Treasury Buybacks, the Federal Reserve's Portfolio, and Changes in Local Supply

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Abstract

We document spillover effects of the 2000-2002 Treasury Buyback program on Treasury returns and the composition of the Federal Reserve's System Open Market Account (SOMA) portfolio. The reduction in bond supply due to the buybacks contributed an average of 95 basis points to the yields of bonds bought back and bonds of similar maturity over the course of the program. Each $10 billion of purchases corresponded with an average yield increase of 7.8 basis points. At a higher frequency, prices of purchased and near substitute bonds increased on settlement dates. Changes to the SOMA portfolio were smaller for securities exposed to the buybacks and tended to occur outside of auction weeks, consistent with the Federal Reserve attempting to avoid exacerbating Treasury supply shortages. We relate our findings to the theoretical literature on asset supply in preferred habitats models of the term structure. Our results suggest that the proposed reintroduction of the Treasury buyback program will have limited effects due to its size and proposed composition.

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1 Introduction

Changes in Treasury supply can affect both the price of that debt and the implementation of monetary policy. In this paper, we study one such change in supply: the 2000-2002 Treasury buyback policy. This policy sizeably reduced the publicly-held supply of certain long-term Treasury bonds. Revisiting this program is both informative about the predictions of preferred habitat models of the term structure and relevant to recently proposed Treasury policy. We use this program (and its particular features) as a quasi-experiment to test whether the effect of changes in asset supply accords with preferred habitats models. Additionally, we investigate whether changes in supply induced by the buybacks might have affected the behavior of a large holder of Treasury debt, the Federal Reserve.

The recent literature on preferred habitats has emphasized that changes in the available supply of a given asset may significantly impact the price of that asset and of its substitutes (Vayanos and Vila (2021)). Indeed, Bernanke et al. (2004) used the change in expected supply from the Treasury's buyback policy announcements as a rationale for central bank asset purchases at the effective lower bound, and Greenwood and Vayanos (2014) argued that the reaction of the yield curve to buybacks was qualitatively consistent with preferred habitats models. However, Han et al. (2007) concluded that the auctions had relatively small effects on Treasury yields and liquidity. The high-frequency study of price response to buybacks in Han et al. (2007), however, did not allow for the spillovers emphasized by the preferred habitat literature, and did not consider cumulative effects.

Revisiting the buyback program is interesting not only due to the mixed evidence in the existing literature, but because it represents a change in the relative supply of assets unconnected with macroeconomic stabilization policy. Many previous studies of local supply effects (for example, D'Amico and King (2013)) have focused on purchases of Treasury debt by the Federal Reserve when interest rates were at the effective lower bound. The buyback program is arguably quite different, not least because it was conducted by the Treasury itself. Furthermore, the policy was introduced when interest rates were away from the effective lower bound. The structural model of King (2019) suggests that exogenous supply changes have different effects depending on whether short rates are close to their lower bound. Overall, we find that the Treasury buybacks had sizeable cumulative effects on bond returns and that purchases spilled over to near substitutes, in accordance with the predictions of preferred habitats models.

Additionally, we highlight the importance of understanding the central bank's reaction to supply-qua-supply shifts, which presents a new empirical fact that can be incorporated into future work. 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. This data was not (to our knowledge) previously publicly available for this period. Omitting SOMA holdings leads to underestimate the effects of the buybacks on Treasury bond returns over the life of the program.

Specifically, we examine both the "stock" and "flow" effects of Treasury buybacks for the 2000-2002 period.[1] We find that the buyback program had a statistically significant and economically sizable impact on prices. This includes both the direct effects of the reduction in available supply of repurchased bonds, as well as changes in the prices of bonds of a similar maturity (the "local supply" channel). Our point estimates imply that, on average, 95 basis points of price returns on bonds exposed to the buybacks can be attributed to changes in the supply of Treasuries. Purchases of Treasury bonds also significantly drove up the prices of near substitute bonds. 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 44%, and failing to control for the composition of the SOMA portfolio understates the effect of buybacks by about 13%. This last point implies that assessments of local supply channels in the Treasury market must take into account effective local supply outside of the Federal Reserve's portfolio, not simply the remaining quantity outstanding.

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. This is a more formal version of the event study approach used in Greenwood and Vayanos (2014) and Bernanke et al. (2004). The advantage of the event

[1] We borrow this terminology from D'Amico and King (2013), 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).

study, relative to the cross-sectional regression, is that we can incorporate fixed effects for individual securities and auctions. We find that among eligible securities, there are significant 1-day returns on settlement dates, but not auction dates. Among ineligible securities, there are significant one day returns on both auction and settlement dates. However, the magnitudes of one day returns are small overall, with implied yield changes of a basis point or smaller. Cumulative price returns around auctions peak and are significant on settlement dates, where the point estimates are largest for own purchases, followed by near substitutes, followed by far substitutes. As with the stock regressions, this is consistent with "local supply" effects of Treasury supply changes.

We then ask whether the Federal Reserve's management of its portfolio was impacted by these purchases. Although the Federal Reserve did not participate in the buyback auctions, we may have expected it to adjust its holdings either to 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. Here, our results are mixed. Own purchases are associated (but not always significantly) with *increased* holdings in the SOMA portfolio all else equal, but near purchases are significantly associated with *decreases*. The latter effect appears to dominate. Summing the predicted effects, SOMA holdings were lower as a result of the buybacks relative to a no-buyback counterfactual. In other words, while the SOMA share of securities increased overall during this period, they increased less for securities that were bought back or for their near substitutes. Our OLS (IV) estimates imply the sum of effects of own and near purchases on the SOMA's relative holdings was -3.4% (-4.3%). At a higher (weekly) frequency, the evidence is also mixed, but mainly points to the Federal Reserve not increasing holdings in weeks following buyback auctions for "treated" securities. In our primary specification, we find zero evidence that the Federal Reserve's probability of purchasing a security was impacted by whether the security had been bought back recently. Some alternative specifications indicate the Federal Reserve 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 Federal Reserve attempting to avoid impacting markets by further limiting the tradeable supply of Treasury bonds during the buyback period.

In addition to theoretical interest, a revisit of the 2000-02 buyback episode can provide insights into the impact of the recently announced Treasury policy. 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. 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 impact on prices, which may result in greater costs of debt issuance.[2] Understanding the impact of buybacks on prices, therefore, is a first-order policy question for the Department of the Treasury.

Although Treasury's plans for new buybacks are still developing, we use our estimated stock effects results to examine the possible impact of the new buyback program. Our estimates imply that 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 and old programs is mainly driven by 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 in general. Overall, our analysis suggests that the proposed buyback revival will have limited impacts on Treasury yields.

As mentioned above, this paper contributes to the literature on the supply of safe assets and its effects on investor behavior and monetary policy. Our results suggest that models of preferred habitats that feature priced supply shocks and endogenous supply generate the "local" nature of price responses to supply changes (like buybacks) that are consistent with both our stock and flow results. However, these models suggest prices should shift when policies are announced (or when the shock occurs). Our event study, by contrast, suggests that policies shifted on settlement dates, several days *after* the change in supply would have been known to market participants. This implies the timing of market reaction to buyback

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

auction is consistent with existing findings in the literature on Treasury issuance auctions (e.g. Lou et al. (2013)).

The next section reviews the institutional details of the buyback episode and the related literature. Following that, we examine the impacts of the buybacks on returns, connect those impacts to the preferred habitats literature, and examine the effects on SOMA portfolio holdings. We then quantify possible price impacts of the Treasury's proposed buyback program revival before concluding.

2 Institutional background and related literature

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 occurred between 2000 and 2002.[4] Over the course of the program, Treasury bought back $67.5 billion of 42 different securities, including 9 callable securities and two Treasury Inflation Protected Securities (TIPS). Importantly, the details of the program's size and pace were not known even after the auction process was finalized. For a given auction, whether a particular CUSIP would be purchased (much less the quantity or price) was also not known until the results were announced. More institutional details, and a timeline of the program, are included in Appendix A.

Treasury buybacks and the SOMA portfolio The buyback auctions, and the broader issue of declining Treasury issuance, created difficulties for the management of the Federal Reserve's SOMA portfolio. In early 2000, the yield curve was inverted; this was attributed,

[3] More extensive reviews of the buyback program are found in Garbade and Rutherford (2007), Merrick (2005), and Han et al. (2007).

[4] 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)). The last three buyback auctions occurred in 2002 and were presented as a way of managing stronger-than-expected tax receipts.

at the time, to the perceived shortage in long-term Treasury debt. 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."[5] In the May 2000 FOMC meeting, Fisher remarked that declining long-term Treasury securities posed challenges in managing the SOMA portfolio, in part due to buybacks. Fisher also noted at that meeting that "most knowledgeable observers" in bond markets anticipated further repurchases in 2001. The FOMC transcripts also suggest that the Federal Reserve was primarily reacting to changes in Treasury supply in an attempt to not disrupt markets. During the January 30, 2001 FOMC meeting, Fisher explained: "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."

In short, 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. However, it was not obvious how this would translate to actual changes in the SOMA portfolio or how the "intramural courtesy" was carried out in practice.

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. Greenwood and Vayanos (2014) examine changes in the yield curve around the first few buyback auctions as evidence supporting a preferred habitats view of price determination. Longstaff (2004) finds that the liquidity premium was 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

[5] March 21, 2000 FOMC meeting transcript.

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 fed back into prices of *ineligible* near-neighbor securities. Furthermore, we also illuminate an additional feedback effect of reductions in local Treasury supply on the Federal Reserve'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 Federal Reserve 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 Federal Reserve's policies in section 3. Our paper is also related to the structural literature on preferred habitats investors following Vayanos and Vila (2021); we discuss this at the end of section 3.

2.3 Data

SOMA holdings Using data obtained via a FOIA request, we construct a weekly panel of Treasury securities held by the public and the Federal Reserve from September 1997-July 2003 at the individual CUSIP level.[6] This data set considerably extends the available sample of security-level data at the weekly level and allows us to quantify the publicly available supply of Treasuries during the Treasury buyback program that 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 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

[6]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. Data from July 2003-onward is publicly available on the Federal Reserve Bank of New York's web site.

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 15% for 30 year securities.[7] In our reconstruction of limits for individual securities shown in figure 1, we assume that the change in the limits is 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[8] and with the amended limits after the introduction of 3-year notes.[9] 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. We make adjustments to the supply measure reported in CRSP. The CRSP daily supply measure is that month's observation from the Monthly Statement on the Public Debt; we convert this measure to a daily frequency by adding new issuance from Treasury auctions and decreases from buybacks and redemptions (the latter taken from the Monthly Statement of the Public Debt).

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" effect of purchases at particular auctions. We adopt this terminology and methodology from D'Amico and King (2013), who studied the effects of the first round of Large Scale Asset Purchases (LSAPs). We argue that their methodology is appropriate for a number of reasons. Like the LSAPs, the buybacks represented a sizeable shift in the supply of Treasuries outstanding. While the absolute scale in dollar terms of the first round of LSAPs was about four and a half

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

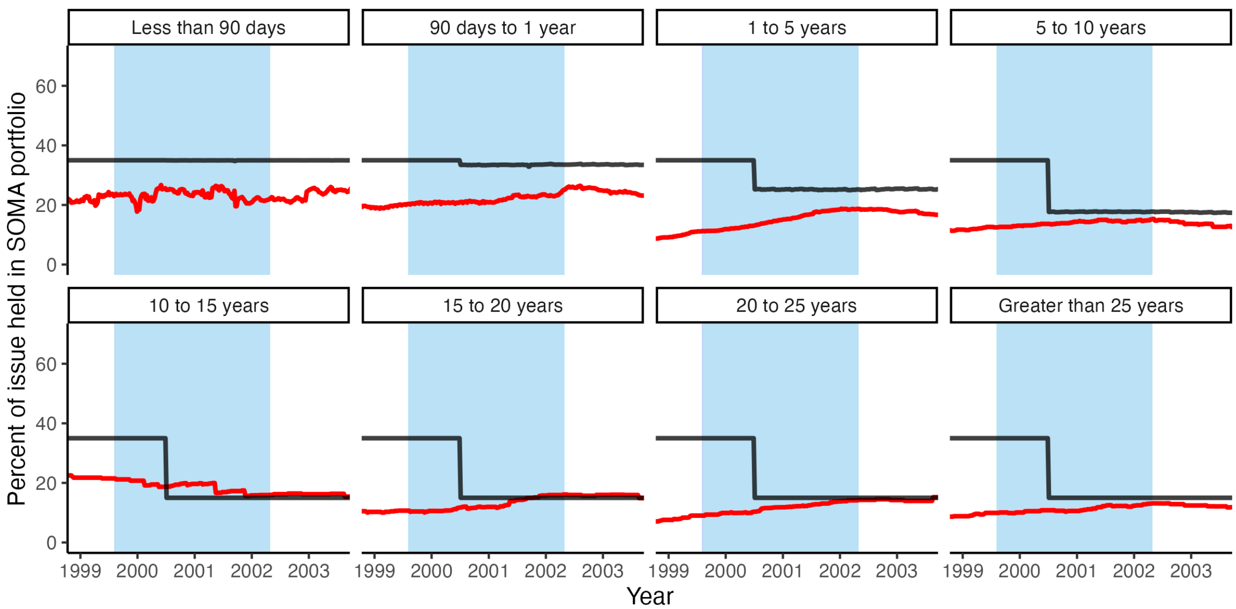

Figure 1: Plot of weighted average share of nominal Treasury securities held in SOMA portfolio by maturity bucket. Red lines indicate weighted average, where weights are calculated by the share of that security relative to total debt outstanding. Black lines indicate self-imposed limits on quantity of 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.

