Leverage Constraints Affect Portfolio Choice: Evidence from Closed-End Funds*

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Abstract

The market for auction rate securities collapsed following a series of failed auctions in February 2008, significantly constraining some closed-end funds' access to leverage. We use this exogenous shock to study empirically how leverage constraints affect investors' portfolio choice. Our main finding is that tightened leverage constraints result in an increased appetite for systematic risk: in the months following the shock, the affected funds bought significantly more high-beta stocks, and sold significantly more low-beta stocks, than their unaffected peers. Our results are consistent with the theoretical predictions of Black (1972) and Frazzini and Pedersen (2014), and provide causal evidence of the central mechanism underlying asset pricing under leverage constraints.

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1 Introduction

A central mechanism in the models of asset pricing with leverage constraints (Black, 1972; Frazzini and Pedersen, 2014) is that constrained investors hold a portfolio of high-risk assets. With a more binding leverage constraint, this increased demand for high-risk assets increases their prices and lowers their expected returns. Hence, these models are better able to justify the empirically observed relatively flat relation between risk and expected return than models without constraints (Black et al., 1972). In addition, these models suggest that market frictions like leverage constraints may not mitigate risk taking in the market but instead change how the risk is taken, which is a valuable insight for studying the determinants of systemic risk.

So far, the literature testing the empirical validity of these models has mainly focused on establishing a relation between measures of leverage constraint tightness and compensations for risk. While the literature shows that a tighter leverage constraint is associated with a flatter risk-return relation (Frazzini and Pedersen, 2014; Boguth and Simutin, 2018; Jylhä, 2018; Lu and Qin, 2020), there is little empirical evidence that leverage constraints affects portfolio choice in a way prescribed by the models. This paper is an attempt to fill this gap.

We provide causal evidence that tighter leverage constraints lead investors to hold portfolios of higher-beta securities. We establish this causal relation by studying the portfolio holdings of closed-end funds (CEF) around an exogenous negative shock to some funds' ability to employ leverage. We investigate whether these "treated" funds change their portfolio allocation in ways suggested by the theory, using their unaffected peers as a control group.

A central problem testing the causal relationship between financial constraints and investors' portfolio allocations is that investors' portfolio choice may be endogenous to the financiers' decision of granting funding. To establish causality we would have to observe a shock to investor's leverage constraints that is independent of her subsequent portfolio allocation. In this paper we use such a natural experiment in financial markets where some levered CEFs experienced a tightening of their debt funding unrelated to their future portfolio decisions.

Unlike many other institutional investors, CEFs are allowed to, and commonly do, use leverage. A common instrument among CEFs for obtaining leverage prior to the financial crisis of 2008-09 were auction rate securities (ARS). The market for these securities collapsed in February 2008 following a series of auction failures. As a result, the CEFs that used ARS to obtain leverage experienced a tightening of leverage constraints. The collapse of the ARS market is plausibly exogenous to CEFs' portfolio choice since the affected CEFs represented only a small fraction of borrowers in this market and the reason for the collapse of the market has usually been blamed on major ARS market makers' unwillingness to provide liquidity due to deterioration of their own financing conditions (see Section 3 for details). Importantly we do *not* argue that ARS market freeze was necessarily exogenous to portfolio choice of all CEFs, since the event was associated with deterioration of aggregate investment opportunities which could subsequently affect the portfolio choice of investors. However we do argue that it was exogenous to the heterogeneous response between ARS levered and non-levered CEFs portfolio choice, since only the former also became leverage constrained. To us, this seems like a reasonably mild assumption.

Comparing the portfolio holdings, and the buy and sell decisions, of ARS-levered and non-levered CEFs around the collapse of the ARS market, we establish the following empirical results. First, and most importantly, tightening of the leverage constraint increases the affected funds' portfolio beta. Figure 1 provides a simple illustration. The blue dots in the figure plot the average portfolio beta of non-levered

U.S. domestic equity CEFs in the years around the collapse of the ARS market.[1] The red triangles plot the average portfolio betas of the ARS-levered funds, and the dashed lines give the 95% confidence intervals. Before the ARS market freeze, the ARS-levered funds held, on average, portfolios with betas around 0.8 whereas the non-levered funds' portfolio betas were around 1.0, the difference between the two being statistically significant. Following the ARS market freeze, the average beta of the ARS-levered funds increases to the level of the non-levered funds' average beta. This result is in perfect harmony with the theoretical predictions of Frazzini and Pedersen (2014).

[Figure 1 here]

Although this graph intuitively captures the main idea behind the relationship between leverage constraints and portfolio beta, drawing a causal interpretation from that alone would be exposed to one major criticism: changes in relative prices and stock beta estimates change portfolio betas even without conscious decisions by the fund managers. Thus, in theory it could be possible for the observed patterns to occur even if the newly-constrained fund managers did not change their portfolio allocation at all. Hence, in our main empirical analysis, we study how the effect of beta on the funds' buy and sell decisions varies over time. These analyses confirm that the simple result presented in Figure 1 is indeed driven by the ARS-levered funds being significantly more likely to buy high-beta stocks immediately following the ARS market freeze than at other times, controlling for variation in the behavior of the non-levered funds.

[1]Event year 0 in Figure 1 corresponds to the 12 months following the collapse of the ARS market, i.e. February 7, 2008, to February 6, 2009. Other time periods in the figure correspond to three years before and after this.

Second, we confirm that our main result is not driven by the affected funds altering their exposure to other stock characteristics correlated with beta. We find that the tightening of the leverage constraint does not significantly affect the funds' appetite for size or value risk. The impact of a stock's market cap or book-to-market ratio on an ARS-levered fund's likelihood to buy the stock does not change as a result of ARS market collapse. We also find that the funds are more likely to sell high-momentum stocks as a result of the tightened leverage constraint. While this result is not predicted by the theories, we believe it to be related to funds deleveraging by selling stocks with relatively good past performance perhaps due to behavioral reasons like the disposition effect (Shefrin and Statman, 1985). In all cases, the finding of increased propensity to buy high-beta stocks is robust to controlling for changes in appetite for other risk factors. This is also true for controlling for various measures of liquidity of the stocks.

Finally, we provide two additional pieces of evidence to support the interpretation that leverage constraints affect portfolio choice. First, we find that the the affected funds try to undo the tighter leverage constraints by buying stocks of more levered firms. This result is consistent with the idea of embedded leverage by Frazzini and Pedersen (2012) that leverage-constrained investors demand leveraged instruments to compensate their own restrictions. Second, the affected funds buying of high-beta stocks is mainly driven by them buying stocks with high market correlation, not so much stocks with high volatility. This indicates, along the arguments of Asness et al. (2020), that the affected funds are buying high-beta stocks to overcome the leverage constraint rather than to increase exposure to lottery-like stocks. Overall, our empirical results provide strong causal evidence in support of the central building block in Black (1972) and Frazzini and Pedersen (2014) that binding leverage constraints make investors hold higher-beta portfolios.

The remainder of the paper is organized as follows. Section 2 provides a theoretical motivation and reviews the most closely related literature. Section 3 describes the CEFs and the ARS market and motivates the empirical analyses. Section 4 describes the data used in this study, Section 5 provides the empirical results, and Section 6 concludes.

2 Portfolio choice under leverage constraints

A key assumption underlying the capital asset pricing model (CAPM) of Sharpe (1964), Lintner (1965), and Mossin (1966) is that investors can use unlimited amounts of leverage. As a result, all investors hold the same portfolio of risky assets, the market portfolio, and combine it with the risk-free asset according to their risk aversion; investors with less-than-average risk aversion borrow to invest in the market portfolio.

Black (1972) presents a model in which investors cannot lever at all. The assumption of no leverage does not square with empirical evidence that many investors do lever. Frazzini and Pedersen (2014) extend the model of Black (1972) by allowing investors to borrow but only up to a limit that may vary across investors. In their model, the leverage constraint will bind for an investors with sufficiently low risk aversion and sufficiently low maximum leverage. For such an investor, it is optimal to hold a portfolio of riskier assets, rather than the tangency portfolio. Figure 2 illustrates the mechanism.

[Figure 2 here]

Imagine a simple world with two risky assets, A and B, and a risk-free asset F. The blue curve $\overline{AB}$ plots the possible portfolios made out of the risky assets, and T plots the tangency portfolio with highest possible Sharpe ratio among the risky portfolios. Now, assume an atomistic investor whose maximum leverage is not limited. She will find her mean-variance optimal portfolio on the blue line $\overrightarrow{FT}$. Assume that the investor has a relatively low risk aversion and her unconstrained optimal portfolio is given by U. The dashed red curve running through portfolio U plots the associated indifference curve.

