The Relationship between Money Market Mutual Fund Maturity and Interest Rates

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Abstract: *This study examines the causal relationship between the average maturity of taxable money market mutual funds (MMMF) and short-term interest rates. The credit and financial crises of 2007-2008 have led to significant changes in the functioning of the short-term credit market. Motivated by these transformations, we also investigate the underlying relationship to find out if a change in the ability of MMMF managers to anticipate and/or react to fluctuations in interest rates has occurred in the postcrisis period. We use the Granger-causality test to examine this relationship. Our findings suggest that the average maturity of MMMF cannot be used to predict changes in T-bill yield. On the contrary, we find that MMMF managers adjust the maturities of their portfolios in response to changes in T-bill yields. Our results also show that MMMF managers appeared to anticipate changes in commercial paper (CP) rates from two to eight weeks in advance in periods prior to the financial crisis (January 3, 1995 to December 26, 2006). We did not find similar evidence in the succeeding periods (2007-2010). This result questions the efficiency of the CP market. Given our findings, we recommend that financial planners should scrutinize the portfolio composition and noninvestment-related features of a fund before recommending it to their clients. If a significant proportion of a fund's portfolio consists of assets, which its portfolio manager possesses no superior ability to select, then recommendations concerning the fund should be based on expense ratios and other convenience features that are directly related to the unique needs of the client.*

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Introduction

Money market mutual funds (MMMFs) came into existence in the early 1970s as a response to the binding Regulation Q interest-rate ceilings on bank transactions and savings deposits. Over the last three decades, they have become one of the fastest growing sectors of the U.S. financial system. At the end of 2009, there were 705 taxable MMMFs available to investors with almost $3.3 trillion under management.[1]

MMMFs are open-end investment management companies registered under the Investment Company Act of 1940. They invest in high-quality, short-term debt instruments such as commercial paper (CPs) and Treasury bills (T-bills). The primary objective of an MMMF is to maximize yield within the constraints set by rules governing the operations and investment activities of the fund. These constraints include the safety of the fund's assets and liquidity for the fund's investors. Other constraints, which usually are mandates issued by regulators, include the maximum weighted average maturity and the quality of the fund's assets.

MMMFs typically structure a laddered portfolio, with maturities ranging from one day up to one year. Except for when redemptions exceed the purchase of new shares, MMMFs usually follow a "buy-and-hold" strategy. If a fund wishes to shorten the average maturity of its portfolio, proceeds of maturing assets can be reinvested in overnight instruments. The fund can also lengthen its average maturity by investing in longer-term securities. A constant portfolio maturity can be sustained by acquiring new securities with maturities that are twice the average maturity of the fund. A goal of the industry is that net

asset values are always set to a constant value of $1 per share, and yields are allowed to fluctuate.

The choice of qualifying investments for MMMFs is limited; therefore, active management to maximize return may be limited to adjusting the average maturity of their funds based upon the managers' forecasts of short-term interest rates.[2] Extant studies[3] also typically examine if MMMF managers maximize return by adjusting the average maturity of their funds in view of their forecasts of short-term interest rates. If interest rates are expected to increase, then the average maturity of the fund will be shortened so that yield would increase more quickly. A fund's manager could also lengthen the average maturity to lock in the higher current yield if interest rates are expected to decrease. Therefore, a study of how changes in the average maturity of MMMFs comove with short-term interest can be used to gauge fund managers' ability to forecast future short-term rates. This paper takes a macro view of this issue. It examines the performance of the MMMF industry as a whole and not the performance of each MMMF manager. It may be possible to encounter dissimilar results for different funds if fund-level data are utilized.[4]

The purpose of this study is to examine the causal relationship between average maturity of taxable MMMF and short-term interest rates. If the short-term credit market is fully efficient, then MMMF managers will be unable to exploit any private information about short-term interest rates. Thus, changes in the average maturity of an MMMF portfolio are more likely to occur after changes in short-term interest rates have occurred. On the other hand, if changes in the average maturity precede changes in the short-term interest rate, this will indicate that MMMF managers possess additional information that is not already reflected in short-term interest rates. The ability of fund managers to sustain a superior track record is often used by sponsors of mutual funds for marketing purposes. Therefore, it is also useful to examine if MMMF managers can forecast interest rate movement in periods of relative calm as well as significant instability in the short-term funds market. Managers who have superior ability to anticipate imminent movements in the market in turbulent periods are well-positioned to address the adverse impact and/or exploit opportunities that may arise with these changes.