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 (2013), we can examine how otherwise similar securities were impacted. Finally, like the first round of LSAPs, 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 buyback program reflected a period of declining deficits and relatively small Treasury issuance. Moreover, short term rates were far from the effective lower bound (ELB) 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 ELB period, we might anticipate that the preferred habitats-driven effects of LSAPs would be different than buybacks. Indeed, in the context of a Vayanos and Vila-style model with an effective lower bound, King (2019) illustrates the effects of supply shocks may be relatively attenuated when rates are close to the ELB. Hence, our estimates may give a better sense of the transmission of local supply shocks away from the ELB and, alongside the results of D'Amico and King (2013), serve as a test of this prediction. 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. Thus, buybacks serve as a clean test of the effects of supply shocks on Treasury prices.

3.1 Stock effects

3.1.1 Methodology

We begin our analysis of the Treasury's buyback program by investigating stock effects on prices: whether changes in local supply of a given security affected cumulative price returns over the length of the program. Our main hypothesis is that a decrease in the local supply of a given Treasury security increased its price and subsequent return. Our starting point for this analysis is August 3, 1999, 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.[10] To the extent that the effects of buybacks might have been 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 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.

For a particular security n, $R_{n,t,t+h}$ is the cumulative percent return of Treasury security n from just before the buyback announcement to the last settlement date. Specifically, t is August 4, 1999, and $t+h$ is April 30, 2002, the last settlement date of the program. We estimate the following Ordinary Least Squares (OLS) regression:

$$R_{n,t,t+h} = \alpha^{OLS} + \beta_0^{OLS} q_{n,0,t,t+h} + \beta_1^{OLS} q_{n,1,t,t+h} + \delta_0^{OLS} X_{n,0,t} + \delta_1^{OLS} X_{n,1,t} + \epsilon_{n,t,t+h}^{OLS} \qquad (1)$$

$q_{n,0,t,t+h}$ (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

[10] 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)).

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 focus on the set of securities with original maturity over 5 years that do not mature prior to April 30, 2002.

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 as the stated purpose of the program was to decrease the average maturity and interest costs of Treasury debt (U.S. Department of Treasury (2000)).[11] Furthermore, the security's remaining maturity (and its square) control for duration and convexity effects that might have differentially affected 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.[12] Lastly, similar to D'Amico and King (2013) 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 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 systematic changes in supply and demand. Summary statistics of the data used in the stock regressions are shown in panel A of table 1. The unweighted data and additional bond characteristics

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

[12]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).

are reported in panel B.

Table 1: Descriptive statistics for stock regressions

Panel A: Scaled as in 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	0.92	[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)	[0.01, 0.65]	0.15	0.12	0.14	[0.03, 0.21]
100 × Pricing error (own)	[-4.07, 0.43]	−0.24	−0.08	0.54	[-0.26, -0.02]
100 × Pricing error (average near)	[-2.45, 0]	−0.19	−0.07	0.33	[-0.21, -0.02]
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]

Panel B: Unscaled stock regression data and additional bond characteristics

Variable	Range	Mean	Median	SD	IQR
Maturity remaining (years) (average near)	[2.02, 28.07]	11.46	8.52	8.75	[3.46, 19.27]
Log price (own)	[4.46, 5.01]	4.71	4.67	0.13	[4.6, 4.81]
Log price (average near)	[3.91, 4.67]	4.47	4.54	0.15	[4.37, 4.58]
Coupon rate (own)	[2.12, 7]	3.98	3.62	1.22	[3, 4.61]
Coupon rate (average near)	[2.71, 5.19]	3.42	3.21	0.51	[3.09, 3.68]
Pricing error (own)	[-39.88, 20.62]	−4.81	−2.73	9.83	[-4.5, -1.63]
Pricing error (average near)	[-19.67, -1]	−3.39	−1.94	3.09	[-3.5, -1.74]
SOMA share (own)	[4.86, 39.38]	13.11	12.73	6.22	[9.25, 13.56]
SOMA share (average near)	[9.09, 23.11]	13.14	11.75	3.56	[11.03, 14.39]
%Δ SOMA holdings	[0, 38.33]	5.04	3.71	5.46	[1.44, 7.25]
Maturity at issue (percent of total):	5 years	17.6%			
	10 years	22.5%			
	20 years	10.8%			
	30 years	49.0%			

Note: Data in panel A (except returns and near purchases) are scaled by the quantity of near outstanding Treasury debt as in the regression; panel B reports raw data. Returns, own purchases, coupon rates, pricing errors, and SOMA shares are all multiplied by 100 to report them in percentage points. Purchases and maturity remaining are expressed as a fraction of the three-year maturity bucket around each security. SOMA shares are expressed as a fraction of total outstanding. 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. "%Δ SOMA holdings " is the change in SOMA holding of a particular security as a fraction of the amount of the security outstanding as of August 3, 1999.

Our main objective is to quantify the overall impact of buybacks on Treasury returns, while allowing for substitution effects motivated by preferred habitats. 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 (2013) 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: an indicator variable for whether a security's maturity at issue was originally 30 years or not, the average maturity (and its square), log bond price, and coupon rate for near securities n.[13]

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 the asset's price prior to the buyback announcement. These factors 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 variable for whether the bond was a 30-year at its 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).

[13] 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 characteristics

	Own Purchases	Near Purchases
Average maturity (Near)	0.172**	1.100***
	(0.072)	(0.322)
Average maturity sq. (Near)	−0.003*	−0.028***
	(0.002)	(0.008)
Average log price (Near)	−0.150	0.494
	(0.130)	(1.059)
Average coupon (Near)	−0.148	−0.241
	(0.129)	(0.473)
30 year issue	−0.002	0.028**
	(0.001)	(0.013)
Average SOMA share (Near)	−1.144	−12.593***
	(0.979)	(3.873)
Remaining maturity	−0.123**	−0.681**
	(0.056)	(0.289)
Remaining maturity sq.	0.002	0.015**
	(0.001)	(0.006)
SOMA share	0.356	−0.950
	(0.239)	(1.464)
log(Price)	0.216	−0.212
	(0.137)	(1.016)
Coupon rate	0.032	−0.126
	(0.031)	(0.196)
Svensson pricing error	0.118	−0.320
	(0.190)	(1.213)
Average pricing error (Near)	−0.952	−7.890
	(1.568)	(5.509)
Num.Obs.	102	102
R2 Adj.	0.724	0.924
F	37.422	178.954

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.

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.

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 2.44% (0.61%) relative increase in the price over the period of August 1999-April 2002. These price changes are consistent with yield changes of -24.03 and -6.01 basis points for Own and Near purchases, respectively, given an average duration of 9.85 years for eventually repurchased securities.[14]

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, then the reduced form regression of returns on buybacks would be biased downward. Qualitatively, 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 calculate the impact of supply changes across the yield curve. The IV estimates facilitate calculation of counterfactual price returns ($R_{n,t,t+h} - \widehat{\beta_0^{IV}}\hat{q}_{n,0,t,t+h} - \widehat{\beta_1^{IV}}\hat{q}_{n,1,t,t+h}$). We use those price returns to calculate the implied price if no purchases had occurred then convert this to a counterfactual yield

[14] These yield changes are based on the approximation of modified duration: $\Delta y_{n,t,t+h} \approx -D_n \times R_{n,t,t+h}$ where $y_{n,t}$ is the yield-to-maturity of bond n and D_n is its modified duration.

Table 3: Stock Effects of Treasury Buybacks

Dependent variable:	Price return	
	OLS	IV
Own purchases	2.443***	3.071**
	(0.494)	(1.462)
Near purchases	0.610***	0.730***
	(0.085)	(0.172)
Remaining maturity	−0.601***	−0.687***
	(0.105)	(0.138)
Remaining maturity sq.	0.014***	0.016***
	(0.003)	(0.004)
SOMA share	−3.156**	−3.441**
	(1.242)	(1.420)
log(Price)	2.183***	2.393***
	(0.250)	(0.274)
Coupon rate	−0.758***	−0.840***
	(0.138)	(0.192)
Svennson pricing error	−1.121	−1.380
	(0.987)	(1.175)
Average pricing error (Near)	−3.450**	−3.848**
	(1.553)	(1.736)
Average SOMA share (Near)	−13.617***	−14.068***
	(3.478)	(3.955)
Num.Obs.	102	102
R2 Adj.	0.695	0.686
F	54.632	
First stage Wald statistic:		30.542
Wu-Hausman test p-value:		0.142

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 was 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.

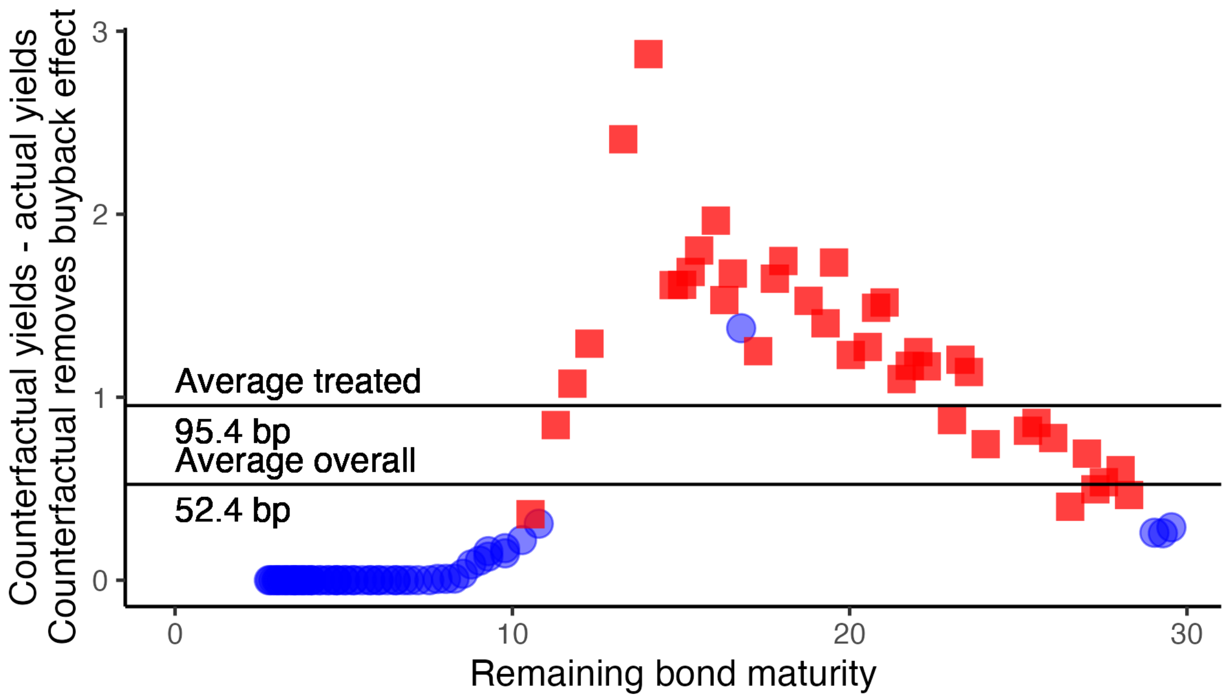

Figure 2: Difference in yields attributable to direct and local changes in supply. Counterfactual price changes are actual price returns minus counterfactual returns predicted by equation (2): $R_{n,t,t+h} - \widehat{\beta_0^{IV}} \hat{q}_{n,0,t,t+h} - \widehat{\beta_1^{IV}} \hat{q}_{n,1,t,t+h}$. Counterfactual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

to maturity. The implied difference in yields relative to this counterfactual is displayed in figure 2. The contribution of supply effects is concentrated in securities with 10-20 years left to maturity, but there are spillovers to securities with fewer than 10 years and as much as 30 years remaining.