If the investor's ability to borrow is completely removed, the portfolios along the line $\overrightarrow{TU}$ become unattainable and the optimal portfolio has to be on the curve $\overline{FTA}$. Moving the indifference curve down reveals that the optimal portfolio without leverage is C. The interesting and important fact about C is that it places a higher weight on the riskier asset A than the tangency portfolio T does. This result is universal: if an investor's unconstrained optimal portfolio involves leverage, her leverage-constrained optimal portfolio will overweight the riskier assets relative to the tangency portfolio. Since the unconstrained portfolio is just a leveraged investment in the tangency portfolio, becoming leverage-constrained exogenously, without changes to preferences or expectations, makes the investor tilt her portfolio towards the riskier assets. In an equilibrium with constrained leverage, the constrained investors' demand for high-risk assets increases their prices and lowers their expected returns. Black (1972) and Frazzini and Pedersen (2014) show that investors' leverage constraints result in the relation between beta and expected return, or the security market line, to be flatter than without constraints.[2]

Much of the related empirical literature focuses on correlating the cross-sectional compensation for risk to a measure of leverage constraints. Frazzini and Pedersen (2014) use their model to motivate a betting-against-beta (BAB) strategy that ex-

[2]A large literature studies various aspects of investors' margin requirements and leverage constraints. For recent examples, see Geanakoplos (2010), Gârleanu and Pedersen (2011), Rytchkov (2014), Chabakauri (2015), Wang (2016), and Chabakauri and Han (2020).

ploits the flat security market line arising from the leverage constraint. They show that the returns to this strategy are correlated with the TED spread (the rate spread between Eurodollar deposits and Treasury bills), a commonly used measure of funding conditions. Boguth and Simutin (2018) measure the tightness of leverage constraints by the aggregate portfolio beta of mutual funds and find that this measure predicts the BAB returns and is priced in the cross-section of asset returns. Jylhä (2018) uses the minimum initial margin requirement set by the Federal Reserve as a measure of the leverage constraint and shows that the security market line is flatter during periods of high margin requirements. Lu and Qin (2020) use the returns of levered index-tracking funds to calculate the cost of leverage and show that this measure correlates with contemporaneous and future BAB returns.

We take a different approach to testing the predictions of Black (1972) and Frazzini and Pedersen (2014). Rather than linking asset returns to leverage constraints, we study how the constraints affect portfolio choice. This portfolio choice channel is a crucial link in how leverage constraints affect asset prices.

Frazzini and Pedersen (2014) already provide some evidence that constrained investors hold higher-beta stocks. They show that investors who are often thought to be more constrained (mutual funds and individuals) hold higher-beta stocks than investors who are thought to be less constrained (private equity funds). While this correlation between perceived constraints and portfolio betas is suggestive, no causal inference can be drawn from this analysis as there might be many other reasons for mutual funds to hold high-beta stocks and private equity funds to hold low-beta stocks. For example, Karceski (2002) shows that mutual funds hold high-beta stocks to outperform during bull markets when the convex flow-performance relation is most pronounced. We augment these results of Frazzini and Pedersen (2014) by providing causal evidence that tightened leverage constraints make investors, closed-end mutual funds in our case, tilt their portfolios toward high-beta stocks.

Testing the theoretical prediction regarding the link between leverage constraints and portfolio choice empirically is challenging for a number of reasons. First, leverage constraint typically depend on the characteristics of the investors and the assets they holds. Exogenous variation in leverage constraints is rare making it difficult to identify any causal effects. Second, high quality data on leverage and portfolio holdings is not broadly available. This, naturally, further limits the possibilities to carry out empirical analyses. We overcome these challenges by studying the portfolio decisions of CEFs that became more leverage-constrained as a result of the collapse of the ARS market. However, we are not the first to study the collapse of the ARS market. McConnell and Saretto (2010) study the ARS market freeze in general. Tang (2012) uses ARS-levered CEFs to study the effects of investors' funding liquidity shock on the market liquidity of the securities that the shocked investors hold. While we use the same setting as Tang (2012), we ask a completely different question.

Our paper is also related to the literature on funds' preference for risky assets and explanations of the low-risk anomalies. As mentioned above, Boguth and Simutin (2018) use mutual funds' aggregate beta as a measure of leverage constraint tightness. Benchmarking, combined with leverage constraint, can make funds hold high-risk assets.[3] Christoffersen and Simutin (2017) show that benchmarking by plan sponsors makes mutual funds managing large amounts of defined contribution pension assets hold higher-beta stocks. Baker et al. (2011) argue that benchmarking may discourage institutional investors from investing in underpriced low-risk assets. These papers also highlight that the appetite for high-risk assets they documented may well contribute to the empirically observed low cross-sectional compensation for beta risk. We extend this literature by providing further causal evidence on the role of leverage constraints

[3]See Buffa et al. (2019) for a theoretical model of benchmarking.

in funds' choice of portfolio beta.

In addition to restricted borrowing and benchmarking, several other explanations for the empirically flat security market line are proposed. These include investors' disagreement and short sales constraints (Hong and Sraer, 2016), investors' preference for lottery-like stocks (Bali et al., 2017), and arbitrage activity or lack of it (Liu et al., 2018; Huang et al., 2018). Though we restrict our focus on borrowing constraints, our results also shed light on issues related to these competing theories and thus advance the debate about the origins of the low-risk anomalies. Furthermore, understanding the risk shifting effects of funding shocks can also be important information for policymakers (see e.g. Drehmann and Nikolaou, 2013, for the link between funding liquidity risk and banking crises).

3 Closed-end funds and auction rate securities

We study the effects of leverage constraints on portfolio choice exploiting an exogenous shock to some CEFs' ability to obtain leverage. CEFs in the U.S. are allowed to, and frequently do, use leverage. The funds obtain leverage by issuing either debt or preferred stock. Section 18 of the 1940 Investment Company Act limits the maximum amount of leverage depending on the type of security issued. In case of debt, borrowed funds can be at maximum 33% of the funds assets, whereas the limit is 50% in the case of preferred stock. In our sample of 98 U.S. domestic equity CEFs 41 use leverage, mostly through preferred stock, at the end of 2007.[4] A common type of preferred stock issued by CEFs prior to 2008 was the so called auction rate preferred stock (ARPS), a category of ARS, which were issued by 23 out of the 41 levered CEF in our sample.

[4] The sample construction is detailed in Section 4 below.

ARS are a class of fixed income securities, bonds and preferred stock, whose coupon rate is re-set in periodic auctions. In these auctions, which typically take place every 7, 28, or 35 days, investors bid for the coupon rate of the security. The lowest bidder wins and pays the previous holder of the security its nominal value. These frequent auctions provide the holders of the securities an opportunity to exit their position at notional value, hence creating liquidity for these fixed income securities that would otherwise be relatively illiquid. ARS are issued mainly by municipalities and other local authorities, student loan providers, and CEFs. In early 2008, there were some $330 billion in outstanding ARS.

An ARS auction is said to fail when the number of bids is less than the number of securities being auctioned. In such a case, the securities remain in the possession of their current holders but the coupon rate is set to a pre-determined maximum level. Prior to 2008, auction failures were rare, at least partly due to major investment banks serving as market makers and stepping in to bid in auctions with otherwise insufficient number of bidders.

Starting February 7, 2008, the major ARS market makers (including Citigroup, UBS, Morgan Stanley, and Merrill Lynch) stopped providing liquidity causing a majority of the auctions to fail and the market for ARS to freeze.[5] These auction failures caused significant increases in the borrowing cost for the ARS issuers prompting them the buy back the securities if possible. Since then the market has mainly dwindled though some ARS are still outstanding.[6]

For the ARS-levered CEFs, the collapse of the ARS market represented a negative exogenous shock to their ability to employ leverage. First, all auctions of CEF-issued ARS failed after February 7, 2008. These auction failures represent a significant

[5]See McConnell and Saretto (2010) for an extensive analysis of the ARS auction failures.

[6]Barron's reported in 2015 that the amount of ARS outstanding is about $50 billion ("Auction-Rate Securities: Still Frozen in Time" by Jacqueline Doherty, March 28, 2015).

increase in the funds' borrowing costs as the coupon rates are set at maximum levels.

Second, on aggregate, the funds significantly reduced their borrowing as a result of the ARS market collapse. Figure 3 plots the total amount borrowed by the 23 CEFs in our sample that had ARS outstanding at the end of 2007. The red line plots the total amount of ARS outstanding and the blue line plots the total amount of all other borrowing. Over 2008-09, the amount of ARS decreased from $7.2 billion to $1.5 billion, whereas the the other sources of debt only increased by $2.3 billion, resulting in a total reduction in borrowing by $3.4 billion or 44%.

[Figure 3 here]

Third, funds that refinanced by borrowing through other sources and buying back the ARS, had difficult time doing so. Obtaining bank loans or other debt financing during one of the worst credit crunches in history was a challenge. The fact that the maximum leverage with debt is significantly lower than with preferred stocks, and that asset prices were falling at the time, further complicated the refinancing. Fourth, the freeze of the ARS market is plausibly exogenous to the CEFs' portfolio choice. The market makers pulled out from the ARS market for reasons related to the overall health of the financial sector, not for reasons related to the CEF portfolios.

