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"Money Market Fund Maturities and Short-Term Interest Rates: New Evidence from Granger Causality Tests"

This report is submitted as part of the requirements for the award of the MSc in Investment Management.

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Abstract

This paper aims to study the relationship between money market fund (MMF) portfolio maturities and short-term interest rates in the United States. As a guide, Domian's paper: *Money Market Mutual Fund Maturity and Interest Rates* is used as a guide to study this relationship with updated data and improved methodology that has been studied in recent years. The central research question is whether changes in MMF maturities anticipate movements in Treasury bill yields or, conversely, whether interest rate fluctuations cause MMF maturity profiles to change. While prior literature has primarily considered MMFs as passive rate takers, recent market developments such as unconventional monetary policy regimes and a changing political climate suggest a more complex interaction that warrants empirical testing.

This project has used a time-series econometric analysis using monthly data of maturities of an average of 3 selected U.S. MMF as a proxy and monthly aggregated 3-month Treasury bills. Granger causality tests are conducted to identify predictive relationships in both directions with robustness checks such as the Augmented Dickey Fuller test and the Akaike Information Criterion to ensure reliable model specification. Graphs are also used to visually compare the relationship between the two variables.

The findings indicate no evidence of any directional Granger causality in both sides, suggesting that neither MMF maturities nor short-term interest rates predict one another within the sample period. However, these results must be interpreted with caution as differences from earlier studies such as updated data, lag selection methods and changes in the underlying relationship may influence the results heavily as the Granger causality tests are sensitive to the underlying data used, where the timeframe used, frequency of data and lags chosen could change results drastically.

Further research could be done to provide a clearer picture of the relationship between MMFs and short-term interest rates by applying subsample or rolling-window approaches, or by extending the framework to a multivariate setting incorporating additional factors such as monetary policy stance, risk sentiment, or MMF sector size.

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Introduction

Money market mutual funds are a type of investment product that invests in liquid high quality short-term debt, such as commercial paper, treasury bills, certificates of deposit, repurchase agreements, and agency debt. They are designed to offer high liquidity, capital preservation and modest returns with a low level of risk where fund managers traditionally taking a passive role.

Under the SEC Rule 2a-7, MMMFs are classified into three primary types which are prime, government, and tax-exempt. Prime funds invest in corporate short-term debt like commercial papers and certificates of deposit, with a floating NAV type and was subject to fees/gates pre-2024 reform. Government money market funds have a stable NAV type that is anchored at 1$ and invests at least 99.5% in U.S. government securities and repos with treasuries, agency debt and repos as its main investments. Tax-exempt money market mutual funds invest in short-term municipal securities with a stable NAV type and is subject to fees/gates.

In response to the 2008 financial crisis, governments and regulatory bodies rushed to enact numerous laws and regulations. MMMF structure has been strongly shaped by three major SEC regulatory waves in 2010(post-Lehman), 2014(which is implemented in March 2016), and in 2024.

The 2016 SEC reform that was announced on 2014 and implemented in October 2016 was introduced to reduce the risk of MMF runs and improve transparency and liquidity. Key changes include NAV structure where institutional prime and municipal funds were required to adopt floating NAVs (Net Asset Values), meaning share prices could fluctuate based on market value whereas retail and government MMFs were allowed to keep a stable $1 NAV. Moreover, funds could impose gates (temporary suspension of redemptions) and fees (up to 2%) if weekly liquid assets fell below thresholds (30%). There were also increased liquidity requirements where funds had to hold at least 10% in daily and 30% in weekly liquid assets. This has caused large investor outflows from prime funds into government MMFs, where prime funds shifted holdings away from commercial paper to safer assets like government funds to avoid floating NAVs and fees. These reclassified funds may show different maturity behaviour before and after reform.