Across all off-the-run Treasuries, our IV estimates imply that the changes in supply from the buyback program increased returns. Among "treated" securities (those bought back or their near neighbors), our estimates imply yields were 95 basis points higher than they would have been in the absence of the buybacks. This change is highly economically significant. For treated securities, the mean predicted return ($R_{n,t,t+h} - \widehat{\beta_0^{IV}} \hat{q}_{n,0,t,t+h} - \widehat{\beta_1^{IV}} \hat{q}_{n,1,t,t+h}$) after removing local supply effects is -3.96%; the actual price return for these securities was 4.54%.

These magnitudes are larger than findings in D'Amico and King (2013). They approximate the average elasticity of the first round of LSAPs by looking at the average effect on the entire yield curve (in their case, approximately 30 basis points); given \$300 billion in purchases, it took approximately \$10 billion in purchases to generate a 1 basis point change in yields. Given an average change in yields (across the entire yield curve) of about 52.4 basis points after $67.5 billion in buybacks, the Treasury buybacks had approximately 7.8 times the effect size as the LSAPs. On face, this is quite surprising, given that the Federal Reserve was explicitly trying to move yields. However, we note two facts that explain the relative effect sizes. First, the buybacks were more concentrated than the first LSAP program, which purchased securities across the yield curve. D'Amico and King (2013) estimate the largest effects of (own) purchases during LSAPs for the most off-the-run bonds and larger effects for bonds with fewer than 15 years of maturity remaining – precisely the set of bonds that the buyback program targeted. Second, the LSAPs occurred at the effective lower bound on interest rates. The shadow rate preferred habitats model in King (2019), suggests that at this bound, the covariance between supply changes and interest rate volatility is attenuated. This implies supply changes have smaller effects on bond prices. In short, both the design of the buyback program and the endogenous change in risks at the effective lower bound help explain why the elasticity of prices with respect to supply decreases is larger for the buyback period.

In appendix B, we illustrate 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 omitted variable bias in both cases is an attenuated estimate of the 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 wa(Longstaff (2004), Merrick (2005), Han et al. (2007)).

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, (3) using a less conservative start date (January 2000, when the actual buyback programs were announced), and (4) using a much more conservative start date (February 2, 1998, the first reference to buybacks in the TBAC minutes). 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 buybacks had direct and indirect effects that were both significant and consistent with a local supply channel, and the effects of purchases were likely impacted by the relative holdings in the SOMA portfolio of own and near substitutes.

We also examine the effects of the buyback program on the cross section of changes in liquidity as proxied by changes in pricing errors (relative to the Svensson-implied price of the bond). Summary statistics of the pricing errors at the start and end of the program (and their change) are found in appendix C.2, as are the estimated results. We find that own purchases are associated with a sizeable increased price relative to the Svennson-implied price and a significant decrease in squared pricing error. There is relatively little evidence of spillover effects on near substitutes. This is suggestive that the buyback program did increase the liquidity of bonds purchased in the buyback.

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 bank-like 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 Treasury securities in the program ultimately being purchased from households and hedge funds (via primary dealers) and the Federal Reserve 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?

We examine this question in the context of a panel event study. Here, we 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 received bids but were not 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 main limitation relative to the stock effects approach is that the window may be too small to capture the full impact of purchases, since the infrequent trading of off-the-run securities might make the prices slow to change.

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 appear at least twice in the sample period of March 9, 2000 (first auction) to April 25, 2002 (the last auction). α_t denotes 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:

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

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.[15]

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 of equations 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. This effect is on the order of trading costs for Treasury bonds estimated

[15] There is a small difference in specification relative to D'Amico and King (2013) and to the stock regression. We use slightly larger groupings than D'Amico and King (2013) 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.

using high-frequency data around this time period.[16] 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 basis point for Own and Near purchases, respectively. Economically, these one day return differences are small; qualitatively, they are consistent with substitution effects due to local supply. Among ineligible securities, we find statistically significant flow effects on settlement dates for "far" substitutes.[17]

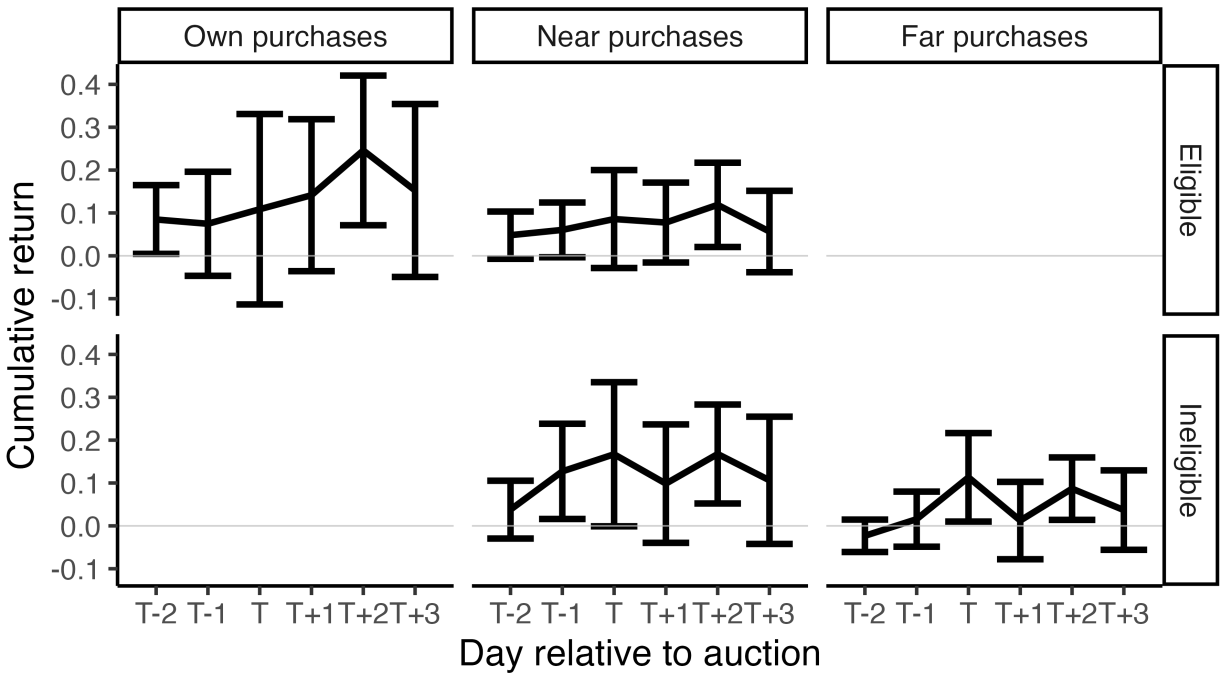

Figure 3: Plot of coefficients of Own, Near, and Far purchases from flow effects regressions. The dependent variables in the regressions are the cumulative returns on Treasury securities relative to three days before each buyback auction. The top row is the subsample of eligible securities, and the bottom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

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 coefficient from

[16]For the period 1995-1997, Chakravarty and Sarkar (2003) estimate that trading costs in Treasury markets were about eight cents per 100 dollars of par value.

[17]The lack of significance for near substitutes among ineligible securities is somewhat surprising. As shown in appendix C.3, this feature holds for some, but not all, specifications we examine; far purchases tend to be significant in the flow regressions on settlement dates, and occasionally on auction dates; near purchases are sometimes, but not always, significant on settlement dates and usually not on auction dates. In table C.11, we include near and far purchases separately and find that near purchases alone are only significant on settlement dates.

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	−0.019		0.033		0.102***	
	(0.039)		(0.069)		(0.026)	
Near Purchases	−0.008	0.082	0.025	0.040	0.035**	0.056
	(0.013)	(0.068)	(0.038)	(0.059)	(0.014)	(0.035)
Far Purchases		0.012		0.099**		0.062**
		(0.041)		(0.047)		(0.032)
Num.Obs.	510	5549	510	5551	510	5551
R2 Adj.	0.989	0.545	0.990	0.578	0.986	0.556
No. CUSIPS:	42	158	42	158	42	158
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 date. Each regression uses CUSIP and auction fixed effects. Own purchases equals the amount of security n purchased at a given buyback 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 on a buyback date divided by the total amount of all Treasury securities maturing within 3 years of n. Far Purchases equals the fraction of all buybacks of far substitutes of n (excluding n itself) repurchased on a buyback date 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 and Far purchases are scaled purchases of securities maturing within 3 years and from 3-6 years of the security n, respectively.

regressing *cumulative* returns relative to three days before each Treasury buyback on bond purchases in figure 3. As the figures demonstrate, for both Own and Near purchases, there were statistically significant and positive cumulative returns on day $T + 2$, the buyback settlement date, and the point estimate of the coefficient tends to be largest on settlement dates. If buyback auction participants were risk neutral, and in the absence of adjustment frictions, we might have expected significant price adjustments on the day of the auction. The fact that there are apparently significant excess returns on settlement relative to the auction is consistent with the empirical pattern documented in the larger literature on Treasury *issuance* auctions (Lou et al. (2013); Herb (2022); Smales (2021); Fleming et al. (2022)).

In appendix C.3, 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 of the coefficients shift as we change the definition of "near" and "far" neighbor, but in general price changes are consistently positive on settlement dates, usually significant, and of similar magnitudes across specifications. In addition, we narrow the set of ineligible securities to remove those that were likely to never be included in the buybacks, with 5 (or 7) years remaining to maturity. In this case, the coefficients on near and far purchases for ineligible securities are significantly positive beginning on the announcement date ($T-1$) and similarly decline after the settlement date. Across nearly all of our specifications, the magnitude of the cumulative effect of own purchases is larger than that of near purchases for eligible securities; the magnitude of near purchases is bigger than far purchases for ineligible securities.[18] These relative magnitudes are consistent with what we would expect from spillovers from supply shocks as predicted by the literature on preferred habitats.

Our results contrast with those in Han et al. (2007), who find insignificant differences in excess returns in a window surrounding auctions between bonds that are included and excluded from buybacks auctions. Our estimates imply that even securities excluded from the buybacks that are near substitutes might have sizable, positive price movements due to local supply effects; in other words, prices of eligible and ineligible bonds with otherwise similar maturities would be expected to move in the same direction, which could explain the

[18]The one exception is when we restrict near neighbors to 0-2 years and far neighbors to 0-4 years, as shown in appendix figure C.2. In that case, while the point estimates are lower for "Near" than "Far" ineligible purchases, the confidence intervals on the former are quite wide.

absence of *differences* in excess returns Han et al. (2007) document using their approach.

3.3 Implications of the stock and flow effects on prices for theory

Our results are closely related to the predictions of theoretical models of the recent term structure that incorporate preferred habitats (originated in Vayanos and Vila (2021) and recently surveyed in Greenwood et al. (2023)). The local nature of our stock and flow effects speak to particular features of this set of models. In particular, Greenwood et al. (2023) argues that generating *local* effects of *permanent* supply changes in the Vayanos and Vila (2021) model requires priced supply risk *and* price-elastic supply. Price-elastic supply means that arbitrageurs adjust holdings of bonds to satisfy their desired risk profile; priced supply risk will imply differences in supply factor loading for bonds of different maturities, which differentially affects the substitutability (and hence changes in prices) *across* maturities. This is consistent with our stock regressions (where own purchases have larger effects than near purchases, but both effects are positive and statistically and economically significant) and with our flow regressions (where near and far substitutes have elevated returns relative to other securities with a maturity distance greater than 6 years).

Additionally, we note two interesting features of our estimates related to the larger literature following the contribution of Vayanos and Vila. The first is that we find quantitatively larger responsiveness of supply changes due to buybacks relative to what D'Amico and King (2013) find for LSAPs. This is consistent with the model in King (2019), which features endogenous changes in factor loadings (and responses of bond yields) because of the non-linearity in short rates created by the effective lower bound on short rates (ELB). Hence, our results give credence to the structural analysis of asset purchases at the ELB in King (2019). Second, our results help reconcile the preferred habitats interpretation of buybacks articulated in Greenwood and Vayanos (2014) and the results of Han et al. (2007), who found negligible flow (price) effects of Treasury buybacks. Our results suggest the limited effects found by Han et al. (2007) are at least partially attributable to the omission of the possibility of spillover effects from purchases due to preferred habitat effects.

Overall, our results are largely consistent with the larger literature on preferred habitat following Vayanos and Vila (2021). Our empirical evidence supports certain features from this literature (price-elastic supply, priced supply shocks, and adjustment frictions) relevant to Treasury markets. Our results also confirm particular predictions of King (2019) and resolve the contrasting findings between Han et al. (2007) and case studies of Treasury buybacks (Greenwood and Vayanos (2014); Bernanke et al. (2004)).