Finally, and more broadly, levered CEFs provide a much better setting to study leverage constraints than many other levered investment vehicles. Levered mutual funds or hedge funds may also experience leverage shocks that could be exploited in such a study.[7] However, for these fund types a leverage shock is likely accompanied by an equity shock caused by large withdrawals by the funds' investors.[8] Disentangling the effects caused by equity and leverage shocks may be difficult, especially as

[7]See Almazan et al. (2004) for an analysis of of use of leverage by mutual funds.
[8]Shleifer and Vishny (2011) provide a review of this literature.

the shocks are likely to be correlated. CEFs are ideal candidates for investigating the effect of leverage shocks because, unlike open-end funds, the are not exposed to equity shocks. Together, these reasons make the ARS-levered CEFs around 2008 an appropriate laboratory for testing the effects of leverage constraints on portfolio choice.

4 Data and methods

Our main research question is whether the ARS-levered funds react to the ARS market collapse by tilting their portfolios towards higher-beta stocks as predicted by the models of Black (1972) and Frazzini and Pedersen (2014). Figure 1 in the introduction shows that the ARS-levered funds, indeed, hold portfolios with higher betas after 2008 than they do before. A portfolio beta can, however, change for reason beyond the fund's discretion. Relative stock price changes shift portfolio weights and and beta estimates fluctuate over time. More formally, a portfolio beta β_t^p at time t is the average of individual stock j betas $\beta_{j,t}$, weighted by the stock prices $p_{j,t}$ and the amount of shares $s_{j,t}$ held by the fund in each stock:

$$\beta_t^p = \frac{\sum_{j=1}^{N} \beta_{j,t} p_{j,t} s_{j,t}}{\sum_{j=1}^{N} p_{j,t} s_{j,t}}. \tag{1}$$

A price taking investor who wants to target a specific level of portfolio beta can only do so through the number shares held, $s_{j,t}$. Stock prices and betas are determined by market forces. So if a fund manager wants to increase his portfolio beta she needs to buy more stocks with high beta and sell more with low beta. To isolate the effect of the funds' active decisions, we study how a stock's beta affects a fund's propensity to buy or sell the stock and whether this propensity varies according to the theoretical predictions.

We collect data on U.S. domestic equity CEFs. As the leverage constraint shock happens in February, 2008, we focus on a sample of funds that are in operation in at the end of 2007. We start by collecting from CRSP names and tickers of all CEFs (share codes ending in a '4'). We match these manually with the Thomson Reuters Mutual Fund Holdings data and SEC's Form N-CSR (annual shareholder report of investment companies) filings from the EDGAR database. We use the holdings and SEC filings to identify funds that invest predominantly in domestic equity. This leaves us with 98 CEFs.

CEFs file annually the Form N-CSR with the SEC. Among other information, this report contains the financial statements of the fund. We use the supplementary information of the funds' balance sheets to identify which CEFs are leveraged and which have issued ARS. Overall, we find that 41 funds are leveraged at the end of 2007 with 23 having issued ARS. The remaining 18 leveraged funds that had not issued ARS, obtained leverage through bonds, bank debt, or fixed-rate preferred stock. We drop these 18 funds with non-ARS leverage and compare the ARS-levered funds to the non-levered funds, as the other leveraged funds may also experience funding constraints during the financial crisis even if they had not issued ARS. This leaves us with a final sample of 80 CEFs.

For the CEFs in our final sample, we collect the quarterly holdings in U.S. common stocks from Thomson/Reuters. As we only have quarterly snapshots of the funds' portfolio, rather than transaction level data on when they buy and sell stocks, our main dependent variables are binary indicators for whether the fund buys or sells a given stock in a given quarter. Variable $Buy_{i,j,t}$ takes the value 1 if fund i purchased stock j during quarter t, and zero otherwise. Likewise, $Sell_{i,j,t}$ equals 1 if the fund sold the stock during the quarter. We also construct variables $Open$, $Close$, $Increase$, and

Decrease to indicate whether the fund opened a position in a new stock, or closed, increased or decreased (without closing) an existing position, respectively. Table 1 presents the total number, and the average per fund-quarter, of positions and different types of transactions the data.

[Table 1 here]

For all the stocks held by the CEFs, we collect price and volume data from CRSP and accounting data from Compustat. We estimate beta, our key explanatory variable, for each stock in each point in time by running a regression of the stock's monthly excess return on the excess market return over the previous 36 months, requiring at least 24 monthly observation. We also use firm size, market-to-book ratio, momentum, idiosyncratic volatility and various measures of liquidity and leverage as additional explanatory variables. The definitions and calculations of all variables are given in Appendix A. Table 2 provides the descriptive statistics of the explanatory variables used in the regressions below. In the regressions, we standardize all explanatory variables within fund-quarter to make our results insensitive to any variation in levels of the variables across time and funds.

[Table 2 here]

For majority of the empirical analyses we compare the stocks that a fund buys to the stocks it sells during the same time period. For this purpose, we mainly focus on a fund-stock-quarter panel that contains all 94,463 observations where the number of stocks held (adjusted for splits) increases or decreases from the previous holdings report. In this data, regressing the *Buy* indicator variable on the stock's beta measures how the funds' propensity to buy a stock depends on beta. Interacting the beta with an indicator variable for ARS-levered funds allows for measuring the difference between ARS-levered and non-levered funds in how the propensities to buy depend on beta. Finally, adding an interactions with a time indicator measures how the difference between the funds changes over time. Due to high number of interaction terms and controls we write our main regression in a simple form

$$Buy_{i,j,t} = b \times Beta_{j,t-1} \times I_{ARS,i} \times I_{t=0} + c'\mathbf{X}_{i,j,t} + e_{i,j,t}. \tag{2}$$

$Buy_{i,j,t}$ equals 1 if fund i buys stock j during quarter t, and zero otherwise. As the panel only contains buys and sells, the *Buy* dummy equals zero when the fund sells the stock. $Beta_{j,t-1}$ is the beta of stock j estimated using data ending by the previous holdings reporting date.[9] $I_{ARS,i}$ equals one if fund i had ARS outstanding at the end of 2007 and zero otherwise. As the data only contains ARS-levered and non-levered funds, $I_{ARS,i}$ is zero for the non-levered funds. $I_{t=0}$ equals one if the holdings reporting date happens within the 12 months following the collapse of the ARS market on February 7, 2008, and zero otherwise. We call the 12-month period following the collapse the "event year." Finally, $X_{i,j,t}$ contains all lower-order elements of the triple interaction, fund and time fixed effects, and possible other control variables interacted with the indicators. We cluster standard errors by fund.

In this regression, the triple interaction coefficient b tells how much the influence of the stock's beta on the buy-sell decisions of the ARS-levered funds increases following the ARS market collapse compared to the same decisions by the non-levered funds. Alternatively, we can interpret the correlation between *Buy* and *Beta* as a

[9] By estimating beta with data up to the previous holdings reporting date we ensure that any trading by the CEFs in our data during quarter t does not affect the beta we use to explain that trading. We measure all the explanatory variables with data available at the previous reporting date or earlier.

measure of the difference in betas of the stocks the fund buys and the stocks it sells. With this interpretation, the triple-interaction coefficient measures how much the difference in betas between buys and sells increases for ARS-levered funds following the ARS collapse compared to the difference in buys and sells of the non-levered funds. Whichever interpretation one adopts, according to Black (1972) and Frazzini and Pedersen (2014), coefficient b should be positive as the ARS-levered funds are expected to move their holdings towards higher-beta assets following the tightening of their leverage constraints.

It is useful to highlight that the regression in Equation (2) is linear with a binary dependent variable. We use this linear probability model since our goal is to identify the sign and size of the effect of the leverage constraint shock on the funds' propensity to buy and sell stocks. A non-linear model would be more appropriate if the goal was to more accurately predict the buy and sell probabilities. A serious limitation of non-linear models in our setting is that those models are not easy to interpret in presence of multiple fixed effects and high-order interaction terms.

5 Results

We now move to the empirical analyses. First, we show that the ARS-levered funds increase purchases, and decrease sales, of high-beta stocks in the months following the ARS-market freeze. Second, we show that this effect is not driven by the funds changing their exposure to other sources of risk or liquidity of the stocks. Third, we provide some additional results to support the interpretation that the ARS-levered funds' increased buying of high-beta stocks is indeed driven by the tightened leverage constraints.

5.1 Main result

We begin the empirical analysis by simply comparing the average betas between the stocks the different kinds of CEFs in our sample buy and sell at different times. Table 3 presents the average betas of stocks bought and sold by ARS-levered and non-levered funds in the 12 months following the ARS market collapse (event year, $t = 0$) and other times ($t \neq 0$) during our 7-year sample period from February 2005 to February 2012. During the non-event years, the differences in average betas between the buys and sells are very small for ARS-levered and non-levered funds. The average for both buys and sells is 1.05 for ARS-levered funds, whereas non-levered funds, on average, buy stocks with average 1.09 beta and sell stocks 1.08 beta. The collapse of the ARS market has no impact on the betas of the buys and sells of the non-levered funds. During the event year, the average buy has beta of 1.08 compared to 1.06 for average sell. The ARS-levered funds, however, seem to react to the collapse of the ARS market, and the resulting tightening in leverage constraint, as predicted by Black et al. (1972) and Frazzini and Pedersen (2014): they increase their portfolio betas sizeably. The average beta of a stock the ARS-levered funds buy during the event year is 1.12, up by 0.07 from the non-event periods. The average sell has a beta of 0.97, down by 0.08 from non-event periods.

