estimates using two stage least squares, instrumenting for Own and Near Purchases. Excluded instruments from the first-stage regressions include: an indicator variable for whether the original maturity of security n 30 years and averages of remaining maturity, remaining maturity squared, log(bond price), current yield, and coupon rate for all securities that are near substitutes of security n. Heteroskedasticity-robust standard errors reported below coefficient estimates. ***, **, and * denote significance at the 1, 5, and 10 percent levels. Near substitutes are defined as all non-TIPS Treasury securities maturing within 3 years of the security n, excluding any securities with less than 1 year left to maturity on the start date.

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

C.2 Flow effects

Table 11: Flow effects of buybacks on bond returns, excluding 2002 buybacks

Dependent variable:	1 day price return					
Date:	Announcement		Auction		Settlement	
Securities:	Eligible	Ineligible	Eligible	Ineligible	Eligible	Ineligible
	(1)	(2)	(3)	(4)	(5)	(6)
Own Purchases	−0.025		0.020		0.111***	
	(0.042)		(0.073)		(0.028)	
Near Purchases	−0.011	0.050	0.023	0.046	0.035**	0.060
	(0.014)	(0.062)	(0.039)	(0.064)	(0.014)	(0.039)
Far Purchases		−0.043		0.099*		0.086***
		(0.036)		(0.055)		(0.029)
Num.Obs.	478	5551	478	5553	478	5553
R2 Adj.	0.989	0.531	0.991	0.561	0.986	0.529
No. CUSIPS:	42	166	42	166	42	166
Cluster:	CUSIP	CUSIP	CUSIP	CUSIP	CUSIP	CUSIP

Note:

This table reports results of "flow effect regressions", excluding the buyback auctions in 2002. The dependent variable is measured as the price return for a particular security from close of the day before the indicated date to close of the indicated debt. Each regression uses CUSIP and auction fixed effects. Own purchases equals the amount of security n purchased between dates t and $t+h$ as a fraction of the total amount of all Treasury securities outstanding within three years of security n. Near Purchases equals the fraction of all buybacks of near substitutes of n (excluding n itself) repurchased between dates t and $t+h$ divided by the total amount of all Treasury securities maturing within 3 years of n. Near Purchases equals the fraction of all buybacks of near substitutes of n (excluding n itself) repurchased between dates t and $t+h$ divided by the total amount of all Treasury securities maturing within 3 years of n. Standard errors are clustered by CUSIP. ***, **, and * denote significance at the 1, 5, and 10 percent levels. Near Purchases and Far purchases are scaled purchases of securities maturing within 3 years and from 3-6 years of the security n, respectively.

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

Table 12: Flow effects of buybacks on bond returns: Neighbor 0-2 years

Dependent variable:	1 day price return					
Date:	Announcement		Auction		Settlment	
Securities:	Eligible	Ineligible	Eligible	Ineligible	Eligible	Ineligible
	(1)	(2)	(3)	(4)	(5)	(6)
Own Purchases	−0.002		0.016		0.057***	
	(0.020)		(0.031)		(0.016)	
Near Purchases	0.001	0.026	0.013	0.024	0.038***	0.016
	(0.011)	(0.061)	(0.018)	(0.057)	(0.010)	(0.038)
Far Purchases		−0.008		0.053*		0.052***
		(0.024)		(0.032)		(0.017)
Num.Obs.	513	5898	513	5900	513	5900
R2 Adj.	0.989	0.524	0.990	0.561	0.986	0.530
No. CUSIPS:	45	168	45	168	45	168
Cluster:	CUSIP	CUSIP	CUSIP	CUSIP	CUSIP	CUSIP

Note:

This table reports results of "flow effect regressions". The dependent variable is measured as the price return for a particular security from close of the day before the indicated date to close of the indicated debt. Each regression uses CUSIP and auction fixed effects. Own purchases equals the amount of security n purchased between dates t and $t+h$ as a fraction of the total amount of all Treasury securities outstanding within three years of security n. Near Purchases equals the fraction of all buybacks of near substitutes of n (excluding n itself) repurchased between dates t and $t+h$ divided by the total amount of all Treasury securities maturing within 2 years of n. Near Purchases equals the fraction of all buybacks of near substitutes of n (excluding n itself) repurchased between dates t and $t+h$ divided by the total amount of all Treasury securities maturing within 3 years of n.. Standard errors are clustered by CUSIP. ***, **, and * denote significance at the 1, 5, and 10 percent levels. Near Purchases and Far purchases are scaled purchases of securities maturing within 2 years and from 2-6 years of the security n, respectively.

