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Asset Price Bubbles and Systemic Risk in Money Market Funds

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January 11, 2025

Abstract

We investigate the systemic risk contribution of 3,500 Money Market Funds (MMFs) in normal periods and during asset price bubbles in the US over January 2004-December 2022. Using state-of-the-art statistical techniques for the detection of bubbles and granular fund-level data on the characteristics of MMFs, we show that these characteristics are important determinants of systemic risk. Large MMFs and government MMFs that invest exclusively in US-Treasury securities are associated with reductions in systemic risks while prime MMFs are associated with higher systemic risk contributions. MMFs denominated in US-dollars but domiciled offshore do not behave differently compared to US-domiciled ones.

Keywords: Financial Crises, Financial Bubbles, Systemic Risk Measures, Panel data.

J.E.L. Classification: C23, G21, G15.

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1 Introduction

While financial crises can take place even in the absence of a preceding asset price bubble, a significant body of literature has established that crises that are preceded by a bubble are more severe (Borio & Lowe, 2002; Reinhart & Rogoff, 2008). Indeed, in some cases bubbles do not simply precede a crisis, but directly cause it. The overall relationship is complex to disentangle and likely to depend on a number of factors that vary across time and space. Given the serious scarring that a financial crisis can leave on the real economy, it is not surprising that research has looked for patterns that can shed light on the role of asset price bubbles and systemic risk.

The overwhelming majority of this research, however, focuses on establishing links between bubbles, systemic risk and the macroeconomy (Reinhart & Rogoff, 2008; Guerron-Quintana et al., 2023; Berger & Sedunov, 2024). Macroeconomic factors are indeed important, but so are the microeconomic determinants of the interaction between bubbles and systemic risk, which have so far received little attention.

A notable exception is Brunnermeier et al. (2020) who analyse the relationship between asset prices bubbles and systemic risk using bank-level data and highlight the importance of bank characteristics in the creation of financial fragility, thereby providing the first evidence that individual institutions contribute to increased systemic risk during asset price bubbles.

Banks are a crucial part of the global financial system and thus deserve the prominent consideration they have been given, however the role of non-bank financial intermediaries (NBFIs) has considerably grown in recent years (Financial Stability Board, 2023, FSB; International Monetary Fund, 2023, IMF; Acharya et al., 2024; Tian et al., 2024). These intermediaries now represent almost 50% of the global financial system and have recently attracted the attention of regulators around the world. Notwithstanding their growth and the regulatory interest, there has been no study of the role that NBFIs play in the formation of asset price bubbles and their interaction with measures of systemic risk. Given the substantial increase in relevance of NBFIs, understanding their contribution to systemic risk and financial stability is now of paramount importance.

In this paper, we aim to begin to fill this gap in the literature by focusing on a core component of the non-bank sector, namely Money Market Funds (MMFs). MMFs have a number of characteristics that make them particularly attractive for our purposes. First, they are the most bank-like institution among NBFIs as they - in practice - guarantee the principal amount invested similarly to what a bank deposit does. Indeed, there is evidence that investors do treat MMFs as an alternative to bank deposits (Bouveret et al., 2022). Second, while some restrictions have been imposed on MMFs in a number of jurisdictions, they have not been subject to rules as stringent as those applied to banks after the 2008 financial crisis and hence some of the risks borne by banks before the financial crisis may have moved to MMFs given that investors see them as substitutes to bank deposits. Third, MMFs have been the source of financial stress in a number of episodes in recent decades, including the 2008 crisis and the 2020 turmoil triggered by COVID-19, showing their importance from a financial stability perspective (Kacperczyk & Schnabl, 2013; Schmidt et al., 2016; La Spada, 2018). This paper contributes to the rapidly expanding literature on MMFs and is particularly related to the strand of literature exploring MMFs risk-taking behaviour (Baba et al., 2009; McCabe, 2010; Bengtsson, 2013; Chernenko & Sunderam, 2014; Hanson et al., 2015; Strahan & Tanyeri, 2015; Parlatore, 2016; Di Maggio & Kacperczyk, 2017; Li, 2021;

Baghai et al., 2022; Lugo, 2023).

We begin our analysis by detecting and timing asset price bubbles in the U.S., focusing on both the stock and real estate markets. We find that the S&P500 and the real estate markets experienced two main periods of bubbles each, with the only overlap being the period following the COVID-19 crisis. We then move our focus onto the contribution of MMFs to systemic risk and their interaction with asset price bubbles. We use $\Delta CoVaR$ (Adrian & Brunnermeier, 2016) as our main measure of the systemic risk contribution of MMFs, but our results are robust to using *Marginal Expected Shortfall* (MES) as the measure of systemic risk (Acharya et al., 2017). $\Delta CoVaR$ has a number of appealing features: first it allows the generation of time-varying estimates of systemic risk contributions of individual MMFs to the financial system as a whole. Second, it is one of the best performing near-coincident indicators due to its ability to assess potential spillovers, providing policymakers with valuable insights into the systemic risk contributions of individual financial institutions (Arsov et al., 2013). Finally, $\Delta CoVaR$ provides early warning signals concerning both the potential systemic damages that may arise from MMFs distress and their vulnerability to the onset of a systemic shock (Zhang et al., 2015).

Given their importance for the financial system as a whole, we focus on MMFs denominated in US dollars. But we do not restrict our focus to US-domiciled funds: there is also a substantial amount of US dollar-denominated assets that are managed offshore which we include in our analysis. The entire sample includes 3,586 MMFs over the January 2004 - December 2022 time period. Given that MMFs share many of the characteristics of banks, one might expect them to have a similar effect on systemic risk. This is only partially true however. Our results show that MMFs are similar to banks insofar as asset price bubbles are important determinants of their contribution to overall systemic risk. And while we also find that the characteristics of MMFs are important to understand their contribution to systemic risk, there are differences compared to the results obtained for banks.

First, contrarily to banks, large MMFs are overall associated with a reduction in systemic risk in normal times, while this effect is in some cases amplified and in others reduced during period of bubbles. On the other hand, similarly to what Brunnermeier et al. (2020) highlight for banks, MMFs with more pronounced maturity mismatches are associated with a reduction in systemic risk. Third, riskier funds are associated with higher contribution to systemic risk in general, but the effect is attenuated during bubble periods. Finally, USD-denominated MMFs that are managed offshore, do not behave differently from domestic US MMFs and hence are unlikely to provide a buffer in periods of stress. We also focus on the period of 'relative calm' as described by and and find that in response to regulatory reforms introduced in the United States and Europe the had an effect on the characteristics of MMFs and, in particular that systemic risk for larger government MMFs decreased, highlighting their role as a potential safe haven.

Our results are robust to several sensitivity checks, using *MES* as an alternative measure of systemic risk; the inclusion of $\Delta CoVaR$ state variables in the estimations; considering an alternative estimation strategy for $\Delta CoVaR$; and excluding the observations during the COVID-19 time period.

The remainder of the paper is structured as follows: Section 2 discusses the institutional of the USD-denominated MMF industry. Section 3 describes the methodology, while Section 4 reports the results of the empirical analysis. Section 5 contains robustness tests and Section 6 concludes.

2 Institutional background

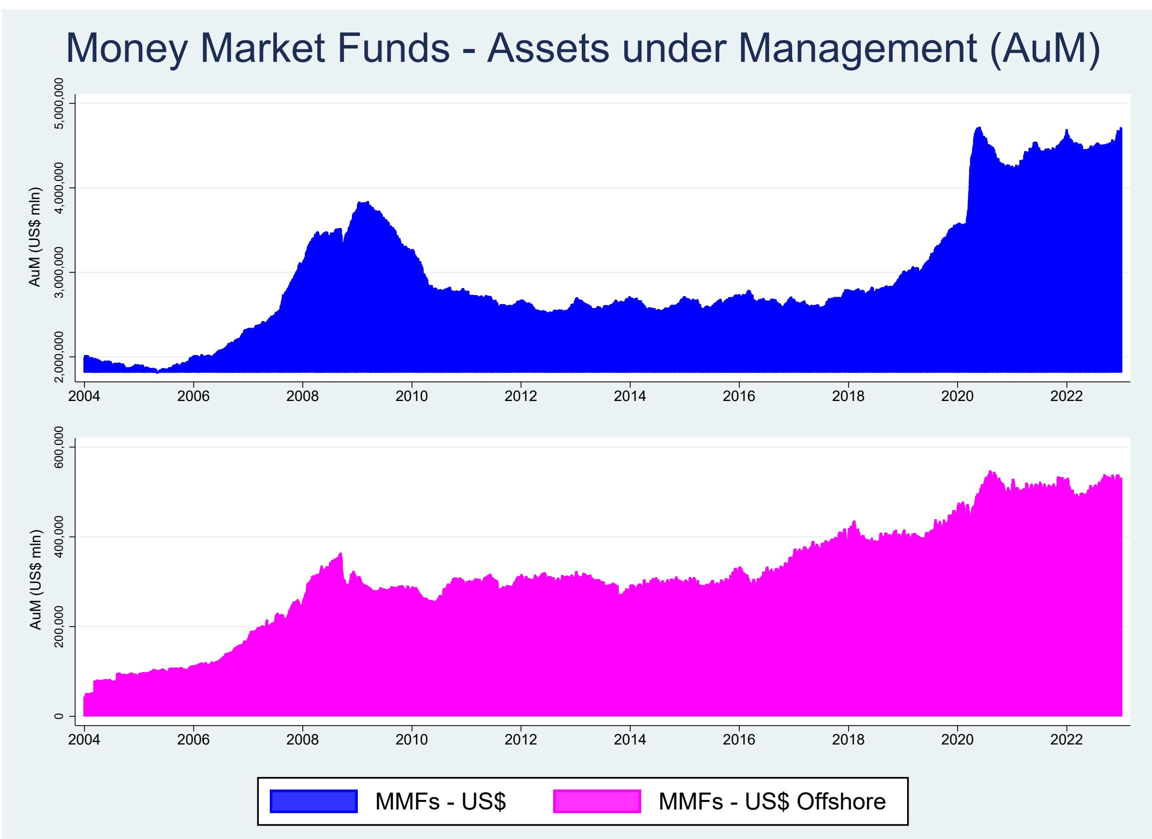
MMFs are open-ended mutual funds whose main aim is to offer investors returns aligned with money market rates. Through channeling such investment into markets, MMFs are a crucial provider of financing to governments, local government entities as well as financial and non financial corporates. MMFs originated in the United States in the 1970s: when Regulation Q imposed a cap on the interest that banks could offer on their deposits, MMFs could instead offer much higher returns to their investors and filled the gap left in the market. Since then, MMFs have occupied a space that was somewhat between banking and the capital market. For instance, for the first few decades of their existence, MMFs would issue checkbooks to their investors highlighting the deposit-like nature of their liabilities. At present, while checkbooks are no longer offered, MMFs still occupy a space next to bank deposits and, for instance, MMF shares are often still considered cash equivalent for accounting purposes[1].

MMFs are now much closer to a capital markets entity than a deposit account. Reforms were introduced after the 2008 global financial crisis, when a large MMF *broke the buck* following losses on Lehman Brothers' paper and additional ones are being implemented following the events of March 2020, when the turmoil generated by the advent of COVID-19 resulted in substantial outflows from MMFs. These reforms aimed at mitigating liquidity mismatches in MMFs and reducing their *moneyness* by forcing some MMFs to redeem shares based on the market value of their assets.

[1]The guidance on International Accounting Standard 7 highlights that a strict reading of the definition of the standard suggests that MMFs units do not qualify as cash equivalents, because they are essentially equity instruments that have no maturity. But these units can be considered *in-substance* cash equivalents as the amount of cash that will be received is known at the time of the initial investment.

Overall there are more than USD 9 trillion invested in MMFs globally (Bouveret et al., 2022). Of these, approximately two thirds are denominated in US dollars. MMFs denominated in US dollars are unsurprisingly mostly domiciled in the US (USD 4.7 trillion a the end of 2022) as they are used by domestic investors to manage their cash needs (see Figure 1). However, there is a substantial market for USD-denominated MMFs outside of the US (USD 590bn at the end of 2022), the overwhelming majority of which are based in the European Union and serve the need of European issuers and investors. The former can raise funds in US dollars from both European and US investors; the latter can get exposure to dollar-denominated money markets.

Figure 1: Money Market Funds (MMFs) US$ and US$ Offshore - Assets under Management (AuM - daily).



Source: Authors elaboration on iMonyNet database.

MMFs are not a homogeneous category: in the US they can be divided into three main groups. *Government* MMFs, which only invest in short-term debt issued by the US government (including federal agencies) and in repurchase agreements collateralised by these securities. These are the safest category of funds, as they have essentially no credit risk. *Prime* MMFs, which can invest in instruments issued by both public and private issuers (including commercial paper and negotiable certificates of deposits), which are the riskiest category of MMFs; and *tax-exempt* MMFs, which invest in short-term state and local government and municipal securities.

In Europe, for USD-denominated funds, while the nomenclature differs, the biggest difference is that there is no *tax-exempt* category, but both *government* and *prime* MMFs exists. These funds invest either in US government securities or in USD-denominated paper issued by European and US issuers.

Government funds, both in the US and Europe, have stable net asset value (NAV), meaning that the value of one unit does not fluctuate with the value of the underlying assets but is kept constant at one dollar. Barring instances in which a fund *breaks the buck*, one unit of an MMF can be converted into cash in a single day. The situation for *prime* funds is more complex. In the US, *prime* funds exclusively offered to retail investors can also maintain a stable NAV, while those offered to institutional investor have a floating NAV. In practice however, fluctuation in the NAV are minimal and hence one unit of an MMF is worth a dollar. In Europe, *prime* funds typically have what is referred to as a low volatility NAV. They can offer a stable NAV but need to switch to a floating NAV if the mark-to-market value of the assets they hold deviates by more than 20 basis points from the stable NAV, this is a very rare occurrence in practice.

3 Methodology

3.1 Defining and detecting asset prices bubbles

The first building block of our methodology requires identifying asset price bubbles, typically identified as episodes in which asset prices experience dramatic increases followed by significant reductions (Blanchard, 1979; Diba & Grossman, 1988; Evans, 1991; Lee & Phillips, 2016; Chen et al., 2023). A number of technical definitions have been proposed in the literature, but they all underline that the main characteristic of bubbles is the deviation of the price of an asset from its fundamental value. This deviation could be the result of a number of underlying reasons. Brunnermeier (2009) highlights that a potential explanation is the belief of current owners that they will be able to resell the asset for an even higher value, while Shiller (2015) focuses on the role of buyers' behaviour rather than fundamental information about value. In the history of financial markets and economic development, bubbles are fairly common occurrences and are well documented in the literature (Quinn & Turner, 2020; Vogel, 2022). But while the identification of asset prices bubbles is relatively straightforward after their occur, it is considerably more difficult to identify bubbles in *real time*. From a practical perspective, as the fundamental value of many assets is almost always not observable, it is difficult to asses if large price changes are justified by changes in fundamentals while the trend is upward. In their seminal analysis Reinhart & Rogoff (2008) always refer to large increases in asset prices rather than bubbles for exactly this reason. Indeed, some authors argue that in a fully efficient market, bubbles should not exist (Fama, 2014).

3.2 *Timing asset bubbles*

Nonetheless, a number of statistical procedures have been developed to detect episodes of exuberance and explosive behaviour in financial time series. Tests that use the full amount of data available go back decades[2], but substantial advances have been made in recent years. These new tests are not simple ex-post rationalisations of the observed behaviour of time series, but tools that rely only on information available up to the point in which the test is carried out. These tools can therefore be used to date when the explosive behaviour started to manifest. An important contribution in this respect is the work of Phillips et al. (2011), which was subsequently expanded in Phillips et al. (2015a,b) to accommodate the potential presence of multiple bubbles in a time series.

In these papers, the authors propose a recursive test procedure based on a right-tailed unit root test to identify bubbles. The procedure involves the following steps. First, conduct an Augmented Dickey Fuller (ADF) regression to test the null hypothesis of a unit root against the alternative of explosive behavior. Second, compute the Supremum Augmented Dickey Fuller (SADF) statistics using a forward-expanding sample and test whether it exceeds the critical value on the right-tail. Similar to the standard ADF test, the rejection of the unit root hypothesis in the SADF test indicates exuberant behavior. However, in contrast to the standard ADF test, the alternative hypothesis of the SADF test suggests exuberance dynamics in specific parts of the sample. Finally, compute the Generalized SADF (GSADF) (Phillips et al., 2015a,b), which has the same alternative hypothesis as the SADF but which covers a larger number of sub samples.

In comparison to the SADF, the GSADF test shows more flexibility on the estimation

[2]See Gurkaynak (2008) and Skrobotov (2023) for a review.

window and it is consistent with multiple bubble periods, while the SADF test is consistent only with a single episode. If the null hypothesis of a unit root is rejected, then the SADF and the GSADF tests can provide a sequence of episodes of exuberance. The inference for the ADF, SADF and GSADF statistics requires critical values computed using Monte Carlo simulations[3]. Consequently, Phillips et al. (2015a,b) introduce the Backward Supremum Augmented Dickey Fuller (BSADF) statistic, which allows identifying episodes of multiple bubbles more effectively. Appendix A describes the estimation approach.

In our empirical analysis, we employ the BSADF approach to identify multiple bubble episodes in the S&P 500 and Case-Shiller index, the latter deflated using the Personal Consumption Expenditures (PCE) index (Pavlidis et al., 2016), for stock and real estate markets, respectively. We then construct four binary variables to indicate episodes where a real estate or stock market bubble emerges or collapses.