There is a consensus that events that transpired during the financial crisis of 2007-2008 have altered the scope of systemic risk in the financial markets.[5] The key events that had profound effects on short-term credit markets and the relationships between short-term interest rates[6] include:

1. The collapse of two highly leveraged Bear Stearns–managed hedge funds on June 20, 2007 and subsequent sale of Bear Stearns to JP Morgan Chase. Bear Stearns' default drew investors' attention to the increase in counterparty risk because Bear Stearns was a major player in the $2.5 trillion repo market.[7]
2. The run on the assets of BNP Paribas on August 9, 2007 by investors, which forced the firm to suspend redemptions on three of its structured investment vehicles.
3. The failure of the fourth largest investment banking firm, Lehman Brothers, on September 12, 2008 and the subsequent effect it had on MMMFs, in particular the Reserve Primary Fund.[8] Due to the level of interconnectedness of financial institutions and the lack of transparency on the types of assets held by these institutions, it was difficult to ascertain the true extent of the problem and how much of the intermediary loss can be passed on to the sponsoring institution. As a result, all short-term funds markets—such as the CP and repurchase agreement markets—began to freeze up, only to function properly again after the infusion of funds from the Fed.[9]
4. The culmination of these effects when the Fed lowered short-term interest rates to almost zero by mid December 2008 and maintained them at that level for more than two years. This new regime could make it more difficult to predict the timing and magnitude of short-term interest rate movements.

Given the increase in the level of uncertainty in the advent of the credit and financial crises of 2007-2008, this study also investigates the underlying relationship to see if there has been a change in the ability of MMMF managers to anticipate and/or react to interest rate movements in the postcrisis period. In parallel to Domian,[10] we use the Granger causality test to examine how the average maturity of MMMFs and short-term interest rates are related. The results will indicate whether changes in the average maturity of MMMFs can be used as a reliable predictor of imminent changes in interest

rates and whether MMMF managers have superior abilities to forecast future interest rates.

Forecasts of future interest rate values are important inputs to many financial decisions made by individuals and businesses. Practitioners use forecasts of interest rates as important inputs to wealth management recommendations prepared for clients. The multiplicity of how forecasts of interest rate movements are used makes them one of the most widely followed strands of financial information and thus, the motivation for this paper. If fund managers on average do not possess superior forecasting skills, an implication for investors is that they should base selection of MMMFs on expense ratios, convenience features (such as minimum initial investment and check-writing privileges), and the unique needs of the investor, rather than the risk-return performance of MMMFs.

Literature Review

A few authors have studied the relationship between average maturity of MMMFs and interest rates and whether MMMF managers have the ability to predict interest rates. Ferri and Oberhelman use data on average maturity of assets and one- and two-month CD rates over the period of 1975-1980 and conclude that money fund managers consistently lengthen (shorten) the average duration of their portfolios ahead of falling (rising) rates.[11] Kane and Marks demonstrate that significant gains could be obtained from accurate forecasts of short-term interest rates.[12] However, only a few funds in their study showed statistically significant forecasting ability over the period of 1978-1981, and the realized gains were small.

Domian used a Granger-causality test and data over the period of 1982-1990 to argue the opposite, namely that money fund managers change average maturity as a reaction to interest rate changes.[13] His results show that interest rates Granger-cause funds' average maturities while changes in maturity do not Granger-cause interest rates changes. This result implies that changes in maturity of MMMFs do not provide useful information for predicting interest rate movements. Seyfried and Packer applied cointegration analysis and a Granger-causality test to weighted average maturity (WAM) and 90-day T-bill yields obtained from 1990 to 1996 and find that MMMF managers both anticipate and react to changes in short-term interest rates.[14]

Data and Methodology

Data

The data utilized in this study are weekly 90-day T-bill yields and weekly one-month AA financial CP rates. In addition to these series, we also obtained the weekly WAM on all taxable MMMFs for the period of January 3, 1995 to March 23, 2010.[15] The primary objective of this paper is to examine the relationship between average maturity of taxable MMMF and short-term interest rates over the entire sample period. We also examined the underlying relationship over two subperiods because existing literature has shown that the relationship between two financial variables is often unstable over time.[16] For example, Pastor and Veronesi posit that many of the puzzling relationships between financial variables can be explained by the instability of the model parameters over time.[17] An unstable relationship between two financial variables feeds additional complexities into the investment decision-making process. In this case, the fund manager will also need to consider when the change in the underlying relationship is likely to occur. In some cases, the change may have occurred before market players become cognizant of it. The 2007-2008 mortgage and credit crises are generally accepted as the triggers for the recent and most significant recession since the Great Depression. We split our sample into two subsamples (precrisis and crisis subperiods) using the beginning of the year 2007 as a point of reference. Our objective is to examine if a change in the underlying relationship has occurred as an aftermath of the recent mortgage and credit crises by repeating our statistical analyses over these two subperiods. The first (precrisis) subperiod extends from January 3, 1995 to December 26, 2006 and the second (crisis) subperiod covers January 2, 2007 to March 23, 2010.[18]

