Scale Economies in the Money Market[*]

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Abstract:

Money-market issuers reward scale when they borrow from prime money funds. The scale they reward isn't the scale of the transaction or of the fund, but rather the scale of the fund complex. For a one-month loan the magnitude is a basis point per fourfold increase in complex size. Larger complexes also enjoy an advantage when exiting holdings: they are both more likely to part with a holding and more likely to exchange it with the issuer for new paper with longer maturity. Our results demonstrate both economies of scale, which can concentrate the industry, and also the importance of relationships in money-market transactions.

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I. Introduction

At the foundation of the capital markets sits the money market, the wholesale market for the shortest-term debt. Because this debt is so short, money-market investors tend to buy at issuance and hold to maturity, and also, they tend to interact with the same issuers many times a year. These attributes of money-market transactions set them apart from the bond and stock transactions usually contemplated in microstructure theory. Microstructure theory leans heavily on the adverse-selection logic of Akerlof (1970), but this logic may not apply as well when investors buy straight from the issuer many times a year, and when they don't sell. An investor repeatedly buying and rolling over might be better modeled as an important and potentially favored customer than as an arms-length party monetizing an informational advantage. This is an important distinction because the effect of scale on money-market transactions helps determine the scale economies of money funds[1], and because money funds are a big part of the shadow banking system. In this paper we estimate the effect of scale on the transactions of prime money funds, the funds investing in the whole range of money-market instruments with minimal credit risk. We analyze the effect both on the pricing of their purchases and on their propensity to exit positions before maturity, and in this analysis we consider the scale of not only the transactions but also of the funds and of the complexes that sponsor them.

Prime money funds are actively managed, and active management is more often associated with scale diseconomies than with scale economies. This association arises from the likely difficulty of scaling up the liquidity demands of an active strategy. If larger liquidity demands fetch worse prices, as in the Kyle (1985) model with asymmetrically-informed traders, then a fund's performance worsens as it grows. As Berk and Green (2004) show, this

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[1] For the purposes of this study 'money fund' means a money market mutual fund operating in the US under section 2a-7 of the Investment Company Act of 1940, or operating elsewhere under similar regulation.

diseconomy of scale can equilibrate funds' prospects through performance-seeking flows. If the effect of scale were instead positive, then instead of equilibration we could get concentration from performance-seeking flows, as inflows would make funds more, not less, attractive. So the effect of scale is important not just to a fund but to the fund industry, and, if concentration threatens financial stability, to the economy in general.

Prime money funds threatened financial stability after the bankruptcy of Lehman Brothers in September 2008. The rapid contraction of prime funds and the resulting contraction of lending to the funds' borrowers were considered threatening enough that the U.S. Treasury committed over $3 Trillion of its balance sheet to the guarantee of money-fund shares.[2] These events led to new disclosure requirements which enable the analysis conducted here, and also to new operational mandates which took effect in 2016 and which significantly rearranged the industry (e.g., Li et al, 2019). Meanwhile in China, the Yu'e Bao money fund, launched in 2013, quickly grew to the world's largest and in 2017 regulators there responded by encouraging its shrinkage.[3] So scale economies among money funds would appear to be a first-order concern, and it is worth considering how the distinctive economics of their transactions might influence the effect of scale.

Regulations require money funds to transact frequently, and the funds transact even more frequently than they have to. Money funds must keep their maturities below low upper bounds, and in practice they keep them well below. A money fund's weighted-average maturity (WAM)

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[2] See "Treasury Department Releases Text of Letter from Secretary Geithner to Hill Leadership on Administration's Exit Strategy for TARP" at https://www.treasury.gov/press-center/press-releases/Pages/tg433.aspx

[3] See "China's giant money market fund relaxes investment restrictions," *Reuters Business News*, April 10th, 2019, at https://www.reuters.com/article/us-ant-financial-funds/chinas-giant-money-market-fund-relaxes-investment-restrictions-idUSKCN1RM0MF

and weighted-average life (WAL)[4] are limited to 60 and 120 days, respectively, and as of September, 2019, the average WAM and WAL of prime funds were 38 and 74 days, respectively. The funds also keep their short-maturity holdings well above the regulatory lower bounds: Daily Liquid Assets (DLA) and Weekly Liquid Assets (WLA)[5] must be at least 10% and 30% of the portfolio, respectively, and as of September 2019, the average DLA and WLA of prime funds were 26% and 43%, respectively. The short maturities mean high turnover: the largest prime fund, Vanguard Prime, reports annual transactions 15 times larger than its average assets, and for the largest institutional prime fund, JPMorgan Prime, the analogous figure is 72 times. These transactions also concentrate in a few counterparties: the Vanguard fund conducted 71% of its transactions with its top ten counterparties, and the JPMorgan fund, 72%.[6] So money funds transact at even higher frequency than they have to, and can be important repeat customers of their counterparties.

The key to gauging the effect of scale on these transactions is the amortized costs the funds report. The amortized cost of a money-fund holding is not its market value, it is a linear interpolation between the purchase price on the purchase date and the principal amount on the maturity date. It is therefore a function only of the purchase price and the passage of time. Therefore, we can compare the value of a holding to the price paid for it by comparing its market value, as calculated by a pricing agent, to its amortized cost. For 65 months, November, 2010 through March, 2016, all money funds reported the amortized cost, market value and principal

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[4] A fund's WAL is the dollar-weighted average of the time to maturity or put option of its holdings, and its WAM is the same except that the maturity of a floating-rate security is shortened to its coupon reset date.

[5] DLA is cash, securities maturing or putable in one business day, and Treasuries, and WLA is DLA plus securities maturing or putable in five business days, plus Agency discount notes within sixty days of maturity.

[6] In form N-CEN/A filed July 9, 2019 for the fiscal year ending August 31, 2018, the Vanguard Prime Fund reports $1.468 Trillion principal value of transactions for the year, $1.046 Trillion of which was with its top ten counterparties, and an average fund size of $98.8 Billion. And in form N-CEN/A filed September 6, 2019 for the fiscal year ending February 28, 2019, the JPMorgan Prime fund reports $3.038 Trillion in transactions, $2.189 Trillion with its top ten counterparties, and an average size of $42.0 Billion.

amount of each of their holdings. This yields a database of over 400 thousand purchases of different security types, predominantly commercial paper (CP) and certificates of deposit (CDs), but also some Agency (AG) and Treasury (TB) securities.[7] We estimate the effect of scale on these purchases with multiple regressions that explain the ratio of market value to amortized cost with the different levels of scale that might matter.

We consider three levels of scale: the size of the transaction, the size of the fund and the size of the fund's complex. The size of the transaction is the scale typically associated with transaction quality, and the sizes of the fund and of the fund complex represent the potential importance of the lender to the borrower. That is, a borrower, or a dealer, might see its important relationship as being with the fund, or instead with the larger institution housing the fund, so either size might be relevant to the transaction.

The main result is that all four security types show economies of scale, where the consistent effect is at the fund complex level, rather than at the fund or transaction level. Statistical significance is high for CP and CDs, and marginal, the 10% rejection level, for AG and TB. The order of magnitude for a 1-month security is a 1bp (bp = basis point, 1/100 of 1%) increase in yield for a fourfold increase in complex size.

We follow up this test on all transactions with a test focusing on within-security effects. That is, to control for all sources of cross-security variation we use fixed security effects, so that all identification comes from price variation across different buyers of the same security. These fixed-effect regressions find significant economies for both CP and AG. The order of magnitude is smaller, about a third of what we find in the regressions on the whole sample.