3.3 Quantifying systemic risk at the MMF level

Having determined periods of stock and real estate bubbles, we now move onto determining the contribution of MMFs to systemic risk as well as their interaction with bubbles using $\Delta CoVaR$ (Adrian & Brunnermeier, 2016) as our systemic risk measure. We begin with a basic regression linking MMFs characteristics to systemic risk, controlling for the macroeconomic environment as follows:

[3] The finite sample critical values for 90%, 95% and 99% confidence levels are obtained from Monte Carlo simulations with 2,000 replications (see Phillips et al., 2015a,b and Vasilopoulos et al., 2022). The window size is given by $r_0 = \left(0.01 + 1.8/\sqrt{T}\right)$ as recommended by Phillips et al. (2015a,b). For both S&P 500 and Case-Shiller index, the time period is 2001:1 - 2022:4 (monthly frequency) and $T = 264$ observations.

$$
\begin{aligned}
\Delta CoVaR_{i,t} = \beta_0 + \beta_1 MMFs\ Char._{i,t-1} + \\
+ [Macro_{t-1}]\ or\ [\Delta CoVaR\ Macro_{t-1}]\ or\ [\textstyle\sum_{t=2004:1}^{2022:12} Time_t] + \varepsilon_{i,t}
\end{aligned}
\tag{1}
$$

We then analyse whether the effects change in bubble periods, and include in our regression the four binary variables indicating booms and busts in real estate and stock markets (I_t^{Bubble}) at time t, and their interaction with the MMF characteristics as described in Equation (2) below:

$$
\begin{aligned}
\Delta CoVaR_{i,t} = \beta_0 + \beta_1 I_t^{Bubble} + \beta_2 MMFs\ Char._{i,t-1} + \beta_3 I_t^{Bubble} * MMFs\ Char._{i,t-1} + \\
+ [Macro_{t-1}]\ or\ [\Delta CoVaR\ Macro_{t-1}]\ or\ [\textstyle\sum_{t=2004:1}^{2022:12} Time_t] + \\
+ \sum_{i=1}^{3,586} MMFs_i + \varepsilon_{i,t}
\end{aligned}
\tag{2}
$$

In our analysis, we employ the following MMF-specific predictors[4]. *Size* is the MMF fund size defined as the natural logarithm of the fund portfolio's outstanding assets ($millions) for MMF i at month *t-1*; *Weighted average maturity* (Wam) is the asset-weighted time (in days) until the securities in the portfolio mature for MMF i at month *t-1*; *Weighted average life* (Wal) is the weighted average life (in days), for MMF i at month *t-1*, based on a security's stated final maturity date or, when relevant, the date of the next demand feature when the fund may receive payment of principal and interest (such as a put feature). *Wal* reflects how a portfolio would react to deteriorating credit (e.g., widening spreads) or tightening liquidity conditions. $\Delta Size$ is the Δln(Size) based on a twelve-month rolling window of

[4]These variables enter the regressions winsorized at the 1% and 99% levels (see Baghai et al., 2022), and we apply cubic spline interpolations to obtain monthly observation (see Brunnermeier et al., 2020).

portfolio assets for MMF i at month t-1[5]. As macroeconomic controls, we consider: ΔGDP as the monthly growth rate of real GDP; ΔCPI is the monthly percentage change in the US Consumer Price Index; *10-year Government Bond* refers to the monthly rate of 10-year Government Bond; *Investment-to-GDP* as the monthly ratio between investment and real GDP[6]. We also control for market conditions by using the US *Money Market MCI* indicator developed by Aldasoro et al. (2022).

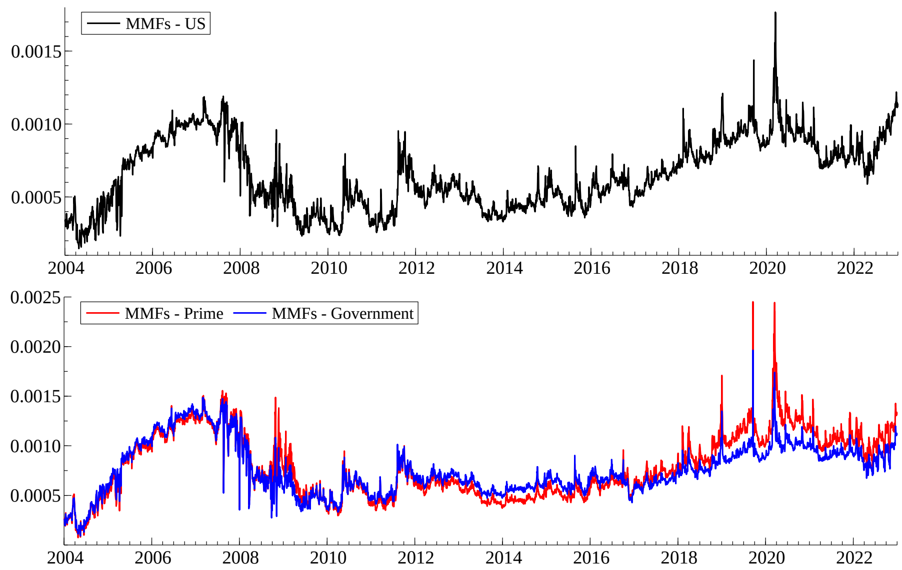
Figures 2 and 3 report the ΔCoVaR trend for MMFs US$ and MMFs US Offshore. The figures show that the $\Delta CoVaR$ of US and offshore MMFs moves together over the period of analysis. The contribution to systemic risk by all US MMFs (Figures 2 and 3, black lines) started increasing before the onset of the 2008-2009 global financial crisis and during systemic events that occurred from September 2008 onwards. In addition to the Lehman bankruptcy and the rescue of the American International Group (AIG), one of the most notable fact is the *breaking of the buck* (ie the value of the fund going below $1 per share) by the Reserve Primary Fund in September 2008. This occurred due to exposure to Lehman Brothers' debt. In response to the crisis in the money market sector, the U.S. Treasury and the Federal Reserve intervened to stabilize the financial markets. Systemic events of 2008 also prompted regulatory reforms to enhance the resilience and the stability of MMFs. The Treasury established the Temporary Guarantee Program for Money Market Funds, providing a temporary guarantee to prevent runs on MMFs.

Monetary policy and a broad range of central bank activities initially alleviated issues with the two funding channels, including the interbank and wholesale funding markets (which

[5]We include $\Delta Size$ according to the extant literature such as Jordà et al. (2015b), Brunnermeier & Schnabel (2016) and Brunnermeier et al. (2020).

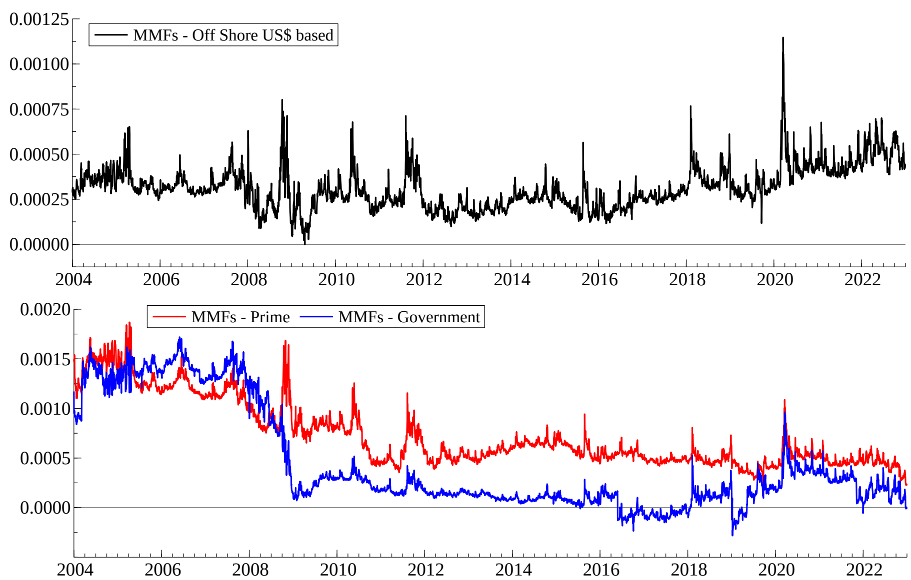
[6]Bank and macroeconomic variables are stationary. The full set of results of the Im et al. (2003) and Pesaran (2007) panel unit root tests is not reported but available upon request.

Figure 2: ΔCoVaR (daily) - US$ MMFs.



Source: Authors elaboration.

Figure 3: ΔCoVaR (daily) - US Off Shore MMFs.



Source: Authors elaboration.

had dried up during the summer of 2008). The system was then stable for a number of years, but instability resurfaced with full force only during the spread of COVID-19 pandemic, during which the mean of $\Delta CoVaR$ increased dramatically. The heightened market volatility and economic uncertainty likely prompted investors to prioritize liquidity. Overall, MMFs experienced substantial inflows, but investors rotated out of *prime*, which experienced large outflows, and into *government* funds.

Figures 2 and 3 also report the $\Delta CoVaR$ for *prime* (red line) and *government* (blue line), respectively. The measure for prime MMFs consistently remains higher throughout the entire period, with a notable increase during the pandemic, in line with the large outflows that these funds experienced. Indeed, *prime* MMFs are generally riskier than *government* MMFs due to their broader range of securities, including those issued by private entities. This increased risk encompasses credit risk associated with the issuers of the securities.

Table 1 provides summary statistics for the $\Delta CoVaR$, MMFs characteristics, macroeconomic variables and $\Delta CoVaR$ macro variables. The frequency of $\Delta CoVaR$ is monthly. In the Internet Appendix, we report the result of the quantile regression used to estimate $\Delta CoVaR$. While the Value at Risk (VaR) of a MMF captures the risk of an individual entity in isolation, the CoVaR is an indicator of systemic risk that can be defined as the VaR of the financial system as a whole, conditional on another firm (or set of firms), exceeding its (their) firm specific VaR. The mean of $\Delta CoVaR$ equals 1.32%, which implies that, on average, distress at one MMF is associated with an increase in the conditional VaR of the financial system by 1.32 percentage points per month.

Table 1: Descriptive statistics.

Variable	Mean	Std. Dev.	Median	5^{th} percentile	95^{th} percentile
Dependent variable					
ΔCoVaR (monthly %)	1.32	1.75	-1.92	1.40	4.01
MMFs characteristics					
Size (monthly $mils)	11,592	24,153.26	109.10	2,572.40	54,163.40
Size (ln)	7.83	1.95	4.69	7.85	10.90
Wam (in days)	34.94	14.27	9.00	36.00	56.00
Wam (ln)	3.42	0.61	2.20	3.58	4.03
Wal (in days)	60.03	28.38	13.00	58.00	107.00
Wal (ln)	3.93	0.67	2.56	4.06	4.67
ΔSize (%)	0.04	1.42	-1.13	-0.01	0.85
Macroeconomic variables					
ΔGDP	16.11	48.85	-38.90	19.80	51.40
ΔCPI	0.002	0.003	-0.002	0.002	0.007
10-year Government Bond	2.86	1.12	1.26	2.71	4.72
Investment-to-GDP	6.99	0.49	6.03	7.00	7.83
Money Market MCI	0.06	1.05	-0.55	-0.29	1.88
ΔCoVaR macro variables					
Liquidity Spread	0.11	0.26	-0.12	0.05	0.59
T-Bill chage	0.02	0.19	-0.20	0.00	0.15
VIX	19.23	8.78	10.85	16.50	34.74
Yield Slope	1.63	1.06	-0.12	1.63	3.35
Credit Spread	2.52	0.78	1.67	2.34	3.52

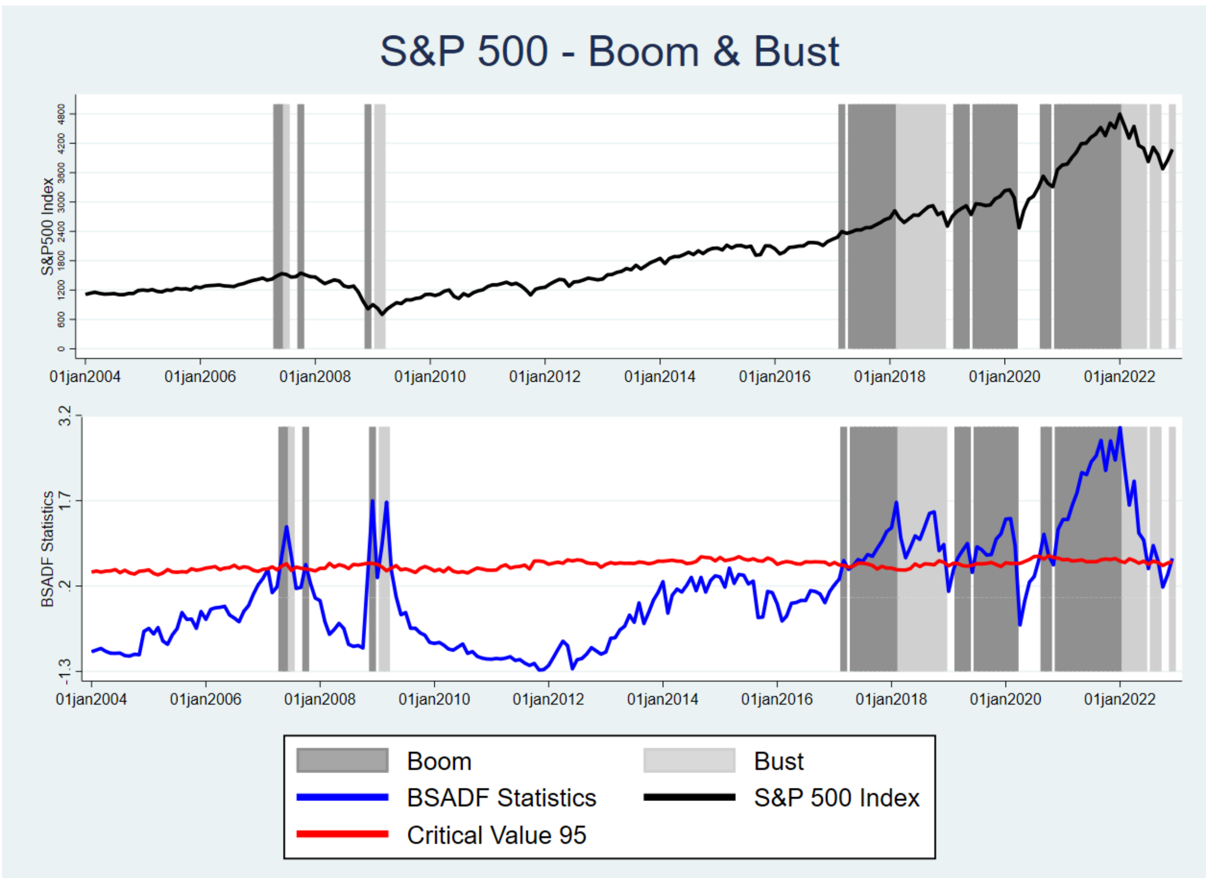
The statistics are computed for the data set used in the baseline regression. *Size* is the MMF fund size defined as the natural logarithm of the fund portfolio's outstanding assets ($millions) for MMF i at month *t-1*; *Weighted average maturity* (Wam) is the asset-weighted time (in days) until the securities in the portfolio mature for MMF i at month *t-1*; *Weighted average life* (Wal) is the weighted average life (in days), for MMF i at month *t-1*, based on a security's stated final maturity date or, when relevant, the date of the next demand feature when the fund may receive payment of principal and interest (such as a put feature). *Wal* reflects how a portfolio would react to deteriorating credit (widening spreads) or tightening liquidity conditions. $\Delta Size$ is the Δln(Size) based on a twelve-month rolling window for MMF i at month *t-1*. As macroeconomic controls, we consider: ΔGDP as the monthly growth rate of real GDP; ΔCPI is the monthly percentage change in the US Consumer Price Index; *10-year Government Bond* refers to the monthly rate of 10-year Government Bond; *Investment-to-GDP* as the monthly ratio between investment and real GDP; *Money Market MCI* is the market indicator for US mony market. As $\Delta CoVaR$ controls, we consider: *Liquidity Spread*, the difference between the 3-month US repo rate and the 3- month US T-bill yield; *T-Bill change*, the first difference of the US Treasury bill secondary market 3-month rate; *VIX*, the volatility index of the Chicago Board Options Exchange (CBOE); *Credit Spread*, the difference between the 10-year Moody's seasoned Baa corporate bond and the 10-year US Treasury bond; *Yield slope*, the first difference curve (yield spread between the US Treasury benchmark 10-year bonds and the US 3-month T-bill). The MMFs variables enter the regressions winsorized at the 1% and 99% levels and we apply cubic spline interpolations to obtain monthly observations.

4 Results

4.1 Asset price bubbles in the US

Figures 4 and 5 show the bubble episodes we identify in the S&P 500 and the Case-Shiller indexes through the implementation of the BSADF test of Phillips et al. (2015a,b), as described in Section 3.2. The test identifies the beginning of a bubble episode as the point in time in which the sequence of BSADF test statistics (blue line) first exceeds its critical value (red line). The end of a bubble episode is reached once the test statistics falls below its critical value without exceeding it again within a minimum break length. The switch between the boom and bust phases of an identified bubble takes place when the statistics peaks.

Figure 4: BSADF test for S&P 500 index.



The Figure reports the Case-Shiller bubble episodes and boom and phase phases. To identify asset price bubbles, we apply the BSADF test of Phillips et al. (2015a,b) (as described in Section 3.2). The test identifies the beginning of a bubble episode as the point in time at which the sequence of BSADF test statistics (blue line) first exceeds its critical value (red line). It thus signals that the price data (black line) is on an explosive trajectory. The end of a bubble episode is reached once the test statistics fall below their critical values without exceeding it again within a minimum break length. The finite sample critical values for 90%, 95% and 99% confidence levels are obtained from Monte Carlo simulations with 2,000 replications (see Phillips et al. (2015a,b) and Vasilopoulos et al. (2022)). The window size is given by $r_0 = \left(0.01 + 1.8/\sqrt{T}\right)$ as recommended by Phillips et al. (2015a,b). The time period is 2004:1 - 2022:4 (monthly frequency) and $T = 228$ observations.

In the S&P 500 index, the test identifies four bubble periods. The first and the second are clearly associated with the 2008-2009 global financial crisis. The test identifies a bubble period starting in May 2007 which is followed by a period in which the index declined substantially. Indeed, from October 2007 to March 2009 the index lost more than 50% of its value. The test then does not identify any period of bubbles for eight years as the index continued stay below the watermark it reached in 2007 until 2013. Starting in March 2017 two more bubble episodes are highlighted, and indeed the statistics is persistently below its critical value only between May and June 2020, as the economy paused in the uncertain phases associated with the COVID-19 pandemic. Euphoria took over once again in the late summer of that year following the manifestation of the effects of the substantial central bank interventions of the previous months, a substantial fiscal package from the US government and optimism about a vaccine. Indeed, the test continued to identifiy a bubble period up until the end of our time series in December 2022 (see Table 2).