The WAM of a money market portfolio is computed as the asset-weighted time until the securities in the portfolio mature. Descriptive statistics for the dataset are presented in Table 1. The mean WAM (column 1) for the entire sample period is 43 days, for the first subperiod it is 44 days, and for the second subperiod it drops to 39 days. The maximum WAM for the entire sample, and the first subperiod is 54 days, but it drops to 49 days in the second subperiod.[19] In addition, the standard devi-

ation of WAM fell from 6 days in the first subperiod to 4 days in the second subperiod. In all, the results highlight a measurable shift in the investment strategy of money managers. It appears that maintaining portfolio liquidity by reducing the maturity exposure of the fund may have been one of the objectives of MMMF managers in the crisis (second subperiod) period.

For the entire sample, the average yields were 3.41% and 3.5% for T-bills (column 2) and CP (column 4), respectively. The maximum yields on T-bills and CP were 6.21% and 6.56%, respectively. The standard deviation (measure of risk) of T-bill yield was 1.90%; the same measure for CP yield was 2.02%. This result provides evidence in support of a widely held view that T-bills have lower investment risk than other short-term credit instruments such as CP.[20] The average T-bill and CP yields (3.84% for T-bill and 3.86% for CP) obtained from the first subperiod exceed the same for the second period for both interest rate series (1.84% for T-bill and 2.4% for CP). On the contrary, the standard deviations for both series were lower in the first subperiod (1.68% for T-bill and 1.7% for CP) than in the second (1.87% for T-bill and 2.06% for CP).

This result implies that the investment risks of T-bill and CP were higher in the second period relative to the first, while the average returns on both securities were lower in the second period than in the first. On the whole, the result reveals a general decline in the investment quality (risk-return trade-off) of both securities in the second period relative to the first.

For comparison, we also report a similar set of statistics for the weekly changes in the T-bill (column 3) and CP (column 5) yields. In general, the mean and standard deviation of weekly changes in T-bill and CP yields are the same for the entire sample period. The mean and standard deviations obtained from the subperiod data were also the same for both series. It is tempting to infer that there is a high degree of correlation between these two series (change in T-bill and change in CP). However, Table 2 shows that while a high degree (0.99) of correlation indeed exists between T-bill and CP yields, the degree of correlation between the weekly changes in T-bill and CP yields, albeit significant, is much lower (0.28).

Figure 1 presents the weekly WAM of MMMF and the two interest rates analyzed herein. There is an inverse relationship between the T-bill yield and WAM, and the CP yield and WAM. The relationship highlighted on the graph is also supported by the correlation coefficients reported in Table 2. The WAM has a signif-

TABLE 1

Descriptive Statistics

	WAM	T-Bill	ΔT-Bill	CP	ΔCP
Count	795	795	794	691	690
Mean	43	3.41	-0.01	3.50	-0.01
S.D.	6	1.90	0.10	2.02	0.10
Min.	30	0.02	-1.00	0.10	-1.22
Max.	54	6.21	0.45	6.56	0.56
First Subperiod					
Count	626	626	625	522	521
Mean	44	3.837	-0.001	3.859	0.000
S.D.	6	1.676	0.079	1.871	0.079
Min.	30	0.824	-0.688	0.980	-0.770
Max.	54	6.208	0.342	6.560	0.300
Second Subperiod					
Count	169	169	169	169	169
Mean	39	1.841	-0.028	2.398	-0.030
S.D.	4	1.871	0.153	2.057	0.154
Min.	32	0.020	-1.002	0.100	-1.220
Max.	49	5.036	0.450	5.300	0.560

Note: WAM is weekly weighted average maturity in days; T-bill is weekly yield on 90-day U.S Treasury Bill; CP is the weekly yield on one-month AA financial CP; ΔT-bill is the weekly change in T-bill yield, ΔCP is the weekly change in CP yield. The sample period is from January 3, 1995 to March 23, 2010. CP rates start from January 7, 1997. The first subperiod spans from January 3, 1995 to December 26, 2006 and the second subperiod covers January 2, 2007 to March 23, 2010.