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[7] The main category we do not explore is repurchase agreements, which due to variation in margining, collateral and counterparties, and also due to the typical one-day maturity, are not good fits to our test design.

Money funds could enjoy scale economies even without this effect on their transaction prices. If the cost of a $100 Million transaction, in trader time, back-office logistics, etc., is less than ten times the cost of a $10 Million transaction, that economy would be another benefit to both sides of the transaction, and the fund complex could share its benefit with its investors through the expense ratio. What we learn from these regressions is that, as the fund complex grows, any such economies are not offset but rather amplified by the effect of scale on the pricing of their funds' purchases.

What about the funds' sales? The regulatory data shed some light on money funds' sales by reporting whether a holding departs the portfolio before the month it matures. We investigate these departures and show first that they occur with more frequency than one might expect. For example, the likelihood that a fund parts with nine-month CP before the month it matures is 29 percent. But are these departures sales? There are two reasons to believe that they are more like early redemptions. One reason is that many of the departures appear to be exchanges, in that they are followed immediately by new investments by the same fund in the same issuer, where at the median, the old and new principal amounts match exactly. Another reason is that the departures tend to occur as late as the filings can reveal, i.e. in the month before the month of maturity, consistent with the lender and borrower finding it mutually beneficial to resolve an impending liability on an earlier day. So the departures are consistent with accommodations between borrowers and lenders, such as repeat business partners might make for each other.

Does the likelihood of such pre-maturity accommodations increase with scale? To find out, we run logistic regressions predicting whether holdings depart before the month of maturity, where the explanatory variables are time to maturity and the levels of scale. And indeed we find that, like purchase quality, the likelihood of departure increases with complex size. So while the data don't allow conclusions about sale quality, they do show that to the extent that departures are favors, these favors are another source of scale economies for large complexes.

We conclude that there are economies of scale in money-market transactions, where these economies accrue to the biggest complexes. Or more precisely, there are economies for large complexes in the absence of panics, which did not occur in our sample period. Whether these economies would operate in a rapid contraction is another question.

The rest of the paper is in four sections. Section II describes the data and provides some background, Section III addresses the quality of purchases, Section IV addresses the incidence of departures, and Section V summarizes and concludes.

II. Data and Background

II.A Data

The database for this paper is the universe of filings of form N-MFP by prime money funds. Form N-MFP reports a money fund's individual holdings as of the month-end, and also reports some shareclass-level and fund-level statistics. The first N-MFP filings cover the end of November, 2010 (we will refer to this as the 11/10 filing, and follow this practice for the other month ends) and the last was the 3/16 filing. Starting with 4/16, the filings of the successor form N-MFP1 do not report either the amortized cost or the principal amount of individual holdings, so they are not useful for our purposes (the same goes for form N-MFP2, which starts 10/16). Thus, the relevant filings run from 11/10 to 3/16, and from these filings we extract all purchases of CP, CD, TB and AG by prime funds during that period. This period does not include the October, 2016 onset of NAV flotation for prime institutional funds, and includes only the early part of the period when the prime sector shrank in advance of that onset (e.g. Li et al, 2019). We reference filings after 3/16 only when we look ahead to see whether and when a fund parts with a holding before maturity, since for this purpose the information in the post-3/16 filings is sufficient.

The amortized cost of a security linearly amortizes the discount or premium at which the security is purchased, so if a security with face value F is purchased n days before maturity for price P, then its amortized cost k days later is $P + (k/n)(F\text{-}P)$. The role of amortized costs in the money-fund industry is to enable the calculation of stable NAVs. For each security we have this amortized cost AC for every month-end it is held (item 41 in N-MFP), and we also have the principal amount PA (item 40) and the market value MV calculated by a pricing agent (item 46). Funds do not disclose the identity of their pricing agents in N-MFP, but there are a number active in the industry. This is apparent in filings of N-CEN, which first appeared in 2018. In its N-CEN filing for 8/18, the Vanguard Prime Fund lists seven pricing agents.[8]

The empirical analysis of transaction quality uses only the earliest observation of a holding, in order to minimize the effect of the passage of time on the amortized cost. So if a fund reports a holding we reference only the first month-end at which the fund reports that holding. Throughout the analysis, all references to the market value, principal amount or amortized cost of a holding refer to this earliest appearance. Because we need to know when a holding appears for the first time, the first month of usable observations is in fact the second month of the sample, i.e. 12/10.

In addition to the valuations and the principal amount, the analysis makes use of the CUSIP (item 28), the category of the security (item 31),[9] the final legal maturity date (item 36),

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[8] See the fund's responses to item C.11 in https://www.sec.gov/Archives/edgar/data/106830/000175272419071574/xslFormN-CEN_X01/primary_doc.xml

[9] A small fraction of the securities, 391 in total, are classified as CDs by at least one fund and also classified as CP by at least one fund. We find that, overall, these dual-category securities are classified as CDs more often than as

and the maturity date that takes into account maturity shortening provisions (item 35). The number of days from the month-end of the report to the date in item 36 is the number of days until the security repays its principal, which we refer to as *DWAL* since it is used in the fund's calculation of its WAL. The number of days to the date in item 35 is the *minimum* of the number of days to repayment and the number of days to interest-rate reset, and we refer to it as *DWAM* because it is used in the fund's calculation of its WAM. So if $DWAM=DWAL$ then the security is fixed-rate, and if $DWAM<DWAL$ then it is floating-rate.

At the fund level we use the category of the fund (item 10), the net assets (item 16), and the investment adviser (item 2). For the size of the fund complex we combine the net assets of all money funds of all categories that have the same investment adviser.

To determine whether two securities came from the same issuer, we use the first six digits of the security's CUSIP. This is a conservative approach, since some issuers use multiple six-digit CUSIPs, potentially to distinguish different issuance programs.[10]

We summarize the resulting database of transactions in Table 1, which shows that many CUSIPs of each security type are placed with more than one complex, usually in the same month. Also, the large majority are fixed-rate rather than floating, and remain in the portfolio through the last month-end before maturity.

CP. On this basis we classify all 391 of them as CDs. Also, sometimes a fund changes its classification of a security between CP and CD. In these cases we use the fund's last classification of the security.

[10] For example, the Treasury's Monthly Statement of the Public Debt for September, 2019 shows different 6-digit CUSIPS for Bills (912796) vs Notes (912828) vs Bonds (912810). See https://www.treasurydirect.gov/govt/reports/pd/mspd/2019/opdm092019.pdf.

II.B Background and Literature

Research on scale economies in securities transactions dates back at least to the analyses of equity trading by Demsetz (1968) and Tinic and West (1972), which focus on liquidity provision by market makers, and which address the scale of daily trading volume rather than of individual trades. The importance of the effect of scaling up individual trades was highlighted by the argument of Berk and Green (2004) that scale diseconomies of open-end funds should equalize their prospects. Many studies of equity funds have addressed the direction and magnitude of their scale economies by gauging the effect of fund size on fund performance,[11] and the studies that directly address the scale economies of the funds' secondary-market trades (e.g. Busse et al, 2019, Christoffersen et al, 2019) highlight the changing nature of trades as they grow by documenting a transition from demanding to supplying liquidity.