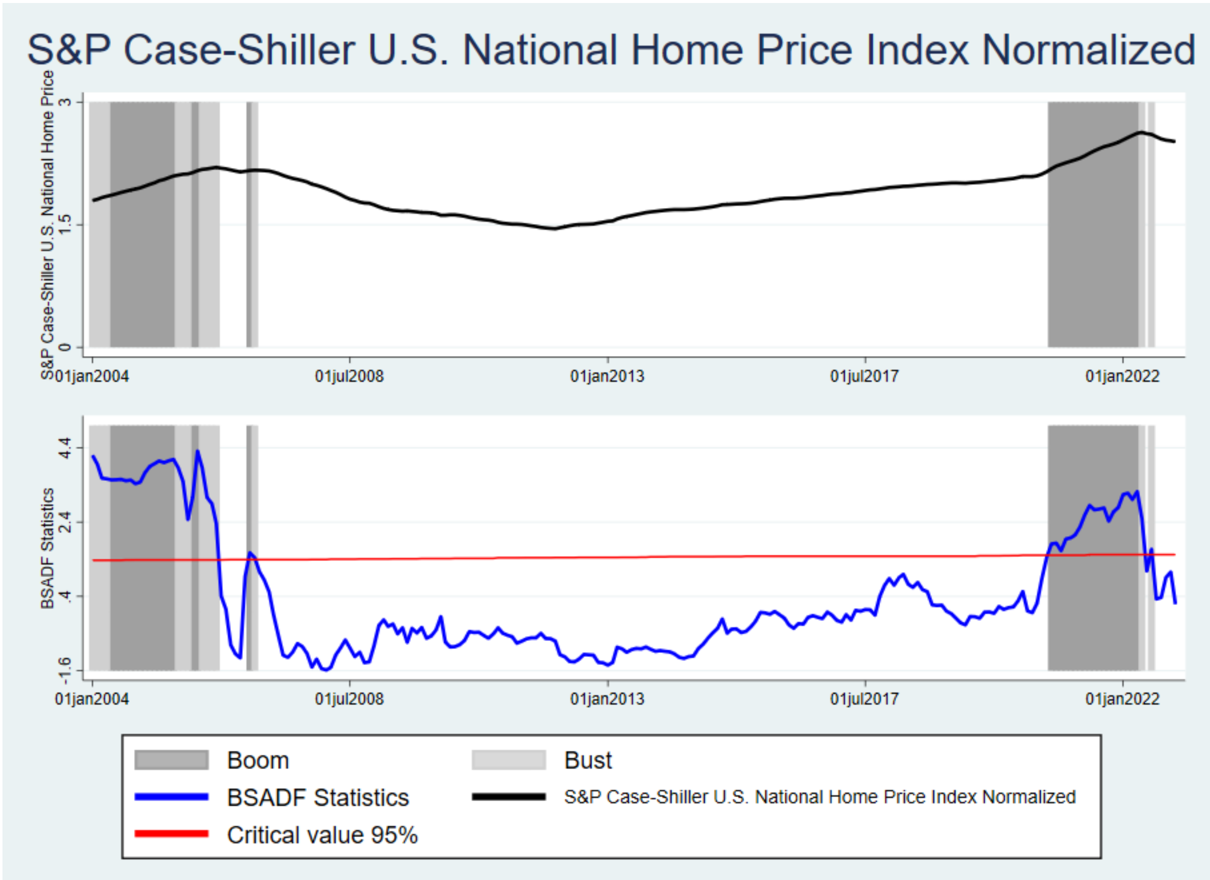
Table 2: S&P 500 Index - Periods of Boom and Bust.

S&P 500 Index					
Time (Monthly)	**Boom**	**Bust**	**Time (Monthly)**	**Boom**	**Bust**
01/05/2007	1	0	01/01/2020	1	0
01/06/2007	1	0	01/02/2020	1	0
01/07/2007	0	1	01/03/2020	1	0
01/10/2007	1	0	01/09/2020	1	0
			01/10/2020	1	0
01/12/2008	1	0	01/12/2020	1	0
01/02/2009	0	1	01/01/2021	1	0
01/03/2009	0	1	01/02/2021	1	0
			01/03/2021	1	0
01/03/2017	1	0	01/04/2021	1	0
01/05/2017	1	0	01/05/2021	1	0
01/06/2017	1	0	01/06/2021	1	0
01/07/2017	1	0	01/07/2021	1	0
01/08/2017	1	0	01/08/2021	1	0
01/09/2017	1	0	01/09/2021	1	0
01/10/2017	1	0	01/10/2021	1	0
01/11/2017	1	0	01/11/2021	1	0
01/12/2017	1	0	01/12/2021	1	0
01/01/2018	1	0	01/01/2022	1	0
01/02/2018	1	0	01/02/2022	0	1
01/03/2018	0	1	01/03/2022	0	1
01/04/2018	0	1	01/04/2022	0	1
01/05/2018	0	1	01/05/2022	0	1
01/06/2018	0	1	01/06/2022	0	1
01/07/2018	0	1	01/08/2022	0	1
01/08/2018	0	1	01/09/2022	0	1
01/09/2018	0	1	01/12/2022	0	1
01/10/2018	0	1			
01/11/2018	0	1			
01/12/2018	0	1			
01/03/2019	1	0			
01/04/2019	1	0			
01/05/2019	1	0			
01/07/2019	1	0			
01/08/2019	1	0			
01/09/2019	1	0			
01/10/2019	1	0			
01/11/2019	1	0			
01/12/2019	1	0			

The Table reports the periods of boom and bust for the S&P 500 index through the implementation of the BSADF test of Phillips et al. (2015a,b). The test identifies the beginning of a bubble episode as the point in time in which the sequence of BSADF test statistics first exceeds its critical value. The end of a bubble episode is reached once the test statistics falls below its critical value without exceeding it again within a minimum break length. The switch between the boom and bust phases of an identified bubble takes place when the statistics peaks.

The BSADF test applied to the Case-Shiller index of house prices, deflated using the personal consumption expenditure index, reveals that the series exhibits explosive behaviour

Figure 5: BSADF test for S&P/Case-Shiller U.S. National Home Price Index - Revised.



The Figure reports the Case-Shiller U.S. National Home Price Index, normalized for the personal consumption expenditure deflator, bubble episodes and boom and phase phases. To identify asset price bubbles, we apply the BSADF test of Phillips et al. (2015a,b) (as described in Section 3.2). The test identifies the beginning of a bubble episode as the point in time at which the sequence of BSADF test statistics (blue line) first exceeds its critical value (red line). It thus signals that the price data (black line) is on an explosive trajectory. The end of a bubble episode is reached once the test statistics fall below their critical values without exceeding it again within a minimum break length. The finite sample critical values for 90%, 95% and 99% confidence levels are obtained from Monte Carlo simulations with 2,000 replications (see Phillips et al. (2015a,b) and Vasilopoulos et al. (2022)). The window size is given by $r_0 = \left(0.01 + 1.8/\sqrt{T}\right)$ as recommended by Phillips et al. (2015a,b). The time period is 2004:1 - 2022:4 (monthly frequency) and $T = 228$ observations.

for in essentially two periods. The first is in the initial part of our samle and predate the global financial crisis: the test highlights periods of exuberance from the beginning of 2004 to mid 2006. The second bubble period identified is afer the onset of the COVID-19. The statistics is above the critical value from October 2020 up to July 2022 (see Figure 5).

Table 3: Case-Shiller Index - Periods of Boom and Bust.

S&P Case-Shiller U.S. National Home Price Index Normalized					
Time (Monthly)	**Boom**	**Bust**	**Time (Monthly)**	**Boom**	**Bust**
01/01/2004	0	1	01/10/2020	1	0
01/02/2004	0	1	01/11/2020	1	0
01/03/2004	0	1	01/12/2020	1	0
01/04/2004	0	1			
01/05/2004	1	0	01/01/2021	1	0
01/06/2004	1	0	01/02/2021	1	0
01/07/2004	1	0	01/03/2021	1	0
01/08/2004	1	0	01/04/2021	1	0
01/09/2004	1	0	01/05/2021	1	0
01/10/2004	1	0	01/06/2021	1	0
01/11/2004	1	0	01/07/2021	1	0
01/12/2004	1	0	01/08/2021	1	0
			01/09/2021	1	0
01/01/2005	1	0	01/10/2021	1	0
01/02/2005	1	0	01/11/2021	1	0
01/03/2005	1	0	01/12/2021	1	0
01/04/2005	1	0			
01/05/2005	1	0	01/01/2022	1	0
01/06/2005	1	0	01/02/2022	1	0
01/07/2005	0	1	01/03/2022	1	0
01/08/2005	0	1	01/04/2022	1	0
01/09/2005	0	1	01/05/2022	0	1
01/10/2005	1	0	01/07/2022	0	1
01/11/2005	1	0			
01/12/2005	0	1			
01/01/2006	0	1			
01/02/2006	0	1			
01/03/2006	0	1			
01/10/2006	1	0			
01/11/2006	0	1			

The Table reports the periods of boom and bust for the Case-Shiller index through the implementation of the BSADF test of Phillips et al. (2015a,b). The test identifies the beginning of a bubble episode as the point in time in which the sequence of BSADF test statistics first exceeds its critical value. The end of a bubble episode is reached once the test statistics falls below its critical value without exceeding it again within a minimum break length. The switch between the boom and bust phases of an identified bubble takes place when the statistics peaks.

Overall, our results show that stock price and real estate bubbles are relatively common in the US market and that there are strong commonalities in the latter part of the sample (see Table 3).

Table 4 presents the descriptive statistics for S&P500 and Real Estate bubble episodes, including a detailed description of the duration (number of months) for both boom and bust periods.

Table 4: Descriptive statistics for S&P500 and Real Estate bubble episodes.

Type of index	Variable	Mean	Std. Dev.	Min.	Max
Equity index - S&P 500	S&P Index	2,021.49	991.18	700.82	4,796.56
	BSADF Statistics	0.09	0.93	-1.28	2.98
	Boom (n. of months)	-	-	1	43
	Bust (n. of months)	-	-	1	21
Real Estate - S&P/Case-Shiller U.S. National Home Price Index	Case-Shiller Index Normalized	1.91	0.29	1.45	2.63
	BSADF Statistics	0.32	1.60	-1.58	4.31
	Boom (n. of months)	-	-	1	36
	Bust (n. of months)	-	-	1	14

The table reports the number (n. of months) for Real Estate and the number (n. of months) for S&P500 index bubble episodes.

4.2 MMFs, systemic risk and asset price bubbles

Table 5 reports the results of regressions using the characteristics of MMFs considering the full sample but without considering the periods of real estate and equity bubbles. We focus on characteristics that mimic some of the features of banks, mainly to understand whether MMFs exhibit similar features as banks. We focus on *Size*, measured as the total amount of assets under management in each MMF, weighted average maturity (*Wam*) and weighted average life (*Wal*). The *Wam* is the asset-weighted number of days until the securities in each fund mature. We use it to measure maturity mismatches. The *Wal* of a fund is the average number of days for which each dollar of the fund's assets remain outstanding. The *Wal* therefore reflects how the portfolio of assets reacts to deteriorating credit or liquidity conditions. We use it to measure the overall riskiness of a fund. In addition, we consider the role of MMFs size growth, as the Δln(Size) based on a twelve-month rolling window.

Table 5 shows that the only MMF characteristic that predicts MMFs' contribution to systemic risk is size, and that it enters the regression with a negative sign, suggesting that larger MMFs are associated with a reduction in systemic risk. Adding macroeconomic controls however reveals that MMF characteristics are important determinants of overall systemic risk. The size variable is no longer significant but changes in size are associated with increases in systemic risk of MMFs and are marginally statistically significant. The *Wam* of a fund is associated with a reduction in systemic risk while the opposite is true for *Wal*.

Table 5: MMFs US$ and US$ Off Shore without periods of bubbles.

Dependent variable: ΔCoVaR	**[i]**	**[ii]**	**[iii]**
$\text{Size}_{i,t-1}$	-0.0002	-0.0006***	-0.0006***
	(0.0001)	(0.0001)	(0.0001)
$\text{Wam}_{i,t-1}$	-0.0026***	0.0000	-0.0005**
	(0.0002)	(0.0002)	(0.0002)
$\text{Wal}_{i,t-1}$	0.0012***	-0.0002	-0.0001
	(0.0002)	(0.0002)	(0.0002)
$\Delta\text{Size}_{i,t-1}$	0.0029*	-0.0019	0.0000
	(0.0011)	(0.0010)	(0.0010)
ΔGDP_{t-1}	-0.0005***		
	(0.0000)		
ΔCPI_{t-1}	0.0875***		
	(0.0093)		
10-year Government Bond_{t-1}	-0.0019***		
	(0.0001)		
Investment-to-GDP_{t-1}	0.0037***		
	(0.0002)		
Money Market MCI_{t-1}	0.0011***		
	(0.0001)		
Constant	0.0024	0.0278***	0.0259***
	(0.0018)	(0.0013)	(0.0016)
Fixed Effects	YES	YES	YES
Time Dummy	NO	NO	YES
Macro Controls	YES	NO	NO
ΔCoVaR state variables	NO	YES	NO
N. Obs.	134,083	134,083	134,083
Adjusted R^2 *within*	0.10	0.26	0.26
F-Test	79.52***	136.34***	80.22***

The table reports the results between systemic risk and MMFs characteristics. The dependent variable is ΔCoVaR. *Size* is the MMF fund size defined as the natural logarithm of the fund portfolio's outstanding assets ($millions); *Weighted average maturity* (Wam) is the asset-weighted time (in days) until the securities in the portfolio mature for MMF; *Weighted average life* (Wal) is the weighted average life (in days); $\Delta Size$ is the Δln(Size) based on a twelve-month rolling window of portfolio assets for MMF. As macroeconomic controls, we consider: ΔGDP as the monthly growth rate of real GDP; ΔCPI is the monthly percentage change in the US Consumer Price Index; *10-year Government Bond* refers to the monthly rate of 10-year Government Bond; *Investment-to-GDP* as the monthly ratio between investment and real GDP; *Money Market MCI* is the market indicator for US money market. We regress the $\Delta CoVaR$ of both US-domiciled and US-Off shore MMFs on the bubble indicators, fund fixed effects, macroeconomic controls (column [i]), $\Delta CoVaR$ state variables (column [ii]) and monthly dummies (column [iii]). Robust (clustered) standard errors are reported in parentheses. *, **, *** denote the 10%, 5% and 1% significance level, respectively.

Moving to the macroeconomic controls themselves reveals that the signs of the estimated coefficients for these controls are aligned with prior expectations. Periods of high GDP growth are associated with a reduction in risk. Increases in the stress indicator in the money markets developed by Aldasoro et al. (2022) are associated with higher measures of systemic risk and so are periods of high inflation. Increases in government bond yields are associated with reductions in systemic risk.

In Table 6, we provide evidence of the correlation between our measure of systemic risk for MMFs and asset price bubbles. First, we regress the $\Delta CoVaR$ of both US-domiciled and offshore MMFs on the bubble indicators, fund fixed effects, macroeconomic controls (column [i]), $\Delta CoVaR$ state variables (column [ii]) and monthly dummies (column [iii]).

The results show that bubble periods are associated with significant changes in $\Delta CoVaR$. The first two columns highlight that, overall, systemic risk increases during bubble period but declines substantially during periods of real estate busts. In the third column, which includes time dummies, some of the signs are reversed, suggesting that systemic risk is lower during bubble periods, as most of the positive association between bubbles and systemic risk is captured by time dummies. However, as most of the bubble periods we identify in our analysis took place from 2017 onward and coincide with a general increase in $\Delta CoVaR$, it is possible that it this contemporaneous correlation that is influencing our estimates. Overall, the econometric analysis confirms that the strong association between bubble indicators and measured systemic risk which Brunnermeier et al. (2020) documented for banks, carries over when looking at MMFs.

The last three columns of Table 6 combine MMF characteristics and bubble periods as described in Equation (2). A number of interesting results emerge. First of all, the relationship between bubbles and $\Delta CoVaR$ remains strong and statistically significant when we include MMFs characteristics in the regressions. In the regression with macroeconomic controls the coefficients associated with these variables do not change their magnitude and remain highly statistically significant, but the coefficients on inflation and on the investment to GDP ratio change sign compared to the regressions without bubbles.

Focusing on MMF characteristics reveals that the size of MMFs is still negatively associated with systemic risk, but that this association is less prevalent in periods of real estate busts. Changes in size also reduce systemic risk, but with one exception: if these changes take place during equity booms then the systemic risk of MMFs increases. The size of the coefficients for this interaction term in various specifications is also particularly large, suggesting that MMFs may contribute to increasing systemic risk in periods of exuberance in the stock market. Moving to discussing other MMFs characteristics *Wam*, our measure of maturity mismatch is negatively associated with our measure of systemic risk in general in the regression with macroeconomic controls, but the effect is completely reversed at times of real estate bubbles. The opposite behaviour is present for *Wal*: it increases systemic risk overall, but its contribution is significantly reduced during bubble periods. Overall, our analysis confirms that MMFs characteristics are important for systemic risk measures.

Table 6: MMFs US$ and US$ Off Shore during 2004:1-2022:12 time period.