TABLE 2

Correlation Coefficients

	T-BILL	WAM	CP	ΔT-BILL	ΔWAM
WAM	**-0.1798**				
	(0.00)				
CP	**0.9855**	**-0.2169**			
	(0.00)	(0.00)			
ΔTBILL	0.0469	-0.0009	-0.0025		
	(0.19)	(0.98)	(0.94)		
ΔWAM	0.0190	0.0594	0.0009	-0.0283	
	(0.59)	(0.09)	(0.98)	(0.43)	
ΔCP	0.0677	-0.0216	0.0522	**0.2843**	**-0.0930**
	(0.08)	(0.57)	(0.17)	(0.00)	(0.01)

Note: *P*-values are in parentheses. Correlation values, which are significant at 0.05 alpha, are in bold.

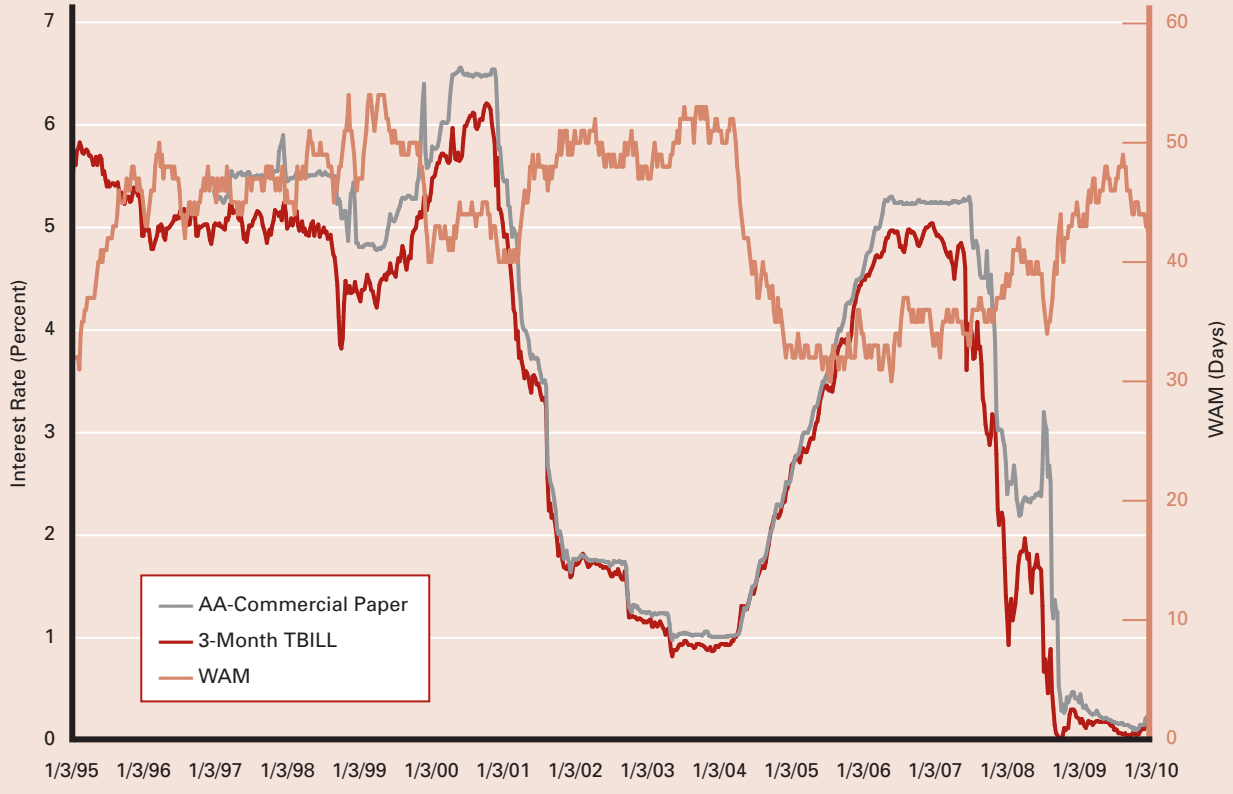
icant and negative correlation with T-bill and CP yields. Weekly changes in WAM also have a significant negative correlation with changes in CP yields. We did not find a significant relationship between changes in WAM and changes in T-bill yields.[21] Figure 1 also highlights the core principle of the investment strategy of money managers—extend maturity when rates are falling to lock in higher rates and reduce maturity when rates are increasing so as to take advantage of higher yield on new assets. While Figure 1 and Table 2 suggest that a negative or inverse relationship exists between the WAM and short-term interest rates, it does not reveal whether an increase in WAM causes interest rates to fall or whether the causality is in the reverse direction. A more sophisticated analysis of the data is required to determine the existence and direction of causality between WAM and the short-term interest series.