The 2023-2024 SEC reform aimed to further reduce systemic risk, especially after the March 2020 COVID-19 market turmoil, where MMFs again faced significant redemptions. Key changes include the removal of redemption gates because redemptions were seen as potentially destabilising in 2020. Swing pricing was introduced to dilute first-mover advantage during large redemptions which adjusts NAV based trading costs. Liquidity requirements also tightened with daily liquid assets increasing from 10% to 25% and weekly liquid assets increasing from 30% to 50%. The liquidity fees framework is revised and is based on fund specific conditions, rather than strict thresholds. This further increases the pressure on institutional prime funds which lead to more conversions to government funds and caused fund managers to balance maturity decisions more conservatively to maintain liquidity ratios. This reform overlaps with the tail end of the dataset, which may cause new liquidity behaviour due to stricter liquidity floors and swing pricing pressure.

In addition, seasonal patterns in money market mutual funds may be present where fund managers adjust their portfolio maturities to take advantage of yield changes. Farinella and Koch(2000) document that yield changes are associated with a corresponding outflow of fund assets at the end of the year and inflow of assets in the beginning of the year. However, no research has documented yield changes relationship with maturities to the best of my knowledge.

Literature review

Relevant research that has been done in the money market mutual funds is done by Domian(1992) that studies the Granger Causality test between money market mutual funds' maturity and interest rates. Results have shown that interest rates Granger causes money market mutual funds' maturity and not the other way around. This implies that managers respond after rate movements, rather than anticipating them.

There is limited direct research extending or replicating these findings, particularly in the context of modern data and causality frameworks. Most related literature focuses on forecasting interest rates and assessing market efficiency through looking at money market mutual funds' behaviour rather than the relationship between interest rates and money market mutual fund maturities. This gap in literature underscores the relevance of the present study, which aims to update and extend Domian's insights by applying contemporary time series methods.

This paper aims to replicate Domian(1992) paper with more recent data that the efficient market hypothesis, where interest rates Granger-cause MMMF average maturity, still stands. More contemporary methods are used such as Augmented Dickey Fuller test and Akaike Information Criterion to reconfirm the hypothesis. Data sources are also updated to what is available today.

Section 1 describes the time series and the data collected. The autoregressive models, results, analysis of the results as well as the justification of methods used are presented in section 2. Concluding remarks are made in section 3.

Methodology

The time series

In the original paper, the major source of information about MMMFs used is IBC/Donohoghue's Money Fund Report. This dataset is no longer available and maintained. Since July 2010, the U.S. SEC has mandated that MMMFs submit monthly filings via Form N-MFP, offering higher-resolution, fund-level data that is machine-readable. This study uses Form N-MFP Filings data spanning June 2016 to June 2025, extracted from SEC filings via SEC EDGAR, to replicate and expand on earlier maturity-interest rate dynamics with updated information. The cutoff point for the data is June 2016 because in March 2016, there was a transition from N-MFP to N-MFP2 which changed the XML namespace and structure which made it difficult to extract data due to the different format.

The data extracted is monthly which amounted to 108 rows of data which is a sizable data to run a Granger Causality test with enough lags. The dataset is smaller than the original paper, which analysed weekly data as opposed to monthly data. This limitation is recognised, as lower frequency data may reduce the ability to detect short-term dynamics.

However, due to the nature of data sourced from SEC Form N-MFP filings, no standardised money market mutual fund index is available. Thus, a representative money market fund portfolio has been built using three large institutional Money Market Funds from major providers:

- Fidelity Hereford Street Trust (CIK: 0000917286)
- JPMorgan Prime Money Market Fund (CIK: 0001217286)
- Goldman Sachs Trust (CIK: 0000822977)

These three funds, at the start of the analysis window, represent the major categories of money market mutual funds: Prime (Fidelity), Government/Treasury (JPMorgan), and Tax-Exempt (Goldman Sachs). These categories reflect distinct regulatory treatments and portfolio compositions which creates a representative view on the overall money market mutual fund's reaction to interest rates.

It is also noted that the JPMorgan fund, initially classified as a Treasury fund in early filings, later transitioned to a Prime classification. This shift reflects industry-wide portfolio rebalancing and reclassification following the 2023-2024 SEC money market reforms.

Through the XML files, I have used python to source the following: Total Net Assets, Filing dates, and Average Portfolio Maturity. I have then compiled the three datasets together and calculated the weighted average of portfolio maturity with the formula below:

$$Average\ Maturity = \frac{\sum_{i=1}^{n} Net\ Assets\ \times Maturity}{\sum_{i=1}^{n} Net\ Assets}$$

The second dataset needed is the 3-month U.S. Treasury bill yield which I sourced from Federal Reserve Economic Data (FRED) database. This data series is chosen due to it being consistently reported and readily accessible. Since this data is daily, I have processed this data by aggregating it monthly to match with the MMMF maturity data collected.