Dependent variable: ΔCoVaR	**Bubbles: Boom & Bust**			**Bubbles with MMF characteristics**		
	[i]	**[ii]**	**[iii]**	**[iv]**	**[v]**	**[vi]**
Real Estate Boom_t	0.0003**	0.0003***	-0.0007***	0.0019**	0.0044***	0.0017**
	(0.0001)	(0.0001)	(0.0001)	(0.0007)	(0.0007)	(0.0006)
Real Estate Bust_t	-0.0010***	-0.0003**	-0.0023***	-0.0032***	(0.0006)	-0.0034***
	(0.0001)	(0.0001)	(0.0001)	(0.0008)	(0.0008)	(0.0008)
Equity Boom_t	0.0044***	0.0009***	-0.0008***	0.0065***	0.0032**	0.0027**
	(0.0002)	(0.0001)	(0.0001)	(0.0012)	(0.0011)	(0.0011)
Equity Bust_t	0.0070***	0.0014***	0.0016***	0.0118***	0.0041***	0.0053***
	(0.0003)	(0.0001)	(0.0001)	(0.0014)	(0.0012)	(0.0012)
$\text{Size}_{i,t-1}$				-0.0003**	-0.0006***	-0.0006***
				(0.0002)	(0.0002)	(0.0002)
$\text{Size}_{i,t-1}$*Real Estate Boom_t				-0.0002**	0.0001	0.0001
				(0.0001)	(0.0001)	(0.0001)
$\text{Size}_{i,t-1}$*Real Estate Bust_t				0.0002**	0.0002**	0.0002**
				(0.0001)	(0.0001)	(0.0001)
$\text{Size}_{i,t-1}$*Equity Boom_t				0.0001	0.0001	0.0001
				(0.0001)	(0.0001)	(0.0001)
$\text{Size}_{i,t-1}$*Equity Bust_t				-0.0001	-0.0001	-0.0001
				(0.0001)	(0.0001)	(0.0001)
$\text{Wam}_{i,t-1}$				-0.0010***	-0.0001	-0.0003
				(0.0002)	(0.0002)	(0.0003)
$\text{Wam}_{i,t-1}$*Real Estate Boom_t				0.0007**	-0.0005**	0.0001
				(0.0002)	(0.0002)	(0.0002)
$\text{Wam}_{i,t-1}$*Real Estate Bust_t				0.0017***	0.0007**	0.0009***
				(0.0002)	(0.0002)	(0.0002)
$\text{Wam}_{i,t-1}$*Equity Boom_t				0.0001	-0.0002	-0.0007**
				(0.0003)	(0.0003)	(0.0003)
$\text{Wam}_{i,t-1}$*Equity Bust_t				0.0001	0.0008**	0.0004
				(0.0004)	(0.0003)	(0.0004)
$\text{Wal}_{i,t-1}$				0.0007**	0.0003	0.0003
				(0.0002)	(0.0002)	(0.0002)
$\text{Wal}_{i,t-1}$*Real Estate Boom_t				-0.0007***	-0.0003	-0.0005**
				(0.0002)	(0.0002)	(0.0002)
$\text{Wal}_{i,t-1}$*Real Estate Bust_t				-0.0012***	-0.0008***	-0.0009***
				(0.0002)	(0.0002)	(0.0002)
$\text{Wal}_{i,t-1}$*Equity Boom_t				-0.0006*	-0.0003	-0.0001
				(0.0003)	(0.0003)	(0.0003)
$\text{Wal}_{i,t-1}$*Equity Bust_t				-0.0011**	-0.0011**	-0.0010**
				(0.0004)	(0.0004)	(0.0004)
$\Delta\text{Size}_{i,t-1}$				0.0005	-0.0031**	-0.0022**
				(0.0012)	(0.0011)	(0.0011)
$\Delta\text{Size}_{i,t-1}$*Real Estate Boom_t				-0.0083**	-0.0056**	-0.0076**
				(0.0029)	(0.0027)	(0.0027)
$\Delta\text{Size}_{i,t-1}$*Real Estate Bust_t				0.0046	0.0006	0.0018
				(0.0063)	(0.0061)	(0.0061)
$\Delta\text{Size}_{i,t-1}$*Equity Boom_t				0.0461***	0.0372**	0.0374**
				(0.0132)	(0.0125)	(0.0125)
$\Delta\text{Size}_{i,t-1}$*Equity Bust_t				0.0149	0.0236*	0.0234
				(0.0162)	(0.0138)	(0.0143)
ΔGDP_{t-1}	-0.0004***			-0.0004***		
	0.0000			0.0000		
ΔCPI_{t-1}	-0.1167***			-0.1154***		
	(0.0054)			(0.0057)		
10-year Government Bond_{t-1}	-0.0020***			-0.0023***		
	(0.0001)			(0.0001)		
Investment-to-GDP_{t-1}	-0.0021***			-0.0014***		
	(0.0002)			(0.0002)		
Money Market MCI_{t-1}	0.0014***			0.0013***		
	(0.0001)			(0.0001)		
Constant	0.0345***	0.0192***	0.0185***	0.0338***	0.0238***	0.0235***
	(0.0012)	(0.0002)	(0.0010)	(0.0020)	(0.0014)	(0.0018)
Fixed Effects	YES	YES	YES	YES	YES	YES
Time Dummy	NO	NO	YES	NO	NO	YES
Macro Controls	YES	NO	NO	YES	NO	NO
ΔCoVaR state variables	NO	YES	NO	NO	YES	NO
N. Obs.	135,291	135,291	135,291	134,083	134,083	134,083
Adjusted R^2 *within*	0.17	0.25	0.27	0.19	0.27	0.27
F-Test	152.23***	151.44***	101.75***	66.59***	70.49***	67.88***

The table reports the results between the measure of systemic risk for MMFs and asset price bubbles. *Size* is the MMF fund size defined as the natural logarithm of the fund portfolio's outstanding assets ($millions); *Weighted average maturity* (Wam) is the asset-weighted time (in days) until the securities in the portfolio mature for MMF; *Weighted average life* (Wal) is the weighted average life (in days); $\Delta Size$ is the Δln(Size) based on a twelve-month rolling window of portfolio assets for MMF. As macroeconomic controls, we consider: ΔGDP as the monthly growth rate of real GDP; ΔCPI is the monthly percentage change in the US Consumer Price Index; *10-year Government Bond* refers to the monthly rate of 10-year Government Bond; *Investment-to-GDP* as the monthly ratio between investment and real GDP; *Money Market MCI* is the market indicator for US money market. We regress the $\Delta CoVaR$ of both US-domiciled and US-Off shore MMFs on the bubble indicators, fund fixed effects, macroeconomic controls (column [i]), $\Delta CoVaR$ state variables (column [ii]) and monthly dummies (column [iii]). Robust (clustered) standard errors are reported in parentheses. *, **, *** denote the 10%, 5% and 1% significance level, respectively.

4.2.1 The varying impact of the different types of MMFs

As discussed above, MMFs are not a homogeneous category and given the varying focus of their investments it would not be surprising to find that their contribution to systemic risk differs substantially depending on their type. We therefore repeat the analysis described above using Equation (2) but separate out the two most important categories of MMFs: *prime* and *government* MMFs. We include a triple interaction term in our regression specification and estimate the following specification:

$$\begin{aligned}\Delta CoVaR_{i,t} = \beta_0 + \beta_1 I_t^{Bubble} + \beta_2 MMFs\ Char._{i,t-1} + \beta_3 I_t^{Bubble} * MMFs\ Char._{i,t-1} + \\ + \beta_4 I_t^{Bubble} * MMFs\ Cat._i * MMFs\ Char._{i,t-1} + \\ + [Macro_{t-1}]\ or\ [\Delta CoVaR\ Macro_{t-1}]\ or\ [\textstyle\sum_{t=2004:1}^{2022:12} Time_t] + \\ + \sum_{i=1}^{3,586} MMFs_i + \varepsilon_{i,t}\end{aligned} \tag{3}$$

Initially, we restrict our sample to MMFs domiciled in the US while in the next subsection we include offshore funds. The results are summarized in Table 7. The coefficients should be interpreted in relation to the third category of MMFs, namely *tax free* funds, which act as a benchmark. The results suggest that the effect of the *Size* of MMFs on systemic risk is the result of different contributions of government and prime MMFs. The negative overall effect is almost completely eliminated for *prime* MMFs suggesting that they contribute significantly more to systemic risk than *government* ones. A possible explanation is that prime MMFs typically invest in a broader range of short-term securities, including those issued by private corporations, potentially resulting in higher yields. Instead, government MMFs primarily invest in short-term securities issued or guaranteed by the U.S. government or its agencies.

So an increase in size in *prime* funds during bubble periods may result in increased risk.

The fact that government MMFs contribute less to systemic risk compared to prime ones holds when looking at the estimates of the effects of MMFs characteristics. The *Wam* and *Wal* coefficients mostly lose significance when they are not interacted with the various categories of MMFs suggesting no overall contribution. However, we find that $\Delta CoVaR$ is sensitive to *Wam* for prime MMFs during real estate bubble periods, particularly during boom phases. A real estate boom may coincide with periods of economic growth and changing interest rate expectations. If interest rates are expected to rise during the real estate boom, prime MMFs with a higher *Wam* may be more exposed to interest rate risk, and thus leading to higher value of systemic risk. Moreover, during a real estate boom, prime MMFs may seek to enhance yields to attract investors. A higher *Wam* enables funds to invest in longer-term securities, typically offering higher yields. However, this comes with increased exposure to interest rate fluctuations and heightened financial instability.

For government MMFs, systemic risk remains unaffected by their *Wam* during a real estate boom. This may be explained by the fact that prime MMFs, unlike government MMFs, often invest in a broader range of short-term instruments, including corporate debt. If a real estate boom is associated with increased economic activity and corporate borrowing, prime funds with a higher *Wam* might have exposure to longer-term corporate debt, introducing additional credit risk, which may lead to an increase in the systemic risk. For both prime and government MMFS, systemic risk is sensitive by their *Wam* during equity bubble periods. While a higher *Wam* may expose prime MMFs to longer-term securities, it could also allow for better credit risk management. During equity boom, investing in longer-term securities may provide opportunities for higher-quality issuers, potentially reducing credit risk, and thus leading to lower systemic risk.

We also observe sensitivity in $\Delta CoVaR$ to both prime and government MMFs' *Wal* during an equity boom. A possible explanation is that if a significant number of MMFs have higher *Wal* and interest rates increase rapidly, it could lead to potential losses, impacting the stability of the financial system. In addition, from a market liquidity perspective, longer-term securities may have reduced liquidity, especially during periods of market stress. If a large number of investors seek redemptions from MMFs with higher *Wal*, it could lead to liquidity challenges and contribute to systemic risk. Moreover, higher *Wal* values may expose MMFs to longer-term securities, including corporate debt. In the event of economic downturns or credit events, the credit quality of these securities could deteriorate, affecting the broader financial system and thus leading to higher values of systemic risk.

Table 7: MMFs US$ by categories during 2004:1-2022:12 time period.

Dependent variable: ΔCoVaR	**[i]**	**[ii]**	**[iii]**	**Marginal Effects for MMFs Prime**			**Marginal Effects for MMFs Government**		
				[i]	**[ii]**	**[iii]**	**[i]**	**[ii]**	**[iii]**
$\text{Size}_{i,t-1}$	0.0007	-0.0009**	-0.0008*	0.0009*	0.0008	0.0007	0.0002	0.0000	-0.0003
	(0.0005)	(0.0005)	(0.0004)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
$\text{Size}_{i,t-1}$*Real Estate Boom_t	-0.0001***	-0.0000***	0.0002***	-0.0006***	-0.0004***	-0.0005***	-0.0001	0.0000	-0.0001*
	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
$\text{Size}_{i,t-1}$*Real Estate Bust_t	0.0003	-0.0005*	0.0004	-0.0002	0.0000	0.0000	0.0003	0.0005*	0.0004
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
$\text{Size}_{i,t-1}$*Equity Boom_t	-0.0003	-0.0002	-0.0003	0.0005	0.0002	0.0002	0.0006**	0.0005*	0.0006**
	(0.0003)	(0.0003)	(0.0002)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
$\text{Size}_{i,t-1}$*Equity Bust_t	0.0002	0.0002	0.0001	0.0002	-0.0001	-0.0001	-0.0001	-0.0001	0.0000
	(0.0003)	(0.0003)	(0.0003)	(0.0004)	(0.0004)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
$\text{Wam}_{i,t-1}$	0.0018	-0.0022	-0.002	0.0018	0.0032	0.0031	0.0001	0.0018	0.0018
	(0.0023)	(0.0023)	(0.0023)	(0.0024)	(0.0024)	(0.0024)	(0.0024)	(0.0023)	(0.0023)
$\text{Wam}_{i,t-1}$*Real Estate Boom_t	-0.0091***	-0.0048**	-0.0057**	0.0108***	0.0044**	0.0063***	0.0110***	0.0044**	0.0058**
	(0.0022)	(0.0018)	(0.0018)	(0.0022)	(0.0018)	(0.0019)	(0.0022)	(0.0018)	(0.0018)
$\text{Wam}_{i,t-1}$*Real Estate Bust_t	0.0011	0.0003	0.0004	0.0017	0.0000	-0.0001	0.0036	0.001	0.0017
	(0.0023)	(0.0021)	(0.0021)	(0.0024)	(0.0022)	(0.0022)	(0.0023)	(0.0021)	(0.0021)
$\text{Wam}_{i,t-1}$*Equity Boom_t	0.0092***	0.0074**	0.0066**	-0.0073**	-0.0068**	-0.0069**	-0.0098***	-0.0074**	-0.0074**
	(0.0027)	(0.0026)	(0.0026)	(0.0028)	(0.0027)	(0.0027)	(0.0027)	(0.0027)	(0.0027)
$\text{Wam}_{i,t-1}$*Equity Bust_t	0.0058**	0.0052*	0.0051*	-0.0064**	-0.0037	-0.0046	-0.0063**	-0.0045	-0.0054*
	(0.0028)	(0.0027)	(0.0028)	(0.0030)	(0.0029)	(0.0029)	(0.0029)	(0.0028)	(0.0028)
$\text{Wal}_{i,t-1}$	0.0012	0.0017	0.0017	-0.0012	-0.0024	-0.0026	-0.0016	-0.0021	-0.0024
	(0.0024)	(0.0024)	(0.0024)	(0.0025)	(0.0024)	(0.0024)	(0.0024)	(0.0024)	(0.0024)
$\text{Wal}_{i,t-1}$*Real Estate Boom_t	0.0082***	0.0039**	0.0051**	-0.0091***	-0.0029	-0.0048**	-0.0088***	-0.0043**	-0.0055**
	(0.0022)	(0.0018)	(0.0018)	(0.0023)	(0.0018)	(0.0019)	(0.0022)	(0.0018)	(0.0018)
$\text{Wal}_{i,t-1}$*Real Estate Bust_t	-0.0003	-0.0013	-0.0011	-0.0003	0.0012	0.0013	-0.0007	0.0007	0.0004
	(0.0024)	(0.0022)	(0.0022)	(0.0025)	(0.0023)	(0.0023)	(0.0024)	(0.0022)	(0.0022)
$\text{Wal}_{i,t-1}$*Equity Boom_t	-0.0072**	-0.0057**	-0.0055**	0.0055*	0.0047*	0.0053*	0.0087**	0.0069**	0.0069**
	(0.0027)	(0.0027)	(0.0027)	(0.0029)	(0.0028)	(0.0028)	(0.0028)	(0.0027)	(0.0027)
$\text{Wal}_{i,t-1}$*Equity Bust_t	-0.0035	-0.0025	-0.0027	0.0043	0.0025	0.0032	0.0044	0.0031	0.0036
	(0.0028)	(0.0027)	(0.0028)	(0.0029)	(0.0028)	(0.0029)	(0.0028)	(0.0028)	(0.0028)
$\Delta\text{Size}_{i,t-1}$	-0.0031**	-0.0060***	-0.0059***	0.0472***	0.0381***	0.0433***	0.0055	0.0168**	0.0139**
	(0.0013)	(0.0013)	(0.0013)	(0.0117)	(0.0089)	(0.0102)	(0.0060)	(0.0069)	(0.0066)
$\Delta\text{Size}_{i,t-1}$*Real Estate Boom_t	-0.0248***	-0.0149**	-0.0124**	0.0208**	0.0235***	0.0135*	0.0318***	0.0177**	0.0108*
	(0.0063)	(0.0053)	(0.0056)	(0.0081)	(0.0067)	(0.0074)	(0.0072)	(0.0062)	(0.0063)
$\Delta\text{Size}_{i,t-1}$*Real Estate Bust_t	-0.0149	0.0279*	0.0058	0.0406**	-0.0224	0.0088	0.0107	-0.0328*	-0.005
	(0.0143)	(0.0163)	(0.0148)	(0.0171)	(0.0185)	(0.0173)	(0.0174)	(0.0188)	(0.0176)
$\Delta\text{Size}_{i,t-1}$*Equity Boom_t	0.2060***	0.1157***	0.1155***	-0.1663***	-0.1184***	-0.1319***	-0.2533***	-0.1204***	-0.1016**
	(0.0370)	(0.0295)	(0.0284)	(0.0392)	(0.0325)	(0.0326)	(0.0410)	(0.0342)	(0.0326)
$\Delta\text{Size}_{i,t-1}$*Equity Bust_t	0.0168	0.0268	0.0333*	-0.1070***	-0.0884**	-0.0860**	0.1853***	0.1164**	0.1196**
	(0.0225)	(0.0188)	(0.0202)	(0.0324)	(0.0279)	(0.0294)	(0.0477)	(0.0436)	(0.0437)
ΔGDP_{t-1}	-0.0006***								
	(0.0000)								
ΔCPI_{t-1}	-0.1413***								
	(0.0071)								
10-year Government Bond_{t-1}	-0.0029***								
	(0.0001)								
Investment-to-GDP_{t-1}	-0.0002								
	(0.0002)								
Money Market MCI_{t-1}	0.0016***								
	(0.0001)								
Constant	0.0345***	0.0330***	0.0326***						
	(0.0025)	(0.0019)	(0.0019)						
Fixed Effects	YES	YES	YES						
Catogories Dummy (Prime and Government)	YES	YES	YES						
Bubbles Dummy	YES	YES	YES						
Dummy MMFs US*Bubbles	YES	YES	YES						
Dummy MMFs US$	YES	YES	YES						
Time Dummy	NO	NO	YES						
Macro Controls	YES	NO	NO						
ΔCoVaR state variables	NO	YES	NO						
N. Obs.	106,108	106,108	106,108						
Adjusted R^2 *within*	0.28	0.37	0.38						
F-Test	60.67***	60.52***	70.42***						

The table reports the results between the measure of systemic risk for MMFs and asset price bubbles. *Size* is the MMF fund size defined as the natural logarithm of the fund portfolio's outstanding assets ($millions); *Weighted average maturity* (Wam) is the asset-weighted time (in days) until the securities in the portfolio mature for MMF; *Weighted average life* (Wal) is the weighted average life (in days); $\Delta Size$ is the Δln(Size) based on a twelve-month rolling window of portfolio assets for MMF. As macroeconomic controls, we consider: ΔGDP as the monthly growth rate of real GDP; ΔCPI is the monthly percentage change in the US Consumer Price Index; *10-year Government Bond* refers to the monthly rate of 10-year Government Bond; *Investment-to-GDP* as the monthly ratio between investment and real GDP; *Money Market MCI* is the market indicator for US money market. We regress the $\Delta CoVaR$ of only US-domiciled MMFs on the bubble indicators, fund fixed effects, macroeconomic controls (column [i]), $\Delta CoVaR$ state variables (column [ii]) and monthly dummies (column [iii]). Robust (clustered) standard errors are reported in parentheses. *, **, *** denote the 10%, 5% and 1% significance level, respectively.

Interestingly, MMFs growth ($\Delta Size$) is highly significant with a negative sign. This implies that higher MMFs growth is associated with lower systemic risk in normal times. This finding suggests healthy MMFs growth outside of bubble periods. However, the relationship changes during bubble episodes, particularly during equity boom. For both prime and government MMFs, during an equity boom, investors may be tempted by higher returns in riskier assets, such as corporate debt with slightly elevated yields. MMFs, aiming to deliver competitive returns, may invest in slightly riskier assets to attain higher yields. This "*reach for yield*" can expose MMFs to increased credit and liquidity risks. We also noticed that systemic risk is more sensitive to the $\Delta Size$ for government MMFs. One possible explanation is that these funds are often perceived as safer during times of crisis, given their primary focus on government-backed securities. Consequently, investors frequently seek the safety of government debt during turbulent times.

4.2.2 The interconnectedness of the domestic and offshore market

The last aspect we tackle in our analysis is to incorporate the contribution of offshore MMFs. The question we aim to answer is: does the fact that funds denominated in US dollars but domiciled in Europe invest in the US market increase or decrease the importance of MMFs for systemic risk? On the one hand, these funds serve investors based in other jurisdictions who may be exposed to other shocks, be in different part of the economic cycle and overall behave in ways that contrast with that of US funds, thereby absorbing stress and reduce systemic risk. On the other hand, these funds may simply have similar reaction functions to US-based ones as they respond to what happens in the US dollar market thereby exacerbating risks[7]. Which one of these prevails overall is essentially an empirical question.