Methodology

We can delve deeper into the relationship between interest rates and WAM by applying Granger causality tests.[22] A time series X1 is said to Granger-cause X2 if past values of X1 contain information that helps predict current values of X2 better than the information contained in past values of X2 alone. In other words, if values of WAM obtained in prior periods help predict current values of short-term interest rate better than past values of the interest rate series alone, then WAM is said to Granger-cause the interest rate series and *vice versa*.[23] To ensure that the results are robust to the specifications of our empirical model, we performed the test using 2, 4, 6, and 8 lags of WAM and both interest rate series. Estimates of the relationships between nonstationary variables could yield unreliable results because they may inaccurately indicate significant relationships between two totally unrelated

FIGURE 1

Weighted Average Maturity and Selected Interest Rates



variables. We address this potential problem by applying the Granger test to both the stationary first difference (change in the weekly values), and the nonstationary level (actual values in each period) data series.[24]

Empirical Results

Tables 3 and 4 report the summarized results of the pair-wise tests of unidirectional and bidirectional Granger causality between WAM and T-bill, and WAM and CP, respectively. Panel A of each table shows the results for the entire period, followed by the results of the first and second subperiods respectively in Panels B and C. The first two lines of each panel contain results of causality running from WAM to the interest rate series, while the last two present the results for causality running in the reverse direction. Remember that significant results for WAM to interest rates would suggest that the MMMF managers anticipate changes to short-term interest rates and act on this information by adjusting the average maturity of their asset holdings. On the contrary, significant interest rate to WAM relationship would denote that fund managers are merely reacting to changes in short-term interest rates by adjusting the WAM.[25]

The results shown in panel A of Table 3 do not support a causal link from WAM to T-bill. All eight results obtained from the Granger tests are insignificant. This suggests that the WAM of MMMF cannot be used to predict impending changes in T-bill yield. On the contrary, there is strong evidence that the T-bill yield Granger causes average maturity. Five of the eight results obtained from the Granger tests are significant. The results from the other two subperiods are almost identical to those obtained for the entire sample period. On the whole, the evidence suggests that MMMF managers adjust the maturities of the portfolio in response to changes in T-bill yields and not the other way around.

TABLE 3

Causality Test Results

Lags	(2,2)	(4,4)	(6,6)	(8,8)
Panel A: January 3, 1995 to March 23, 2010				
		ΔWAM Causes ΔTBILL		
Level	X[a]	X	X	X
1st Difference	X	X	X	X
		ΔTBILL Causes ΔWAM		
Level	X	X	Sig[b]	Sig
1st Difference	X	Sig	Sig	Sig
Panel B: Subperiod I: January 3, 1995 to Dec. 26, 2006				
		ΔWAM Causes ΔTBILL		
Level	X	X	X	X
1st Difference	X	X	X	X
		ΔTBILL Causes ΔWAM		
Level	X	X	Sig	Sig
1st Difference	X	Sig	Sig	Sig
Panel C: Subperiod II: January 2, 2007 to March 23, 2010				
		ΔWAM Causes ΔTBILL		
Level	X	X	X	X
1st Difference	X	X	X	X
		ΔTBILL Causes ΔWAM		
Level	Sig	Sig	Sig	Sig
1st Difference	X	X	Sig	Sig

[a] Insignificant at 0.05 alpha.
[b] Significant at 0.05 alpha.

TABLE 4

Causality Test Results

Lags	(2,2)	(4,4)	(6,6)	(8,8)
Panel A: January 3, 1995 to March 23, 2010				
		ΔWAM Causes ΔCP		
Level	X[a]	X	X	X
1st Difference	X	X	X	X
		ΔCP Causes ΔWAM		
Level	Sig[b]	Sig	Sig	Sig
1st Difference	Sig	Sig	Sig	Sig
Panel B: Subperiod I: January 3, 1995 to Dec. 26, 2006				
		ΔWAM Causes ΔCP		
Level	X	Sig	Sig	Sig
1st Difference	X	Sig	Sig	Sig
		ΔCP Causes ΔWAM		
Level	X	X	Sig	Sig
1st Difference	X	Sig	Sig	Sig
Panel C: Subperiod II: January 2, 2007 to March 23, 2010				
		ΔWAM Causes ΔCP		
Level	Sig	Sig	X	X
1st Difference	X	X	X	X
		ΔCP Causes ΔWAM		
Level	Sig	Sig	Sig	Sig
1st Difference	Sig	Sig	Sig	Sig

[a] Insignificant at 0.05 alpha.
[b] Significant at 0.05 alpha.