4 Effects of buybacks on the Federal Reserve 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 adjusted SOMA management strategy at the same time that 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 Federal Reserve (relative to its costs). Since the Federal Reserve'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.

Stock effects 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.[19]

The results of the stock regressions on the SOMA portfolio are reported in table 5. Recall

[19]The simultaneity concern here is somewhat different than in the case of price returns. When considering prices, it is possible that supply shifts affect returns and the "cheapness" of bonds affected what was purchased. Here, the simultaneity bias would arise if SOMA changed its holdings because of supply changes, and if Treasury's decision to repurchase bonds was driven by changes the SOMA managers made in their portfolio. Our review of the institutional evidence seems to suggest that the SOMA managers essentially reacted to Treasury officials' actions, and not the other way around. Ultimately, the total effects we estimate are similar regardless of the method we use, and the signs of coefficients are consistent across methods, although the magnitudes and significance differ.

Table 5: Stock effects of Treasury buybacks on SOMA portfolio

Dependent variable:	Change in SOMA share	
	OLS	IV
Own purchases	0.695	5.949***
	(0.643)	(2.103)
Near purchases	−0.442***	−0.950***
	(0.137)	(0.269)
Remaining maturity	−0.060	0.174
	(0.156)	(0.198)
Remaining maturity sq.	0.002	−0.004
	(0.004)	(0.005)
SOMA share	−7.557***	−8.071***
	(1.829)	(2.134)
log(Price)	0.240	−0.010
	(0.408)	(0.435)
Coupon rate	0.106	−0.276
	(0.188)	(0.239)
Svennson pricing error	0.751	0.228
	(1.498)	(1.537)
Average SOMA share (Near)	−7.145	−3.549
	(5.576)	(5.579)
Num.Obs.	102	102
R2 Adj.	0.182	0.039
F	6.851	
First stage Wald statistic:		6.494
Wu-Hausman test p-value:		0.060

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. 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 was 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.

that the dependent variable is the change in holdings, relative to the amount outstanding on August 3, 1999. The estimated coefficients for our OLS (IV) model imply that, all else equal, a one-percent increase in own purchases (relative to the amount of near-Treasury maturities available) leads to a 0.7% (5.9%) relative increase in the amount held in the SOMA portfolio. By contrast, a 1% near purchase lead to a 0.4% (1.0%) decrease in relative holdings, all else equal. The coefficient estimates and significance are, at first glance, quite different across the OLS and IV models. However, both models imply *total* effects that are relatively similar. We calculate this total contribution by taking the coefficient estimates from table 5, multiplying the own-purchases coefficient the quantity of own purchases and likewise for near purchases. The average summed effect is -3.4% for the OLS estimates and -4.2% for IV purchases; the negative change from near purchases is quantitatively more important than the own-purchase effects. In other words, the SOMA managers seemed to decrease their holdings (*relative* to a counterfactual of zero buybacks) of securities exposed to the buyback, all else equal. We emphasize that this is a relative change. The *unconditional* change in the percentage of bonds held in SOMA (relative to the pre-buyback amount outstanding) was 2.7% for bonds exposed to the buyback and 7.9% for bonds that were not exposed (directly or indirectly). The Federal Reserve did not, on net, decrease its holdings of *any* of the securities in the stock regressions over the buyback period (as reported in table 1).

Figure 4 illustrates the cumulative increase in holdings in the SOMA portfolio as a function of buybacks. Most of the large increases in holdings are in very short-term securities, consistent with the desires of FOMC participants.[20]. The most illiquid, off-the-run securities were in the 10-15 year range, and the SOMA portfolio managers did not increase their holdings of those securities. Other securities further from maturity were held in increased quantities. Our estimates imply that the increases were smaller for securities that were exposed to buybacks.

Flow effects It is also possible that the stock effect regressions mask higher-frequency changes – perhaps the Federal Reserve made immediate moves following auctions to help offset price changes, but reversed them over time. Unfortunately, the SOMA portfolio data

[20]SOMA manager Peter Fisher, in the May 2000 FOMC meeting: " We have over time had a preference for the shorter rather than longer maturity issues. We have expressed that preference principally through our large holdings of bills [...]"

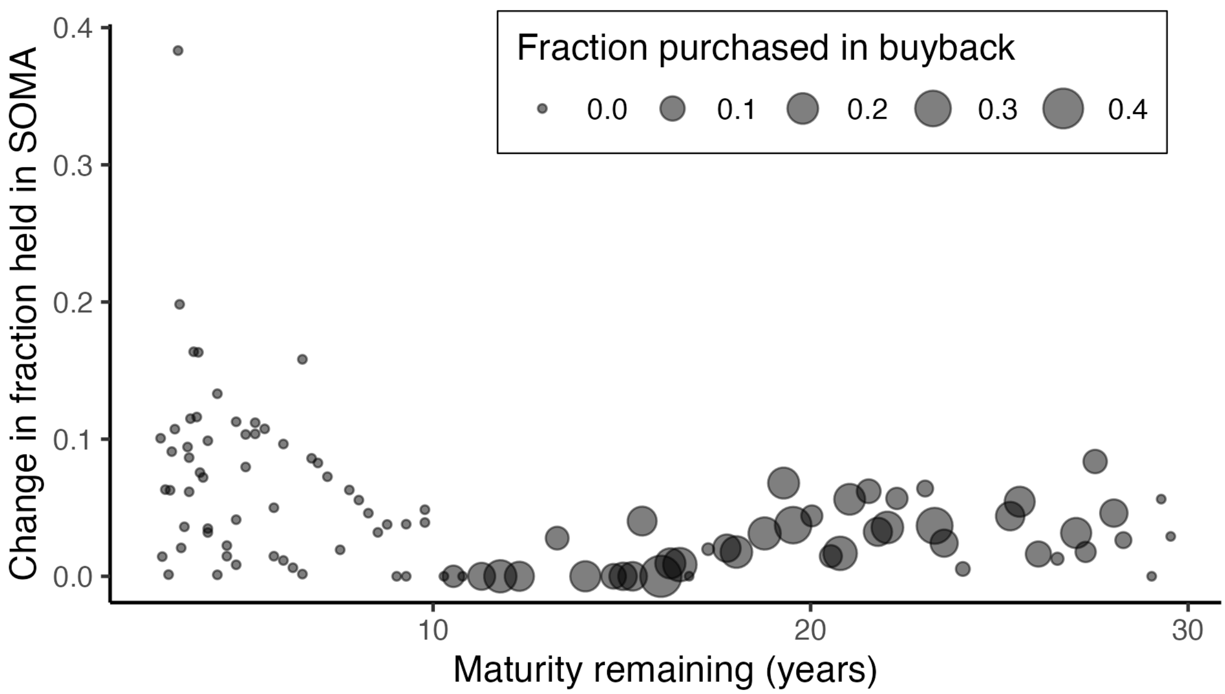

Figure 4: Cumulative change in the fraction of bonds outstanding held in the SOMA portfolio (vertical axis) as a function of the maturity structure (horizontal axis) and the size of the overall buyback (dot size). Securities are included if they were exposed to treatment (e.g., if there were own or near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

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 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. Similar to the stock effect analysis, we note that the SOMA did not decrease its holdings of *any* of these bonds. Moreover, we see very little change in SOMA holdings for this group of securities during 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 weekly logistic regression model where the outcome of interest is whether the holdings of a given security were *increased*. 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, where each column of the table shows the odds ratio for increasing holdings of a security in the week of an auction (first column) and subsequent weeks (columns 2-4). We do not find any significant differences in odds ratios for own and near purchases, which is consistent with the SOMA manager trying to avoid 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; a few coefficient estimates are significant in some specifications. When significant, the estimated odds ratios are less than 1, and often close to zero, which implies that the Federal Reserve was much *less* likely to make purchases the week of auctions to exposed securities. Overall, the robustness results are broadly consistent with a reduced likelihood to

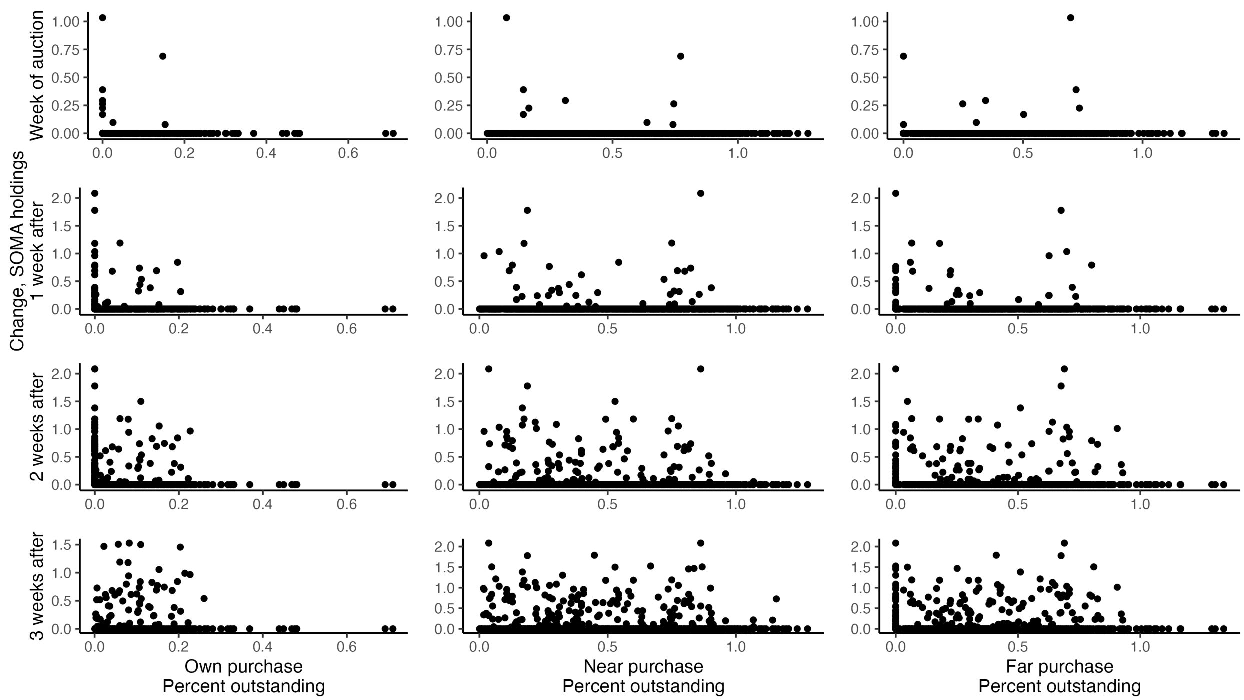

Figure 5: Percentage change in SOMA holdings (vertical axis) as a function of the size of the "treatment" (horizontal axis). The columns (left to right) are own, near and far purchases as a fraction of the outstanding quantity prior to the start of the buyback. The rows represent weeks relative to the 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).

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

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.

purchase securities affected by auctions. This latter is consistent with "intramural courtesy" extended by the SOMA managers mentioned in section 2.

5 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. In this section, we examine the proposed buyback program (as articulated in Office of Debt Management (2023)) in light of our results.

The new buyback policy is 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 preliminary policy indicates that the 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. More formally, we can use our estimated elasticities to predict the effects of buybacks. Office of Debt Management (2023) identifies 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.[21] It has also indicated that it intends to buy no more than $4 billion from any of the nominal buckets and no more than $30 billion total.

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 that date.

We conduct three experiments "as if" the buybacks for a given quarter occur on that date. Our three experiments are

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

Within each bucket, we assume that purchases of individual CUSIPs are in proportion to each security's amount outstanding within the bucket. The latter two scenarios are selected to illustrate the possible pricing effects of more concentrated buybacks within a set of bonds.