Table 8: MMFs US$ and US$ Off Shore by categories during 2004:1-2022:12 time period.

Dependent variable: ΔCoVaR	**[i]**	**[ii]**	**[iii]**	**Marginal Effects for MMFs Prime**			**Marginal Effects for MMFs Government**		
				[i]	**[ii]**	**[iii]**	**[i]**	**[ii]**	**[iii]**
$Size_{i,t-1}$	-0.0007*	-0.0009**	-0.0008*	0.0006	0.0005	0.0006	0.0004	0.0002	-0.0001
	(0.0005)	(0.0004)	(0.0004)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
$Size_{i,t-1}$*Real Estate $Boom_t$	-0.0000***	-0.0000***	0.0002***	-0.0005***	-0.0002**	-0.0003**	0.0000	0.0001	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
$Size_{i,t-1}$*Real Estate $Bust_t$	-0.0002	-0.0003	-0.0002	-0.0002	0.0000	0.0000	0.0003	0.0005**	0.0005**
	(0.0002)	(0.0002)	(0.0002)	(0.0003)	(0.0003)	(0.0003)	(0.0002)	(0.0002)	(0.0002)
$Size_{i,t-1}$*Equity $Boom_t$	0.0002	0.0001	0.0003	0.0004	0.0001	0.0001	0.0003	0.0002	0.0003
	(0.0003)	(0.0002)	(0.0002)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
$Size_{i,t-1}$*Equity $Bust_t$	0.0001	0.0001	0.0001	0.0004	0.0001	0.0002	-0.0001	-0.0002	-0.0001
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
$Wam_{i,t-1}$	-0.0032*	-0.0031*	-0.0027*	0.0043**	0.0049**	0.0042**	0.0017	0.0027*	0.0024
	(0.0017)	(0.0016)	(0.0016)	(0.0017)	(0.0017)	(0.0017)	(0.0017)	(0.0016)	(0.0016)
$Wam_{i,t-1}$*Real Estate $Boom_t$	-0.0055***	-0.0055***	-0.0055***	0.0070***	0.0053***	0.0060***	0.0071***	0.0054***	0.0058***
	(0.0016)	(0.0014)	(0.0014)	(0.0017)	(0.0015)	(0.0015)	(0.0016)	(0.0014)	(0.0015)
$Wam_{i,t-1}$*Real Estate $Bust_t$	-0.0049***	-0.0058***	-0.0059***	0.0087***	0.0086***	0.0087***	0.0071***	0.0067***	0.0071***
	(0.0011)	(0.0011)	(0.0011)	(0.0012)	(0.0012)	(0.0012)	(0.0011)	(0.0011)	(0.0011)
$Wam_{i,t-1}$*Equity $Boom_t$	0.0099***	0.0099***	0.0084***	-0.0095***	-0.0100***	-0.0087***	-0.0110***	-0.0111***	-0.0100***
	(0.0020)	(0.0020)	(0.0019)	(0.0021)	(0.0020)	(0.0020)	(0.0020)	(0.0020)	(0.0020)
$Wam_{i,t-1}$*Equity $Bust_t$	0.0069***	0.0077***	0.0070***	-0.0084***	-0.0078***	-0.0072***	-0.0077***	-0.0078***	-0.0077***
	(0.0021)	(0.0021)	(0.0021)	(0.0022)	(0.0022)	(0.0022)	(0.0021)	(0.0021)	(0.0021)
$Wal_{i,t-1}$	0.0023	0.0023	0.0021	-0.0034*	-0.0036**	-0.0032*	-0.0025	-0.0025	-0.0025
	(0.0017)	(0.0017)	(0.0016)	(0.0018)	(0.0017)	(0.0017)	(0.0017)	(0.0017)	(0.0017)
$Wal_{i,t-1}$*Real Estate $Boom_t$	0.0042**	0.0044**	0.0047***	-0.0050**	-0.0044**	-0.0050***	-0.0045**	-0.0048***	-0.0051***
	(0.0016)	(0.0014)	(0.0014)	(0.0016)	(0.0014)	(0.0015)	(0.0016)	(0.0014)	(0.0015)
$Wal_{i,t-1}$*Real Estate $Bust_t$	0.0038***	0.0046***	0.0047***	-0.0067***	-0.0068***	-0.0070***	-0.0052***	-0.0058***	-0.0059***
	(0.0008)	(0.0008)	(0.0008)	(0.0010)	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0009)
$Wal_{i,t-1}$*Equity $Boom_t$	-0.0076***	-0.0079***	-0.0069***	0.0079***	0.0087***	0.0077***	0.0098***	0.0101***	0.0092***
	(0.0019)	(0.0019)	(0.0019)	(0.0021)	(0.0020)	(0.0020)	(0.0020)	(0.0020)	(0.0019)
$Wal_{i,t-1}$*Equity $Bust_t$	-0.0044**	-0.0048**	-0.0044**	0.0055**	0.0057**	0.0051**	0.0056**	0.0060**	0.0057**
	(0.0020)	(0.0020)	(0.0020)	(0.0021)	(0.0021)	(0.0021)	(0.0020)	(0.0020)	(0.0020)
$\Delta Size_{i,t-1}$	-0.0024*	-0.0049***	-0.0042***	0.0436***	0.0352***	0.0400***	0.0003	0.0098*	0.0045
	(0.0012)	(0.0012)	(0.0012)	(0.0122)	(0.0094)	(0.0102)	(0.0056)	(0.0055)	(0.0056)
$\Delta Size_{i,t-1}$*Real Estate $Boom_t$	-0.0192**	-0.0146**	-0.0113**	0.0149*	0.0227***	0.0142**	0.0202**	0.0113*	0.0043
	(0.0059)	(0.0052)	(0.0054)	(0.0076)	(0.0067)	(0.0072)	(0.0066)	(0.0061)	(0.0061)
$\Delta Size_{i,t-1}$*Real Estate $Bust_t$	(0.0102)	0.0216	0.0058	0.0283*	-0.0154	0.0054	-0.0057	-0.0324*	-0.0165
	(0.0145)	(0.0160)	(0.0150)	(0.0170)	(0.0181)	(0.0172)	(0.0175)	(0.0184)	(0.0177)
$\Delta Size_{i,t-1}$*Equity $Boom_t$	0.1435***	0.0904***	0.0807**	-0.1322***	-0.1002**	-0.1031**	-0.1782***	-0.0832**	-0.0557*
	(0.0321)	(0.0270)	(0.0261)	(0.0383)	(0.0329)	(0.0323)	(0.0359)	(0.0303)	(0.0292)
$\Delta Size_{i,t-1}$*Equity $Bust_t$	0.0080	0.0212	0.0271	-0.0820**	-0.0724**	-0.0767**	0.1209**	0.0776*	0.0728*
	(0.0218)	(0.0191)	(0.0200)	(0.0311)	(0.0274)	(0.0283)	(0.0469)	(0.0431)	(0.0429)
ΔGDP_{t-1}	-0.0004***								
	(0.0000)								
ΔCPI_{t-1}	-0.1118***								
	(0.0061)								
10-year Government $Bond_{t-1}$	-0.0023***								
	(0.0001)								
Investment-to-GDP_{t-1}	-0.0011***								
	(0.0002)								
Money Market MCI_{t-1}	0.0013***								
	(0.0001)								
Constant	0.0342***	0.0248***	0.0220***						
	(0.0040)	(0.0035)	(0.0035)						
Fixed Effects	YES	YES	YES						
Catogories Dummy (Prime and Government)	YES	YES	YES						
Bubbles Dummy	YES	YES	YES						
Dummy MMFs US*Bubbles	YES	YES	YES						
Dummy MMFs US$	YES	YES	YES						
Time Dummy	NO	NO	YES						
Macro Controls	YES	NO	NO						
ΔCoVaR state variables	NO	YES	NO						
N. Obs.	134,083	134,083	134,083						
Adjusted R^2 *within*	0.23	0.30	0.31						
F-Test	37.23***	38.56***	42.50***						

The table reports the results between the measure of systemic risk for MMFs and asset price bubbles. *Size* is the MMF fund size defined as the natural logarithm of the fund portfolio's outstanding assets ($millions); *Weighted average maturity* (Wam) is the asset-weighted time (in days) until the securities in the portfolio mature for MMF; *Weighted average life* (Wal) is the weighted average life (in days); Δ*Size* is the Δln(Size) based on a twelve-month rolling window of portfolio assets for MMF. As macroeconomic controls, we consider: Δ*GDP* as the monthly growth rate of real GDP; Δ*CPI* is the monthly percentage change in the US Consumer Price Index; *10-year Government Bond* refers to the monthly rate of 10-year Government Bond; *Investment-to-GDP* as the monthly ratio between investment and real GDP; *Money Market MCI* is the market indicator for US money market. We regress the Δ*CoVaR* of only US-Off shore MMFs on the bubble indicators, fund fixed effects, macroeconomic controls (column [i]), Δ*CoVaR* state variables (column [ii]) and monthly dummies (column [iii]). Robust (clustered) standard errors are reported in parentheses. *, **, *** denote the 10%, 5% and 1% significance level, respectively.

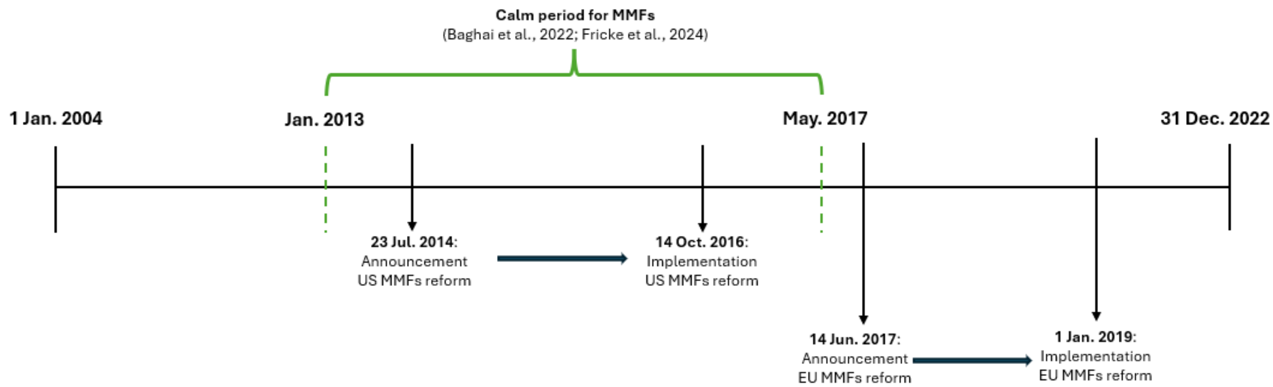
[7]Previous studies have documented the connectedness of the US and European markets, showing that EU issuers rely on US MMFs for funding (Aquilina et al., 2023).

To answer it, we repeat the analysis (see Equation (3)) including offshore MMFs in our sample. As there are no offshore *tax free* MMFs, the interpretation of the coefficients does not change compared to the previous analysis. The results are reported in Table 8. The goodness of fit of the estimated models is reduced somewhat, but the results show that the inclusion of offshore MMFs does not significantly change the picture compared to the analysis performed only with US-domiciled funds. The signs of most of the coefficients do not change while some of the marginal effects associated with *government* and *prime* funds during bubble periods are of a slightly smaller magnitude suggesting that the inclusion of offshore funds may dilute the overall effects of MMFs on systemic risk. However, we do not find evidence that the existence of offshore funds acts as either an amplifier or as a significant buffer for the systemic risk caused by money market funds.

4.2.3 A calm period for MMFs and the regulatory reforms in the US and Europe

Following the great financial crisis in 2008, authorities in both the United States and Europe introduced various reforms in the MMF sector to mitigate the risks it posed. In this section, we investigate what the effects of such reforms, which aimed to improve liquidity and increase transparency (Figure 6) where. In the mind of authorities, these changes should help stabilize MMFs, making them less likely to cause financial problems during market stress.

Figure 6: Timeline of US and EU MMF reforms.



The Figure reports the dates of different reforms of the MMF industry in the US and the EU financial systems.

The response of systemic risk of MMFs, their characteristics and the role played by the reforms is investigated using the following regression model:

$$\begin{aligned}\Delta CoVaR_{i,t} = \beta_0 + \beta_1 I_t^{MMFs\ Reforms} + \beta_2 MMFs\ Char._{i,t-1} + \\ + \beta_3 I_t^{MMFs\ Reforms} * MMFs\ Char._{i,t-1} + \\ + \beta_4 I_t^{MMFs\ Reforms} * MMFs\ Cat._i * MMFs\ Char._{i,t-1} + \\ + [Macro_{t-1}]\ or\ [\Delta CoVaR\ Macro_{t-1}]\ or\ [\textstyle\sum_{t=2004:1}^{2022:12} Time_t] + \\ + \sum_{i=1}^{3,586} MMFs_i + \varepsilon_{i,t}\end{aligned} \tag{4}$$

where $I_t^{MMFs}\ Reforms$ captures the US and the EU MMF reforms over the period 2013:1-2017:5. We follow Baghai et al. (2022) and Fricke et al. (2024), that highlight how the period 2013:1-2017:5 is one of calm for MMFs and also overlaps with many of the reforms in the US and Europe. Tables 9 shows the results. We find that this period is associated with changes in the characteristics of MMFs and in their contribution to systemic risk. In particular, over this period, the systemic risk for larger government MMFs decreased, highlighting their role as a potential safe haven, which was evident in March 2020, when they experienced substantial inflows at the outset of the COVID-19 pandemic. Indeed, for prime MMFs (both denominated in US$ and offshore), systemic risk is unaffected by their size after MMFs reforms.

We also find that over the period of reforms, both the *Wam* and *Wal* of MMF assets changed. Starting with the former, as regulations added liquidity requirements and limited certain investments prime MMFs tried to keep their yields by investing in longer-maturity assets. Longer maturities usually offer higher yields, but they also raise risks related to interest rates and liquidity. This can worsen systemic risk if investors want to redeem their investments during market stress.

Additionally, we observe that the MMF's *Wal* decrease systemic risk following the period of reform in MMFs. By shortening the *Wal* of MMFs, regulators have ensured that these funds may respond more quickly to redemption requests without incurring substantial losses. This change has also enhanced their resilience and improved their capability to manage redemption pressures effectively.

Table 9: MMFs US$ and US$ Off Shore by categories during 2004:1-2022:12 time period and MMFs Reforms.

Dependent variable: ΔCoVaR	**[i]**	**[ii]**	**[iii]**	**Marginal Effects for MMFs Prime**			**Marginal Effects for MMFs Government**		
				[i]	**[ii]**	**[iii]**	**[i]**	**[ii]**	**[iii]**
MMFs Reforms$_t$	-0.0105***	-0.0125***	-0.0092***	0.0056	0.0038	0.0056	0.0232***	0.0222***	0.0236***
	(0.0026)	(0.0027)	(0.0026)	(0.0036)	(0.0037)	(0.0036)	(0.0031)	(0.0032)	(0.0031)
Size$_{i,t-1}$	-0.0014***	-0.0018***	-0.0016***	0.0012**	0.0017***	0.0013**	0.0008*	0.0017***	0.0012**
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0005)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Size$_{i,t-1}$*MMFs Reforms$_t$	0.0005	0.0005	0.0005	-0.0004	-0.0005	-0.0004	-0.0005	-0.0006*	-0.0006*
	(0.0003)	(0.0003)	(0.0003)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Wam$_{i,t-1}$	0.0021**	0.0020*	0.0030**	-0.0020*	-0.0027**	-0.0021*	-0.0035**	-0.0041***	-0.0037***
	(0.0010)	(0.0011)	(0.0011)	(0.0011)	(0.0012)	(0.0011)	(0.0011)	(0.0011)	(0.0011)
Wam$_{i,t-1}$*MMFs Reforms$_t$	-0.0063**	-0.0078**	-0.0080**	0.0098**	0.0109***	0.0098**	0.0069**	0.0080**	0.0074**
	(0.0032)	(0.0032)	(0.0032)	(0.0032)	(0.0032)	(0.0032)	(0.0032)	(0.0032)	(0.0032)
Wal$_{i,t-1}$	-0.0021*	-0.0023**	-0.0028**	0.0018	0.002	0.0020*	0.0036**	0.0046***	0.0045***
	(0.0011)	(0.0012)	(0.0011)	(0.0011)	(0.0012)	(0.0012)	(0.0011)	(0.0012)	(0.0012)
Wal$_{i,t-1}$*MMFs Reforms$_t$	0.0064**	0.0074**	0.0076**	-0.0086**	-0.0090**	-0.0088**	-0.0097**	-0.0104**	-0.0103**
	(0.0032)	(0.0033)	(0.0032)	(0.0033)	(0.0033)	(0.0033)	(0.0033)	(0.0033)	(0.0033)
ΔSize$_{i,t-1}$	-0.002	-0.0035**	-0.0064***	0.0256**	0.0305**	0.0227**	0.0178**	0.0152**	0.0204***
	(0.0014)	(0.0015)	(0.0014)	(0.0098)	(0.0098)	(0.0095)	(0.0056)	(0.0051)	(0.0055)
ΔSize$_{i,t-1}$*MMFs Reforms$_t$	-0.0135***	-0.0140***	-0.0067**	0.0117**	0.0128**	0.0127**	0.0111***	0.0153***	0.0077**
	(0.0029)	(0.0031)	(0.0029)	(0.0045)	(0.0047)	(0.0045)	(0.0032)	(0.0033)	(0.0031)
ΔGDP$_{t-1}$		-0.0003***							
		.00000							
ΔCPI$_{t-1}$		-0.1177***							
		(0.0102)							
10-year Government Bond$_{t-1}$		-0.0013***							
		(0.0001)							
Investment-to-GDP$_{t-1}$		0.0034***							
		(0.0002)							
Money Market MCI$_{t-1}$		0.0007***							
		(0.0000)							
Constant	0.0280***	0.0145***	0.0324***						
	(0.0033)	(0.0041)	(0.0033)						
Fixed Effects	YES	YES	YES						
Time Dummy	YES	NO	NO						
Macro Controls	NO	YES	NO						
ΔCoVaR state variables	NO	NO	YES						
Categories Dummy (Prime and Government)	YES	YES	YES						
N. Obs.	134,083	134,083	134,083						
Adjusted R^2 *within*	0.32	0.26	0.32						
F-Test	54.99***	45.89***	58.68***						

The table reports the results between the measure of systemic risk for MMFs and asset price bubbles. *Size* is the MMF fund size defined as the natural logarithm of the fund portfolio's outstanding assets ($millions); *Weighted average maturity* (Wam) is the asset-weighted time (in days) until the securities in the portfolio mature for MMF; *Weighted average life* (Wal) is the weighted average life (in days); $\Delta Size$ is the Δln(Size) based on a twelve-month rolling window of portfolio assets for MMF. As macroeconomic controls, we consider: ΔGDP as the monthly growth rate of real GDP; ΔCPI is the monthly percentage change in the US Consumer Price Index; *10-year Government Bond* refers to the monthly rate of 10-year Government Bond; *Investment-to-GDP* as the monthly ratio between investment and real GDP; *Money Market MCI* is the market indicator for US money market. We regress the $\Delta CoVaR$ of only US-Off shore MMFs on the bubble indicators, fund fixed effects, macroeconomic controls (column [i]), $\Delta CoVaR$ state variables (column [ii]) and monthly dummies (column [iii]). Robust (clustered) standard errors are reported in parentheses. *, **, *** denote the 10%, 5% and 1% significance level, respectively.