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

Table 13: Flow effects of buybacks on bond returns: Neighbor 0-4 years

Dependent variable:	1 day price return					
Date:	Announcement		Auction		Settlement	
Securities:	Eligible	Ineligible	Eligible	Ineligible	Eligible	Ineligible
	(1)	(2)	(3)	(4)	(5)	(6)
Own Purchases	−0.035		0.068		0.134***	
	(0.065)		(0.118)		(0.044)	
Near Purchases	0.002	0.047	0.073	0.069	0.026	0.080**
	(0.031)	(0.075)	(0.067)	(0.065)	(0.033)	(0.040)
Far Purchases		−0.037		0.138		0.113**
		(0.058)		(0.085)		(0.049)
Num.Obs.	513	5898	513	5900	513	5900
R2 Adj.	0.989	0.524	0.990	0.561	0.986	0.530
No. CUSIPS:	45	168	45	168	45	168
Cluster:	CUSIP	CUSIP	CUSIP	CUSIP	CUSIP	CUSIP

Note:

This table reports results of "flow effect regressions". The dependent variable is measured as the price return for a particular security from close of the day before the indicated date to close of the indicated debt. Each regression uses CUSIP and auction fixed effects. Own purchases equals the amount of security n purchased between dates t and $t+h$ as a fraction of the total amount of all Treasury securities outstanding within three years of security n. Near Purchases equals the fraction of all buybacks of near substitutes of n (excluding n itself) repurchased between dates t and $t+h$ divided by the total amount of all Treasury securities maturing within 4 years of n. Near Purchases equals the fraction of all buybacks of near substitutes of n (excluding n itself) repurchased between dates t and $t+h$ divided by the total amount of all Treasury securities maturing within 3 years of n.. Standard errors are clustered by CUSIP. ***, **, and * denote significance at the 1, 5, and 10 percent levels. Near Purchases and Far purchases are scaled purchases of securities maturing within 4 years and from 4-6 years of the security n, respectively.