Research on bond-market scale economies addresses the question from several directions. Looking across secondary-market trades, Edwards, Harris and Piwowar (2007) find lower costs for larger trades. In the statutory filings of insurance companies, Schultz (2001) also finds lower costs for larger trades, and also that more-active traders get better prices, and O'Hara, Wang and Zhou (2016) conclude that more active traders get better prices even when controlling for circumstances including the dealer. Also looking at insurance-company trades, Hendershott et al (2017) find that buys get cheaper but sells get more expensive as trade size grows. They also find that larger insurers get better prices: a tenfold increase in insurer size corresponds to a 4bp decrease in transactions cost.

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[11] Notable examples include Chen et al (2004), Pollet and Wilson (2008), Yan (2008), Reuter and Zitzewitz (2010), Edelen, Evans and Kadlec (2009), Elton, Gruber and Blake (2012) and Pástor, Stambaugh and Taylor (2015)

In money-market research, Domian and Reichenstein (1998) find that money funds' net returns increase with both expense ratios and fund size below $300 Million in net assets, but not above, which they take as evidence economies of scale among smaller but not larger funds.

III. Empirical Analysis of Money Market Purchases

In this section we test for the effect of scale on money-market transaction quality. We do this with two sets of regressions, one that takes a broad perspective and the other a narrow perspective. In each case, the dependent variable is a measure of transaction quality and the explanatory variables include measures of scale. The difference is that the first regressions identify the effect from all purchases, controlling for the variation across securities by relating their market values to their amortized costs, whereas the latter regressions use fixed security effects to identify the effect only from within-security variation of purchase prices across complexes. So the fixed-effect regressions are more tightly identified but they reflect only the differential pricing within offerings.

III.B Regressions using all fixed-rate securities

The first set of regressions answer the question, do funds get more market value per dollar of purchase price when scale is greater? So the dependent variable in each regression is the ratio of *MV* to *AC*, as observed at the end of the month of purchase, and the independent variables include measures of scale. There are three measures: the transaction size (i.e. principal amount) *TS*, the fund size *FS*, and the complex size *CS*, all measured as of that month-end. There is also one control variable, *DWAL* as of that same date, and all standard errors are clustered at the complex level. The results are in Table 2, which has one panel for each security type, and which repeats the regression with various combinations of regressors. T-statistics for the null hypothesis of zero relation are below the coefficients, and standard errors are clustered at the complex level. All regressions are in logs, and the dependent variable is multiplied by 10,000 so the results can be interpreted in basis point terms.

Before getting to the results, it is worth being explicit about the assumptions embedded in this regression model. The key assumption is that the model picks up the effect of scale on transaction quality, as opposed to some external force correlated with both scale and transaction quality. So if for example larger complexes use pricing agents that calculate higher market values, regardless of transaction size, the regression would misinterpret that as better transaction quality for larger complexes, regardless of transaction size. Also, the varying number of days from the unknown transaction date within the month to the end of the month adds noise to our estimate of transaction quality, so we are assuming that this noise does not correlate with scale.

We find that bigger complexes get better transaction quality in all four markets. Neither transaction size nor fund size is significantly positive in the presence of complex size. The regressions explaining the quality of the funds' Treasury and Agency purchases find a similar positive effect of complex size, and again no effect of fund or transaction size. The coefficients for TB and AG are similar to those for CP and CDs, but, potentially as a consequence of the smaller samples, statistical significance is only at the 10% rejection level.

For a sense of the magnitude of the scale economies we can convert the price effect in the regressions to a yield effect. The coefficients on $\log(CS)$ are in the neighborhood of 0.06, which for a one-month security extrapolates to a $(12)(0.06) = 0.72$bp annualized return. So an increase of $1/0.72 = 1.39$ in $\log(CS)$ means a 1bp increase in yield, and since $e^{1.39} = 4$, this means a fourfold increase in complex size leads to 1bp more yield on a one-month security.

III.C Regressions using securities sold to multiple complexes

The Table 2 identification assumes that other factors don't correlate scale with the relationship of market value to amortized cost. We can avoid this assumption by avoiding market values, which we can do by identifying instead from within-security effects of scale. As Table 1 reports, a fraction of securities, 28% of CDs and 44% of CP, are purchased by different complexes in the same month. With this subsample of securities purchased by multiple complexes in the same month we can estimate whether larger complexes get better prices within a given offering. The test design is a regression model where the dependent variable is the principal amount, not the market value, divided by the amortized cost, and the independent variables include fixed effects for the individual securities along with the measures of scale. The dependent variable can replace the market value with the principal amount because with fixed security effects there is no role for market values: each security's market value is captured by its fixed effect. An assumption of this approach is that the different complexes buying a security buy on the same day, i.e. that the variation of amortized costs reflects the variation of prices paid for the same thing at the same time. In practice the purchases do not have to be simultaneous, since issuers can reopen securities first issued earlier and securities also trade on the secondary market, and we can see some of this in Table 1 in the difference between the fourth and fifth columns of Panel A. So we assume that variation from differing purchase dates does not correlate with the variables of interest, the measures of scale.

The fixed-effect regressions address another question left open by the Table 2 regressions, which is whether complex size enters at the expense of transaction size due to transactions being struck at the complex level. That is, to the extent that complexes make complex-level transactions which they then parcel out to their funds, complex size might explain transaction quality better than the transactions of individual funds could, even if transaction size were the true determinant of transaction quality. To account for this possibility, we aggregate transactions up to the complex level, [12] so that the two measures of scale are *CS* and this aggregate transaction size, which we label *ATS*.

The regressions break the full sample into subsamples due to computing-capacity limits. The large number of fixed effects expands the regressions beyond our capacity, so we run separate periodic regressions, quarterly for CP and annual for CDs. The regressions are again in logs, and the standard errors are again clustered at the complex level. The results are presented graphically, with 95% confidence intervals, as Figures 1A, 1B, 1C and 1D, showing the effect of *CS* on CD, CP, AG and TB transactions, respectively, and Figures 2A, 2B, 2C and 2D, showing instead the effect of *ATS* on those transactions.

Figure 1 shows, consistently across the sample period, that larger complexes get better pricing in CP and AG offerings. The point estimates are smaller than what we find in Table 2, a third to a half the size, but the confidence intervals are almost always above zero. The point estimates for TB are similar but the confidence intervals are wide. For CD there is no effect: the confidence intervals are tight around zero. In the *ATS* results in Figure 2 the only statistical significance is for AG, where the coefficient is consistently negative, indicating diseconomies of scale for the aggregate transaction size, and occasionally statistically significant.

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[12] Note that this might fall short of the total complex-level transaction size, since there might be other investment pools within the complex, such as securities-lending collateral reinvestment pools, which are administered by the same team but do not file N-MFP.

III.D Discussion of Scale regressions

When we compare transaction quality across our whole sample, we find that larger complexes buy at better prices, and this is true regardless of the individual transaction or fund sizes. When we compare pricing within individual security placements we get some of this result: larger complexes still enjoy an advantage, though smaller, when buying CP and AG, but they get no preferential pricing for CDs. The contrast between the results may reflect weakness in the original identification, but it may also reflect the difference between negotiating with one buyer and negotiating with multiple buyers. For example, dealers marketing to multiple buyers might prefer one take-it-or-leave-it price over a series of negotiations. Also, banks issuing CDs may strongly prefer issuing at par, which would lead them to favor better customers with customized CDs carrying higher coupons, rather than with discount prices on the same CDs sold to others at par. This would not arise with CP, which is generally not at par in the first place.