[Table 3 here]

To formally test for changes in the differences in betas between buys and sells, we estimate Equation (2) without additional controls, and report the results in the first column of Table 4. The coefficient of the greatest interest, the triple-interaction $Beta_{i,j,t} \times I_{ARS,i} \times I_{t=0}$ coefficient, is positive (0.0501) and statistically very significant (t-stat 3.03). This shows that the beta-sensitivity of ARS-levered funds' decisions to buy stocks increases significantly in the 12 months following the ARS market freeze compared to the non-levered funds. The statistically non-significant coefficient of $Beta_{i,j,t} \times I_{t=0}$ shows that there is no change following the ARS market collapse in how the non-levered funds' buy and sell decisions depend on stock betas. Hence, the relative increase in the ARS-levered funds' buying of high-beta stocks is fully driven by the ARS-levered funds, not by the non-levered funds. To gauge the economic significance of the result, note that 50% of the transactions in our data are buys and 50% are sells. A one standard deviation increase in beta increases an ARS-levered funds' probability of buying to 55% during the 12 months following the ARS market collapse.[10]

[Table 4 here]

The remaining columns of Table 4 provide further results regarding changes in the ARS-levered funds' trading behavior following the ARS collapse. Columns 2-4 focus on the extensive margin of the fund portfolios. In column 2, the dependent variable is $Open_{i,j,t}$ which takes the value one only if fund i did not hold a position in stock j at end of quarter $t-1$ but buys the stock during quarter t. The sample in this regression is all the fund-stock-quarter observations where the fund did not hold a position in the stock at the end of the previous quarter. There are of course each quarter thousands of stocks that a fund does not open a position in and, hence, the sample size is much larger than in column 1 where the focus is just on buys and sells. The coefficient of interest is positive (0.0501) and statistically significant (t-stat 3.03) showing that ARS-levered funds are more likely to open new positions in high-beta stocks following the leverage constraint shock. While the coefficient is small, it is

[10]Note that Equation (2) is a linear probability model and the estimated probabilities should be interpreted as indicative.

useful to note that the unconditional probability of opening a position in a stock is very small as well, only 0.25%, and the magnitude of the effect is economically significant.

In column 3, the dependent variable is $Close_{i,j,t}$ which equals one if the fund sells all its shares of stock j during the quarter. The sample in this case consists of all the stocks the fund held at the end of the previous quarter. The triple-interaction coefficient is negative, as predicted, but lacks any statistical significance (t-stat -0.11). This implies that the ARS-levered funds do not respond to the tightened leverage constraints by closing more low-beta positions, as could be predicted based on the theory. In column 4, the dependent variable is $Open_{i,j,t}$ and the data consists of all the fund-stock-quarter observations where either $Open_{i,j,t}$ or $Close_{i,j,t}$ equals one. In effect, this specification compares the stocks in which funds open new positions to those stocks in which they close existing positions. Given that the triple-interaction effect is significant for the position openings in column 2 and zero for closings in column 3, it is not surprising that it is also positive (0.0661) and statistically very significant (t-stat 2.8) when comparing openings to closings. This result implies, that the difference in betas of the stocks in which the ARS-levered funds open and close positions widens as a result of the ARS market collapse. We conclude that leverage constraints affect the funds' appetite for beta on the extensive margin of their portfolios, but only through position openings, not closings.

Columns 5-7 present similar analyses but for the intensive margin of the portfolios. In column 5, the dependent variable is $Increase_{i,j,t}$ which equals one if the fund buys more of a stock it already holds, whereas in column 6 analyzes $Decrease_{i,j,t}$ which indicates partial selling of a position. The results show that ARS-funds are significantly more likely to increase, and less likely to decrease, positions in high-beta stocks during the event year. The triple-interaction coefficient is 0.0142 (t-stat 2.2) for $Increase_{i,j,t}$ and -0.0228 (t-stat -2.8) for $Decrease_{i,j,t}$. Finally, in column 7, we focus on the subset of data where the fund either decreases or increases its existing positions. The dependent variable in column 7 is $Increase_{i,j,t}$ and the analysis, in effect, compares the stock in which funds increase positions to those where positions are decreased. Given the estimates in columns 5 and 6, it is natural that the triple-interaction coefficient in column 7 is positive (0.0468) and statistically significant (t-stat 2.3). Taken together, these results show that the ARS-levered funds react to the tightened leverage constraint by significantly reallocating their portfolios towards the higher-beta stocks.

Overall, the results presented in Table 4 provide strong empirical support for the theories of Black (1972) and Frazzini and Pedersen (2014). Tightened leverage constraints cause the ARS-funds to increase portfolio betas by opening new positions in higher-beta stocks and reallocating existing holdings from lower-beta to higher-beta stocks.

In the remaining analyses, we focus on the dataset used in column 1 of Table 4 which contains all the fund-stock-quarter observations where the fund either buys or sells the stocks. Table 5 and Figure 4 show that our main result is not driven by differing trends in the buy-sell decisions of the ARS-levered and non-levered funds. We do this by including in the regression separate dummies for each 12-month period for up to three years before and after the event year and interacting these time dummies with the stock beta and the ARS dummy.

[Table 5 and Figure 4 here]

The results in Table 5 show that there are no significant differences in the buy-sell decisions' sensitivity to stock beta between the ARS-levered and non-levered funds in any other period than immediately following the ARS market collapse. Figure 4 illustrates this clearly. The figure plots the coefficient of beta with 95% confidence interval for each year separately for ARS-levered funds and non-levered funds. During the 12 months following the collapse of the ARS-market, the ARS-levered funds buy significantly higher-beta stocks. In all other periods, there is no significant difference between the betas of their buys and sells. Before and after the event year, the non-levered funds and ARS-levered funds behave very similarly in terms their of buy-sell decisions depending stock betas. The only difference happens during the event year. Overall, we conclude that the behavior of the funds is very similar except immediately following the tightening of the ARS-levered funds' leverage constraints.

It is worth noting that the results presented in Table 5 and Figure 4 do not imply that the ARS-levered funds lower their portfolio betas in the years after the event year. In the regressions we relate the decision to buy a stock to the stocks' beta. Hence, the results speak to the changes in, not the levels of, portfolio betas. The results here suggest that the tightened leverage constraints cause the affected funds to increase portfolio betas in the first 12 months following the tightening. In the subsequent years, the funds maintain this higher level of beta as their buy-sell decisions do not depend on betas, positively or negatively. This is also evident in Figure 1.

5.2 Other possible explanations

We next explore whether the funds react to the leverage constraints by changing exposures to other stock characteristics and whether such changes can explain the increased propensity to buy high-beta stocks. We begin this analysis by including in Equation (2) other standard measures of risk and interacting them with the ARS and event year dummies. The other risk measures we include are market capitalization, book-to-market ratio, cumulative return over the previous 12 to 2 months, and idiosyncratic volatility.[11]

[Table 6 here]

Columns 1 and 2 of Table 6 show that the ARS-levered funds do not significantly alter their trading behavior with respect to firm size as a response to the ARS market collapse. The point estimates of the triple-interaction of size and the dummies are negative—indicating that the ARS-levered funds increase buying of smaller stocks—but lack statistical significance. Also, inclusion of size as an explanatory variable does not affect the triple-interaction coefficient related to beta which remains positive and statistically significant. The same is true for book-to-market ratio in columns 3 and 4 and idiosyncratic volatility in columns 7 and 8.

Momentum is an exception, in the sense that it seems to matter in addition to beta. The ARS-levered funds significantly decrease buying of stocks with relatively high returns and increase selling of stocks with lower returns. This result is not directly consistent with the theoretical predictions if one interprets momentum as a risk factor. The result can be, at least partially, justified by the funds liquidating positions to repurchase their ARS. Selling stocks with relatively high past return may be easier due to better liquidity or preferred for behavioral reasons, such as disposition effect of Shefrin and Statman (1985). Overall, the other standard risk factors have a very limited role and do not affect the results relating to beta.

Next, we take a closer look at the role of stock liquidity. ARS funds increase selling as a result of the leverage constraint shock to de-lever their portfolios. This is evident in column 1 of Table 4 where the coefficient of $I_{ARS,i} \times I_{t=0}$ is statistically

[11]The definitions of these variables are provided in Appendix A.

significant negative. It is plausible that the liquidating funds would seek to sell their more liquid holdings to avoid negative price impacts. If liquidity and beta are positively correlated, this could contribute to our findings above. Table 7 presents results, similar to those presented in Table 6, of adding measures of liquidity to the baseline regression. We use four measures of stock liquidity: turnover and the measures suggested by Amihud (2002), Roll (1984), and Corwin and Schultz (2012). We multiply the measures by -1, if necessary, so that a higher value always implies a more liquid stock.