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

D Flow of Funds

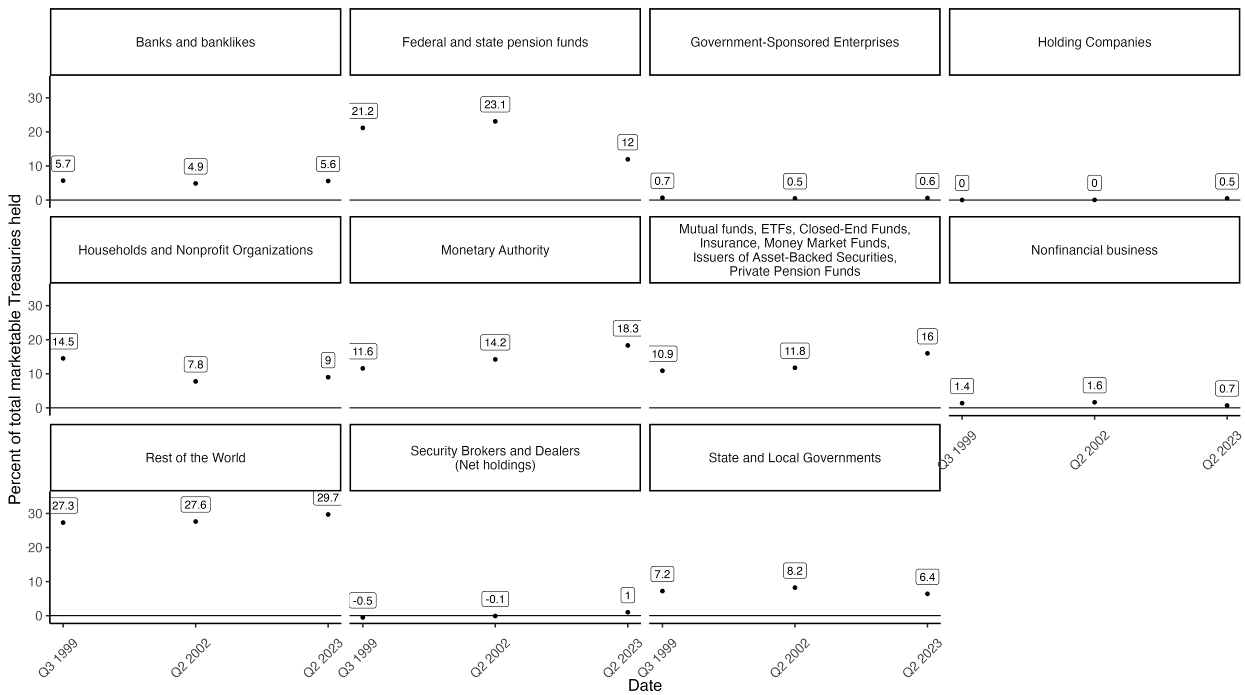

Figure 11: Holdings of Treasuries as assets, as a percentage of total Treasuries held as assets. Data taken from the Federal Reserve Board Flow of Funds data. Dates shown correspond to quarters at beginning and end of window for stock effect regressions and most recent data available. "Banks and Banklikes" includes U.S.-Chartered depository institutions, foreign banking offices in the U.S., Banks in U.S.-affiliated areas, and credit unions. Nonfinancial business includes holdins of both nonfinancial corporate and nonfinancial noncorporate business.

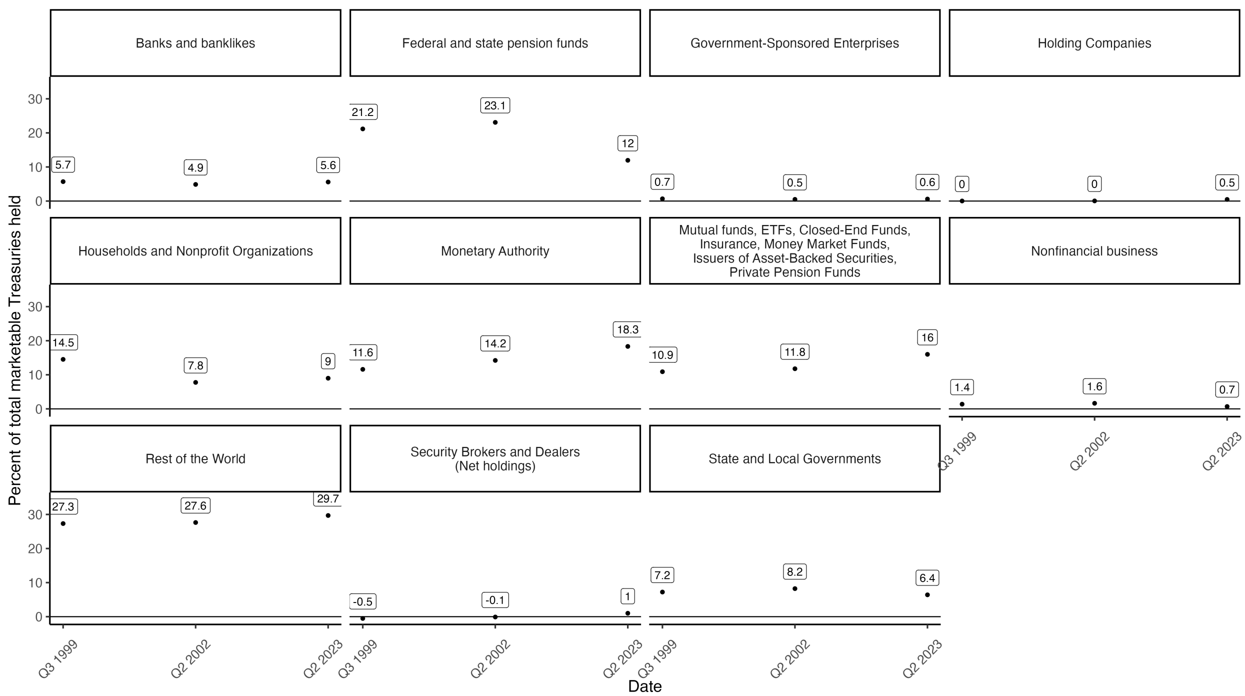

Figure 12: Holdings of Treasuries as assets, as a in billions of nominal USD. Data taken from the Federal Reserve Board Flow of Funds data. Dates correspond to quarters at beginning and end of window for stock effect regressions and most recent data available. "Banks and Banklikes" includes U.S.-Chartered depository institutions, foreign banking offices in the U.S., Banks in U.S.-affiliated areas, and credit unions. Nonfinancial business includes holdins of both nonfinancial corporate and nonfinancial noncorporate business.