The similarity between the CP and CD results and the AG and TB results contrasts with the difference between their market structures. The primary market for a Treasury security is an auction, where it is impossible for the issuer to favor one buyer over another. The primary markets for the Reference Bills sold by Freddie Mac and the Benchmark Bills sold by Fannie Mae are also auctions, [13] but the Discount Notes they both sell are marketed like CP through dealers. So there is some scope for the Agencies, but not the Treasury, to favor larger complexes, and if larger complexes bid more intelligently, that could also produce the same result. Also, they could see better treatment from repeat counterparties in the secondary market.

Besides the complex-level scale economies, the other main result concerns transaction size: we find almost no effect of transaction size on transaction quality. This does not mean that

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[13] See http://www.freddiemac.com/debt/auctions/reference-bills.html and https://www.fanniemae.com/resources/file/debt/pdf/debt_library.pdf.

there are no economies of scale in transactions, it just means that whatever economies exist are not shared through the pricing, but rather just enjoyed internally and separately by the buyer and the seller. Another way of looking at it is that the adverse-selection cost of larger purchases analyzed in Kyle (1985) is not in evidence in the money market, so if there are economies of scale in purchases, there is not a countervailing adverse-selection cost to restrain the effect of these economies on the growth of money funds.

Fund complexes see economies of scale in their buys, but what about their sells? Regarding their sales, the filings reveal when a fund parts with a holding before the month it matures, and they also reveal what the fund buys next. The next section uses this data to gauge the role of scale in this activity.

IV. Empirical Analysis of Departures

If a fund holds a security until it matures, then it should appear as a holding through the last month-end before the reported maturity date. In this section we analyze the departures of securities before this last month-end. Our data include all departures that occur before the month of maturity. Our question for these departures is whether scale imparts an advantage, as it does with purchases.

How likely is a fund to part with a security before the maturity month? Table 1 gives the big picture: 7% of CDs, 4% of CP, 12% of AG and 19% of TB holdings depart. These figures don’t compare cleanly, though, since departure is likely to increase with original time to maturity, and the security types are on average bought at different times to maturity. To improve comparability, we sort each type into original-maturity buckets, and then calculate the fraction of securities in each bucket that depart. For each security type, the *n*-month bucket contains the securities that were between *n*-1 and *n* months to maturity when they first appeared as holdings. The results are reported, with one line per security type, as Figure 3.

The maturity-specific results find more similarity between the security types than do the unconditional averages. The chance that a fund parts with a CD is not that different from the chance that it parts with CP or a TB with the same original maturity. The line for CP climbs to a 29% chance for 9-month paper, and then gaps down from 9 to 10 months, a potential consequence of the different regulatory environment for CP issued with more than 270 days to maturity.[14] This 29% rate for nine months is in the neighborhood of the twelve-month rate found for bonds: Cici and Gibson (2012) find an annual turnover rate of 43.2% in bond funds, after removing maturing securities from the calculation.

How long before maturity does paper depart? We can gauge this using the same buckets, looking now at just those securities in the bucket that depart. For each original-maturity bucket we calculate the fraction of departures occurring at each remaining month to maturity. If a security last appears with *m* months to maturity, i.e. its maturity date is between *m*-1 and *m* months after the last month-end at which the fund holds it, then we take it to have departed with *m*-1 months to maturity (i.e. it would have had *m*-1 months to maturity as of the first month-end it is absent from the portfolio). We plot one line for each original-maturity bucket from *n*=3 to 13, where the values on each line sum to 100%, and present the results as Figure 3A (CDs), 3B (CP), 3C (AG) and 3D (TB).

The figure shows that departures spread across times to maturity, but it also shows that for CDs and CP they concentrate shortly before maturity: the lines slope up sharply at the end,

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[14] Paper beyond 270 days is issued as 4(a)(2) paper, rather than 3(a)(3) paper, and 4(a)(2) paper faces additional resale restrictions. See “Frequently Asked Questions about Commercial Paper and Commercial Paper Programs” from Morrison and Foerster, accessed at https://media2.mofo.com/documents/faqs-commercial-paper-and-commercial-paper-programs.pdf.

generally hitting their peaks in the month before maturity. This is not true for AG and TB, which show sales generally less likely near maturity.

Departures close to maturity raise several possibilities. One is the impact of regulation, and in particular, regulatory capital requirements that encourage issuers to reduce the volume of securities maturing within 30 days, either for their own direct benefit or for the benefit of institutions providing liquidity facilities.[15] This could lead issuers to approach managers holding paper close to maturity with offers to swap into longer paper. It could also explain why we see so many near-maturity departures among CDs and CP but not TB and AG, since the Treasury and the Agencies are unlikely to make such offers for these or any other reasons.

Another possible motive for the near-maturity departures is the fund's investment strategy, particularly regarding its chosen spots on the yield curve. Waiting for paper to mature moves the fund along the curve, so a manager expecting to roll over into new paper soon might inquire about doing it sooner. The manager might also just want out of a holding, maybe to meet a redemption, and for this might find it best to approach the issuer or the issuer's appointed dealer, who might benefit from the fund not shopping the paper around. All of these motives could favor larger customers: an issuer gets more capital relief from a deal with a bigger customer, and likely benefits more from accommodating a bigger customer, whether it's an exchange or a liquidation.

We explore these possibilities by addressing two questions. First, to what extent are these departures actually exchanges? And second, is a security more likely to depart if it is held by a bigger complex? To address the first, we look ahead from every departure of CP or CDs

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[15] See, e.g., "Morgan Stanley Joins JPM in Offering New Product," *The Bond Buyer*, January 24th, 2013. Conceivably, some of the sales we see were actually callable paper that was called, or extendible notes that weren't extended, but we can find no evidence of this.

from a fund to the fund's next filing to see whether it holds new securities from the same issuer. We do this separately for CP and CDs, and summarize the findings in Table 3, which shows a high incidence of such exchanges. Among CP departures, 39% are immediately followed by new securities from the same issuer, where at both the 25th and the 50th percentile the principal amount of the new securities matches that of the old. Among CD departures the percentage of exchanges is 43%, and again the 25th and 50th percentiles exactly match. These exchanges are generally maturity extensions: at the median, the CP extends by 80 days and the CDs by 85 days. So to summarize, a large fraction of the departures of CDs and CP appear to be straight exchanges that extend maturity.

Are larger complexes more likely to part with a holding? We address this question with logistic regressions, where the dependent variable is 1 if a holding departs and 0 otherwise, and the explanatory variables are the holding's initial days to maturity and the measures of scale. We run the regression separately for each of the security types, and also run separate regressions for all departures (Panel A), departures with replacement (Panel B) and departures without replacement (Panel C). Standard errors are again clustered at the complex level.

The logistic regressions for CDs and CP reveal that their chance of departure increases with complex size, and it also increases with transaction size while decreasing with fund size. This is true whether or not the securities are immediately replaced. The complex-size result bears out the hypothesis that departures reflect the same customer-relationship capital reflected in purchases. The transaction-size result fits this model too, in that a larger transaction more easily justifies the cost of modifying the repayment schedule. The hypothesis does not predict the fund-size result, which might result from larger funds finding it easier to execute their plans through their larger flow of purchases and redemptions, without resorting to such modifications.