[Table 7 here]

Overall, liquidity, like the additional risk factors, seem to have a very limited effect. The only liquidity measure with robust significant results is the bid-ask spread of Corwin and Schultz (2012). According to the results in columns 7 and 8 of the table, the ARS-levered funds seem to sell stocks with tighter bid-ask spreads following the ARS market collapse. These funds, however, do not buy more or less stocks with higher turnover (columns 1 and 2), better Amihud (2002) liquidity (columns 3 and 4), or better Roll (1984) liquidity (columns 5 and 6). Including any of the four liquidity measures does not affect the results related to beta.

Overall, the results presented in Tables 6 and 7 show that changes to fund behavior with respect to other risk factors and stock liquidity are rather limited. Most importantly, including additional control variables does not affect the result that funds react to tightened leverage constraints by buying significantly higher-beta stocks.

5.3 Further evidence on role of leverage constraints

In this section we provide further evidence that the ARS-levered CEFs buying of high-beta stocks following the collapse of the ARS market is, indeed, driven by their tightened leverage constraints. First, we add measures of firm leverage as explanatory variables in the baseline regression and interact them with the indicator variables. Table 8 presents the results.

[Table 8 here]

In columns 1 and 2, the measure of leverage is the firm's financial leverage, total debt divided by total assets, at the end of the previous fiscal year. The triple interaction of financial leverage, the ARS indicator, and the event year indicator is positive and statistically significant, especially when stock beta is also included as an explanatory variable (column 2). This implies that following the ARS market collapse the ARS-levered funds buy significantly more stocks of levered firms. This result is consistent with the idea of embedded leverage by Frazzini and Pedersen (2012) that leverage-constrained investors use leveraged financial instruments to alleviate their own constraints. While Frazzini and Pedersen (2012) focus on options and leveraged ETFs, the idea seems to work also in the context of individual stocks.[12] In columns 3 and 4, we use the measure of operating leverage by Novy-Marx (2011), operating costs divided by assets. While the triple-interaction coefficients associated with operating leverage are also positive, they are not statistically significantly different from zero. Hence, it seems that the ARS-levered funds do not increase, or decrease, their exposure to firms with high operating leverage.

[12] Whether leverage-constrained investors' buying of high-leverage stocks contribute to the low average returns of those stocks, documented by among others Fama and French (1992) and George and Hwang (2010), is beyond the scope of this paper.

Finally, a competing behavioral explanation for the low-risk anomalies suggests that behavioral biases induce investors to holds stocks with lottery-like returns, like high-beta stocks. Kumar (2009) reports that some investors prefer to buy stocks that exhibit lottery-like characteristics. Bali et al. (2017) and Liu et al. (2018) suggest that such demand for high-risk stocks also affect the cross-sectional pricing of risk. In Table 6 above we show that controlling for idiosyncratic volatility does not alter the results. To further investigate the mechanisms behind beta itself we decompose beta into two components, market correlation and volatility relative to market, and test which of the two is more important in explaining the behavior of the CEFs. This analysis is motivated by Asness et al. (2020) who test the theories of low-risk anomalies with a similar decomposition. They argue that the leverage-constraint explanations of low-risk anomalies are more related to market correlation whereas behavioral explanations are more about volatility. In our context, this would imply that if the funds increase portfolio betas due to increased demand for lottery-like stocks, the effect should show up mostly as increased demand for volatility rather than market correlation.

The results in Table 9 show that our main result in Table 4 is mainly driven by market correlation. The ARS-levered funds buy significantly more high-correlation stocks following the collapse of the ARS market. The effect on buying of high-volatility stocks is positive but not statistically significant. These results support the interpretation that the ARS-levered funds increase their portfolio betas due to tightened leverage constraints rather than any possible behavioral reasons.

[Table 9 here]

6 Conclusions

In this paper we test directly the portfolio choice implications of investors' leverage constraints. Using the collapse of the market for auction rate securities in February 2008 as an exogenous shock to leverage constraints, we show that those closed-end funds that used these particular securities to lever, significantly increase their portfolio betas in the months following the shock. This result provides strong empirical support for the causal mechanism underlying the theories of asset pricing under leverage constraints by Black (1972) and Frazzini and Pedersen (2014). We further show that the result is robust to inclusion of other risk factors and measures of stock liquidity. We also show that the affected funds also increase purchases of levered firms and that the main result is mainly driven by market correlation, not volatility. To our knowledge, we are the first to provide evidence on how leverage constraints causally affect investors' portfolio choice and, especially, appetite for systematic risk.

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Figures and tables

Figure 1: Portfolio betas. This figure plots the average portfolio betas of ARS-levered and non-levered CEFs. Portfolio betas are calculated for each fund as a value-weighted average of the betas of the stocks in the fund's portfolio. The average betas plotted here are equal-weighted averages of the fund betas. Event year 0 is from February 7, 2008, to February 6, 2009. The other time periods are three years before and after the event year, i.e. from February 7, 2005, to February 6, 2012.

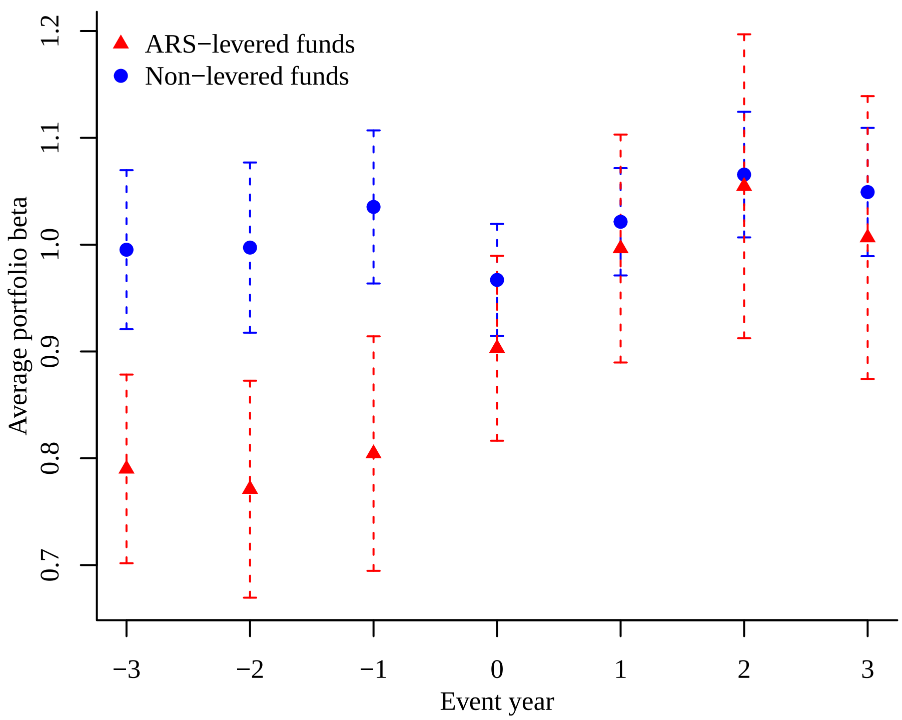

Figure 2: Portfolio choice with leverage constraint. This figure illustrates portfolio choice with and without leverage constraints. There are two risky assets, A and B, and a risk-free asset F. The blue lines represent possible portfolios, and T is the tangency portfolio. U is the optimal portfolio of an unconstrained investor with relatively low risk aversion. C is the optimal portfolio with same risk aversion but under a constraint that prevents the use of leverage. The dashed red lines represent indifference curves.

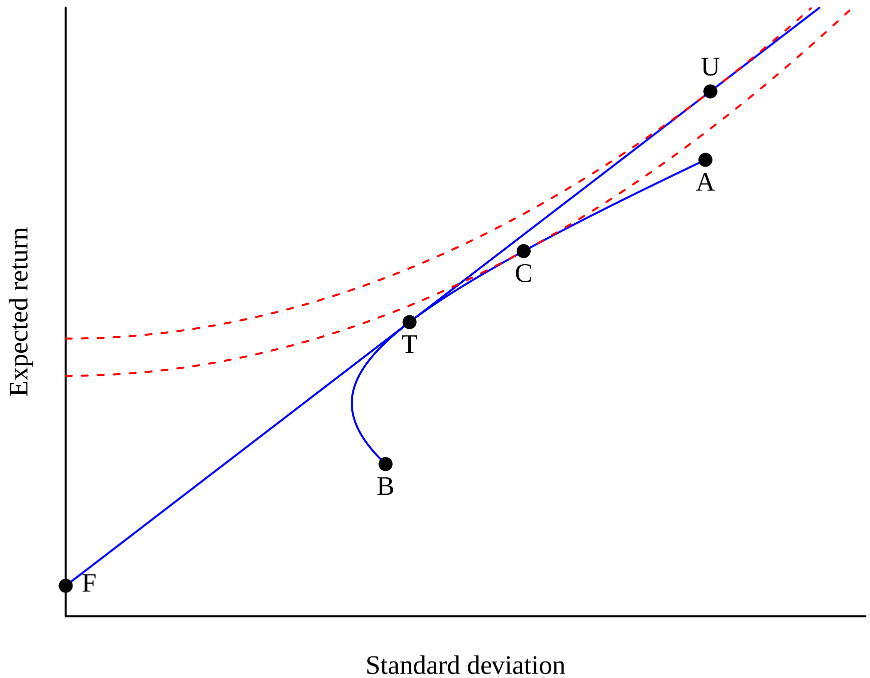

Figure 3: Closed-end fund debt. This figure plots the total debt outstanding of the 21 ARS-levered CEFs in our final sample. The red line plots the amount of ARS outstanding and the blue line plots the amount of all other debt, mainly bank loans.