5 Robustness checks

To ensure the robustness of our analysis, we performed a number of checks and in this section, we report their results. We devote most of the discussion to replacing the systemic risk measure in our analysis with *MES* and we only briefly describe the additional checks we performed. In particular we validate our results considering an alternative estimation strategy for $\Delta CoVaR$ and we replicate our analyses after excluding the observations during the COVID-19 time period.

5.1 Marginal Expected Shortfall

The Marginal Expected Shortfall (*MES*) of a financial institution measures the degree to which that institution is exposed to tail shocks and systemic risk. It is a useful complement to $\Delta CoVaR$ which measures the institution contribution to overall systemic risk. As neither of the measures are grounded in solid economic theory researchers typically use multiple measures and look for common trends. In our case, we are more interested in the contribution of each MMFs to overall systemic risk rather to its exposure, and so we focused on $\Delta CoVaR$ in the main analysis. Nonetheless, it makes sense to check the robustness of our results to a change in the variable of interest. We calculate the *MES* as the average return of each MMF during the 5% of days when the financial system experienced the most severe losses. Specifically, we analyze the 5% worst system returns over the past 12 months on a monthly basis. Following Acharya et al. (2017), we use the overall market return, proxied by the S&P 500 index.

We then repeat the analysis we carried out in Section 4 using *MES* as our dependent variable. Table 10 reports the results. Most of the results carry over using this alternative systemic risk measure. The signs and magnitudes of the control variables are stable and most of the effect of the MMFs characteristics are confirmed. Specifically, larger MMFs have lower *MES* and bubble periods are indeed associated with higher systemic risk. Some differences emerge with respect to the effect of *Wam* and *Wal* when they are interacted with boom and busts dummies. In the robustness regressions, these variables are mostly associated with increases in systemic risk during bubble periods. A potential explanation is the fact that while a higher *MES* indicates that a MMF has greater systemic risk *exposure*, a higher $\Delta CoVaR$ indicates that a MMF has a larger systemic risk *contribution*. So MMFs with higher maturity mismatches or that are more exposed to credit risk could suffer more during bubble periods, more than contributing to increases in systemic risk.

In particular, when we analyze MMFs in the US, we find that both $\Delta CoVaR$ and *MES* decrease with higher values of *Wam*, while both measures increase with higher *Wal* values. Similar to $\Delta CoVaR$, *MES* also decreases with greater growth of *Government* MMFs during equity market bubble periods. Both $\Delta CoVaR$ and *MES* increase with greater growth of *Government* MMFs during bust periods of the S&P 500. There are only two differences between $\Delta CoVaR$ and *MES*: the first corresponds to the growth of *Government* MMFs during real estate boom periods, and the second corresponds to the growth of *Prime* MMFs during equity market bust periods.

When we consider both MMFs in the US off shore, we find that both $\Delta CoVaR$ and *MES* decrease with increasing *Wam*, while both increase with higher *Wal*. Additionally, similar to $\Delta CoVaR$, *MES* decreases with greater growth of *Government* MMFs during equity market bubble periods. Both $\Delta CoVaR$ and *MES* increase with greater growth of *Government* MMFs during bust periods of the S&P 500. However, there are three differences between $\Delta CoVaR$ and *MES*: first, in correspondence with the *Size* of *Prime* MMFs; second, in correspondence with the *Wal* of *Prime* MMFs during real estate boom periods; and third, in correspondence with the growth of *Prime* MMFs during equity market bust periods.

Table 10: MMFs US$ and US$ Off Shore using MES.

Dependent variable: MES	MMFs US and MMFs Off Shore	MMFs US$	Prime	Government	MMFs US and MMFs Off Shore	Prime	Government
	[i]	[i]	[ii]	[iii]	[i]	[ii]	[iii]
$\text{Size}_{i,t-1}$	-0.0001	0.0042	-0.0063	0.0024	0.0005	-0.0095**	0.0120**
	(0.0019)	(0.0034)	(0.0041)	(0.0037)	(0.0036)	(0.0047)	(0.0042)
$\text{Size}_{i,t-1}$*Real Estate Boom	-0.0043***	-0.0076**	-0.0047	0.0072**	-0.0031	0.0038	0.0093**
	(0.0001)	(0.0027)	(0.0040)	(0.0031)	(0.0029)	(0.0051)	(0.0034)
$\text{Size}_{i,t-1}$*Real Estate Bust_t	0.0073***	-0.0018	0.002	0.0061**	-0.0018	0.0085**	0.0111***
	(0.0010)	(0.0015)	(0.0025)	(0.0019)	(0.0019)	(0.0037)	(0.0023)
$\text{Size}_{i,t-1}$*Equity Boom_t	-0.0013	0.0036*	0.0152***	-0.0036	0.0059**	-0.0011	-0.0128***
	(0.0013)	(0.0022)	(0.0041)	(0.0026)	(0.0022)	(0.0044)	(0.0029)
$\text{Size}_{i,t-1}$*Equity Bust_t	-0.0036**	0.0053**	0.0034	-0.0071**	0.0089***	-0.0091**	-0.0170***
	(0.0013)	(0.0022)	(0.0031)	(0.0024)	(0.0024)	(0.0031)	(0.0028)
$\text{Wam}_{i,t-1}$	0.0059*	0.0035	0.0043	-0.012	0.0290*	0.0233	-0.0369**
	(0.0031)	(0.0183)	(0.0190)	(0.0187)	(0.0152)	(0.0170)	(0.0156)
$\text{Wam}_{i,t-1}$*Real Estate Boom_t	0.0892***	-0.0158	0.0145	0.0928***	-0.1524***	0.1719***	0.2697***
	(0.0046)	(0.0184)	(0.0216)	(0.0191)	(0.0198)	(0.0236)	(0.0207)
$\text{Wam}_{i,t-1}$*Real Estate Bust_t	0.0343***	0.0367**	-0.0887***	-0.0165	-0.0547**	0.0797**	0.0956***
	(0.0038)	(0.0131)	(0.0157)	(0.0138)	(0.0226)	(0.0254)	(0.0231)
$\text{Wam}_{i,t-1}$*Equity Boom_t	-0.0669***	0.0271	-0.0002	-0.1003***	0.0752***	-0.1023***	-0.1647***
	(0.0044)	(0.0220)	(0.0255)	(0.0226)	(0.0138)	(0.0190)	(0.0150)
$\text{Wam}_{i,t-1}$*Equity Bust_t	-0.0331***	-0.0342	0.0570**	0.0199	0.0074	-0.0573**	-0.0380**
	(0.0039)	(0.0229)	(0.0243)	(0.0234)	(0.0154)	(0.0189)	(0.0164)
$\text{Wal}_{i,t-1}$	-0.0034	-0.0039	0.007	-0.0085	-0.0364**	0.0014	0.0254
	(0.0031)	(0.0188)	(0.0193)	(0.0190)	(0.0154)	(0.0169)	(0.0158)
$\text{Wal}_{i,t-1}$*Real Estate Boom_t	-0.0744***	0.0077	-0.0376*	-0.0540**	0.1589***	-0.2245***	-0.2756***
	(0.0037)	(0.0193)	(0.0225)	(0.0208)	(0.0200)	(0.0264)	(0.0224)
$\text{Wal}_{i,t-1}$*Real Estate Bust_t	-0.0560***	-0.0473***	0.0685***	-0.0033	0.0482**	-0.0976***	-0.1458***
	(0.0037)	(0.0141)	(0.0158)	(0.0160)	(0.0230)	(0.0255)	(0.0246)
$\text{Wal}_{i,t-1}$*Equity Boom_t	0.0690***	-0.0029	0.0123	0.0635**	-0.0484***	0.1364***	0.1436***
	(0.0041)	(0.0226)	(0.0269)	(0.0239)	(0.0136)	(0.0225)	(0.0171)
$\text{Wal}_{i,t-1}$*Equity Bust_t	0.0574***	0.0486**	-0.0418	-0.0019	0.0146	0.0711***	0.0600***
	(0.0037)	(0.0244)	(0.0256)	(0.0244)	(0.0158)	(0.0188)	(0.0171)
$\Delta\text{Size}_{i,t-1}$	0.0139	0.0172	0.4435***	-0.2287**	0.0104	0.6192**	-0.4193***
	(0.0137)	(0.0153)	(0.0922)	(0.0885)	(0.0177)	(0.1904)	(0.1169)
$\Delta\text{Size}_{i,t-1}$*Real Estate Boom_t	-0.1416**	-0.3319***	-0.2275	0.5604***	-0.3653***	-0.0757	0.5875***
	(0.0445)	(0.0962)	(0.1555)	(0.1045)	(0.0895)	(0.1763)	(0.0968)
$\Delta\text{Size}_{i,t-1}$*Real Estate Bust_t	-0.2396***	-0.5080***	0.6318***	0.5780***	-0.4622***	0.3800**	0.4559***
	(0.0647)	(0.0550)	(0.1013)	(0.0998)	(0.0533)	(0.1179)	(0.1086)
$\Delta\text{Size}_{i,t-1}$*Equity Boom_t	1.4103***	2.0237***	1.2656*	-4.4805***	2.1972***	-0.1595	-4.3878***
	(0.3757)	(0.3341)	(0.7172)	(0.4360)	(0.2920)	(0.7244)	(0.4155)
$\Delta\text{Size}_{i,t-1}$*Equity Bust_t	2.5389***	1.4380***	0.6694	0.295	1.4742***	1.2178**	0.0629
	(0.2616)	(0.1228)	(0.5695)	(0.5446)	(0.1253)	(0.5788)	(0.5304)
ΔGDP	-0.0148***	-0.0190***			-0.0142***		
	(0.0004)	(0.0002)			(0.0004)		
ΔCPI_{t-1}	-2.9109***	-3.9401***			-3.3014***		
	(0.1079)	(0.1098)			(0.1052)		
10-year Government Bond	0.0108***	0.0056***			0.0109***		
	(0.0009)	(0.0009)			(0.0009)		
$\text{Investment-to-GDP}_{t-1}$	0.1069***	0.1474***			0.0959***		
	(0.0048)	(0.0028)			(0.0040)		
Money Market MCI_{t-1}	0.0450***	0.0525***			0.0439***		
	(0.0007)	(0.0005)			(0.0007)		
Constant	-0.7308***	-0.9679***			-0.6498***		
	(0.0365)	(0.0238)			(0.0446)		
Fixed Effects	YES	YES			YES		
Catogories Dummy (Prime and Government)	NO	YES			YES		
Bubbles Dummy	YES	YES			YES		
Dummy MMFs US*Bubbles	YES	YES			YES		
Dummy MMFs US$	YES	YES			NO		
Dummy MMFs US Offshore	NO	NO			YES		
Macro Controls	YES	YES			YES		
N. Obs.	126,703	106,108			126,703		
Adjusted R^2 *within*	0.51	0.63			0.53		
F-Test	367.91***	459.75***			193.19***		

The table reports the results between MES, as alternative systemic risk measure for MMFs, and asset price bubbles. *Size* is the MMF fund size defined as the natural logarithm of the fund portfolio's outstanding assets ($millions); *Weighted average maturity* (Wam) is the asset-weighted time (in days) until the securities in the portfolio mature for MMF; *Weighted average life* (Wal) is the weighted average life (in days); $\Delta Size$ is the Δln(Size) based on a twelve-month rolling window of portfolio assets for MMF. As macroeconomic controls, we consider: ΔGDP as the monthly growth rate of real GDP; ΔCPI is the monthly percentage change in the US Consumer Price Index; *10-year Government Bond* refers to the monthly rate of 10-year Government Bond; *Investment-to-GDP* as the monthly ratio between investment and real GDP; *Money Market MCI* is the market indicator for US money market. Robust (clustered) standard errors are reported in parentheses. *, **, *** denote the 10%, 5% and 1% significance level, respectively.

5.2 Further sensitivity analyses

Finally, we conducted two further sensitivity analyses to our main results. First, we compute MMFs' VaR from their past equity returns using 1-year rolling windows; second, we replicate our analyses after excluding the COVID-19 period, specifically from June 2019 to June 2020 to make sure that they are not driven simply by an exogenous stress episode. The results are reported in Table C1 and in Table C2, respectively, of the Internet Appendix. In both cases, the paper's main findings are confirmed.

6 Conclusions

In this paper, we investigate, using $\Delta CoVaR$ the systemic risk contribution of 3,586 Money Market Funds during asset price bubbles in the US over the period January 2004 - December 2022. Using state-of-the-art statistical techniques for the detection of bubbles and granular fund-level data on the characteristics of MMFs, we show that these characteristics are important determinants of systemic risk.

Our results show that large MMFs and *government* MMFs that invest exclusively in US Treasury securities are associated with reductions in systemic risks while *prime* MMFs - which invest primarily in commercial paper and certificates of deposit - are associated with higher systemic risk contributions. More specifically, we find that rather than size *per se*, it is the rapid growth of a fund that is mostly relevant for systemic risk during bubble periods. At times of equity bubbles, systemic risk increases significantly with higher MMFs growth. This is possibly related to investors looking to *reach for yield* during an equity boom. In addition, $\Delta CoVaR$ is sensitive to the weighted average maturity for *prime* MMFs during real estate bubble periods, particularly during boom phases. On the other hand, for *government* MMFs, systemic risk remains unaffected by *Wam*. We also find that $\Delta CoVaR$ responds to both a fund's weighted average life during an equity boom, potentially as MMFs with a higher *Wal* could give rise to higher losses, impacting the stability of the financial system. We also show that MMFs denominated in US dollars but domiciled offshore do not behave differently compared to US domiciled ones.

Our results are robust to using *MES* rather than $\Delta CoVaR$ as the measure of systemic risk, the inclusion of $\Delta CoVaR$ state variables in the estimations, considering an alternative estimation strategy for $\Delta CoVaR$; and, excluding the COVID-19 time period from the analysis.

The findings in this paper have a number of policy implications and give rise to suggestions for future research. First, the result that growth in a fund's asset increase systemic risk suggest that supervisors should pay particular attention to MMFs that experience large increases in total assets, especially in times of exuberance. Second, our results highlight the importance of looking at the microeconomic drivers of systemic risk, and not simply at the macroeconomic variables that may correlate with asset price bubbles. In particular, we highlight the important role played by non-bank intermediaries - whose contribution has been so far underexplored in the literature - in contributing to systemic risk. In terms of next steps, exploring the linkages between banks and non-bank financial intermediaries, how these entities interact to co-determine systemic risk in response to changing economic, financial and regulatory environments would be of crucial importance to design a financial system that can be resilient to shocks. We leave these interesting developments to future research.

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INTERNET APPENDIX.

Asset Price Bubbles and Systemic Risk in Money Market Funds

January 11, 2025

Appendix A Measuring Bubble Episodes

Exuberance behavior in asset prices is a primary indicator of market exuberance during the phase of a bubble. These episodes may be subject to econometric testing using recursive testing procedures, like the right-sided unit root tests in Phillips et al. (2011). Recursive right-sided unit root tests seem to be particularly effective as real-time detection mechanisms for slightly explosive behavior and market exuberance.

As first step, we start with the following Augmented Dickey Fuller (ADF) regression equation:

$$\Delta y_t = \alpha_{r_1,r_2} + \beta_{r_1,r_2} y_{t-1} + \sum_{i=1}^{k} \delta^i_{r_1,r_2} \Delta y_{t-i} + \varepsilon_t \tag{A1}$$

where Δ is the first-difference operator; y_t denotes the time series of interest at time t; k is a scalar that denotes the number of lags of the dependent variable that are included to accommodate serial correlation; r_1 and r_2 denote the fraction of the total number of time periods in the sample that specify the starting and the ending points, respectively; α_{r_1,r_2}, β_{r_1,r_2} and $\delta^i_{r_1,r_2}$ are regression coefficients; ε_t is the error term. We test the null hypothesis of a unit root in y_t, $H_0 : \beta_{r_1,r_2} = 0$, against the alternative of exuberance behavior, $H_1 : \beta_{r_1,r_2} > 0$.

The ADF test statistic corresponding to the null hypothesis is given by: $ADF_{r_1}^{r_2} = \frac{\hat{\beta}_{r_1,r_2}}{s.e.(\hat{\beta}_{r_1,r_2})}$.

Phillips et al. (2011) propose a methodology that is consistent with a single boom-bust episode. The methodology involves estimating Equation (A1) using a forward expanding sample. In this setting, the beginning of the sub sample is held constant at $r_1 = 0$, while the end of the sub sample, r_2, increases from r_0 (the minimum window size) to 1 (the entire sample period). Recursive estimation of Equation (A1) yields a sequence of $ADF_0^{r_2}$ statistics. The supremum of this sequence is called the SADF and is defined as follows:

$$SADF_{r_0} = \sup_{r_2 \in [r_0,1]} ADF_0^{r_2} \tag{A2}$$

similar to the standard ADF test, when the SADF statistic exceeds the right-tailed critical value, the unit root hypothesis is rejected in favor of exuberance behavior. However, in contrast to the standard ADF test, the alternative hypothesis of the SADF test is that of exuberance dynamics in some parts of the sample. One potential limitation of the recursive approach suggested by Phillips et al. (2011) is that it provides consistent estimates of the origination and ending dates of the first bubble but not subsequent ones.

Phillips et al. (2015a,b) propose an extension of the SADF, the Generalized SADF (GSADF), which has the same alternative hypothesis as the SADF but which covers a larger number of sub samples. The GSADF test involves an extensive set of regressions, in which the first observation varies from 0 to $r_2 - r_0$, while the last observation varies from r_0 to 1. In comparison to the SADF, the GSADF test shows a more flexibility on the estimation window and it is consistent with multiple exuberance periods, while the SADF test is consistent only with a single episode. The GSADF statistic is defined as:

$$GSADF_{r_0} = \sup_{r_2 \in [r_0, 1], r_1 \in [0, r_2 - r_0]} ADF_{r_1}^{r_2} \tag{A3}$$

The rejection of the unit root hypothesis in favor of exuberance behavior requires that the test statistic exceeds the right-tailed critical value from its limit distribution. If the null of a unit root in y_t is rejected, then the SADF and the GSADF methodologies can provide a sequence of episodes of exuberance. The inference for the ADF, SADF and GSADF statistics requires critical values computed using Monte Carlo simulations.