E Robustness: SOMA portfolio

E.1 Stock effects

Table 14: Stock effects of Treasury buybacks on SOMA portfolio: alternative sample dates

Dates:	Jan 12, 2000 – Apr 30, 2002		Aug 3, 1999 – Dec 24, 2001	
Dependent variable:	Change in SOMA share			
	OLS	IV	OLS	IV
Own purchases	0.523	6.227**	1.178*	7.418***
	(0.637)	(2.388)	(0.676)	(2.533)
Near purchases	−0.484***	−1.004***	−0.400***	−0.931***
	(0.142)	(0.299)	(0.132)	(0.299)
Remaining maturity	0.033	0.206	−0.068	0.144
	(0.168)	(0.215)	(0.147)	(0.200)
Remaining maturity sq.	−0.001	−0.005	0.002	−0.003
	(0.004)	(0.005)	(0.004)	(0.005)
SOMA share	−7.470***	−9.529***	−8.214***	−8.990***
	(1.819)	(2.638)	(1.818)	(2.274)
log(Price)	0.078	−0.057	0.230	0.047
	(0.494)	(0.541)	(0.382)	(0.426)
Coupon rate	0.052	−0.290	0.076	−0.341
	(0.189)	(0.255)	(0.170)	(0.245)
Svennson pricing error	0.222	−0.326	0.110	−0.323
	(1.723)	(1.792)	(1.375)	(1.488)
Average SOMA share (Near)	−3.902	−0.141	−4.202	−0.372
	(7.457)	(7.747)	(5.244)	(5.588)
Num.Obs.	106	106	109	109
R2 Adj.	0.171	0.011	0.086	−0.053
F	7.525		6.877	
First stage Wald statistic:		5.820		5.507
Wu-Hausman test p-value:		0.037		0.084

Note:

This table reports results of "stock effect regressions" on the change in holdings in the SOMA portfolio. The dependent variable is measured as the change in the par value of security n held in the SOMA portfolio between t and $t + h$, as a fraction of the amount outstanding at time t. Own Purchases equals the amount of security n purchased between dates t and $t + h$ as a fraction of the total amount of all Treasury securities outstanding within three years of security n. Near Purchases equals the fraction of all buybacks of near substitutes of n (excluding n itself) repurchased between dates t and $t+h$ divided by the total amount of all Treasury securities maturing within 3 years of n. In all regressions, all security-level variables are weighted by the amount outstanding of security n divided by total amount of all Treasury securities outstanding maturing within 3 years of that security. Column 2 reports estimates using two stage least squares, instrumenting for Own and Near Purchases. Excluded instruments from the first-stage regressions include: an indicator variable for whether the original maturity of security n 30 years and averages of remaining maturity, remaining maturity squared, log(bond price), current yield, and coupon rate for all securities that are near substitutes of security n. Heteroskedasticity-robust standard errors reported below coefficient estimates. ***, **, and * denote significance at the 1, 5, and 10 percent levels. Near substitutes are defined as all non-TIPS Treasury securities maturing within 3 years of the security n.

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

Table 15: Stock effects of Treasury buybacks on SOMA portfolio: alternative window definitions

Near substitute:	Within 2 years		Within 4 years	
Dependent variable:	Change in SOMA share			
	OLS	IV	OLS	IV
Own purchases	0.397	5.119***	1.774**	10.011***
	(0.376)	(1.865)	(0.887)	(3.458)
Near purchases	−0.429***	−1.022***	−0.390***	−0.993***
	(0.124)	(0.301)	(0.114)	(0.290)
Remaining maturity	−0.010	0.172	−0.217	0.048
	(0.093)	(0.134)	(0.190)	(0.248)
Remaining maturity sq.	0.000	−0.004	0.006	−0.001
	(0.002)	(0.003)	(0.005)	(0.006)
SOMA share	−5.682***	−6.667***	−11.697***	−11.913***
	(1.250)	(1.834)	(2.573)	(3.255)
log(Price)	0.090	−0.139	0.645	0.556
	(0.207)	(0.258)	(0.639)	(0.712)
Coupon rate	0.086	−0.193	0.083	−0.633
	(0.118)	(0.217)	(0.270)	(0.382)
Svennson pricing error	−0.508	−0.959	−0.402	−1.355
	(1.070)	(1.180)	(1.811)	(2.227)
Average SOMA share (Near)	−3.020	1.718	−9.502	−9.578
	(2.569)	(3.239)	(10.117)	(10.910)
Num.Obs.	109	109	109	109
R2 Adj.	0.099	−0.111	0.087	−0.058
F	7.987		8.459	
First stage Wald statistic:		6.472		6.214
Wu-Hausman test p-value:		0.039		0.025