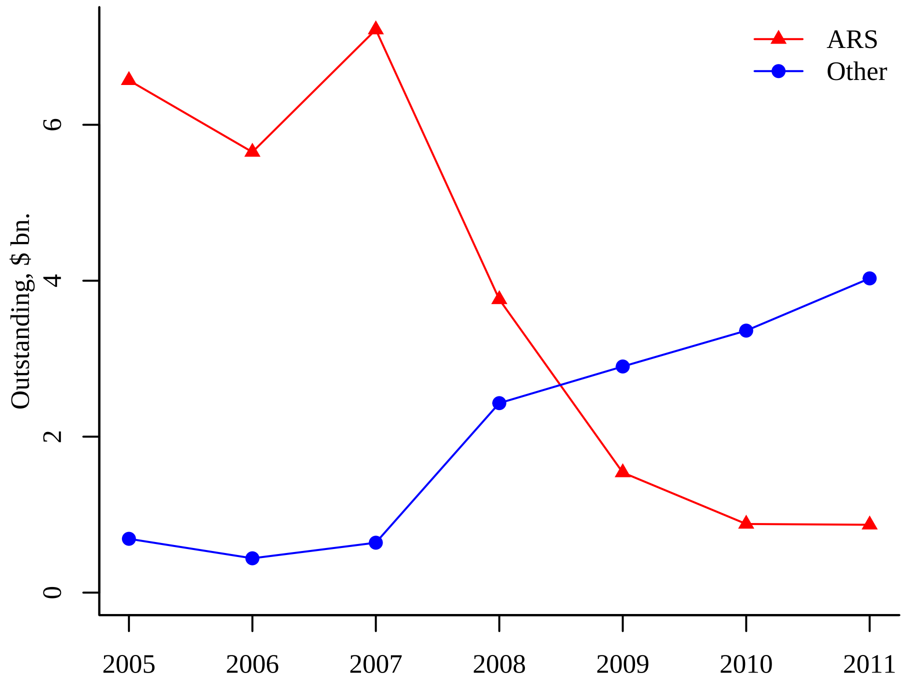

Figure 4: Time variation. This figure plots the coefficient of beta in a regression of *Buy* on *Beta* estimated separately for each event year, and for ARS-levered and non-levered funds. The data in these regressions is a fund-stock-quarter panel. The dependent variable, *Buy* equals one if the fund buys the stock and zero if the fund sells the stock. *Beta* is the stock's beta. The dashed lines plot the 95% confidence intervals based on standard errors clustered by fund. Event year 0 is from February 7, 2008, to February 6, 2009. The other time periods are three years before and after the event year, i.e. from February 7, 2005, to February 6, 2012. This figure is equivalent to results reported in column 3 of Table 5.

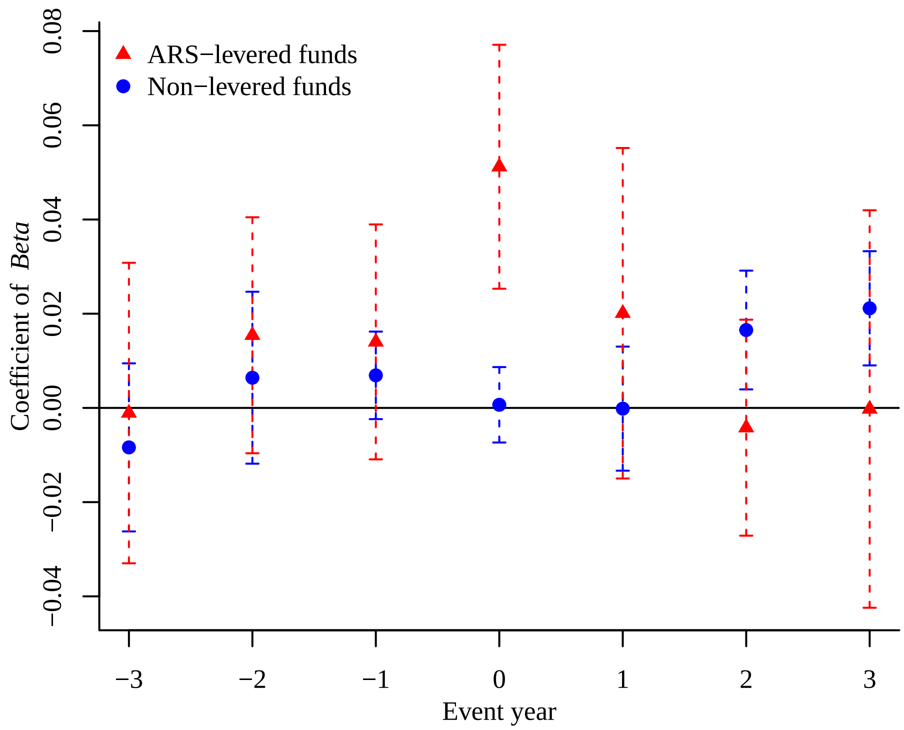

Table 1: Positions and transactions. This table gives the total number of positions and different types of transactions in the final data. *Total* gives the total amounts and *Mean* gives the amounts for and average fund-quarter observation. The figures are reported for all funds and separately for ARS-levered and non-levered funds.

	All funds		ARS-levered		Non-levered	
	Total	Mean	Total	Mean	Total	Mean
Funds	80		23		57	
Positions	153,409	93.26	33,068	63.35	120,898	106.89
Buys	38,647	23.49	7,370	14.31	31,277	27.68
Sells	55,841	33.95	8,988	17.45	46,853	41.46
Opens	13,703	8.33	3,311	6.43	10,392	9.20
Closes	13,146	7.99	3,195	6.20	9,951	8.81
Increases	24,953	15.17	4,059	7.88	20,894	18.49
Decreases	42,719	25.97	5,793	11.25	36,926	32.68

Table 2: Descriptive statistics. This table gives the descriptive statistics of the stock-level variables used in the regressions. These are time series averages of quarterly cross-sectional statistics. Variable definitions are given in Appendix A. The sample period is from 2005 to 2012.

	Mean	St.dev.	Q1	Median	Q3
Beta	1.258	0.814	0.702	1.114	3.865
Market equity ($ bn.)	9.674	25.942	0.936	2.587	132.637
Book-to-market	0.575	0.639	0.292	0.497	2.310
Momentum	0.103	0.497	-0.124	0.043	1.474
Idiosyncratic volatility	0.095	0.053	0.061	0.083	0.290
Turnover	1.253	1.020	0.643	0.989	5.029
Amihud illiquidity	0.088	0.965	0.000	0.002	1.180
Roll illiquidity	0.010	0.010	0.001	0.008	0.039
Corwin-Schultz spread	0.002	0.003	0.001	0.002	0.011
Financial leverage	0.594	0.256	0.418	0.592	1.205
Operating leverage	0.717	0.732	0.254	0.551	3.313
Market correlation	0.462	0.174	0.351	0.480	0.780
Relative volatility	2.843	1.465	1.871	2.537	8.009

Table 3: Average betas. This table presents the average betas of stocks bought and sold by ARS-levered and non-levered closed-end funds during the event year ($t = 0$, February 7, 2008, to February 6, 2009) and during other times ($t \neq 0$).