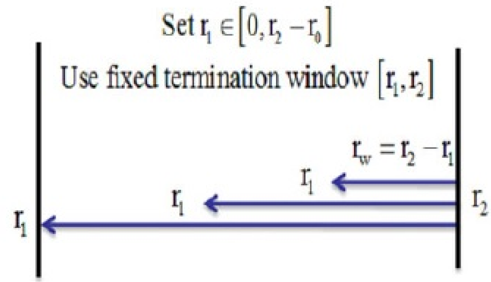
Consequently, Phillips et al. (2015a,b) introduce the the Backward Supremum Augmented Dickey Fuller (BSADF) statistic defined as follows:

$$BSADF_{r2}(r_0) = \sup_{r_1 \in [0, r_2 - r_0]} \left\{ SADF_{r_1}^{r_2} \right\} \tag{A4}$$

where r_1 and r_2 denote the starting and the ending fraction of the sample, respectively, implying that $r_1 < r_2$; r_0 is the fractional threshold and it is chosen on a lower bound of 1% of the full sample with the following functional form: $r_0 = \left(0.01 + 1.8/\sqrt{T}\right)$, where T refers to the number of observations in the sample. We denote r_w, the window size of the regression, as $r_1 - r_2$. Appendix A describes the estimation approach.

Phillips et al. (2015a) suggest to implement the BSADF test on a sample sequence where the end point is fixed at r_2, and expands backwards to the starting point, r_1, which varies between 0 and $(r_2 - r_0)$. Let r_e the fraction of the sample at which the bubble starts, r_f the fraction of the sample at which it ends, and $\hat{r}_e$ and $\hat{r}_f$ the estimators of both. The origination

Figure A1: Recursive nature of the BSADF test.



Source: Phillips et al. (2015a, p. 1052).

and termination points of a bubble, i.e. r_e and r_f, are calculated according to the Equations (A5) and (A6):

$$\hat{r}_e = \inf_{r_2 \in [r_0, 1]} \left[r_2 : BSADF_{r_2}(r_0) > scv^{\beta}_{r_2} \right] \tag{A5}$$

$$and \quad \hat{r}_f = \inf_{r_2 \in [\hat{r}_e + \delta log(T), 1]} \left[r_2 : BSADF_{r_2}(r_0) < scv^{\beta}_{r_2} \right] \tag{A6}$$

where T is the number of observations, $scv^{\beta}_{r_2}$ is the critical value of the BSADF statistic based on $\lfloor Tr_2 \rfloor$ observations and confidence level β. $\lfloor Tr_2 \rfloor$ refers to the largest integer smaller than or equal to Tr_2. Phillips et al. (2015a) impose a condition that for a bubble to exist its duration must exceed a slowly varying (at infinity) quantity such as $L_T = log(T)$. This condition helps to exclude short lived blips in the fitted autoregressive coefficient and can be adjusted to consider the data frequency. Thus, $\delta log(T)$ is a minimal bubble length, and δ is a frequency-dependent parameter chosen freely.

Tables A1 and A2 report the BSADF and the BSADF 95% critical values computed on the Case-Shiller index and on the S&P500, respectively.

Table A1: Case-Shiller Index - Periods of Explosiveness, Boom and Bust.

Case-Shiller U.S. National Price Index Normalized for the personal consumption expenditure deflator																	
Date (monthly)	**BSADF statistics**	**Critical Value 95**	**Expl.**	**Boom phase**	**Bust phase**	**Date (monthly)**	**BSADF statistics**	**Critical Value 95**	**Expl.**	**Boom phase**	**Bust phase**	**Date (monthly)**	**BSADF statistics**	**Critical Value 95**	**Expl.**	**Boom phase**	**Bust phase**
01/01/2004	4.20	1.37	1	0	1	01/05/2010	-0.95	1.42	0	0	0	01/09/2016	-0.16	1.48	0	0	0
01/02/2004	3.96	1.37	1	0	1	01/06/2010	-0.90	1.42	0	0	0	01/10/2016	-0.20	1.48	0	0	0
01/03/2004	3.58	1.37	1	0	1	01/07/2010	-0.79	1.42	0	0	0	01/11/2016	-0.02	1.48	0	0	0
01/04/2004	3.56	1.37	1	0	1	01/08/2010	-0.55	1.42	0	0	0	01/12/2016	-0.10	1.48	0	0	0
01/05/2004	3.54	1.37	1	1	0	01/09/2010	-0.57	1.42	0	0	0	01/01/2017	-0.25	1.48	0	0	0
01/06/2004	3.54	1.37	1	1	0	01/10/2010	-0.56	1.42	0	0	0	01/02/2017	-0.29	1.48	0	0	0
01/07/2004	3.55	1.37	1	1	0	01/11/2010	-0.65	1.42	0	0	0	01/03/2017	-0.09	1.48	0	0	0
01/08/2004	3.51	1.38	1	1	0	01/12/2010	-0.73	1.42	0	0	0	01/04/2017	-0.24	1.48	0	0	0
01/09/2004	3.53	1.38	1	1	0	01/01/2011	-0.61	1.42	0	0	0	01/05/2017	0.03	1.48	0	0	0
01/10/2004	3.43	1.38	1	1	0	01/02/2011	-0.44	1.44	0	0	0	01/06/2017	0.00	1.48	0	0	0
01/11/2004	3.48	1.38	1	1	0	01/03/2011	-0.59	1.44	0	0	0	01/07/2017	0.05	1.48	0	0	0
01/12/2004	3.73	1.38	1	1	0	01/04/2011	-0.64	1.44	0	0	0	01/08/2017	0.04	1.48	0	0	0
01/01/2005	3.90	1.38	1	1	0	01/05/2011	-0.68	1.44	0	0	0	01/09/2017	-0.11	1.48	0	0	0
01/02/2005	3.97	1.38	1	1	0	01/06/2011	-0.86	1.44	0	0	0	01/10/2017	0.39	1.48	0	0	0
01/03/2005	4.05	1.38	1	1	0	01/07/2011	-0.81	1.44	0	0	0	01/11/2017	0.69	1.48	0	0	0
01/04/2005	4.00	1.38	1	1	0	01/08/2011	-0.74	1.44	0	0	0	01/12/2017	0.88	1.48	0	0	0
01/05/2005	4.05	1.38	1	1	0	01/09/2011	-0.72	1.44	0	0	0	01/01/2018	0.70	1.48	0	0	0
01/06/2005	4.09	1.38	1	1	0	01/10/2011	-0.72	1.44	0	0	0	01/02/2018	0.90	1.48	0	0	0
01/07/2005	3.86	1.38	1	0	1	01/11/2011	-0.59	1.44	0	0	0	01/03/2018	1.00	1.48	0	0	0
01/08/2005	3.49	1.38	1	0	1	01/12/2011	-0.73	1.44	0	0	0	01/04/2018	0.73	1.48	0	0	0
01/09/2005	2.47	1.38	1	0	1	01/01/2012	-0.74	1.44	0	0	0	01/05/2018	0.64	1.48	0	0	0
01/10/2005	3.06	1.38	1	1	0	01/02/2012	-0.80	1.44	0	0	0	01/06/2018	0.77	1.48	0	0	0
01/11/2005	4.31	1.38	1	1	0	01/03/2012	-1.17	1.44	0	0	0	01/07/2018	0.58	1.48	0	0	0
01/12/2005	3.86	1.38	1	0	1	01/04/2012	-1.22	1.44	0	0	0	01/08/2018	0.53	1.48	0	0	0
01/01/2006	3.06	1.38	1	0	1	01/05/2012	-1.35	1.44	0	0	0	01/09/2018	0.17	1.48	0	0	0
01/02/2006	2.89	1.38	1	0	1	01/06/2012	-1.36	1.44	0	0	0	01/10/2018	0.15	1.48	0	0	0
01/03/2006	2.36	1.38	1	0	1	01/07/2012	-1.29	1.45	0	0	0	01/11/2018	0.16	1.48	0	0	0
01/04/2006	0.41	1.38	0	0	0	01/08/2012	-1.16	1.45	0	0	0	01/12/2018	0.00	1.48	0	0	0
01/05/2006	0.06	1.39	0	0	0	01/09/2012	-1.17	1.45	0	0	0	01/01/2019	-0.07	1.48	0	0	0
01/06/2006	-0.90	1.39	0	0	0	01/10/2012	-1.18	1.45	0	0	0	01/02/2019	-0.19	1.48	0	0	0
01/07/2006	-1.15	1.39	0	0	0	01/11/2012	-1.38	1.45	0	0	0	01/03/2019	-0.31	1.48	0	0	0
01/08/2006	-1.26	1.39	0	0	0	01/12/2012	-1.39	1.45	0	0	0	01/04/2019	-0.37	1.48	0	0	0
01/09/2006	0.94	1.39	0	0	0	01/01/2013	-1.45	1.45	0	0	0	01/05/2019	-0.14	1.48	0	0	0
01/10/2006	1.57	1.39	1	1	0	01/02/2013	-1.38	1.45	0	0	0	01/06/2019	-0.15	1.48	0	0	0
01/11/2006	1.44	1.39	1	0	1	01/03/2013	-0.97	1.45	0	0	0	01/07/2019	-0.19	1.49	0	0	0
01/12/2006	1.07	1.39	0	0	0	01/04/2013	-1.01	1.45	0	0	0	01/08/2019	-0.02	1.49	0	0	0
01/01/2007	0.84	1.39	0	0	0	01/05/2013	-1.10	1.45	0	0	0	01/09/2019	-0.02	1.49	0	0	0
01/02/2007	0.52	1.39	0	0	0	01/06/2013	-1.03	1.45	0	0	0	01/10/2019	-0.06	1.49	0	0	0
01/03/2007	-0.09	1.39	0	0	0	01/07/2013	-1.00	1.45	0	0	0	01/11/2019	0.13	1.49	0	0	0
01/04/2007	-0.66	1.39	0	0	0	01/08/2013	-1.01	1.45	0	0	0	01/12/2019	0.05	1.50	0	0	0
01/05/2007	-1.18	1.39	0	0	0	01/09/2013	-0.96	1.45	0	0	0	01/01/2020	0.10	1.50	0	0	0
01/06/2007	-1.24	1.39	0	0	0	01/10/2013	-1.02	1.46	0	0	0	01/02/2020	0.12	1.50	0	0	0
01/07/2007	-1.10	1.39	0	0	0	01/11/2013	-1.08	1.46	0	0	0	01/03/2020	0.27	1.50	0	0	0
01/08/2007	-0.87	1.39	0	0	0	01/12/2013	-1.06	1.46	0	0	0	01/04/2020	0.53	1.51	0	0	0
01/09/2007	-0.95	1.39	0	0	0	01/01/2014	-1.08	1.46	0	0	0	01/05/2020	0.01	1.51	0	0	0
01/10/2007	-1.14	1.39	0	0	0	01/02/2014	-1.09	1.47	0	0	0	01/06/2020	-0.04	1.51	0	0	0
01/11/2007	-1.50	1.39	0	0	0	01/03/2014	-1.15	1.47	0	0	0	01/07/2020	0.21	1.51	0	0	0
01/12/2007	-1.29	1.39	0	0	0	01/04/2014	-1.24	1.47	0	0	0	01/08/2020	0.88	1.51	0	0	0
01/01/2008	-1.54	1.39	0	0	0	01/05/2014	-1.27	1.47	0	0	0	01/09/2020	1.46	1.51	0	0	0
01/02/2008	-1.58	1.39	0	0	0	01/06/2014	-1.22	1.47	0	0	0	01/10/2020	1.81	1.51	1	1	0
01/03/2008	-1.51	1.40	0	0	0	01/07/2014	-1.20	1.47	0	0	0	01/11/2020	1.83	1.51	1	1	0
01/04/2008	-1.18	1.40	0	0	0	01/08/2014	-1.00	1.47	0	0	0	01/12/2020	1.63	1.51	1	1	0
01/05/2008	-0.99	1.40	0	0	0	01/09/2014	-0.89	1.47	0	0	0	01/01/2021	1.95	1.51	1	1	0
01/06/2008	-0.77	1.40	0	0	0	01/10/2014	-0.73	1.47	0	0	0	01/02/2021	1.98	1.51	1	1	0
01/07/2008	-0.99	1.40	0	0	0	01/11/2014	-0.58	1.47	0	0	0	01/03/2021	2.05	1.51	1	1	0
01/08/2008	-1.22	1.40	0	0	0	01/12/2014	-0.46	1.47	0	0	0	01/04/2021	2.27	1.51	1	1	0
01/09/2008	-1.10	1.41	0	0	0	01/01/2015	-0.21	1.47	0	0	0	01/05/2021	2.59	1.51	1	1	0
01/10/2008	-1.38	1.41	0	0	0	01/02/2015	-0.59	1.47	0	0	0	01/06/2021	2.85	1.52	1	1	0
01/11/2008	-1.36	1.41	0	0	0	01/03/2015	-0.48	1.47	0	0	0	01/07/2021	2.73	1.52	1	1	0
01/12/2008	-0.93	1.41	0	0	0	01/04/2015	-0.48	1.47	0	0	0	01/08/2021	2.75	1.52	1	1	0
01/01/2009	-0.38	1.41	0	0	0	01/05/2015	-0.57	1.47	0	0	0	01/09/2021	2.78	1.52	1	1	0
01/02/2009	-0.23	1.41	0	0	0	01/06/2015	-0.54	1.48	0	0	0	01/10/2021	2.43	1.52	1	1	0
01/03/2009	-0.41	1.41	0	0	0	01/07/2015	-0.42	1.48	0	0	0	01/11/2021	2.68	1.52	1	1	0
01/04/2009	-0.34	1.41	0	0	0	01/08/2015	-0.27	1.48	0	0	0	01/12/2021	2.79	1.52	1	1	0
01/05/2009	-0.61	1.41	0	0	0	01/09/2015	-0.03	1.48	0	0	0	01/01/2022	3.14	1.52	1	1	0
01/06/2009	-0.44	1.41	0	0	0	01/10/2015	-0.04	1.48	0	0	0	01/02/2022	3.18	1.52	1	1	0
01/07/2009	-0.84	1.41	0	0	0	01/11/2015	-0.08	1.48	0	0	0	01/03/2022	3.01	1.52	1	1	0
01/08/2009	-0.46	1.41	0	0	0	01/12/2015	0.00	1.48	0	0	0	01/04/2022	3.22	1.52	1	1	0
01/09/2009	-0.58	1.41	0	0	0	01/01/2016	-0.09	1.48	0	0	0	01/05/2022	2.50	1.52	1	0	1
01/10/2009	-0.43	1.42	0	0	0	01/02/2016	-0.18	1.48	0	0	0	01/06/2022	1.08	1.52	0	0	0
01/11/2009	-0.73	1.42	0	0	0	01/03/2016	-0.37	1.48	0	0	0	01/07/2022	1.67	1.52	1	0	1
01/12/2009	-0.67	1.42	0	0	0	01/04/2016	-0.46	1.48	0	0	0	01/08/2022	0.33	1.52	0	0	0
01/01/2010	-0.50	1.42	0	0	0	01/05/2016	-0.33	1.48	0	0	0	01/09/2022	0.37	1.52	0	0	0
01/02/2010	-0.14	1.42	0	0	0	01/06/2016	-0.35	1.48	0	0	0	01/10/2022	0.91	1.52	0	0	0
01/03/2010	-0.83	1.42	0	0	0	01/07/2016	-0.16	1.48	0	0	0	01/11/2022	1.05	1.52	0	0	0
01/04/2010	-0.96	1.42	0	0	0	01/08/2016	-0.12	1.48	0	0	0	01/12/2022	0.19	1.52	0	0	0

The Table reports *BSADF* and the *BSADF* 95% critical values (cv) computed on the Case-Shiller index. The *BSADF* 95% critical values are based on a window size given by $r_0 = \left(0.01 + 1.8/\sqrt{T}\right)$, where T refers to the number of observations in the sample. Explosive behavior is an indicator variable equal to 1 when *BSADF* is above its 95% critical value and 0 otherwise.

Table A2: S&P 500 Index - Periods of Explosiveness, Boom and Bust.