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

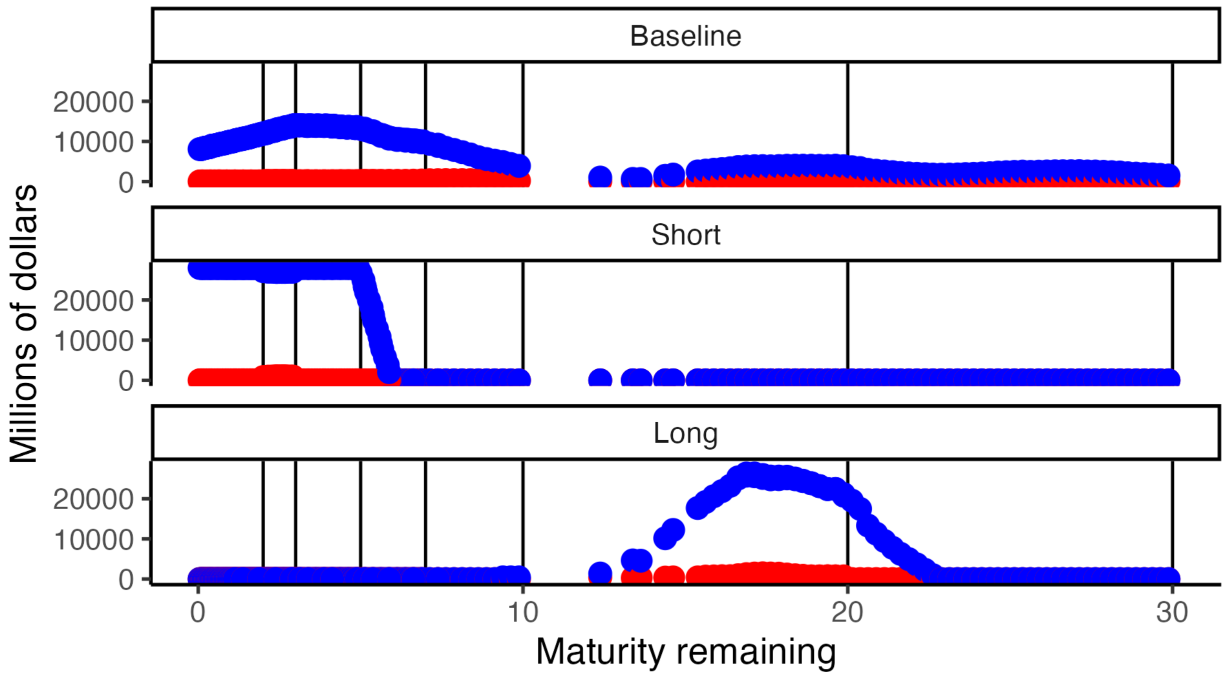

Figure 6: Dollars of own (red) and near-substitute (blue) purchases under three different policy scenarios. Baseline assumes \$4 billion in purchases across maturity buckets, Short assumes \$28 billion in purchases from bonds with tenors between 2 and 3 years, and Long assumes \$28 billion in purchases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

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 maturities 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 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

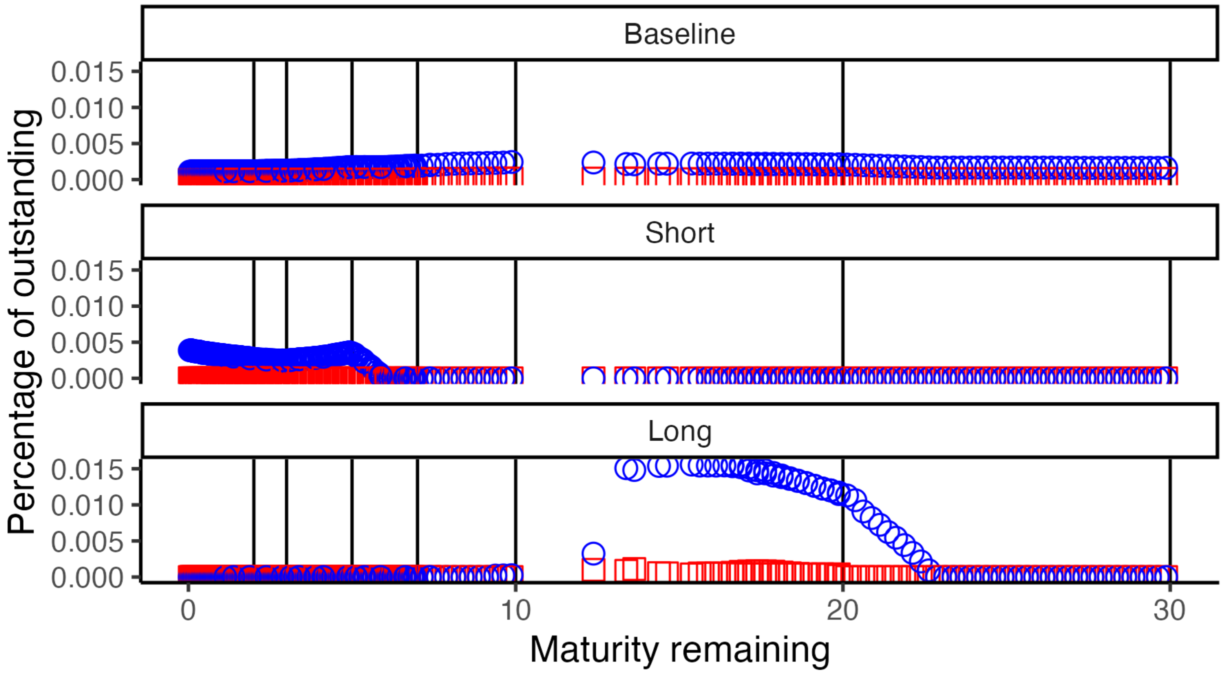

Figure 7: Percentage of outstanding issue repurchased of own (red squares) and near-substitute (blue circles) securities under three different policy scenarios. Baseline assumes \$4 billion in purchases across maturity buckets, Short assumes \$28 billion in purchases from bonds with tenors between 2 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).

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.[22] Our estimates suggest that the effects of the proposed buyback program, at least within a 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 basis point decrease,

[22] In figure 2, the counterfactual exercise was the *absence* of buybacks; here, the counterfactual is the new round *relative* to the absence.

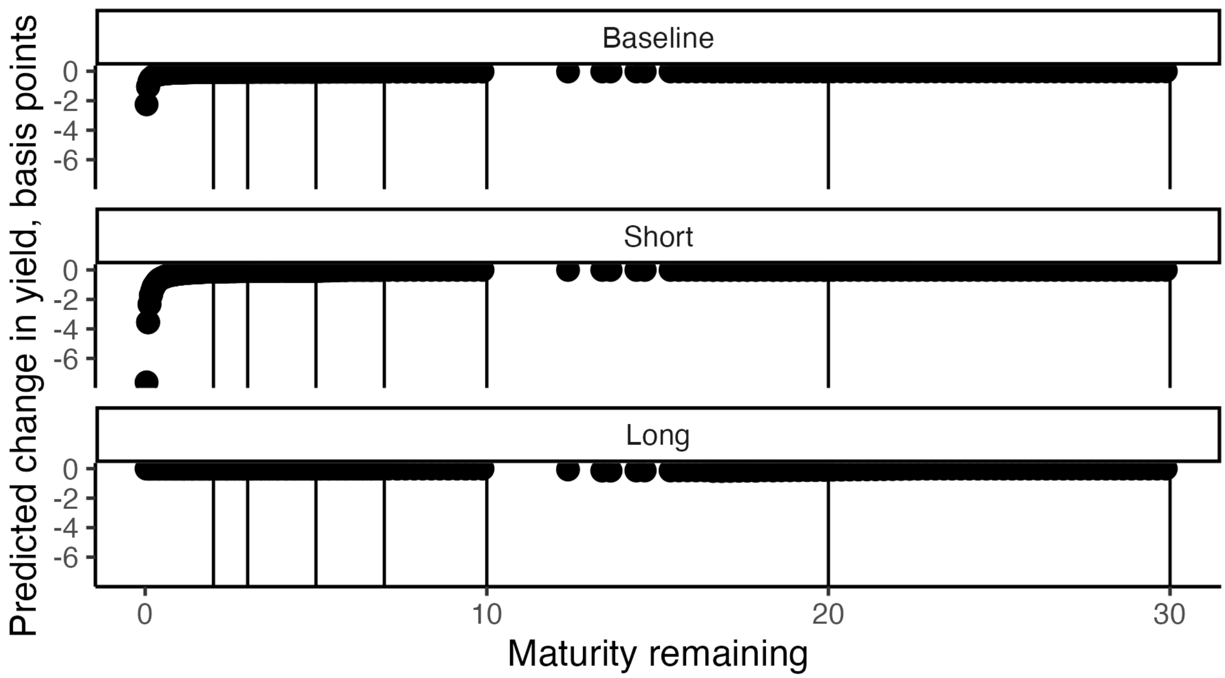

Figure 8: Predicted change in yield due to supply changes. The difference is calculated as yields with no repurchases minus predicted yields after repurchases under the three different scenarios outlined in the text: Baseline assumes $4 billion in purchases across maturity buckets, Short assumes $28 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. Vertical lines indicate boundaries of maturity buckets outlined in Office of Debt Management (2023).

with a maximum decrease of 2.13 basis points at the short end. For comparison, the median daily change in annualized yield to maturity for Treasury notes and bonds was 0.04 basis points, and the median standard deviation of the daily change was 8 basis points. While buybacks might lead to a shift in yields within a month, our results suggest the effects will be on the order of normal fluctuations in Treasury yields – a drop in the (maturity) bucket.

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 decrease 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;

Scenario	Mean	Median	Std. Deviation	Range
Baseline	-0.08	-0.03	0.18	(-2.25, -0.01)
Short	-0.20	-0.06	0.60	(-7.62, 0.00)
Long	-0.01	0.00	0.39	(-0.16, 0.00)

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.

the change in price is larger in absolute terms, but not large enough to impact yields to maturity. Overall, the exercise suggests that buybacks are not likely to have substantive impacts on the costs of financing Treasury debt.

We note some caveats to these estimates. First, we are assuming that estimated (own- and cross-) price elasticities of supply are unchanged from the 2000-02 round of buybacks. One reason this could fail to be true is if the nature of demand in Treasury markets has changed. 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. Third, there are other changes to bond market procedures (e.g., the shift to fully electronic trading) that could have affected the speed of price discovery and the provision of liquidity by dealers, which could affect the transmission of supply shocks in ways we have not controlled for (Duffie et al. (2023)).

Other policy considerations The results in section 3.2 suggest that the largest effects of buybacks on returns mainly occur on settlement dates. This is a potentially important facet to consider when choosing the timing of buybacks. To the extent that buyback auction participants hedge risks associated with participation, buybacks could be associated with changes in 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 margin requirements, changes in Treasury prices associated with 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. However, given the modest scale of the proposed buybacks, these risks are likely small.

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.

6 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 document direct effects of bond purchases, as well as spillover effects, both 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, consistent with preferred habitats models with price-elastic supply. We also find, consistent with statements in FOMC transcripts, that the SOMA managers largely avoided changing their holdings of

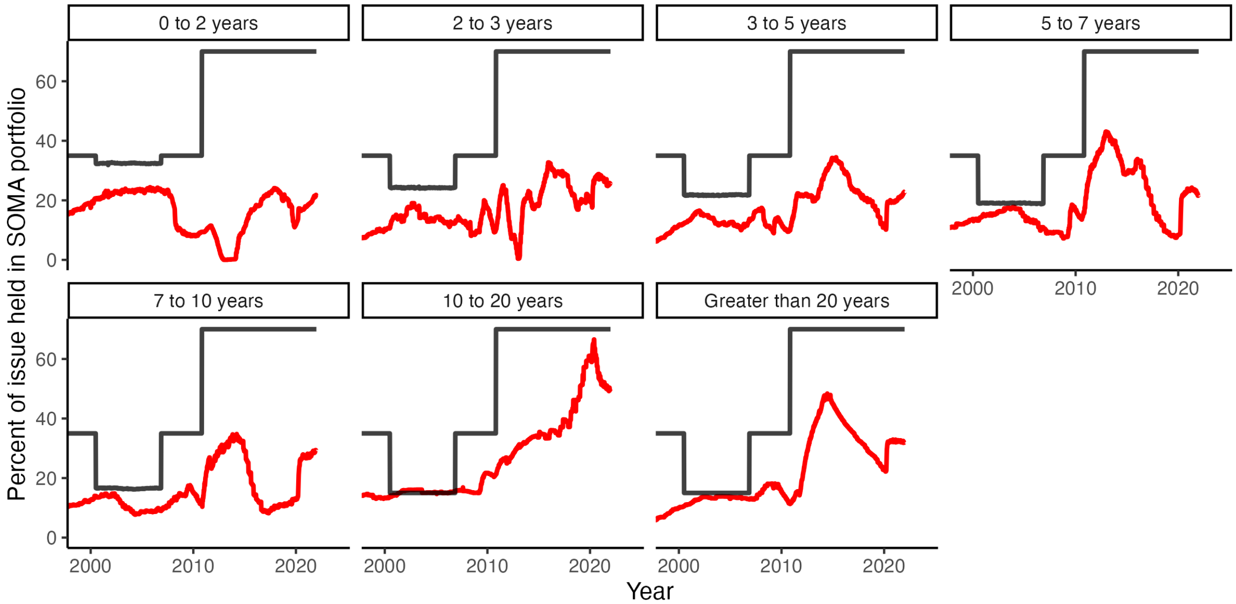

Figure 9: Plot of weighted average share of nominal Treasury securities held in SOMA portfolio, by maturity bucket. Buckets are chosen to match maturity groupings in Office of Debt Management (2023). Red bars indicate weighted average, where weights are calculated by the share of that security relative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

securities around the time of buyback purchases, and that the buybacks induced (on net) relatively small effects on holdings in the SOMA portfolio. 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, but the nature of that delay is not obvious (e.g., whether trading costs made it unprofitable to exploit semi-predictable yield changes or whether there was some hedging behavior we do not observe in our sample). 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 and how buyback auctions spill over into other related markets, such as repo and futures markets.