For a sense of the scale of the effect we can consider the consequence of a fourfold increase in complex size. In Panel A, the coefficients of CDs and CP on log(*CS*) are 0.1531 and 0.1388, which average to 0.146, so a fourfold increase in *CS* implies a log(4)(0.146) = 0.202 increase in the log odds of a departure, which means a 20.2% increase in the odds of a departure.

We conclude from these results that larger complexes enjoy economies of scale in departures as well as purchases, at least in the relatively stable times represented in our sample period. In unstable times, such as the recession shortly before our sample period, adverse selection problems might play a bigger role (e.g. Kacperczyk and Schnabl, 2010). Also, considering the evidence in Kacperczyk and Schnabl (2013) that larger funds and larger complexes saw larger redemptions in the days after the Lehman bankruptcy (Table VIII, column 1 of that paper), size might not be the same advantage in distressed times.

V. Summary and Conclusion

We assess the impact of scale on transactions by money funds. Looking at the funds' purchases, we find economies rather than diseconomies of scale, where the relevant scale isn't that of the transaction or of the fund, but rather of the fund complex. This is apparent for all four asset classes we study, and at the point estimate the effect is 1bp of yield for a fourfold increase in complex size. When we limit our analysis to differential pricing within security placements, we still find economies of scale, though only for Commercial Paper and Agency securities. Looking instead at the funds' sales we again find economies of scale for complex size: securities bought by larger complexes are more likely to be sold before maturity. And many of these sales appear to be exchanges, swaps of near-maturity for longer-dated paper.

One lesson from these results is that relationship management plays a large role in the money market. Large customers get better pricing going into a position, whether the position is big or small, and they also enjoy more latitude down the road for early redemption or rollover. Complex size imparts an advantage, and the complex shares some of this advantage with its funds' shareholders through these transactions. How the complex distributes this fruits of this advantage across all possible beneficiaries is a promising area for further research.

Another lesson from these results is the standard consequence of economies of scale: the economics of money-fund transactions will tend to concentrate the money-fund industry. This could be best for consumers, though it is possible that the effects of scale are different, with potentially a different sign, in bad times. So the impact of scale on distressed sales is another promising area for future research.

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Figure 1: Coefficients of Log CS in the Fixed-effect Regression

The following charts plot the coefficients for the term *log CS* in the fixed-effect regression. The dependent variable is *log(APR/AAC)* where *APR* is the aggregate principal value and *AAC* is the aggregate amortized cost of the security up to the complex level. We have coefficients of *log CS* for CDs in Panel A, CP in Panel B, AG in Panel C and TB in Panel D. Standard errors are clustered at the fund complex level.

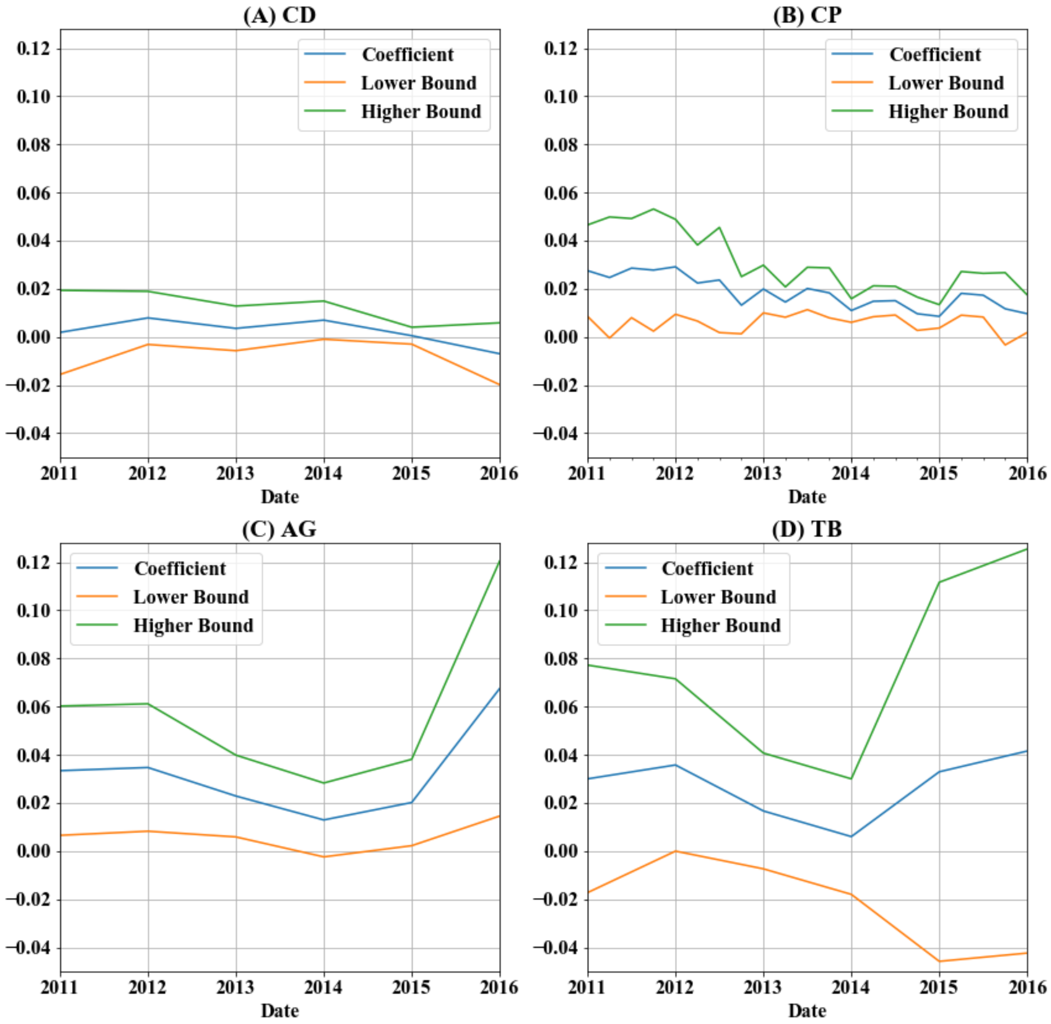

Figure 2: Coefficients of *Log ATS* in the Fixed-effect Regression

The following charts plot the coefficients for the term *log ATS* in the fixed-effect regression where *ATS* is the aggregate principal amount of the security up to the complex level. The dependent variable is *log(APR/AAC)* where *APR* is the aggregate principal value and *AAC* is the aggregate amortized cost of the security up to the complex level. We have coefficients of *log CS* for CDs in Panel A, CP in Panel B, AG in Panel C and TB in Panel D. Standard errors are clustered at the fund complex level.