These findings are similar to those reported by Domian.[26] It is also interesting to note that the recent financial crisis did not affect the underlying causal relationship between MMMF maturity and T-bill yield. The 2010 Investment Company Factbook shows that while T-bill holdings account for approximately 25.8% of MMMFs' portfolio, the entire mutual fund industry held only 12% of the market for Treasury and agency securities, compared to 51% of the market for CP securities.[27] This may explain why MMMFs have little or no influence on the outcomes of the T-bill market.

Table 4 reports the results of pair-wise causality tests between WAM and CP yields. For the entire period, the results reported in Panel A show that the null hypotheses of no causality from WAM to CP cannot be rejected in all lag structures. However, the null hypothesis of no causality from CP to WAM is robustly rejected in all lag structures. These findings are identical to those obtained by using T-bill rates as the proxy for money market interest rates. In all, they suggest that MMMF managers are unable to predict the future direction of short-term interest rates and, thus, unable to adjust their portfolio to take advantage of imminent movements in short-term interest rates.

The results of the subperiod tests of causality between WAM and CP are different from those obtained for the entire sample. In particular, they suggest that there was causality from WAM to CP in the first subperiod (panel B); this relationship by and large ceased to exist in the second subperiod (panel C). On the other hand, causality from CP to WAM was found in both subperiods.

On the whole, the additional insight gained from the subperiod results is that the financial crisis may have altered the causal linkage between MMMF and CP rates. The bidirectional causality that existed between WAM and CP prior to the financial crisis appears to have reduced into a unidirectional causality, which now exists only from CP to WAM. The breakdown in the causality between WAM and CP may have been contributed by factors such as: 1) flight to quality where MMMF managers moved away for CP at the advent of the financial crisis; 2) the near freeze-up of the CP market and the change in the perception of CPs as relatively safe investments during the financial crisis; 3) that CPs may have been substituted with other sources of financing by firms; 4) adverse selection between CP issuers and investors; and 5) institutional constraints faced by MMMFs (see Kacperczyk and Schnabl for a detailed discussion on the role CP played during the financial crises of 2007-08).[28]

Conclusion

This paper presents mixed evidence on whether specialization in short-term debt instruments has provided MMMF managers superior knowledge of future movements in short-term rates. Our findings support the view that the T-bill market is highly efficient and that investors cannot gain any additional insights by analyzing the maturity structure of MMMFs for information that is not already reflected in the T-bill rates. Fund managers in general do not adjust the maturity of their portfolios until after the change in T-bill rates has occurred. The results pertaining to CP rates are less straight forward. They indicate that between January 3, 1995 and December 26, 2006, MMMF managers appeared to anticipate changes in CP rates from two to eight weeks in advance. However, the increase in uncertainty in the aftermath of the recent financial crisis appears to have weakened the ability of managers to anticipate changes in CP rates. This calls into question the notion that the CP market has always been efficient.

Given the findings of this study, we recommend that financial planners scrutinize each money market fund for insight on the composition of the fund's portfolio before recommending the fund. This will provide a reasonable expectation about how movements in short-term interest rates will influence the investment action of the fund's manager. The information gleaned from this scrutiny will improve the fit of fund recommendations to the client's goal. Although MMMFs in general share similar characteristics in terms of their overall investment objectives and strategy, there are distinct features that investors can use to distinguish them. These features include tax consideration, minimum initial contribution, expense ratios, and convenience features such as free or low-fee personalized financial services, commission-free trades, and check-writing privileges. If fund managers collectively do not possess superior interest rate forecasting skills, the optimal choice of an MMMF should be decided through a personalized cost-benefit analysis of these distinguishing features rather than the risk-return performance of MMMFs.

Finally, this study utilized industry level data, and thus provides a macro view of the MMMF industry. In

all, we did not find pervasive evidence of superior predictive skill at the industry level; however, it is possible that fund level data may yield dissimilar results. We believe this question deserves consideration in future research. ■

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(1) In comparison, hedge funds controlled about $2 trillion at the same point in time, and the number of investors for MMMFs is much higher than for hedge funds. See 2010 Investment Company Factbook," 50th Edition (Washington, DC: Investment Company Institute, 2009); http://www.icifactbook.org/pdf/2010_factbook.pdf.

(2) M.L. Stigum, *The Money Market: Myth, Reality, and Practice* (New York: Dow Jones-Irwin, 1978).