Moreover, our results suggest that the Federal Reserve was essentially passive during the buyback period – it largely avoided changing its relative holdings during buybacks. It also did not sterilize the decrease in available supply by unloading securities of its portfolio. It would be interesting for theoretical work to examine whether this strategy is optimal from the perspective of ensuring smooth Treasury market functioning, or if more coordination between Treasury and the New York Federal Reserve's trading desk is warranted. Models of preferred habitats subsume central bank holdings into the demand of preferred habitat investors. While this assumption may sometimes be innocuous, the Federal Reserve now holds a considerable share of Treasuries. It would be interesting to study how their presence and strategic incentives impact the incentives of other 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 whom the Treasury ultimately bought from, as in Carpenter et al. (2015)'s study of the LSAP program.

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A Institutional Background: Additional Details

A.1 Details and background of the 2000-2002 Treasury Buyback program

Initially, buyback auctions were announced two days in advance, a period that was reduced to one day in May 2000. 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)).

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.[23]

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 announced.

Additional details of SOMA and FOMC reaction to buybacks As mentioned in section 2.1, the notion of a "shortage" of Treasury debt was front of mind for both investors SOMA managers in 1999 and 2000. For instance, The New York Times reported in early February 2000 that

> [...] the Federal Reserve 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

[23]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))

> 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 Federal Reserve's interest rate increases will have on the economy. (Morgenson (2000))

By May 2000, then-SOMA manager Peter Fisher explicitly noted the shortages of marketable Treasury securities at the long end of the yield curve, in part due to buybacks, to the FOMC:

> [...] 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)

In January 2001, Fisher explained that SOMA was juggling its portfolio holdings to adjust to shortages of marketable securities, but also attempting to not complicate buyback operations:

The FOMC transcripts also suggest that the Federal Reserve 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)

A.2 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. Treasury continues to include “no buyback” notices at quarterly refunding statements for several quarters before dropping mention of buybacks.

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 for 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 B.1; 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 B.1.

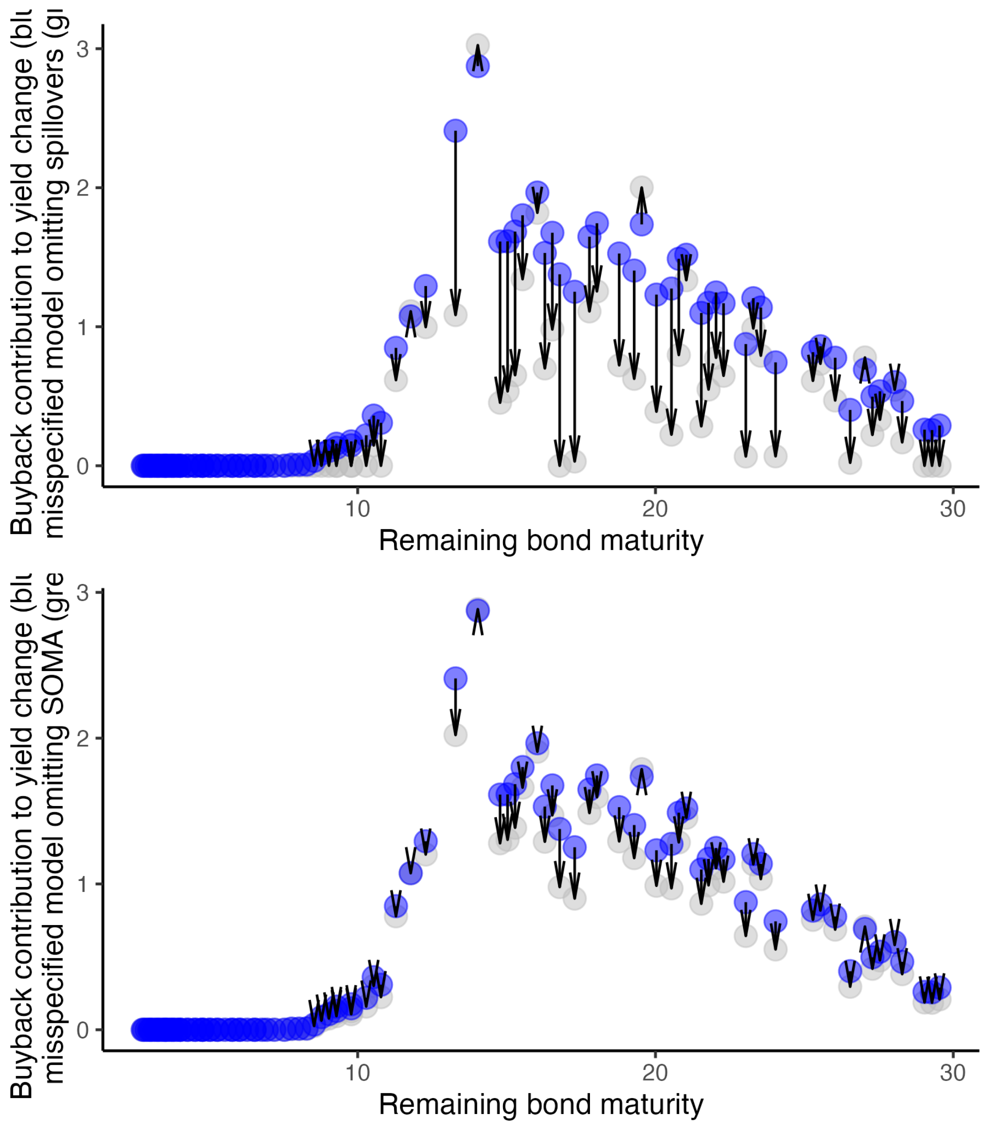

Figure B.1: Differences in implied contribution from supply changes when near purchases are omitted as a control in the second stage regression (top), and when SOMA share is omitted as a control (bottom) Calculated by subtracting the fitted contributions of own and near purchases using (2), re-estimated 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 and extensions: Treasury prices

C.1 Stock effects

Table C.1: Stock regression: alternative near substitute definitions

Near substitute:	Within 2 years		Within 4 years	
Dependent variable:	Price return			
	OLS	IV	OLS	IV
Own purchases	1.360***	0.272	2.230***	1.168
	(0.424)	(1.194)	(0.768)	(2.009)
Near purchases	0.545***	0.853***	0.505***	0.788***
	(0.099)	(0.191)	(0.101)	(0.228)
Remaining maturity	−0.366***	−0.470***	−0.673***	−0.864***
	(0.073)	(0.096)	(0.156)	(0.213)
Remaining maturity sq.	0.009***	0.012***	0.016***	0.020***
	(0.002)	(0.002)	(0.004)	(0.005)
SOMA share	−1.458*	−1.152	−3.197*	−3.617*
	(0.783)	(0.922)	(1.675)	(1.994)
log(Price)	1.228***	1.407***	2.682***	3.043***
	(0.151)	(0.182)	(0.448)	(0.530)
Coupon rate	−0.410***	−0.373***	−0.970***	−0.936***
	(0.088)	(0.136)	(0.185)	(0.273)
Svennson pricing error	−0.459	−0.365	−2.637*	−2.835
	(0.631)	(0.764)	(1.428)	(1.914)
Average SOMA share (Near)	−6.064***	−7.495***	−20.409***	−21.712***
	(1.826)	(2.512)	(7.032)	(7.863)
Num.Obs.	109	109	109	109
R2 Adj.	0.633	0.583	0.548	0.520
F	31.640		23.909	
First stage Wald statistic:		19.909		10.631
Wu-Hausman test p-value:		0.004		0.072

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 that are near substitutes 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 was 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 C.2: 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	3.060***	4.968***	1.987***	1.942
	(0.549)	(1.572)	(0.468)	(1.647)
Near purchases	0.796***	0.942***	0.568***	0.710***
	(0.086)	(0.192)	(0.094)	(0.187)
Remaining maturity	−0.557***	−0.689***	−0.604***	−0.686***
	(0.111)	(0.148)	(0.116)	(0.146)
Remaining maturity sq.	0.014***	0.017***	0.014***	0.017***
	(0.003)	(0.004)	(0.003)	(0.004)
SOMA share	−2.189	−3.256*	−2.943**	−3.068**
	(1.525)	(1.949)	(1.172)	(1.292)
log(Price)	2.078***	2.451***	2.039***	2.213***
	(0.273)	(0.324)	(0.266)	(0.284)
Coupon rate	−0.836***	−1.035***	−0.622***	−0.649***
	(0.165)	(0.215)	(0.124)	(0.188)
Svensson pricing error	−1.247	−1.930	−1.062	−1.200
	(1.295)	(1.674)	(0.914)	(1.069)
Average SOMA share (Near)	−10.250**	−10.673**	−12.467***	−13.196***
	(4.731)	(5.366)	(3.234)	(3.779)
Num.Obs.	106	106	109	109
R2 Adj.	0.789	0.767	0.607	0.600
F	72.116		51.193	
First stage Wald statistic:		32.337		22.571
Wu-Hausman test p-value:		0.006		0.279

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 settlement 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 C.3: 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:		30.542
Wu-Hausman test p-value:		0.142

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.

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

Table C.4: Stock Effects of Treasury Buybacks: Early start date

Dependent variable:	Price return	
	OLS	IV
Own purchases	2.054***	0.243
	(0.487)	(1.797)
Near purchases	0.540***	0.791***
	(0.101)	(0.222)
Remaining maturity	−0.526***	−0.686***
	(0.106)	(0.183)
Remaining maturity sq.	0.011***	0.015***
	(0.003)	(0.005)
SOMA share	−0.778	−1.420
	(0.922)	(1.040)
log(Price)	2.088***	2.275***
	(0.237)	(0.292)
Coupon rate	−0.873***	−0.682**
	(0.160)	(0.261)
Svensson pricing error	−0.996	−0.830
	(0.910)	(0.989)
Average pricing error (Near)	−3.886*	−2.855
	(2.081)	(2.183)
Average SOMA share (Near)	−10.180***	−11.392***
	(2.753)	(3.488)
Num.Obs.	86	86
R2 Adj.	0.687	0.659
F	35.835	
First stage Wald statistic:		21.632
Wu-Hausman test p-value:		0.148

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 February 2, 1998, 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.

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

Table C.5: Summary statistics of liquidity measure

Variable	Range	Mean	Median	SD	IQR
Svensson pricing error (start)	[-0.4, 0.21]	-0.05	-0.03	0.10	[-0.04, -0.02]
Pricing error (end)	[-0.58, 0.12]	-0.06	-0.02	0.12	[-0.04, -0.01]
Pricing error (change)	[-0.18, 0.06]	-0.01	-0.01	0.05	[-0.02, 0.02]
Pricing error (squared change)	[0, 0.03]	0.00	0.00	0.01	[0, 0]

Note:

Summary statistics of Svensson pricing error, calculated as the difference between the price of the bond and the price implied from using the smooth discount function estimates from Gürkaynak et al. (2007). Pricing errors reported in same units used in regression. (start) indicates value of variable on August 3, 1999; (end) indicates value of variable on April 30, 2002.