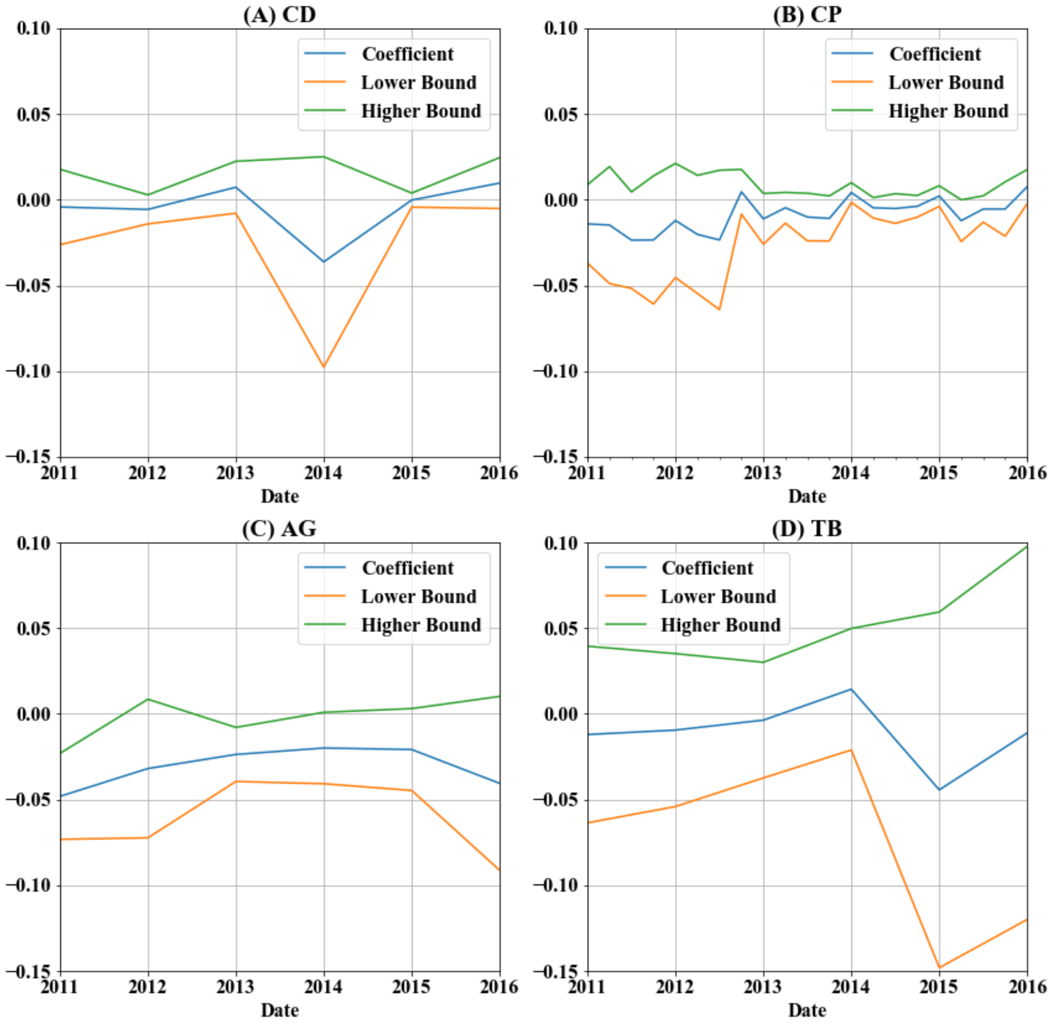

Figure 3: Departures for Each Security Type

This following chart plots the fraction of securities in each maturity bucket that depart for each security type. The *n*-month maturity bucket contains the securities that were between *n-1* and *n* months to maturity when they first appeared as holdings.

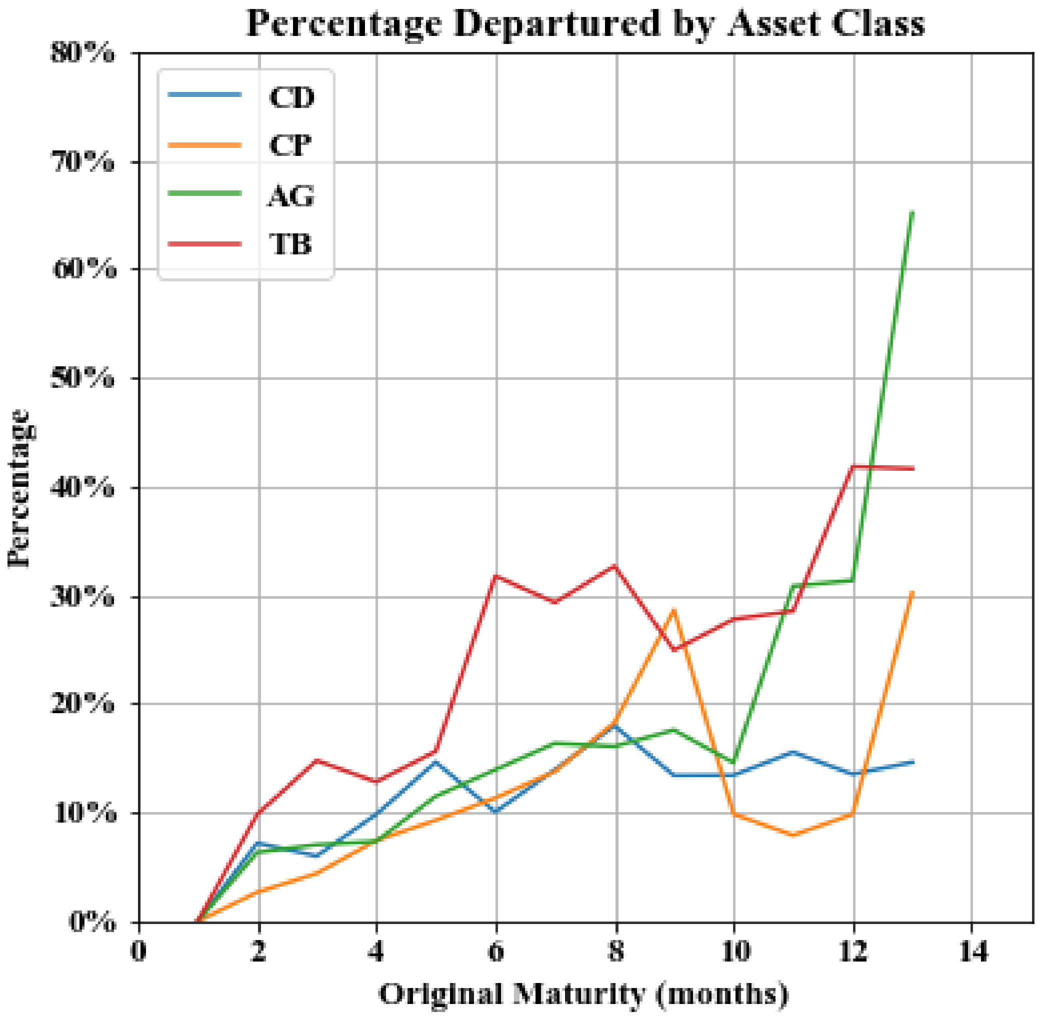

Figure 4: Departures for Each Original Maturity, by Month Sold

The following charts plot the fraction of securities that depart *m* (*m*<*n*) months before maturity for each original *n*-month maturity securities that depart before their final maturities. The *n*-month maturity bucket contains the securities that were between *n-1* and *n* months to maturity when they first appeared as holdings. Panel A presents the result for CD, Panel B for CP, Panel C for AG, and Panel D for TD.