In contrast to the original paper, the BOND series, for yields on high-grade corporate bonds is not included as no long-term analysis is done due to the short-term dynamic nature of money market mutual funds today. The original study has included long-term bond yields to explore broader interest rate influenced on maturity decisions, but this long-term analysis is beyond the scope of this study.

Below is a graph that shows both datasets collected:

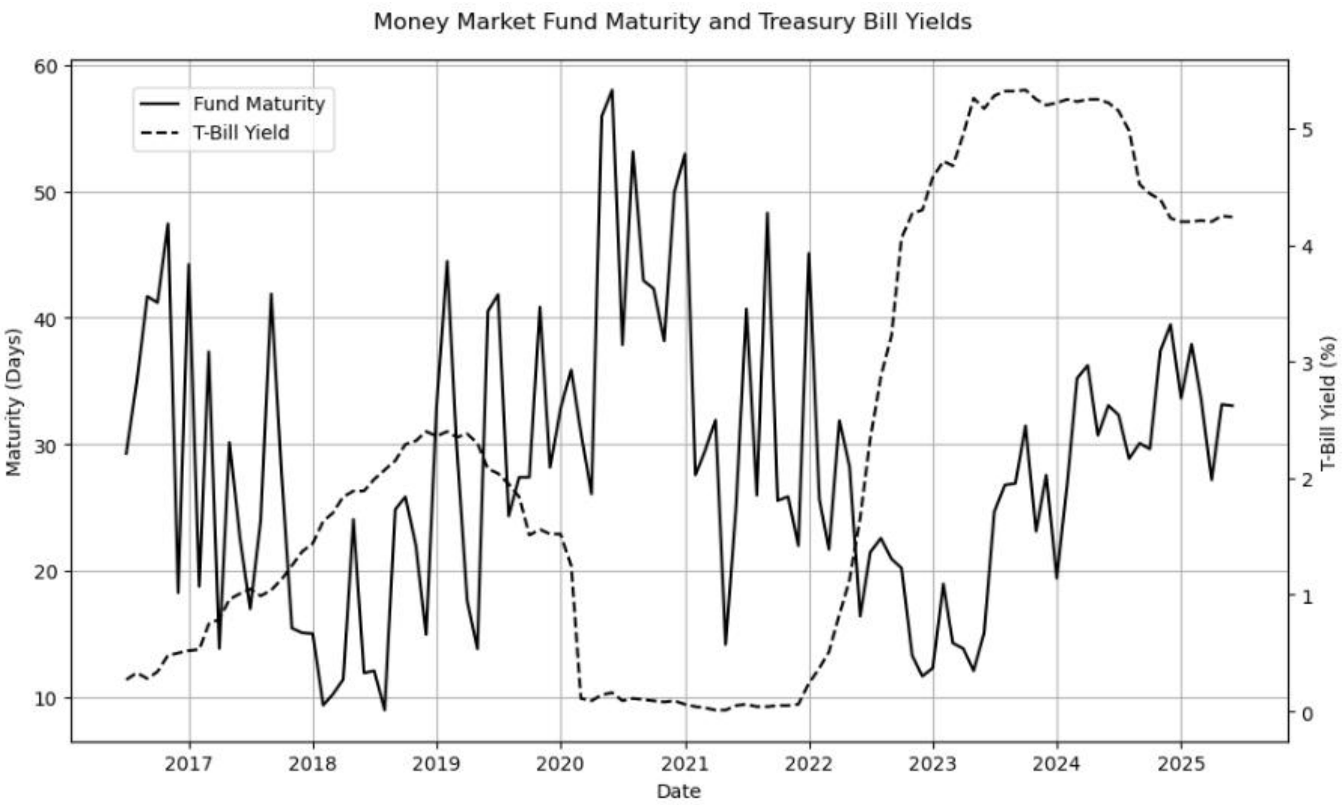

Figure 1: Money Market Fund Maturity and Treasury Bill Yields

Compared to the original paper that analyses weekly data from 1982 to 1990, the monthly data ranging from June 2016 to June 2025 does not reveal a clear inverse relationship between MMMF maturity and Treasury bill yields. More statistical analysis must be done to show any causational relationship as recent data is more volatile due to unconventional monetary policies (e.g. zero interest rate policy and quantitative easing) and macroeconomic shocks such as COVID-19.