(3) A few of these include L.D. Domian, "Money Market Mutual Fund Maturity and Interest Rates," *Journal of Money, Credit and Banking* 22 (1992): 519–527; M.G. Ferri and H.D. Oberhelman, "A Study of the Management of Money Market Mutual Funds: 1975-1980," *Financial Management,* 10(1981): 24–29; and W. Seyfried and J. Packer, "Money Market Mutual Funds and Market Efficiency: Implications for Individual Investors," *Business Quest* (2001). This paper also follows the same methodology, but extends the literature by using additional proxies for short-term interest rates.

(4) The data analyzed in this paper are aggregate average weighted maturity of all money market mutual funds (industry-level data). We would like to thank an anonymous reviewer for pointing this out to us.

(5) V.V. Acharya, T. Philippon, M. Richardson, and N. Roubini, "The Financial Crisis of 2007–2009: Causes and Remedies," *Financial Markets, Institutions & Instruments* 18 (2009): 89–137.

(6) In January 2007, the three-month T-bill rate stood around 4.9% and the LIBOR around 5.3%, implying a risk premium on LIBOR of 40 basis points. By January 2008, the T-bill rate plunged to 3.0% and the LIBOR spread reached around 100 basis points (authors' calculation; sources: http://research.stlouisfed.org and http://www.wsjprimerate.us/libor/libor_rates_history.htm.

(7) Acharya et. al, "The Financial Crisis of 2007–2009: Causes and Remedies."

(8) It is beyond the scope of this paper to provide a detailed account of the causes and consequences of 2007-08 financial crises; interested readers can review the papers by Acharya, and M. Kacperczyk and P. Schnabl, "When Safe Proved Risky: Commercial Paper during the Financial Crisis of 2007–2009," *Journal of Economic Perspectives* 24 (2010): 29–50.

(9) Acharya et. al, "The Financial Crisis of 2007–2009: Causes and Remedies."

(10) Domian, "Money Market Mutual Fund Maturity and Interest Rates."

(11) Ferri and Oberhelman, "A Study of the Management of Money Market Mutual Funds."

(12) A. Kane and S.G. Marks, "The Rocking Horse Analyst," *Journal of Portfolio Management* 13 (1987): 32–37.

(13) Domian, "Money Market Mutual Fund Maturity and Interest Rates."

(14) Seyfried and Packer, "Money Market Mutual Funds."

(15) All data, with the exception of commercial paper rate, were obtained from iMoneyNet. The commercial paper rates were downloaded from FRED® at the St. Louis Federal Reserve Bank. The commercial paper rates are available starting from January 7, 1997. Thus, the data for the full period and the first subperiod is adjusted accordingly.

APPENDIX A: GRANGER CAUSALITY

The pair-wise Granger tests for unidirectional and bidirectional causality consist of restricted and unrestricted equations and are presented as follows:

$$I_{j,t} = a_0 + \sum_{i=1}^{n} a_i I_{j,t-i} + e_{j,t} \quad (1)$$

$$I_{j,t} = a_0 + \sum_{i=1}^{n} a_i I_{j,t-i} + \sum_{i=1}^{n} b_i WAM_{t-i} + e_{j,t} \quad (2)$$

$$WAM_t = c_0 + \sum_{i=1}^{n} c_i WAM_{t-i} + e_{j,t} \quad (3)$$

$$WAM_t = c_0 + \sum_{i=1}^{n} c_i WAM_{t-i} + \sum_{i=1}^{n} d_i I_{j,t-i} + e_{j,t} \quad (4)$$

where I_j is the interest rate (j = 1, and 2; T-bill, and CP rates, respectively), *WAM* is the weighted average maturity of MMMFs, and *e* is the random disturbance, assumed to be normally distributed and uncorrelated across equations. As a point of explanation, unidirectional causality from *WAM* to interest rate is indicated if the $\sum b_i$ coefficients in equation (2) are, as a group, statistically significant, while $\sum d_i$ coefficients in equation (4) are not statistically different from zero. Similarly, unidirectional causality from interest rate to *WAM* is established when the $\sum d_i$ coefficients in equation (4) are significant and those of $\sum b_i$ in equation (2) are statistically insignificant.