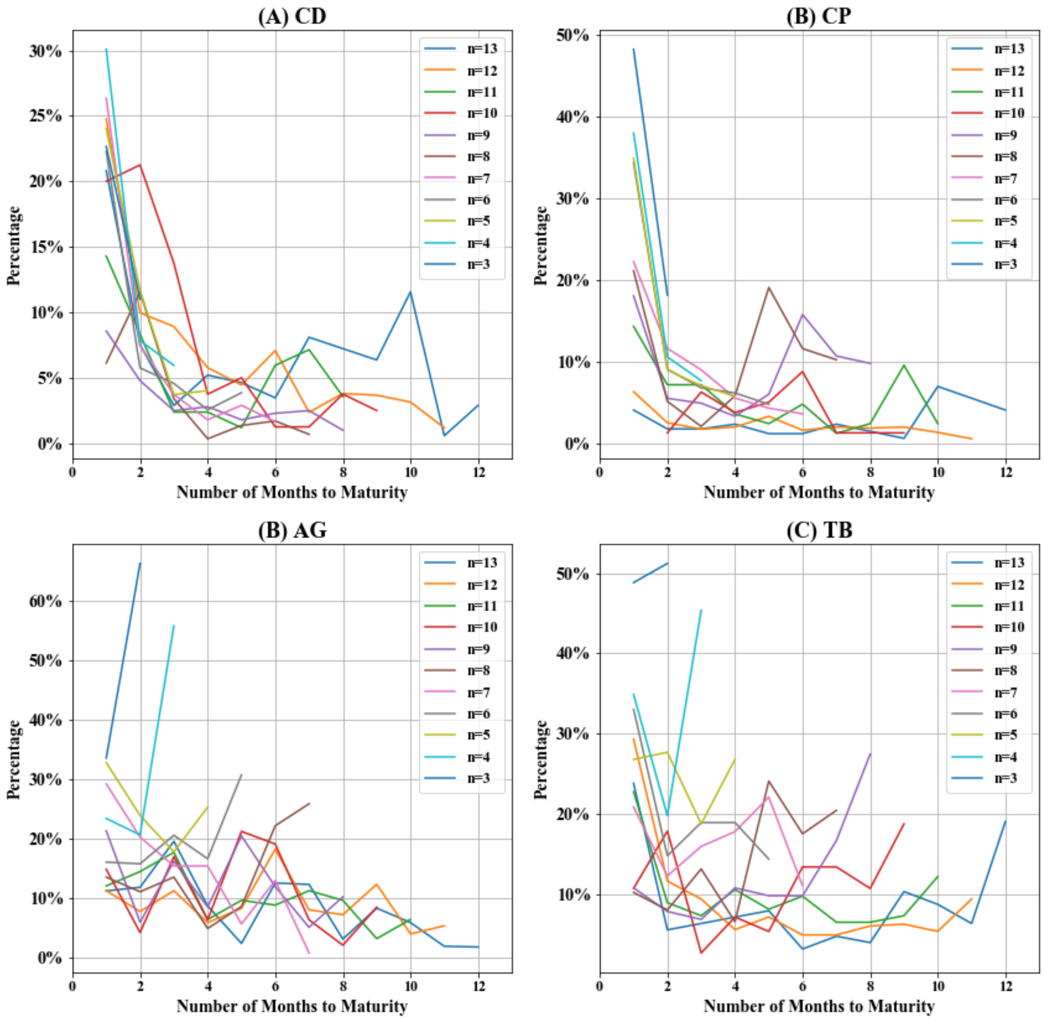

Table 1: Summary Statistics

This table reports summary statistics, by security type, for the holdings of prime funds and their fund complexes. Departures are holdings that depart the portfolio before the month they mature. The AUM of a fund complex is the aggregate AUM of its money funds of all types.

Panel A

		Purchases			Fixed-rate		Departures	
Type	N	One Complex	Multiple Complexes	Multiple and Same Month	Number	Dollar	Number	Dollar
CD	97211	65.6%	34.4%	28.4%	86.8%	88.4%	6.8%	7.0%
CP	302627	43.1%	56.9%	43.7%	97.7%	95.8%	3.2%	4.2%
AG	44682	20.7%	79.3%	63.5%	89.9%	86.5%	9.6%	12.0%
TB	13870	1.2%	98.8%	83.3%	97.9%	98.8%	19.6%	19.1%

Panel B

	N	P25	Median	Mean	P75	SD
Maturity of Securities (days)						
CD	97211	17	76	92.7	132	89.0
CP	302627	12	35	54.7	77	58.5
AG	44681	28	62	111.6	138	157.1
TB	13869	55	146	158.9	229	134.2
Principal of Securities (millions)						
CD	97209	10	35	93.4	100	161.6
CP	302624	4.5	12	34.7	36.11	73.8
AG	44682	3	10	49.2	40	130.8
TB	13867	5.065	20	109.6	80	287.4
Prime Funds AUM (millions)						
30-Nov-10	269	265.3	1092.0	6870.0	5961.5	16194.2
31-Mar-16	192	314.3	1354.4	7949.7	7366.5	16993.2
MMF Complexes AUM (millions)						
30-Nov-10	98	942.7	4069.6	31651.4	13780.1	74761.1
31-Mar-16	70	1326.0	6143.4	44392.0	41530.3	87638.0

Table 2: Determinants of Transaction Quality

This table reports regressions where the dependent variable is the logarithm of Market Value divided by Amortized Cost (*MV/AC*) of a security at the end of the month of purchase, multiplied by 10,000. The securities are CP in Panel A, CDs in Panel B, AG in Panel C and TB in Panel D. The dependent variable in each case is log(*MV/AC*). The independent variables are: *log CS*, the log of Complex Size, i.e. the total assets of all money funds of the fund family including the fund that made this purchase, *log FS*, the log of the assets of the purchasing fund, *log TS*, the log of the principal amount of the purchased security, and *mat*, the maturity, in days, of the purchased security. Standard errors are clustered at the fund complex level.

Panel A

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	0.2549***	-0.1647	-0.6971*	-1.8364***	-0.7037*	-1.7824**	-1.8674**
	(4.71)	(-0.56)	(-1.85)	(-2.58)	(-1.87)	(-2.40)	(-2.52)
mat	-0.0046***	-0.0045***	-0.0046***	-0.0046***	-0.0047***	-0.0046***	-0.0047***
	(-4.48)	(-4.50)	(-4.50)	(-4.52)	(-4.65)	(-4.57)	(-4.64)
log CS				0.0840***		0.0866***	0.0787***
				(2.92)		(3.13)	(2.86)
log FS			0.0426**		0.0771**		0.0334
			(2.44)		(2.57)		(1.24)
log TS		0.0241			-0.0440	-0.0069	-0.0336
		(1.36)			(-1.46)	(-0.47)	(-1.11)
No. Observations:	97101	97101	97101	97101	97101	97101	97101
Adj. R-squared:	0.031	0.031	0.032	0.034	0.032	0.034	0.035

Panel B

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	0.0890**	-0.6281***	-0.7262*	-1.3112***	-0.7816**	-1.4434***	-1.4106***
	(2.02)	(-3.51)	(-1.71)	(-2.96)	(-2.33)	(-3.72)	(-3.46)
mat	-0.0004	-0.0005	-0.0006	-0.0008	-0.0006	-0.0008	-0.0008
	(-0.42)	(-0.54)	(-0.66)	(-0.90)	(-0.66)	(-0.91)	(-0.90)
log CS				0.0598***		0.0558***	0.0658***
				(3.15)		(2.58)	(3.76)
log FS			0.0381*		0.0258		-0.0302
			(1.92)		(0.59)		(-0.73)
log TS		0.0444***			0.0197	0.0141	0.0375
		(4.07)			(0.48)	(0.99)	(0.92)
No. Observations:	300953	300953	300953	300953	300953	300953	300953
Adj. R-squared:	0.000	0.002	0.002	0.006	0.002	0.006	0.006