Before proceeding with tests in the next section, we need to examine whether the series are covariance stationary. Thus, with the two datasets, I ran an Augmented Dickey Fuller (ADF) test to test for stationarity, which is essential for time series models like Granger Causality. Non-stationary series may lead to misleading inferences and spurious results. The ADF test is a statistical test that determines if a time series has a unit root. The null hypothesis is that the time series has a unit root, meaning it is non-stationary.

The Augmented Dickey Fuller (ADF) test is chosen as opposed to the Dickey Fuller test in the original paper as it adds lagged differences to correct for autocorrelation and is more robust as it handles autocorrelated residuals. According to Palm, Smeekes, and Urbain (2006), ADF test perform better than DF tests especially when using sieve bootstrap methods. Given the moderate sample size of this study (108 observations), the standard ADF test is run as opposed to bootstrap versions. The potential limitations of this approach are acknowledged, particularly regarding near-unit-root processes.

Lag length was selected automatically using the Akaike Information Criterion (AIC) to ensure valid ADF test results and account for autocorrelation.

Due to the raw data's non-stationary nature, further transformations are needed for the next step. The Average Portfolio Maturity and treasury bills data is then transformed through first differencing, natural logarithmic transformation, and log differencing the time series. To ensure alignment across variables, missing values arising from differencing and logging were removed. As noted in the original study and in Christiano and Ljungqvist (1988), these transformations may come with a trade-off of potentially introducing noise and discarding economically relevant information. This limitation is acknowledged, though transformations are needed to ensure valid inference from Granger causality tests.

Table 1: Augmented Dickey Fuller Test results

Transformation	Series	ADF Test Statistic	p-value
None	Maturity	-3.1207	0.0251

	T-bill	-1.5947	0.4863
Logs	Maturity	-3.4306	0.0100
	T-bill	-2.2028	0.2052
First Differences	Maturity	-4.6415	< 0.0001
	T-bill	-2.9403	0.0409
Log First Differences	Maturity	-4.9413	< 0.0001
	T-bill	-4.3429	< 0.0001

Based on the table above, we can conclude that the first differences and log first differences set of data, where both the maturity and T-bill time series data, are stationary. This is due to the low p-value that is below 0.05 indicating a significant value to reject the null hypothesis of the time series containing a unit root. However, the raw data and the logged sets of data are not stationary as the p-values are above 0.05. This suggests that differencing, particularly log first differencing, is required to achieve stationarity that is suitable for time series modelling like VAR or cointegration analysis.

In comparison to the original paper, I have yielded the same results with first differences and log first differences being stationary while the raw maturity time series differs with my results being significant while the paper shows no evidence of stationarity.

Autoregressive Models and Granger Causality test

The following bivariate autoregressive models are used to investigate the causality for the MMMF average maturity series MATURITY and the Treasury bill yield TBILL:

$$TBILL_t = \alpha_j + \sum_{j=1}^{J} \alpha_j TBILL_{t-j} + \sum_{k=1}^{K} b_k MATURITY_{t-k} + u_t$$

and

$$MATURITY_t = c_0 + \sum_{m=1}^{M} c_m MATURITY_{t-m} + \sum_{n=1}^{N} d_n TBILL_{t-n} + v_t$$

Both equations are estimated using ordinary least squares (OLS). Granger causality is tested by performing joint exclusion tests on the lagged independent variables of the second series. In the first equation, if the lagged values of MATURITY significantly improve the prediction of TBILL, then MATURITY is said to Granger-cause TBILL, suggesting that fund managers adjust maturity in anticipation of interest rate changes. Similarly, if lagged TBILL values significantly explain MATURITY in the second equation, this implies that managers adjust maturity in response to interest rate movements.