Note:

This table reports results of "stock effect regressions". In columns 1 and 2, the definition of "near substitute" is all securities maturing within two years (in absolute value) of a given security. In columns 3 and 4, the definition of "near substitute" is all securities maturing within four years (in absolute value) of a given security. Own Purchases equals the amount of security n purchased between dates t and $t+h$ as a fraction of the total amount of all Treasury securities outstanding within three years of security n. Near Purchases equals the fraction of all buybacks of near substitutes of n (excluding n itself) repurchased between dates t and $t+h$ divided by the total amount of all Treasury securities that are near substitutes of n. In all regressions, all security-level variables are weighted by the amount outstanding of security n divided by total amount of all Treasury securities that are near substitutes of security n. Columns 2 and 4 reports estimates using two stage least squares, instrumenting for Own and Near Purchases. Excluded instruments from the first-stage regressions include: an indicator variable for whether the original maturity of security n 30 years and averages of remaining maturity, remaining maturity squared, log(bond price), current yield, and coupon rate for all securities that are near substitutes of security n. Heteroskedasticity-robust standard errors reported below coefficient estimates. ***, **, and * denote significance at the 1, 5, and 10 percent levels.

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

E.2 Flow effects

Table 16: Flow effects of buybacks on SOMA portfolio: Neighbor 0-2 years

Dependent Variable:	Cumulative Change in SOMA			
Number of Weeks:	0	1	2	3
	(1)	(2)	(3)	(4)
Own Purchases	0.00*	0.00*	0.08	0.72
	(-1.93)	(-1.76)	(-1.45)	(-0.29)
Near Purchases (<2yr)	0.83	0.81	0.56*	0.63*
	(-0.39)	(-0.51)	(-1.85)	(-1.83)
Far Purchases (2-6yr)	0.81	1.07	0.71*	0.97
	(-0.65)	(0.29)	(-1.68)	(-0.18)
Observations	4,749	5,196	5,488	5,491
CUSIPs	115	127	134	135
Pseudo R-squared	0.14	0.09	0.09	0.08
CUSIP Fixed Effects	Y	Y	Y	Y
Auction Date Fixed Effects	Y	Y	Y	Y

This table reports results of where n denotes a particular Treasury security. The estimating equation is: $Pr((S_{n,t,t+h} > 0)|q_{n,0,t}, q_{n,1,t}) = F(\alpha_t + \alpha_n + \beta_0 q_{n,0,t} + \beta_1 q_{n,1,t})$, where F is the cumulative logistic distribution function. $S_{n,t-1,t+h}$ is the change in the amount of security n held in Fed's SOMA account between weeks t and $t+h$ divided by the total amount outstanding in week t. $q_{n,0,t}$ (Own Purchases) equals the amount of security n purchased in auction week t as a fraction of the total amount of all Treasury securities outstanding that are maturing within 2 years of security n (in absolute value terms). $q_{n,1,t}$ (Near Purchases) equals the fraction of all buybacks maturing within 2 years of security n (excluding n) repurchased in auction week t divided by the total amount of all Treasury securities outstanding that are maturing within 2 years of security n (in absolute value terms). $q_{n,2,t}$ (Far Purchases) equals total purchases maturing within 2-6 years divided by the total amount of all Treasury securities outstanding that are maturing within 2 years of security n. The sample includes all off-the-run Treasury securities with an original maturity greater than 5 years that were both eligible and ineligible to be repurchased on a given buyback date. The inclusion of CUSIP fixed effects necessitates that each security appears at least twice in the sample period of March 9, 2000 (first auction) to April 25, 2002 (last auction) and has at least one positive observation of $S_{n,t-1,t+h}$. Standard errors reported below coefficient estimates are clustered at the CUSIP level. ***, **, and * denote significance at the 1, 5, and 10% levels.