(16) L. Pastor and P. Veronesi, "Learning in Financial Markets," NBER WP 14646 (2009) provides an exhaustive review of literature that highlights how parameter instabilities explain the volatility and predictability of asset returns, stock price bubbles, portfolio choice, mutual fund flows, trading volume, and firm profitability.
(17) *Ibid.*
(18) The commercial paper rates start from January 7, 1997.
(19) The test of means (t = 10.20) strongly supports that the mean WAM for the first subperiod (44 days) is statistically different from that of the second subperiod (39 days).
(20) The null hypothesis of equality of variances is rejected at the 90% confidence level (F=1.12, p-value = 0.055).
(21) Our correlation matrix was estimated using contemporaneous observations. It is possible for two series to lack contemporaneous correlations but share lagged correlations.
(22) C.W.J. Granger, "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods," *Econometrica* 37 (1969): 424–438.
(23) Appendix A contains the mathematical model and the p-values of the F-statistics of the Granger causality test.
(24) Stationary variables have long-run mean and variance, which do not change over time. Nonstationary variables usually follow a trend process in which the mean and variance may change over time.
(25) Significant F-values (i.e. p-value ≤ 0.05) for WAM to interest rates suggest that the MMMF managers are in a position to anticipate changes to short-term interest rates by adjusting the average maturity of their asset holdings. On the other hand, significant interest rate to WAM relationship (*i.e.* p-value ≤ 0.05) denotes that the fund managers react to changes in short-term interest rates by adjusting the WAM.
(26) Domian, "Money Market Mutual Fund Maturity and Interest Rates."
(27) "2010 Investment Company Factbook," 50th Edition (Washington, DC: Investment Company Institute, 2010); http://www.icifactbook.org/pdf/2010_factbook.pdf.
(28) Additionally, from 2006 to prior to the 2007 financial crisis, the share of the total market outstanding for CP held by mutual funds increased from 33% to 47%. Between 2007 and 2008, the proportion of the market for commercial paper held by mutual funds fell from 45% to 44%. This reduction in the holdings of commercial paper is more meaningful when viewed in the context that the total value of the market for commercial paper outstanding also fell by 11% within the same period. See Kacperczyk and Schnabl, "When Safe Proved Risky," and "2009 Investment Company Factbook," 49th Edition (Washington,DC: Investment Company Institute, 2009); http://www.icifactbook.org/2009/fb_sec1.html#role.

TABLE A1

***P* Values of Causality Test Results**

Series	Lags			
P-Values	(2,2)	(4,4)	(6,6)	(8,8)
Panel A: January 3, 1995 to March 23, 2010				
	ΔWAM Causes ΔTBILL			
Level	0.85	0.21	0.24	0.16
1st Difference	0.43	0.22	0.12	0.16
	ΔTBILL Causes ΔWAM			
Level	0.26	0.61	0.01	0.00
1st Difference	0.26	0.03	0.00	0.00
Panel B: Subperiod I: January 3, 1995 to Dec. 26, 2006				
	ΔWAM Causes ΔTBILL			
Level	0.07	0.14	0.26	0.30
1st Difference	0.52	0.57	0.54	0.37
	ΔTBILL Causes ΔWAM			
Level	0.06	0.13	0.02	0.00
1st Difference	0.11	0.04	0.00	0.00
Panel C: Subperiod II: January 2, 2007 to March 23, 2010				
	ΔWAM Causes ΔTBILL			
Level	0.18	0.19	0.14	0.31
1st Difference	0.30	0.30	0.33	0.53
	ΔTBILL Causes ΔWAM			
Level	0.02	0.00	0.00	0.00
1st Difference	0.62	0.17	0.01	0.02

Note: *P*-value ≤ 0.05 implies significance at 95% confidence level.

TABLE A2

***P* Values of Causality Test Results**

Series	Lags			
P-Values	(2,2)	(4,4)	(6,6)	(8,8)
Panel A: January 3, 1995 to March 23, 2010				
	ΔWAM Causes ΔCP			
Level	0.95	0.91	0.51	0.21
1st Difference	0.97	0.53	0.32	0.11
	ΔCP Causes ΔWAM			
Level	0.00	0.00	0.00	0.00
1st Difference	0.00	0.00	0.00	0.00
Panel B: Subperiod I: January 3, 1995 to Dec. 26, 2006				
	ΔWAM Causes ΔCP			
Level	0.05	0.04	0.01	0.02
1st Difference	0.58	0.03	0.02	0.03
	ΔCP Causes ΔWAM			
Level	0.06	0.13	0.00	0.00
1st Difference	0.06	0.00	0.00	0.00
Panel C: Subperiod II: January 2, 2007 to March 23, 2010				
	ΔWAM Causes ΔCP			
Level	0.02	0.04	0.10	0.14
1st Difference	0.53	0.74	0.46	0.31
	ΔCP Causes ΔWAM			
Level	0.00	0.00	0.00	0.00
1st Difference	0.00	0.02	0.00	0.00

Note: *P*-value ≤ 0.05 implies significance at 95% confidence level.