Once stationarity was achieved for both variables, the Granger Causality test is then run to test the causation and relationship between both variables. To do this, lag selection is crucial with many methods to choose from such as the Akaike final prediction error (FPE), which is the method chosen in the original paper, the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC).

The AIC tends to choose a longer lag that mildly penalises complexity and is good in small samples while BIC tends to choose a shorter lag with a stronger penalty for complexity. BIC's strength is it is parsimonious and consistent. Lastly, the FPE tends to choose longer lags with no penalty for complexity and is more intuitive in prediction settings. AIC is best suited to capture as much of the underlying data-generating process as possible which is beneficial in testing causality relationships that manifest with longer delays but this flexibility can come at the cost of overfitting. BIC is suited to hypothesis-driven studies such as Granger causality and is often recommended when the goal is to avoid spurious causality due to overfitting.

FPE is useful in forecasting contexts, where out-of-sample performance is the main objective. As this paper focuses on replicating results with modern data to prove that interest rates Granger-cause fund maturity instead of forecasting, FPE is not a suitable method for lag selection. Thus, AIC is more favourable to select lag length as it is consistent with standard practice in contemporary time series analysis. However, it is noted that under broad process assumptions, there is a universal property binding their optimality which is supported by Jirak & Köstenberger (2024).

The table shows the results for lag selection for the differenced and log first differenced set of data:

Table 2: Lag Selection Results

Criterion	Optimal Lag (First differenced)	Optimal Lag (Log first differenced)
AIC	1	1
BIC	1	0(not usable)
FPE	1	1

Nearly all selection criteria chose 1 lag. As noted by Kuha (2004), AIC and BIC are based on fundamentally different selection goals which are predictive accuracy versus consistency. Kuha (2004) also suggests that researchers examine the contextual purpose of the analysis and relative penalty structure of each criterion. BIC's recommendation may be preferred since Granger causality testing is sensitive to overfitting and tends to benefit from model parsimony. However, since BIC recommends an unusable value, it may be appropriate to use the next most conservative recommendation which is AIC. AIC and FPE's differences have been discussed before with both being robust methods for lag selection as they are derived with the same objective of balancing fit and complexity. Thus, the Granger causality test will be run using 1 lag for the first differenced set of data and 1 lag for the log-differenced set of data as suggested by AIC.

The results are shown below:

Table 3 :Granger-causality test results for first differenced data at 1 lag

	F-statistic	p-value
Testing if Maturity Granger-causes Interest Rates (DTB3)	0.0520	0.8206

Testing if Interest Rates (DTB3) Granger-cause Maturity	0.0455	0.8319

Table 4: Granger-causality test results for log-differenced data at 1 lag

	F-statistic	p-value
Testing if Maturity Granger-causes Interest Rates (DTB3)	0.1524	0.6979
Testing if Interest Rates (DTB3) Granger-cause Maturity	0.7309	0.3967

The results indicate that for first differenced data, the null hypothesis for both directions of causality have been failed to be rejected as there is no significant evidence with a p-value at 0.8206 that Interest Rates Granger-cause Maturity and a p-value of 0.8319 that Maturity Granger-cause Interest Rates. Similarly for log-differenced data, there is no statistically significant Granger causality in either direction. The null hypothesis that funds' maturity does not Granger-cause interest rates could not be rejected, nor could the null that interest rates do not Granger-cause fund maturity.

The original results by Domian (1992) have shown consistent evidence that interest rates Granger-cause fund maturity across all series transformations. Replication using more recent data and contemporary lag selection techniques have found no evidence of this finding.

There are a few reasons that could explain why the F-statistics and p-values differ from the original paper such as updated data, lag selection method and potential changes in the underlying relationship between short-term interest rates and fund maturity. Results may also differ with different datasets used such as different periods or a different selection of funds. As for the relationship between short-term interest rates and fund maturity, a possible change that could affect the results would be the unconventional monetary policy regimes during 2020-2022 period where there seems to be no pattern tying together the two variables.