	$t = 0$		$t \neq 0$	
	Buy	Sell	Buy	Sell
ARS-levered	1.122	0.967	1.049	1.049
Non-levered	1.078	1.065	1.092	1.080

Table 4: Baseline results. This table presents the results of regressing a funds decision to trade a stock on on the stock's beta, an indicator for whether the fund uses ARS to lever, and an indicator for whether the decision happens during the event year. The data is a fund-stock-quarter panel. All the dependent variables are binary indicators for different types of transactions. In column 1, *Buy* is one if the fund buys the stock and zero otherwise. Here the sample consists of observations where the number of stocks held (adjusted for splits) increases or decreases from the previous holdings report (i.e. buys and sells). In column 2, *Open* indicates the fund buying the stock and did not hold it previously. Here the sample is all fund-stock-quarter observations where the fund did not hold a position in the stock at the end of the previous quarter. In column 3 *Close* indicates the fund selling all its share in the stock. Here the sample consists of all the stocks the fund held at the end of the previous quarter. In column 4, the sample consists of all the fund-stock-quarter observations where either $Open_{i,j,t}$ or $Close_{i,j,t}$ equals one. In effect, this column compares the stocks in which funds open new positions to those stocks in which they close existing positions. In column 5-6 the sample consists of all the stocks the fund held at the end of the previous quarter. *Increase* indicates the fund buying more of a stock it already holds, and *Decrease* indicates the fund selling part of its holdings in a stock. In column 7, the sample consist of data where the fund either decreases or increases its existing positions and the analysis, in effect, compares the stock in which funds increase positions to those where positions are decreased. *Beta* is the beta of the stock estimated with data up to the previous holdings report date. I_{ARS} equals one for funds that have ARS outstanding at the end of 2007 and zero otherwise. $I_{t=0}$ equals one for observations between 2/7/2008 and 2/6/2009. All regressions include fund and event year fixed effects. t-statistics reported in parenthesis are based on standard errors clustered by fund. R^2 are reported excluding the fixed effects. Sample period is from 2/7/2005 to 2/6/2012.

	Trades	Extensive margin			Intensive margin		
	Buy	Open	Close	Open	Increase	Decrease	Increase
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$Beta \times I_{ARS} \times I_{t=0}$	0.0501	0.0005	0.0006	0.0661	0.0142	-0.0228	0.0468
	(3.03)	(2.21)	(0.11)	(2.81)	(2.23)	(-2.76)	(2.33)
$Beta \times I_{ARS}$	0.0005	0.0000	-0.0019	0.0017	0.0041	0.0169	-0.0021
	(0.08)	(0.26)	(-0.65)	(0.18)	(1.25)	(4.22)	(-0.35)
$Beta \times I_{t=0}$	-0.0066	-0.0001	0.0042	-0.0291	0.0058	0.0046	0.0031
	(-1.36)	(-0.79)	(1.50)	(-3.09)	(1.78)	(1.05)	(0.57)
$Beta$	0.0073	-0.0003	0.0094	0.0033	-0.0006	-0.0141	0.0072
	(2.76)	(-3.93)	(7.70)	(0.56)	(-0.21)	(-4.91)	(2.22)
$I_{ARS} \times I_{t=0}$	-0.1381	-0.0006	0.0134	-0.0846	-0.0687	0.0917	-0.1276
	(-2.54)	(-2.22)	(1.22)	(-3.97)	(-2.80)	(2.21)	(-1.96)
R^2	0.0020	0.0000	0.0014	0.0014	0.0010	0.0019	0.0017
Observations	94,463	4,949,093	152,852	26,751	152,852	152,852	67,616

Table 5: Year dummies. This table presents the results of regressing a funds decision to trade a stock on on the stock's beta, an indicator for whether the fund uses ARS to lever, and indicators for different time periods. The data is a fund-stock-quarter panel. The dependent variable is *Buy*, an indicator variable that equals one if the fund buys the stock and zero if the fund sells the stock. *Beta* is the beta of the stock estimated with data up to the previous holdings report date. I_{ARS} equals one for funds that have ARS outstanding at the end of 2007 and zero otherwise. The time indicator variables, $I_{t=\tau}$ equal one for observations between 2/7 of year $2008+\tau$ and 2/6 of year $2009+\tau$, $\tau=-3,\ldots,3$. All regressions include fund and event year fixed effects. t-statistics reported in parenthesis are based on standard errors clustered by fund. R^2 are reported excluding the fixed effects. Sample period is from 2/7/2005 to 2/6/2012.

	(1)	(2)	(3)
$Beta \times I_{ARS} \times I_{t=-3}$			0.0073
			(0.39)
$Beta \times I_{ARS} \times I_{t=-2}$		0.0184	0.0090
		(0.76)	(0.57)
$Beta \times I_{ARS} \times I_{t=-1}$	0.0151	0.0165	0.0071
	(1.10)	(1.13)	(0.52)
$Beta \times I_{ARS} \times I_{t=0}$	0.0585	0.0599	0.0505
	(3.15)	(2.75)	(3.65)
$Beta \times I_{ARS} \times I_{t=1}$	0.0282	0.0296	0.0203
	(1.28)	(1.09)	(1.06)
$Beta \times I_{ARS} \times I_{t=2}$		-0.0113	-0.0207
		(-0.56)	(-1.55)
$Beta \times I_{ARS} \times I_{t=3}$			-0.0214
			(-0.95)
R^2	0.0025	0.0026	0.0043
Observations	94,463	94,463	94,463

Table 6: Additional risk factors. This table presents the results of regressing a funds decision to trade a stock on on the stock's beta, other risk factors, an indicator for whether the fund uses ARS to lever, and an indicator for whether the decision happens during the event year. The data is a fund-stock-quarter panel. The dependent variable is *Buy*, an indicator variable that equals one if the fund buys the stock and zero if the fund sells the stock. *Beta* is the beta of the stock estimated with data up to the previous holdings report date. ME is the logarithm of the stock's market equity, $BEME$ is the logarithm of the stock's book-to-market ratio, MOM is the stock's cumulative return over the previous 2 to 12 months, and $IVOL$ is the stock's idiosyncratic volatility. All the risk variables are observed at the time of the fund's previous holdings report date. I_{ARS} equals one for funds that have ARS outstanding at the end of 2007 and zero otherwise. $I_{t=0}$ equals one for observations between 2/7/2008 and 2/6/2009. All regressions include fund and event year fixed effects. t-statistics reported in parenthesis are based on standard errors clustered by fund. R^2 are reported excluding the fixed effects. Sample period is from 2/7/2005 to 2/6/2012.

	ME		BEME		MOM		IVOL	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Beta \times I_{ARS} \times I_{t=0}$		0.0468		0.0445		0.0432		0.0560
		(2.77)		(2.55)		(2.67)		(3.07)
$X \times I_{ARS} \times I_{t=0}$	-0.0212	-0.0142	-0.0084	-0.0015	-0.0388	-0.0315	0.0062	-0.0186
	(-1.17)	(-0.77)	(-0.55)	(-0.10)	(-2.97)	(-2.55)	(0.35)	(-0.97)
$Beta \times I_{ARS}$		0.0025		0.0031		-0.0003		0.0128
		(0.42)		(0.50)		(-0.06)		(2.06)
$Beta \times I_{t=0}$		-0.0044		-0.0069		-0.0025		-0.0088
		(-0.79)		(-1.42)		(-0.46)		(-1.27)
$Beta$		0.0077		0.0070		0.0080		-0.0023
		(2.72)		(2.79)		(2.98)		(-0.59)
$X \times I_{ARS}$	0.0096	0.0099	-0.0122	-0.0124	-0.0200	-0.0205	-0.0143	-0.0218
	(0.96)	(0.95)	(-1.20)	(-1.20)	(-1.61)	(-1.65)	(-1.87)	(-2.52)
$X \times I_{t=0}$	0.0126	0.0115	-0.0078	-0.0075	0.0222	0.0224	0.0058	0.0094
	(1.11)	(0.96)	(-0.84)	(-0.79)	(2.72)	(2.65)	(0.71)	(0.93)
X	0.0000	0.0018	0.0014	0.0011	0.0113	0.0118	0.0158	0.0171
	(-0.00)	(0.19)	(0.40)	(0.31)	(2.46)	(2.54)	(2.78)	(2.36)
$I_{ARS} \times I_{t=0}$	-0.1381	-0.1381	-0.1436	-0.1436	-0.1380	-0.1380	-0.1381	-0.1381
	(-2.54)	(-2.54)	(-2.66)	(-2.66)	(-2.54)	(-2.54)	(-2.54)	(-2.54)
R^2	0.0017	0.0022	0.0018	0.0023	0.0028	0.0032	0.0026	0.0030
Observations	94,463	94,463	92,789	92,789	94,453	94,453	94,463	94,463

Table 7: Liquidity. This table presents the results of regressing a funds decision to trade a stock on on the stock's beta, its liquidity, an indicator for whether the fund uses ARS to lever, and an indicator for whether the decision happens during the event year. The data is a fund-stock-quarter panel. The dependent variable is *Buy*, an indicator variable that equals one if the fund buys the stock and zero if the fund sells the stock. *Beta* is the beta of the stock estimated with data up to the previous holdings report date. $Turnover$ is the stock's average turnover ratio, *Amihud* is the negative of the stock's Amihud (2002) illiquidity ratio, *Roll* is the negative of the stock's Roll (1984) illiquidity measure, and CS is the negative of the stock's Corwin and Schultz (2012) bid-ask spread measure. All the liquidity variables are estimated using 12 months of daily data ending at the time of the fund's previous holdings report date. Some measures of liquidity are multiplied by negative one so that a higher value represents a more liquid stock. I_{ARS} equals one for funds that have ARS outstanding at the end of 2007 and zero otherwise. $I_{t=0}$ equals one for observations between 2/7/2008 and 2/6/2009. All regressions include fund and event year fixed effects. t-statistics reported in parenthesis are based on standard errors clustered by fund. R^2 are reported excluding the fixed effects. Sample period is from 2/7/2005 to 2/6/2012.