C.2 Stock effects: liquidity

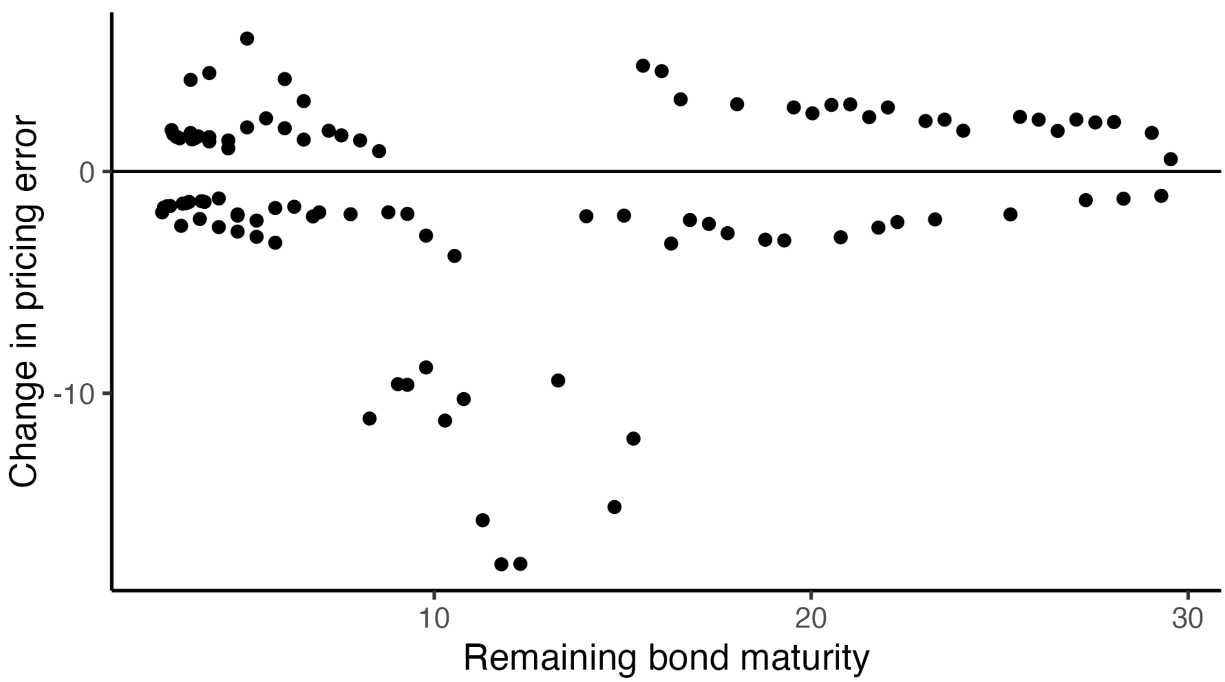

Figure C.1: Plot of change in Svensson pricing error from August 3, 1999 to April 30, 2002. Vertical axis is in change in percentage points.

Table C.6: Stock Effects of Treasury Buybacks on liquidity measures

Dependent variable:	Δ pricing error		(Δ pricing error)^2	
	OLS	IV	OLS	IV
Own purchases	4.376***	11.509***	−0.404***	−1.380***
	(1.166)	(2.494)	(0.123)	(0.332)
Near purchases	0.049	−0.250	−0.004	0.043
	(0.199)	(0.249)	(0.022)	(0.030)
Remaining maturity	−0.529***	−0.457**	0.064***	0.050**
	(0.163)	(0.196)	(0.019)	(0.021)
Remaining maturity sq.	0.013***	0.011**	−0.001***	−0.001**
	(0.004)	(0.005)	(0.000)	(0.001)
SOMA share	−6.040**	−7.219**	0.116	0.270
	(2.339)	(2.925)	(0.282)	(0.345)
log(Price)	2.390***	2.567***	−0.324***	−0.341***
	(0.383)	(0.392)	(0.057)	(0.061)
Coupon rate	−0.855**	−1.451***	0.130***	0.211***
	(0.350)	(0.349)	(0.032)	(0.043)
Svensson pricing error	−1.220	−2.354	−0.150	−0.001
	(2.404)	(2.401)	(0.283)	(0.296)
Average pricing error (Near)	−15.028***	−19.957***	2.763***	3.439***
	(3.559)	(3.864)	(0.595)	(0.674)
Average SOMA share (Near)	−32.704***	−29.722***	5.193***	4.757***
	(6.676)	(6.505)	(1.132)	(1.014)
Num.Obs.	102	102	102	102
R2 Adj.	0.477	0.187	0.615	0.254
F	10.797		6.946	
First stage Wald statistic:		11.914		9.058
Wu-Hausman test p-value:		0.000		0.000

Note:

This table reports results of "stock effect regressions". The dependent variable ("Δ pricing error") is the change in pricing error relative to a Svensson-implied price of the bond (or its square) for a particular security on $t+h$ =April 30, 2002, relative to characteristics as of t =August 3, 1999. 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 C.7: 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	−0.019		0.025		0.109***	
	(0.040)		(0.070)		(0.027)	
Near Purchases	−0.009	0.073	0.026	0.044	0.034**	0.062*
	(0.014)	(0.067)	(0.038)	(0.060)	(0.014)	(0.035)
Far Purchases		−0.012		0.116**		0.070**
		(0.040)		(0.050)		(0.031)
Num.Obs.	478	5229	478	5231	478	5231
R2 Adj.	0.989	0.551	0.991	0.578	0.986	0.554
No. CUSIPS:	42	157	42	157	42	157
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 date. 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.

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

C.3 Flow effects

D Flow of Funds

Table C.8: Flow effects of buybacks on bond returns : narrow substitute definition

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	−0.001		0.018		0.056***	
	(0.020)		(0.030)		(0.016)	
Near Purchases	0.002	0.037	0.014	0.013	0.037***	0.011
	(0.010)	(0.064)	(0.018)	(0.056)	(0.010)	(0.036)
Far Purchases		0.038		0.064		0.055**
		(0.047)		(0.045)		(0.024)
Num.Obs.	510	5549	510	5551	510	5551
R2 Adj.	0.989	0.545	0.990	0.576	0.986	0.555
No. CUSIPS:	42	158	42	158	42	158
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 date. Each regression uses CUSIP and auction fixed effects. In this set of regressions, we narrowly define near and far substitutes as being with 2 and 4 years, respectively. 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 two 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. Far Purchases equals the fraction of all buybacks of far 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. 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 2-4 years of the security n, respectively.

Table C.9: Flow effects of buybacks on bond returns: Neighbor 0-2 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	−0.001		0.018		0.056***	
	(0.020)		(0.030)		(0.016)	
Near Purchases	0.002	0.053	0.014	0.021	0.037***	0.021
	(0.010)	(0.064)	(0.018)	(0.055)	(0.010)	(0.035)
Far Purchases		0.014		0.056*		0.041**
		(0.026)		(0.029)		(0.018)
Num.Obs.	510	5549	510	5551	510	5551
R2 Adj.	0.989	0.545	0.990	0.577	0.986	0.556
No. CUSIPS:	42	158	42	158	42	158
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 date. 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. 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.

Table C.10: Flow effects of buybacks on bond returns: Near Neighbor is 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	−0.022		0.079		0.132***	
	(0.062)		(0.112)		(0.042)	
Near Purchases	0.008	0.097	0.078	0.064	0.026	0.067*
	(0.031)	(0.079)	(0.063)	(0.061)	(0.031)	(0.040)
Far Purchases		−0.003		0.156*		0.091*
		(0.057)		(0.081)		(0.050)
Num.Obs.	510	5549	510	5551	510	5551
R2 Adj.	0.989	0.545	0.990	0.578	0.986	0.556
No. CUSIPS:	42	158	42	158	42	158
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 date. 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 4 years and from 5-6 years of the security n, respectively.

Table C.11: Flow effects of buybacks on bond returns: separating purchases

Dependent variable:	1 day price return					
Date:	Announcement		Auction		Settlement	
Securities:	Ineligible					
	(1)	(2)	(3)	(4)	(5)	(6)
Near Purchases	0.085		0.065		0.072**	
	(0.072)		(0.058)		(0.036)	
Far Purchases		0.019		0.102**		0.067**
		(0.044)		(0.046)		(0.032)
Num.Obs.	5549	5549	5551	5551	5551	5551
R2 Adj.	0.545	0.545	0.576	0.578	0.555	0.556
No. CUSIPS:	158	158	158	158	158	158
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 date. 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.

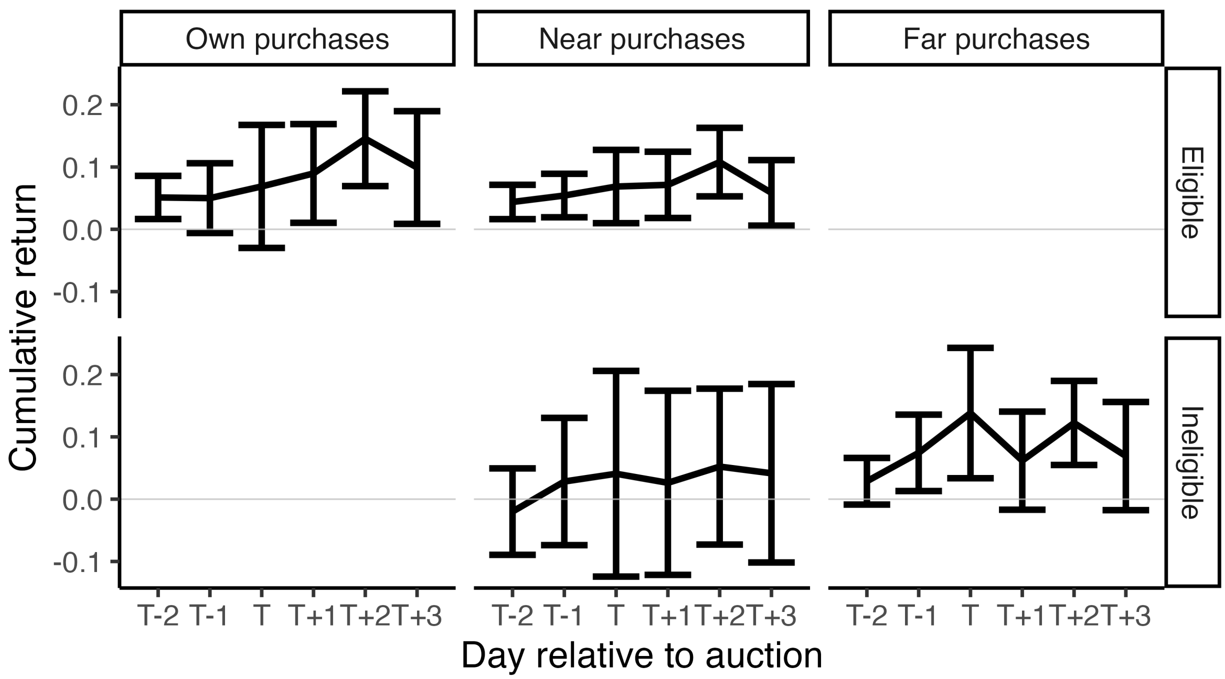

Figure C.2: Plot of coefficients of Own, Near, and Far purchases from flow regressions. In this alternative specification, we restrict "Near" purchases to those occurring within 0-2 years of the maturity of the purchased security, and "Far" to those within 2-4 years. The dependent variables in the regressions 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.

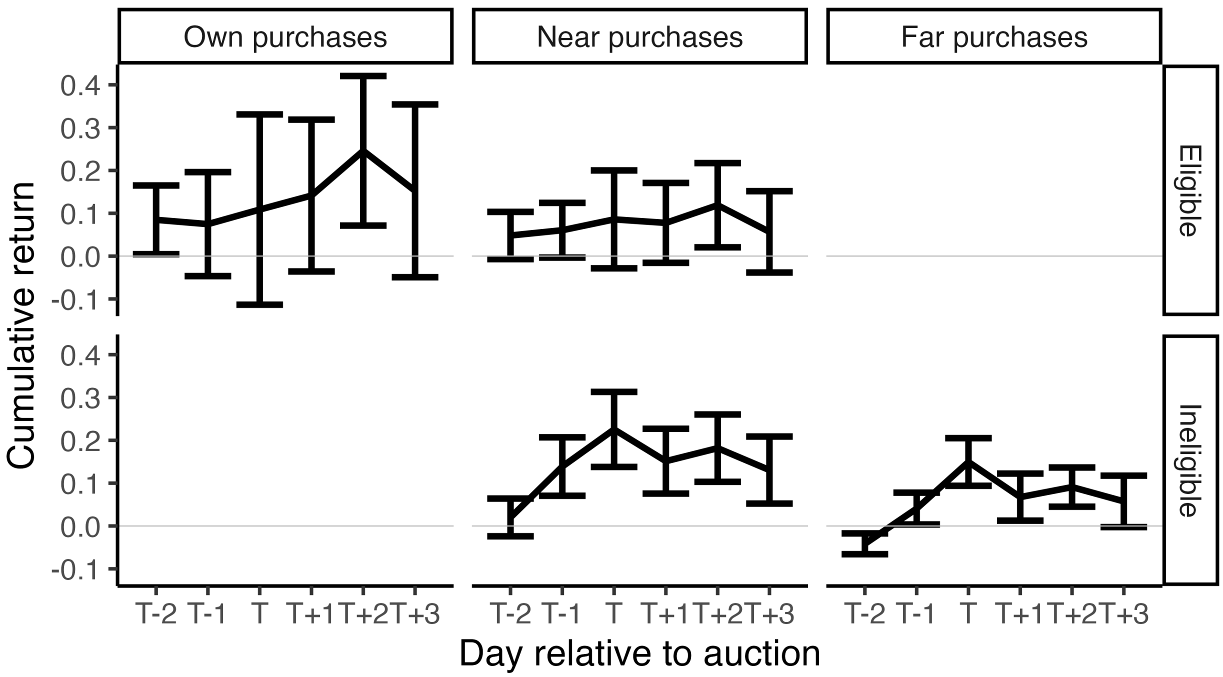

Figure C.3: Plot of coefficients of Own, Near, and Far purchases from flow regressions. In this alternative specification, we drop all securities with less than 5 years remaining to maturity from the sample. The dependent variables in the regressions are the cumulative returns on Treasury securities 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.