Table 17: Flow effects of buybacks on SOMA portfolio: Neighbor 0-4 years

Dependent Variable:	Cumulative Change in SOMA			
Number of Weeks:	0	1	2	3
	(1)	(2)	(3)	(4)
Own Purchases	0.00*	0.00	0.02	0.51
	(-1.65)	(-1.51)	(-1.32)	(-0.30)
Near Purchases (<4yr)	0.46	0.74	0.41**	0.63
	(-1.20)	(-0.57)	(-2.24)	(-1.40)
Far Purchases (4-6yr)	0.68	1.38	0.52	1.05
	(-0.42)	(0.45)	(-1.15)	(0.10)
Observations	4,749	5,196	5,488	5,491
CUSIPs	115	127	134	135
Pseudo R-squared	0.14	0.09	0.09	0.08
CUSIP Fixed Effects	Y	Y	Y	Y
Auction Date Fixed Effects	Y	Y	Y	Y

This table reports results of where n denotes a particular Treasury security. The estimating equation is: $Pr((S_{n,t,t+h} > 0)|q_{n,0,t}, q_{n,1,t}) = F(\alpha_t + \alpha_n + \beta_0 q_{n,0,t} + \beta_1 q_{n,1,t})$, where F is the cumulative logistic distribution function. $S_{n,t-1,t+h}$ is the change in the amount of security n held in Fed's SOMA account between weeks t and $t+h$ divided by the total amount outstanding in week t. $q_{n,0,t}$ (Own Purchases) equals the amount of security n purchased in auction week t as a fraction of the total amount of all Treasury securities outstanding that are maturing within 4 years of security n (in absolute value terms). $q_{n,1,t}$ (Near Purchases) equals the fraction of all buybacks maturing within 4 years of security n (excluding n) repurchased in auction week t divided by the total amount of all Treasury securities outstanding that are maturing within 4 years of security n (in absolute value terms). $q_{n,2,t}$ (Far Purchases) equals total purchases maturing within 4-6 years divided by the total amount of all Treasury securities outstanding that are maturing within 4 years of security n. The sample includes all off-the-run Treasury securities with an original maturity greater than 5 years that were both eligible and ineligible to be repurchased on a given buyback date. The inclusion of CUSIP fixed effects necessitates that each security appears at least twice in the sample period of March 9, 2000 (first auction) to April 25, 2002 (last auction) and has at least one positive observation of $S_{n,t-1,t+h}$. Standard errors reported below coefficient estimates are clustered at the CUSIP level. ***, **, and * denote significance at the 1, 5, and 10% levels.

Table 18: Flow effects of buybacks on SOMA portfolio: December 2001 End Date

Dependent Variable:	Cumulative Change in SOMA			
Number of Weeks:	0	1	2	3
	(1)	(2)	(3)	(4)
Own Purchases	0.00*	0.00	0.02	0.64
	(-1.86)	(-1.64)	(-1.54)	(-0.24)
Near Purchases (<3yr)	0.57	0.70	0.50*	0.63
	(-0.92)	(-0.74)	(-1.93)	(-1.60)
Far Purchases (3-6yr)	0.99	1.26	0.61	1.06
	(-0.02)	(0.56)	(-1.49)	(0.21)
Observations	4,437	4,893	5,167	5,167
CUSIPs	114	127	134	134
Pseudo R-squared	0.15	0.09	0.09	0.08
CUSIP Fixed Effects	Y	Y	Y	Y
Auction Date Fixed Effects	Y	Y	Y	Y

This table reports results of where n denotes a particular Treasury security. The estimating equation is: $Pr((S_{n,t,t+h} > 0)|q_{n,0,t}, q_{n,1,t}) = F(\alpha_t + \alpha_n + \beta_0 q_{n,0,t} + \beta_1 q_{n,1,t})$, where F is the cumulative logistic distribution function. $S_{n,t-1,t+h}$ is the change in the amount of security n held in Fed's SOMA account between weeks t and $t+h$ divided by the total amount outstanding in week t. $q_{n,0,t}$ (Own Purchases) equals the amount of security n purchased in auction week t as a fraction of the total amount of all Treasury securities outstanding that are maturing within 3 years of security n (in absolute value terms). $q_{n,1,t}$ (Near Purchases) equals the fraction of all buybacks maturing within 3 years of security n (excluding n) repurchased in auction week t divided by the total amount of all Treasury securities outstanding that are maturing within 3 years of security n (in absolute value terms). $q_{n,2,t}$ (Far Purchases) equals total purchases maturing within 3-6 years divided by the total amount of all Treasury securities outstanding that are maturing within 3 years of security n. The sample includes all off-the-run Treasury securities with an original maturity greater than 5 years that were both eligible and ineligible to be repurchased on a given buyback date. The inclusion of CUSIP fixed effects necessitates that each security appears at least twice in the sample period of March 9, 2000 (first auction) to December 24, 2001 and has at least one positive observation of $S_{n,t-1,t+h}$. Standard errors reported below coefficient estimates are clustered at the CUSIP level. ***, **, and * denote significance at the 1, 5, and 10% levels.