	Turnover		Amihud		Roll		CS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Beta \times I_{ARS} \times I_{t=0}$		0.0490		0.0468		0.0500		0.0547
		(2.64)		(2.85)		(3.02)		(3.36)
$Liq \times I_{ARS} \times I_{t=0}$	0.0288	0.0044	-0.0082	-0.0059	-0.0031	-0.0023	-0.0169	-0.0258
	(2.60)	(0.35)	(-0.48)	(-0.34)	(-0.31)	(-0.22)	(-1.72)	(-2.53)
$Beta \times I_{ARS}$		0.0029		0.0035		0.0006		0.0007
		(0.43)		(0.58)		(0.10)		(0.12)
$Beta \times I_{t=0}$		-0.0127		-0.0057		-0.0066		-0.0088
		(-2.05)		(-1.13)		(-1.37)		(-1.87)
$Beta$		0.0091		0.0065		0.0073		0.0070
		(3.10)		(2.28)		(2.78)		(2.70)
$Liq \times I_{ARS}$	-0.0063	-0.0068	0.0150	0.0158	0.0003	0.0003	-0.0034	-0.0031
	(-0.74)	(-0.70)	(1.23)	(1.25)	(0.04)	(0.05)	(-0.60)	(-0.53)
$Liq \times I_{t=0}$	0.0067	0.0127	0.0087	0.0076	-0.0006	-0.0010	0.0100	0.0109
	(1.22)	(1.88)	(0.85)	(0.72)	(-0.11)	(-0.16)	(1.51)	(1.71)
Liq	0.0002	-0.0040	-0.0066	-0.0054	0.0007	0.0011	0.0030	0.0024
	(0.03)	(-0.56)	(-0.61)	(-0.48)	(0.31)	(0.44)	(0.91)	(0.72)
$I_{ARS} \times I_{t=0}$	-0.1381	-0.1381	-0.1369	-0.1370	-0.1380	-0.1380	-0.1381	-0.1381
	(-2.54)	(-2.54)	(-2.50)	(-2.50)	(-2.54)	(-2.54)	(-2.54)	(-2.54)
R^2	0.0017	0.0021	0.0017	0.0021	0.0015	0.0020	0.0017	0.0022
Observations	94,462	94,462	94,410	94,410	94,422	94,422	94,458	94,458

Table 8: Leverage. This table presents the results of regressing a funds decision to trade a stock on on the stock's beta, its leverage, an indicator for whether the fund uses ARS to lever, and an indicator for whether the decision happens during the event year. The data is a fund-stock-quarter panel. The dependent variable is *Buy*, an indicator variable that equals one if the fund buys the stock and zero if the fund sells the stock. *Beta* is the beta of the stock estimated with data up to the previous holdings report date. *Financial* leverage is measured as the stock's total debt divided by assets, and *Operating* leverage is operating costs divided by assets. The leverage variables are updated every June based on the previous fiscal year and observed at the time of the fund's previous holdings report date. I_{ARS} equals one for funds that have ARS outstanding at the end of 2007 and zero otherwise. $I_{t=0}$ equals one for observations between 2/7/2008 and 2/6/2009. All regressions include fund and event year fixed effects. t-statistics reported in parenthesis are based on standard errors clustered by fund. R^2 are reported excluding the fixed effects. Sample period is from 2/7/2005 to 2/6/2012.

	Financial		Operating	
	(1)	(2)	(3)	(4)
$Beta \times I_{ARS} \times I_{t=0}$		0.0548		0.0525
		(3.03)		(2.90)
$Lev \times I_{ARS} \times I_{t=0}$	0.0293	0.0346	0.0151	0.0155
	(1.93)	(2.31)	(1.14)	(1.12)
$Beta \times I_{ARS}$		0.0035		0.0038
		(0.57)		(0.64)
$Beta \times I_{t=0}$		-0.0050		-0.0046
		(-0.95)		(-0.87)
$Beta$		0.0047		0.0049
		(1.75)		(1.92)
$Lev \times I_{ARS}$	-0.0129	-0.0134	0.0044	0.0042
	(-1.97)	(-2.01)	(0.64)	(0.61)
$Lev \times I_{t=0}$	-0.0077	-0.0080	0.0001	0.0002
	(-1.22)	(-1.26)	(0.01)	(0.03)
Lev	0.0049	0.0051	-0.0163	-0.0165
	(1.99)	(2.07)	(-4.58)	(-4.58)
$I_{ARS} \times I_{t=0}$	-0.1381	-0.1381	-0.1380	-0.1380
	(-2.54)	(-2.54)	(-2.54)	(-2.54)
R^2	0.0017	0.0021	0.0026	0.0030
Observations	94,463	94,463	94,442	94,442

Table 9: Beta components. This table presents the results of regressing a funds decision to trade a stock on the components of the stock's beta, an indicator for whether the fund uses ARS to lever, and an indicator for whether the decision happens during the event year. The data is a fund-stock-quarter panel. The dependent variable is *Buy*, an indicator variable that equals one if the fund buys the stock and zero if the fund sells the stock. Cor is the stock's correlation with the market, and Sd is the stock's volatility divided by the market volatility. The beta components are estimated with data up to the previous holdings report date. I_{ARS} equals one for funds that have ARS outstanding at the end of 2007 and zero otherwise. $I_{t=0}$ equals one for observations between 2/7/2008 and 2/6/2009. All regressions include fund and event year fixed effects. t-statistics reported in parenthesis are based on standard errors clustered by fund. R^2 are reported excluding the fixed effects. Sample period is from 2/7/2005 to 2/6/2012.

	(1)	(2)	(3)
$Cor \times I_{ARS} \times I_{t=0}$	0.0517		0.0502
	(2.83)		(2.69)
$Sd \times I_{ARS} \times I_{t=0}$		0.0157	0.0173
		(0.87)	(1.01)
$Cor \times I_{ARS}$	0.0154		0.0170
	(2.59)		(2.81)
$Cor \times I_{t=0}$	-0.0073		-0.0057
	(-0.93)		(-0.69)
Cor	-0.0065		-0.0082
	(-1.59)		(-1.89)
$Sd \times I_{ARS}$		-0.0126	-0.0142
		(-1.68)	(-1.86)
$Sd \times I_{t=0}$		0.0035	0.0027
		(0.47)	(0.35)
Sd		0.0151	0.0160
		(2.87)	(2.89)
$I_{ARS} \times I_{t=0}$	-0.1381	-0.1381	-0.1381
	(-2.54)	(-2.54)	(-2.54)
R^2	0.0021	0.0025	0.0031
Observations	94,463	94,463	94,463

Appendix A Variables

Variable	Description
ARS indicator	Equal to one if fund used auction rate securities to lever at the end of 2007, zero otherwise.
Event year indicator	Equal to one if holdings report date is between February 7, 2008, and February 6, 2009, zero otherwise.
Beta	The coefficient of the market excess return in a regression of stock excess returns on market excess returns. Estimated using a minimum of 24 monthly observations over the previous 36 months.
Market equity	Number of shares outstanding time share price.
Book-to-market	Book value of equity at the end of previous fiscal year divided by market value of equity at the end of previous year. Updated at the end of June each year.
Momentum	Stock's cumulative return over the previous 12 to 2 months.
Idiosyncratic volatility	The standard deviation of error terms in a regression regression of stock excess returns on market excess returns. Estimated using a minimum of 24 monthly observations over the previous 36 months.

Variable	Description
Turnover	Average of daily trading volume divided by number of shares outstanding. Estimated over the previous year. Standardized by dividing by stock exchange average (NYSE and AMEX treated as one exchange) to account for different ways of accounting for volume.
Amihud illiquidity	Average of daily absolute return divided by dollar trading volume (Amihud, 2002). Estimated over the previous year. Standardized by dividing by stock exchange average (NYSE and AMEX treated as one exchange) to account for different ways of accounting for volume.
Roll illiquidity	Two times the negative of the first order serial covariance of daily stock returns (Roll, 1984). Estimated over the previous year. Zero in cases of positive first order serial covariance.
Corwin-Schultz spread	An estimate of the stock's bid-ask spread based on the daily high and low prices (Corwin and Schultz, 2012). Estimated over the previous year. Negative values replaced by zero.
Financial leverage	Long term debt plus debt in current liabilities divided by assets. Updated in June each year.
Operating leverage	Annual operating costs divided by assets. Updated in June each year (Novy-Marx, 2011).

Variable	Description
Market correlation	Correlation between stock excess returns and market excess returns. Estimated using a minimum of 24 monthly observations over the previous 36 months.
Relative volatility	Standard deviation of stock excess returns divided by standard deviation of market excess returns. Estimated using a minimum of 24 monthly observations over the previous 36 months.