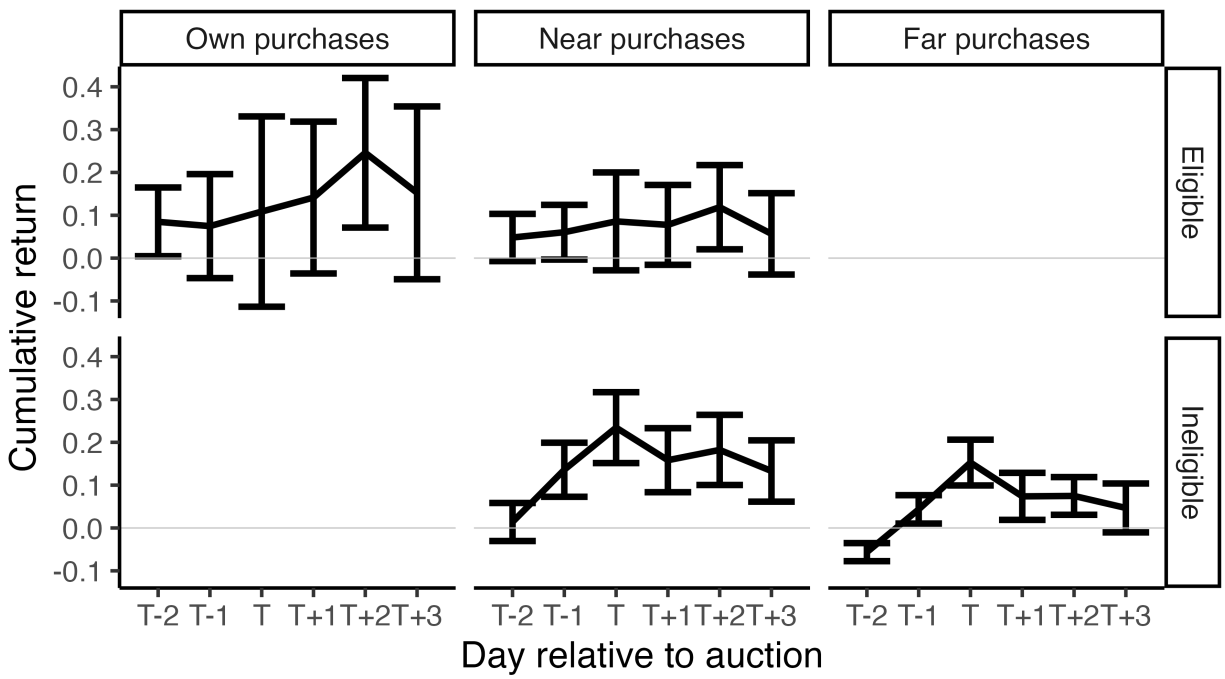

Figure C.4: Plot of coefficients of Own, Near, and Far purchases from flow regressions.In this alternative specification, we drop all securities with less than 7 years remaining to maturity from the sample. The dependent variables in the regressions are the cumulative returns on Treasury securities relative 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.

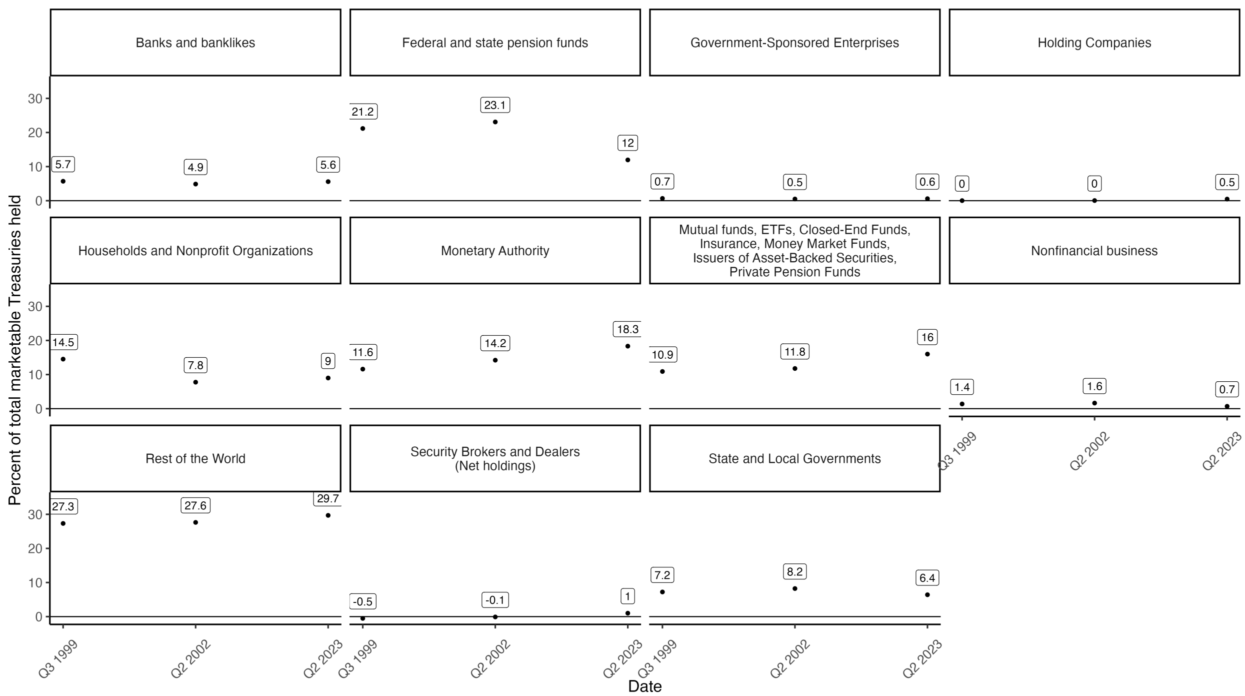

Figure D.1: Holdings of Treasuries as assets, as a percentage of total Treasuries held as assets. Data taken from the Federal Reserve Board Flow of Funds data. Dates shown correspond to quarters at beginning and end of window for stock effect regressions and most recent data available. “Banks and Banklikes” 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 holdings of both nonfinancial corporate and nonfinancial noncorporate business.

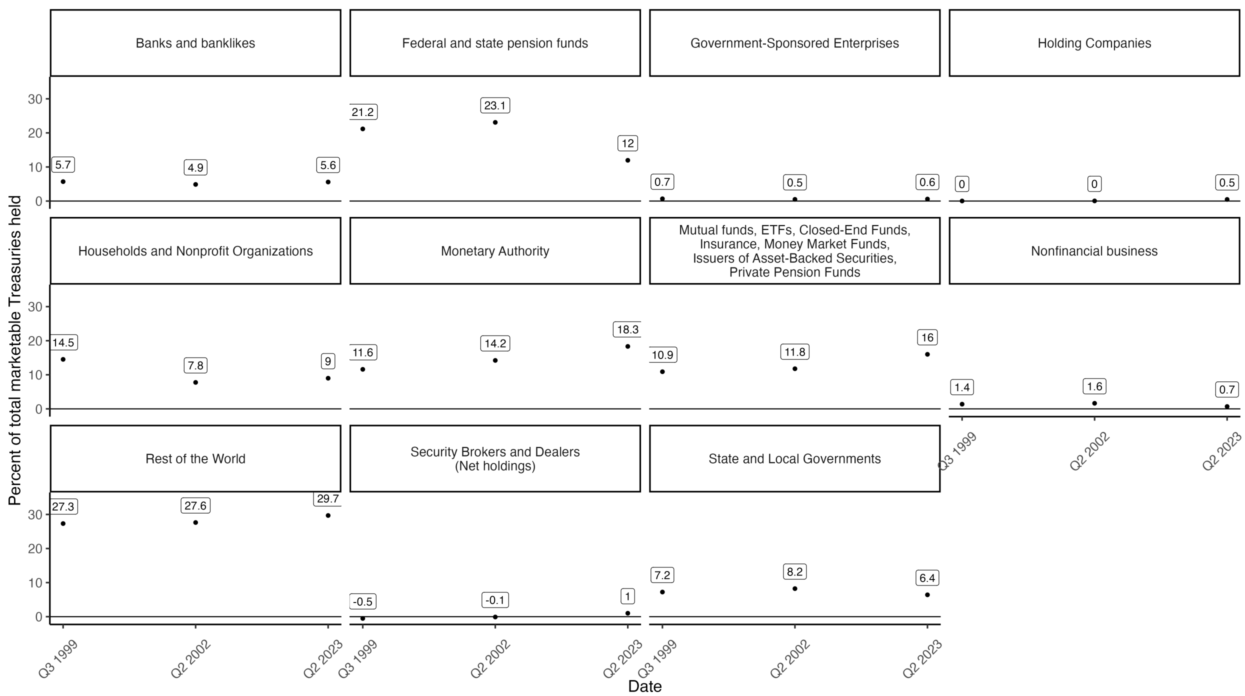

Figure D.2: Holdings of Treasuries as assets, as a in billions of nominal USD. Data taken from the Federal Reserve Board Flow of Funds data. Dates correspond to quarters at beginning and end of window for stock effect regressions and most recent data available. "Banks and Banklikes" includes U.S.-chartered depository institutions, foreign banking offices in the U.S., banks in U.S.-affiliated areas, and credit unions. "Nonfinancial business" includes holdings of both nonfinancial corporate and nonfinancial noncorporate business.

E Robustness: SOMA portfolio

E.1 Stock effects

Table E.1: 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	0.506	6.031***	1.112*	6.778***
	(0.621)	(2.279)	(0.639)	(2.139)
Near purchases	−0.462***	−1.008***	−0.351***	−0.847***
	(0.134)	(0.286)	(0.118)	(0.245)
Remaining maturity	−0.012	0.196	−0.160	0.052
	(0.149)	(0.196)	(0.143)	(0.174)
Remaining maturity sq.	0.000	−0.005	0.004	−0.001
	(0.004)	(0.005)	(0.004)	(0.004)
SOMA share	−7.500***	−9.537***	−8.188***	−8.975***
	(1.798)	(2.600)	(1.737)	(2.132)
log(Price)	0.220	−0.016	0.499	0.281
	(0.444)	(0.490)	(0.394)	(0.410)
Coupon rate	0.041	−0.282	0.062	−0.319
	(0.186)	(0.247)	(0.173)	(0.222)
Svennson pricing error	0.253	−0.303	0.143	−0.307
	(1.673)	(1.776)	(1.283)	(1.396)
Average SOMA share (Near)	−6.106	−1.316	−8.283	−4.109
	(6.798)	(7.094)	(5.654)	(5.760)
Num.Obs.	106	106	109	109
R2 Adj.	0.172	0.018	0.092	−0.022
F	7.464		6.803	
First stage Wald statistic:		6.412		6.874
Wu-Hausman test p-value:		0.043		0.143

Note:

This table reports results of "stock effect regressions" on the change in holdings in the SOMA portfolio with alternative sample dates. 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 was 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 E.2: 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	0.375	4.946***	1.598*	9.630***
	(0.366)	(1.789)	(0.829)	(3.307)
Near purchases	−0.416***	−0.983***	−0.344***	−0.930***
	(0.118)	(0.276)	(0.111)	(0.258)
Remaining maturity	−0.027	0.148	−0.311	−0.016
	(0.089)	(0.122)	(0.224)	(0.279)
Remaining maturity sq.	0.001	−0.004	0.008	0.001
	(0.002)	(0.003)	(0.006)	(0.007)
SOMA share	−5.677***	−6.634***	−11.658***	−12.230***
	(1.231)	(1.779)	(2.457)	(3.333)
log(Price)	0.136	−0.083	0.926	0.665
	(0.201)	(0.237)	(0.734)	(0.842)
Coupon rate	0.086	−0.186	0.087	−0.580
	(0.118)	(0.209)	(0.275)	(0.394)
Svennson pricing error	−0.510	−0.957	−0.424	−1.232
	(1.055)	(1.154)	(1.801)	(2.224)
Average SOMA share (Near)	−3.708	0.910	−13.856	−10.243
	(2.604)	(3.145)	(11.250)	(11.575)
Num.Obs.	109	109	109	109
R2 Adj.	0.100	−0.095	0.096	−0.039
F	8.182		8.305	
First stage Wald statistic:		7.041		7.291
Wu-Hausman test p-value:		0.053		0.058

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 that are near substitutes 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 was 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 E.3: 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

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 E.4: 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

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 E.5: 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

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.