Moreover, any causality test result interpretations must consider the possibility of spurious causality. It is possible that a third factor could affect two unrelated series, and the direction of spurious causality would depend on this third factor even after minimising risks by first differencing the series, avoiding nonstationarity, and using Akaike Information Criterion (AIC) to select an appropriate lag structure. Therefore, the results of the Granger causality test must interpret with caution. This is also highlighted in Thornton and Batten (1985), where a statistically significant Granger relationship may arise if both series are influenced by a third, unobserved variable. Nevertheless, as the timing relation itself is the focus of this paper, spurious causality does not affect this finding. Timing relation refers to whether one series tends to move before the other, in a statistically significant way.

There are a few suggestions to make a more robust finding on the relationship between MMMF maturities and interest rates. Firstly, a subsample analysis could be done to investigate whether the Granger causality relationship holds consistently over time or is concentrated in specific periods. This is especially important during unconventional monetary policy periods such as around 2020 till 2022 during COVID where interest rates were at 0%. Subsamples could be created by identifying structural breakpoints, such as monetary policy regime shifts, or by applying rolling-window Granger causality tests. The latter approach involves estimating the causality relationship within a fixed-size time window that moves through the dataset, allowing for time-varying dynamics without the need to predefine breakpoints. Alam et al. (2021) has applied similar this technique to study the relationship between economic growth and CO_2 emissions in G-7 countries. While the subject differs, the methodology is transferable. However, there are limitations to this analysis as currently as only monthly data up to January 2014 is available. Future work could revisit this question using more recent or higher-frequency data especially if weekly data from commercial sources or SEC EDGAR is available.

Secondly, to avoid spurious causality a third variable could be added to analyse this problem using a multivariate Granger causality test as opposed to the current bivariate VAR model. This is because real-world financial relationships are rarely isolated and variables such as monetary policy, risk appetite and liquidity conditions could affect both interest rates and money market mutual funds' maturity indirectly separately. Some possible third variables that could be investigated further is Effective Federal Funds Rate (EFFR) as a proxy for monetary policy stance, VIX Index as a measure of market uncertainty or risk aversion, and Total MMF assets under management (AUM) as a measure of size or liquidity of the MMF sector. By adding more variables, a clearer and more representative picture could be painted of the relationship between interest rates and MMMF maturities. However, this could introduce the risk of overfitting or adding noise where the third variable does not contribute any meaningful data and complicate the interpretation of causality. This analysis may also need more degrees of freedom which is not possible with the current dataset.

Conclusion

The findings in this paper have differed with the original Domian (1992) paper and with the efficient market hypothesis. There is no evidence that there is any directional causality between the MMMF average maturity and short-term interest rates. The Granger causality test did not yield any results for MMMF average maturity causing and predicting short-term interest rates nor did short-term interest rates effect MMMF average maturity. This shows that fund managers' behaviour has changed over time as previously short-term interest rates could predict MMMF average maturity as fund managers adjust their portfolios according to the interest rates. However, the extent of change and the nature of this change must be studied further.

References

Domian, D.L., 1992. *Money Market Mutual Fund Maturity and Interest Rates.* Journal of Money, Credit and Banking, **24**(4), pp.519–527

Farinella, J.A. and Koch, T.W., 2000. *Seasonal patterns in money market mutual funds*. Journal of Financial Research, **23**(4), pp.479–499.

Palm, F.C., Smeekes, S. and Urbain, J.P., 2006. *Bootstrap unit root tests: comparison and extensions*. Journal of Time Series Analysis, **27**(5), pp.675–698.

Christiano, L.J. and Ljungqvist, L., 1988. *Money does Granger-cause output in the bivariate money-output relation*. Journal of Monetary Economics, **22**(2), pp.217–235.

Kuha, J., 2004. *AIC and BIC: Comparisons of assumptions and performance*. Sociological Methods & Research, **33**(2), pp.188–229.

Alam, M.R., Paramati, S.R., Shahbaz, M. and Bhattacharya, M., 2021. *The role of financial stability and corruption in environmental sustainability: Evidence from South Asian economies*. Journal of Environmental Management, **294**, p.112915.

Allen, K., Saha, P., Whitledge, M. and Winters, D., *Money market reforms: The effect on the commercial paper market*. [online] Available at: https://www.fdic.gov/analysis/cfr/working-papers/2022/cfr-wp2022-05.pdf [Accessed 9 August 2025].