Table 2: Continued

Panel C

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	0.4490***	0.7855	0.7454	-0.2264	0.7733	0.1100	0.2038
	(4.66)	(1.40)	(1.14)	(-0.28)	(1.18)	(0.13)	(0.23)
mat	-0.0002	-0.0002	-0.0002	-0.0003	-0.0002	-0.0003	-0.0003
	(-0.39)	(-0.37)	(-0.36)	(-0.48)	(-0.36)	(-0.49)	(-0.49)
log CS				0.0292		0.0480	0.0612*
				(0.81)		(1.41)	(1.91)
log FS			-0.0140		0.0019		-0.0431
			(-0.44)		(0.04)		(-0.77)
log TS		-0.0209			-0.0226	-0.0478*	-0.0160
		(-0.62)			(-0.40)	(-1.72)	(-0.28)
No. Observations:	44143	44143	44143	44143	44143	44143	44143
Adj. R-squared:	0.000	0.000	0.000	0.001	0.000	0.002	0.002

Panel D

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	0.1519**	-0.2274	-0.4447	-0.9679**	-0.4443	-0.9212**	-0.9026**
	(2.07)	(-0.90)	(-1.30)	(-2.01)	(-1.31)	(-1.97)	(-2.00)
mat	0.0008	0.0008	0.0008	0.0006	0.0007	0.0006	0.0006
	(1.38)	(1.41)	(1.27)	(1.04)	(1.19)	(1.01)	(1.02)
log CS				0.0485**		0.0511**	0.0531*
				(2.19)		(2.14)	(1.91)
log FS			0.0283*		0.0368		-0.0076
			(1.65)		(1.18)		(-0.21)
log TS		0.0224			-0.0106	-0.0063	-0.0006
		(1.44)			(-0.40)	(-0.54)	(-0.02)
No. Observations:	12383	12383	12383	12383	12383	12383	12383
Adj. R-squared:	0.003	0.003	0.003	0.005	0.003	0.005	0.005

Table 3: Characteristics of the Departures

This table summarizes the departures of holdings, where "replacement" means the next month-end shows new holdings with the same six-digit CUSIP. In Panel A, "Liquidation" is the departures from funds that liquidate and "Conversion" is departures from funds that convert from Prime to Government. Panel B summarizes the replacements along three dimensions: Day_to_Maturity is the number of days remaining to maturity as of the first month-end after the departure, Dif_Maturity is weighted-average maturity of the replacement securities minus the weighted average of the departed securities, and Ratio_Principal is the principal amount of the new securities divided by the principal amount of the departed securities. In Panel C, we first sort the universe of all purchases in an asset class by the size of the complex that purchased them into quartiles. Then within each quartile, calculate the percentage of the securities in that quartile that were replaced by new securities from the same issuer before maturity.

Panel A

Type	Total Departures	Liquidation	Conversion	Replacement	Other
CD	6829	3.16%	4.61%	43.42%	56.58%
CP	9904	4.20%	3.55%	38.53%	61.47%
AG	3951	2.20%	N/A	30.25%	69.75%
TB	2595	3.04%	N/A	47.94%	52.06%

Panel B

Type	Variable	P25	Median	Mean	P75
CD	Day_to_Maturity	8.4	24.0	50.8	58.0
CD	Dif_Maturity	36.0	85.0	95.2	143.4
CD	Ratio_Principal	1.0	1.0	1.6	1.5
CP	Day_to_Maturity	8.0	18.0	42.6	46.0
CP	Dif_Maturity	47.0	80.0	83.9	119.0
CP	Ratio_Principal	1.0	1.0	1.6	1.5
AG	Day_to_Maturity	6.3	21.0	89.6	128.1
AG	Dif_Maturity	20.0	43.9	40.6	88.0
AG	Ratio_Principal	1.0	1.3	4.5	4.0
TB	Day_to_Maturity	37.3	92.0	118.9	153.0
TB	Dif_Maturity	13.7	65.4	80.8	144.4
TB	Ratio_Principal	0.8	1.4	8.5	2.8

Panel C

Type	Rank 0	Rank 1	Rank 2	Rank 3
CD	0.00%	2.93%	2.18%	3.17%
CP	0.27%	0.98%	0.74%	1.70%
AG	1.74%	3.07%	1.15%	3.91%
TB	4.20%	8.32%	5.34%	12.37%

Table 4: Determinants of Departures for Each Security Type

This table reports logistic regressions where the dependent variable is 1 if a security departs and 0 otherwise, and the explanatory variables are: *mat*, the security's initial days to maturity, *log TS*, the log size of the security, *log FS*, the log size of the fund, and *log CS*, the log size of the complex. In Panel A, the dependent variable is 1 for any departure. In Panel B the dependent variable is 1 only for departures with replacement, and Panel C it is 1 only departures without replacement.

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Panel A

	CD	CP	AG	TB
Constant	-5.3745***	-6.7046***	-5.1628***	-5.3912***
	(-4.43)	(-4.65)	(-3.28)	(-3.46)
Mat	0.0066***	0.0112***	0.0051***	0.0296***
	(11.64)	(13.08)	(7.82)	(6.86)
log TS	0.2589***	0.2438***	0.1359	-0.1118
	(3.63)	(2.93)	(1.35)	(-1.48)
log FS	-0.2825***	-0.2273***	-0.0305	0.1255*
	(-3.88)	(-3.37)	(-0.35)	(1.78)
log CS	0.1531**	0.1388**	0.0232	0.0585
	(2.40)	(2.34)	(0.29)	(0.87)
No. Observations:	97209	302624	42525	13262
Pseudo R-squared:	0.066	0.115	0.120	0.394

Panel B

	CD	CP	AG	TB
Constant	-7.3504***	-8.9082***	-6.3128***	-7.2874***
	(-4.36)	(-4.95)	(-2.77)	(-3.59)
mat	0.0050***	0.0100***	0.0018**	0.0104***
	(8.92)	(8.92)	(1.96)	(9.29)
log TS	0.2383***	0.1834*	0.1923	-0.0315
	(2.87)	(1.91)	(1.39)	(-0.37)
log FS	-0.1954**	-0.1255**	-0.0327	0.0904
	(-2.07)	(-2.40)	(-0.26)	(1.08)
log CS	0.1415*	0.1424*	0.0033	0.1133
	(1.76)	(1.84)	(0.04)	(1.29)
No. Observations:	97209	302624	42525	13262
Pseudo R-squared:	0.035	0.089	0.021	0.187

Table 4: Continued

Panel C

	CD	CP	AG	TB
constant	-4.9198***	-6.2940***	-5.3659***	-3.6663***
	(-3.82)	(-4.04)	(-2.74)	(-3.17)
mat	0.0069***	0.0108***	0.0056***	0.0110***
	(11.93)	(14.77)	(9.63)	(7.53)
log TS	0.2485***	0.2662***	0.0852	-0.1348*
	(2.60)	(2.98)	(0.96)	(-1.71)
log FS	-0.3196***	-0.2770***	-0.0176	0.0684
	(-3.63)	(-3.34)	(-0.21)	(1.14)
log CS	0.1477**	0.1316*	0.0319	0.0627
	(2.40)	(1.89)	(0.30)	(1.44)
No. Observations:	97209	302624	42525	13262
Pseudo R-squared:	0.056	0.091	0.152	0.179