S&P 500 Index																	
Date (monthly)	**BSADF statistics**	**Critical Value 95**	**Expl.**	**Boom phase**	**Bust phase**	**Date (monthly)**	**BSADF statistics**	**Critical Value 95**	**Expl.**	**Boom phase**	**Bust phase**	**Date (monthly)**	**BSADF statistics**	**Critical Value 95**	**Expl.**	**Boom phase**	**Bust phase**
1/1/2004	-0.95	0.45	0	0	0	5/1/2010	-0.93	0.46	0	0	0	9/1/2016	0.10	0.63	0	0	0
2/1/2004	-0.92	0.47	0	0	0	6/1/2010	-0.87	0.44	0	0	0	10/1/2016	0.06	0.62	0	0	0
3/1/2004	-0.90	0.45	0	0	0	7/1/2010	-0.82	0.45	0	0	0	11/1/2016	-0.09	0.62	0	0	0
4/1/2004	-0.95	0.46	0	0	0	8/1/2010	-0.98	0.43	0	0	0	12/1/2016	0.10	0.57	0	0	0
5/1/2004	-0.98	0.47	0	0	0	9/1/2010	-0.95	0.48	0	0	0	1/1/2017	0.22	0.62	0	0	0
6/1/2004	-0.98	0.49	0	0	0	10/1/2010	-1.03	0.52	0	0	0	2/1/2017	0.32	0.57	0	0	0
7/1/2004	-0.98	0.43	0	0	0	11/1/2010	-1.07	0.50	0	0	0	3/1/2017	0.65	0.57	1	1	0
8/1/2004	-1.02	0.48	0	0	0	12/1/2010	-1.08	0.48	0	0	0	4/1/2017	0.49	0.53	0	0	0
9/1/2004	-1.03	0.43	0	0	0	1/1/2011	-1.09	0.48	0	0	0	5/1/2017	0.56	0.55	1	1	0
10/1/2004	-1.00	0.41	0	0	0	2/1/2011	-1.07	0.48	0	0	0	6/1/2017	0.67	0.60	1	1	0
11/1/2004	-1.01	0.46	0	0	0	3/1/2011	-1.08	0.54	0	0	0	7/1/2017	0.63	0.60	1	1	0
12/1/2004	-0.60	0.47	0	0	0	4/1/2011	-1.07	0.57	0	0	0	8/1/2017	0.75	0.59	1	1	0
1/1/2005	-0.54	0.49	0	0	0	5/1/2011	-1.04	0.52	0	0	0	9/1/2017	0.72	0.56	1	1	0
2/1/2005	-0.64	0.42	0	0	0	6/1/2011	-1.11	0.54	0	0	0	10/1/2017	0.86	0.50	1	1	0
3/1/2005	-0.53	0.40	0	0	0	7/1/2011	-1.09	0.54	0	0	0	11/1/2017	0.99	0.55	1	1	0
4/1/2005	-0.77	0.43	0	0	0	8/1/2011	-1.15	0.57	0	0	0	12/1/2017	1.16	0.52	1	1	0
5/1/2005	-0.82	0.49	0	0	0	9/1/2011	-1.20	0.50	0	0	0	1/1/2018	1.22	0.52	1	1	0
6/1/2005	-0.66	0.45	0	0	0	10/1/2011	-1.16	0.64	0	0	0	2/1/2018	1.67	0.49	1	1	0
7/1/2005	-0.55	0.44	0	0	0	11/1/2011	-1.28	0.64	0	0	0	3/1/2018	1.05	0.48	1	0	1
8/1/2005	-0.27	0.45	0	0	0	12/1/2011	-1.27	0.63	0	0	0	4/1/2018	0.70	0.48	1	0	1
9/1/2005	-0.39	0.45	0	0	0	1/1/2012	-1.20	0.58	0	0	0	5/1/2018	0.88	0.51	1	0	1
10/1/2005	-0.38	0.51	0	0	0	2/1/2012	-1.05	0.60	0	0	0	6/1/2018	1.08	0.59	1	0	1
11/1/2005	-0.54	0.48	0	0	0	3/1/2012	-0.91	0.62	0	0	0	7/1/2018	1.02	0.54	1	0	1
12/1/2005	-0.25	0.49	0	0	0	4/1/2012	-0.77	0.60	0	0	0	8/1/2018	1.24	0.59	1	0	1
1/1/2006	-0.39	0.52	0	0	0	5/1/2012	-0.85	0.66	0	0	0	9/1/2018	1.48	0.59	1	0	1
2/1/2006	-0.21	0.53	0	0	0	6/1/2012	-1.25	0.64	0	0	0	10/1/2018	1.50	0.57	1	0	1
3/1/2006	-0.18	0.54	0	0	0	7/1/2012	-1.09	0.66	0	0	0	11/1/2018	0.82	0.65	1	0	1
4/1/2006	-0.17	0.49	0	0	0	8/1/2012	-1.07	0.65	0	0	0	12/1/2018	0.93	0.62	1	0	1
5/1/2006	-0.16	0.52	0	0	0	9/1/2012	-0.99	0.61	0	0	0	1/1/2019	0.11	0.56	0	0	0
6/1/2006	-0.31	0.52	0	0	0	10/1/2012	-0.88	0.60	0	0	0	2/1/2019	0.49	0.60	0	0	0
7/1/2006	-0.36	0.57	0	0	0	11/1/2012	-0.94	0.60	0	0	0	3/1/2019	0.70	0.60	1	1	0
8/1/2006	-0.43	0.51	0	0	0	12/1/2012	-1.00	0.53	0	0	0	4/1/2019	0.83	0.56	1	1	0
9/1/2006	-0.24	0.54	0	0	0	1/1/2013	-0.96	0.58	0	0	0	5/1/2019	0.95	0.55	1	1	0
10/1/2006	-0.14	0.53	0	0	0	2/1/2013	-0.72	0.61	0	0	0	6/1/2019	0.44	0.57	0	0	0
11/1/2006	0.06	0.48	0	0	0	3/1/2013	-0.71	0.59	0	0	0	7/1/2019	0.89	0.59	1	1	0
12/1/2006	0.22	0.46	0	0	0	4/1/2013	-0.57	0.61	0	0	0	8/1/2019	0.84	0.59	1	1	0
1/1/2007	0.34	0.50	0	0	0	5/1/2013	-0.51	0.60	0	0	0	9/1/2019	0.74	0.60	1	1	0
2/1/2007	0.49	0.50	0	0	0	6/1/2013	-0.31	0.60	0	0	0	10/1/2019	0.75	0.61	1	1	0
3/1/2007	0.08	0.54	0	0	0	7/1/2013	-0.44	0.60	0	0	0	11/1/2019	1.03	0.58	1	1	0
4/1/2007	0.19	0.48	0	0	0	8/1/2013	-0.10	0.62	0	0	0	12/1/2019	1.11	0.54	1	1	0
5/1/2007	0.73	0.55	1	1	0	9/1/2013	-0.46	0.61	0	0	0	1/1/2020	1.38	0.61	1	1	0
6/1/2007	1.24	0.59	1	1	0	10/1/2013	-0.27	0.59	0	0	0	2/1/2020	1.39	0.60	1	1	0
7/1/2007	0.73	0.47	1	0	1	11/1/2013	-0.05	0.61	0	0	0	3/1/2020	0.91	0.60	1	1	0
8/1/2007	0.16	0.53	0	0	0	12/1/2013	0.09	0.64	0	0	0	4/1/2020	-0.48	0.60	0	0	0
9/1/2007	0.18	0.51	0	0	0	1/1/2014	0.28	0.64	0	0	0	5/1/2020	-0.07	0.63	0	0	0
10/1/2007	0.58	0.50	1	1	0	2/1/2014	-0.28	0.65	0	0	0	6/1/2020	0.27	0.67	0	0	0
11/1/2007	0.24	0.49	0	0	0	3/1/2014	0.04	0.65	0	0	0	7/1/2020	0.37	0.72	0	0	0
12/1/2007	-0.01	0.47	0	0	0	4/1/2014	0.15	0.64	0	0	0	8/1/2020	0.68	0.72	0	0	0
1/1/2008	-0.06	0.51	0	0	0	5/1/2014	0.09	0.64	0	0	0	9/1/2020	1.11	0.67	1	1	0
2/1/2008	-0.43	0.51	0	0	0	6/1/2014	0.21	0.59	0	0	0	10/1/2020	0.74	0.73	1	1	0
3/1/2008	-0.65	0.60	0	0	0	7/1/2014	0.35	0.60	0	0	0	11/1/2020	0.57	0.70	0	0	0
4/1/2008	-0.56	0.53	0	0	0	8/1/2014	0.12	0.63	0	0	0	12/1/2020	1.20	0.69	1	1	0
5/1/2008	-0.45	0.58	0	0	0	9/1/2014	0.35	0.72	0	0	0	1/1/2021	1.37	0.66	1	1	0
6/1/2008	-0.55	0.55	0	0	0	10/1/2014	0.09	0.70	0	0	0	2/1/2021	1.37	0.67	1	1	0
7/1/2008	-0.82	0.51	0	0	0	11/1/2014	0.30	0.70	0	0	0	3/1/2021	1.62	0.64	1	1	0
8/1/2008	-0.86	0.58	0	0	0	12/1/2014	0.38	0.64	0	0	0	4/1/2021	1.84	0.65	1	1	0
9/1/2008	-0.84	0.57	0	0	0	1/1/2015	0.36	0.70	0	0	0	5/1/2021	2.20	0.66	1	1	0
10/1/2008	-0.89	0.59	0	0	0	2/1/2015	0.18	0.65	0	0	0	6/1/2021	2.16	0.63	1	1	0
11/1/2008	0.41	0.60	0	0	0	3/1/2015	0.52	0.66	0	0	0	7/1/2021	2.39	0.63	1	1	0
12/1/2008	1.70	0.60	1	1	0	4/1/2015	0.25	0.68	0	0	0	8/1/2021	2.49	0.63	1	1	0
1/1/2009	0.35	0.58	0	0	0	5/1/2015	0.40	0.72	0	0	0	9/1/2021	2.76	0.66	1	1	0
2/1/2009	0.95	0.53	1	0	1	6/1/2015	0.39	0.67	0	0	0	10/1/2021	2.23	0.68	1	1	0
3/1/2009	1.67	0.47	1	0	1	7/1/2015	0.24	0.66	0	0	0	11/1/2021	2.75	0.67	1	1	0
4/1/2009	0.47	0.52	0	0	0	8/1/2015	0.29	0.68	0	0	0	12/1/2021	2.42	0.68	1	1	0
5/1/2009	0.02	0.56	0	0	0	9/1/2015	-0.35	0.64	0	0	0	1/1/2022	2.98	0.64	1	1	0
6/1/2009	-0.30	0.48	0	0	0	10/1/2015	-0.34	0.64	0	0	0	2/1/2022	2.24	0.61	1	0	1
7/1/2009	-0.27	0.50	0	0	0	11/1/2015	0.11	0.69	0	0	0	3/1/2022	1.62	0.68	1	0	1
8/1/2009	-0.54	0.47	0	0	0	12/1/2015	0.09	0.66	0	0	0	4/1/2022	2.04	0.65	1	0	1
9/1/2009	-0.54	0.44	0	0	0	1/1/2016	-0.11	0.58	0	0	0	5/1/2022	1.13	0.60	1	0	1
10/1/2009	-0.62	0.51	0	0	0	2/1/2016	-0.41	0.61	0	0	0	6/1/2022	1.01	0.64	1	0	1
11/1/2009	-0.66	0.54	0	0	0	3/1/2016	-0.33	0.63	0	0	0	7/1/2022	0.51	0.58	0	0	0
12/1/2009	-0.79	0.51	0	0	0	4/1/2016	-0.10	0.62	0	0	0	8/1/2022	0.91	0.64	1	0	1
1/1/2010	-0.81	0.47	0	0	0	5/1/2016	-0.09	0.59	0	0	0	9/1/2022	0.64	0.61	1	0	1
2/1/2010	-0.79	0.49	0	0	0	6/1/2016	-0.05	0.59	0	0	0	10/1/2022	0.18	0.56	0	0	0
3/1/2010	-0.84	0.45	0	0	0	7/1/2016	-0.05	0.63	0	0	0	11/1/2022	0.40	0.61	0	0	0
4/1/2010	-0.91	0.52	0	0	0	8/1/2016	0.12	0.62	0	0	0	12/1/2022	0.69	0.62	1	0	1

The Table reports *BSADF* and the *BSADF* 95% critical values (cv) computed on the S&P500 index. The *BSADF* 95% critical values are based on a window size given by $r_0 = \left(0.01 + 1.8/\sqrt{T}\right)$, where T refers to the number of observations in the sample. Explosive behavior is an indicator variable equal to 1 when *BSADF* is above its 95% critical value and 0 otherwise.

Appendix B Measuring Systemic Risk

Over the last decade, several global systemic risk measures have been proposed (see Benoit et al., 2017) accounting for specific sources such as contagion, bank runs or liquidity crises. The Marginal Expected Shortfall (*MES*) of Acharya et al. (2017), the *SRISK* of Brownlees & Engle (2016), and the $\Delta CoVaR$ of Adrian & Brunnermeier (2016) are the most central measures in the systemic risk literature (Zhang et al., 2015; Benoit et al., 2017; Dičpinigaitienė & Novickytė, 2018; Grundke & Tuchscherer, 2019). In this section, we briefly describe the two measures of systemic risk $\Delta CoVaR$ (*Section B.1*), and *MES* (*Section B.2*).

B.1 $\Delta CoVaR$

The *CoVaR* is an indicator of systemic risk defined as the Value at Risk (*VaR*) for the entire financial system, conditional on another financial institution, exceeding its specific *VaR*. *VaR* is the threshold loss that will not be exceeded at a given level of confidence. The $CoVaR_q^{system|C(X^i)}$ is defined by the *q-th* quantile of the conditional probability distribution:

$$Prob(X^{system|C(X^i)} \leq CoVaR_q^{system|C(X^i)}) = q\% \tag{B1}$$

where X^i is the market-valued asset return of institution i, and X^{system} is the return of the financial system, computed as the average of the X^i's weighted by the lagged market value assets of the institutions. Adrian & Brunnermeier (2016) measure the contribution of each financial institution to systemic risk by the $\Delta CoVaR$, namely the difference between $CoVaR$ conditional on the institution being in distress and *CoVaR* in the median state of the institution. Formally, the $\Delta CoVaR_q^i$, i.e. the contribution to systemic risk of institution i during the q quartile, is defined as follows:

$$\Delta CoVaR_q^i = CoVaR_q^i - CoVaR_{50}^i = \hat{\beta}_q^i (VaR_q^i - VaR_{50}^i) \tag{B2}$$

where the q is set to be 5%, so that $CoVaR^i$ identifies the system losses predicted on the 5% loss of financial institution i, while $\Delta CoVaR^i$ identifies the deterioration in the system losses, when the financial institution i moves from its median state to its 5% worst scenario. *VaRs* and *CoVaRs* estimations are obtained using quantile regressions (q) (Koenker & Bassett, 1978).

To obtain the time-varying VaR_t and $CoVaR_t$, we estimate the following quantile regressions on weekly data:

$$X_t^i = \alpha_q^i + \gamma_q^i \mathbf{M}_{t-1} + \varepsilon_{q,t}^i \tag{B3a}$$

$$X_t^{system|i} = \alpha_q^{system|i} + \beta_q^{system|i} X_t^i + \gamma_q^{system|i} \mathbf{M}_{t-1} + \varepsilon_{q,t}^{system|i} \tag{B3b}$$

where $\mathbf{M}_t$ includes the set of US state variables. We then use the predicted values from these regressions to obtain:

$$VaR_{q,t}^i = \hat{\alpha}_q^i + \hat{\gamma}_q^i \mathbf{M}_{t-1} \tag{B4a}$$

$$CoVaR_{q,t}^i = \hat{\alpha}_q^{system|i} + \hat{\beta}_q^{system|i} VaR_{q,t}^i + \hat{\gamma}_q^{system|i} \mathbf{M}_{t-1} \tag{B4b}$$

Regarding the US financial system, we consider: *Liquidity Spread*, the difference between the 3-month US repo rate and the 3- month US T-bill yield; *Credit Spread*, the difference between the 10-year Moody's seasoned Baa corporate bond and the 10-year US Treasury bond; *Yield slope*, the first difference curve (yield spread between the US Treasury benchmark 10-year bonds and the US 3-month T-bill); *T-Bill change*, the first difference of the US Treasury bill secondary market 3-month rate; *S&P 500 Returns*, the returns of S&P500 composite; *VIX*, the volatility index of the Chicago Board Options Exchange (CBOE).

Table B1 reports the correlation matrix between $\Delta CoVaR$ and the full set of US state variables, respectively, while Table B2 reports the summary statistics for the US state variables, respectively.

Table B1: Correlation matrix among US state variables. Dependent variable $\Delta CoVaR$.

	$\Delta CoVaR_t$	Liquidity Spread$_{t-1}$	Credit Spread$_{t-1}$	Yield slope$_{t-1}$	T-Bill change$_{t-1}$	S&P 500 Returns$_{t-1}$	VIX$_{t-1}$
$\Delta CoVaR_t$	1						
Liquidity Spread$_{t-1}$	0.0657*	1					
Credit Spread$_{t-1}$	0.3440*	-0.0658*	1				
Yield slope$_{t-1}$	0.0616*	-0.4519*	0.4090*	1			
T-Bill change$_{t-1}$	-0.1219*	-0.0170*	-0.1372*	0.0919*	1		
S&P 500 Returns$_{t-1}$	-0.0437*	-0.0459*	-0.0280*	0.0115*	0.1349*	1	
VIX$_{t-1}$	0.4179*	0.0430*	0.7010*	0.2042*	-0.1360*	0.0397*	1

The table reports the correlations among state variables on weekly data from 1999:4-2022:2 time period. *Liquidity Spread*, the difference between the 3-month US repo rate and the 3- month US T-bill yield; *Credit Spread*, the difference between the 10-year Moody's seasoned Baa corporate bond and the 10-year US Treasury bond; *Yield slope*, the first difference curve (yield spread between the US Treasury benchmark 10-year bonds and the US 3-month T-bill); *T-Bill change*, the first difference of the US Treasury bill secondary market 3-month rate; *S&P 500 Returns*, the returns of S&P500 composite; *VIX*, the volatility index of the Chicago Board Options Exchange (CBOE). All these variables are sampled weekly.

Table B2: US State Variables - Summary statistics.

	Mean	**Median**	**Minimum**	**Maximum**	**Std. Dev.**	**Skewness**	**Kurtosis**
Liquidity Spread	0.139	0.090	-0.330	1.280	0.169	2.000	9.402
Credit Spread	2.592	2.527	1.403	6.589	0.752	1.654	8.106
Yield slope	1.721	1.766	-0.836	3.815	1.105	-0.136	2.101
T-Bill change	-0.003	0.000	-0.800	0.690	0.092	-2.255	29.000
S&P500 Returns	0.001	0.002	-0.182	0.121	0.025	-0.604	9.251
VIX	19.863	17.720	9.140	79.130	8.708	2.184	10.791

Summary statistics of the state variables: *Liquidity Spread*, the difference between the 3-month US repo rate and the 3- month US T-bill yield; *Credit Spread*, the difference between the 10-year Moody's seasoned Baa corporate bond and the 10-year US Treasury bond; *Yield slope*, the first difference curve (yield spread between the US Treasury benchmark 10-year bonds and the US 3-month T-bill); *T-Bill change*, the first difference of the US Treasury bill secondary market 3-month rate; *S&P 500 Returns*, the returns of S&P500 composite; *VIX*, the volatility index of the Chicago Board Options Exchange (CBOE). All these variables are sampled weekly.

B.2 Marginal Expected Shortfall

The Marginal Expected Shortfall (*MES*) of a financial institution is defined as the contribution of that institution to the Expected Shortfall (ES) of the system (Acharya et al., 2017). The *ES* of the system is defined as the expected value of the market return conditional to the event that the market return is lower than a certain threshold C with the market return defined as the weighted average of all financial institutions' returns:

$$ES_{m,t}(C) = \mathbb{E}_{t-1}(r_{m,t}|r_{m,t} < C) = \sum_{i=1}^{N} \omega_{i,t}\mathbb{E}_{t-1}(r_{i,t}|r_{m,t} < C) \tag{B5}$$

where $r_{m,t} = \sum_{i=1}^{N} \omega_{i,t} r_{i,t}$, and $\omega_{i,t}$ is the market share or capitalization of financial institution i. We set the threshold C at 5% level to ensure comparability with the other measures of systemic risk. The contribution of institution i to the System Expected Shortfall (the *MES* of institution i) is, therefore, defined as the partial derivative of the *ES* with respect to the weight of institution i, hence the term "marginal":

$$MES_{i,t} = \frac{\partial ES_{m,t}(C)}{\partial \omega_{i,t}} = \mathbb{E}_{t-1}(r_{i,t}|r_{m,t} < C) \tag{B6}$$

We calculate the *MES* as the average return of the MMF during the 5% of days when the financial system experienced the most severe losses. Specifically, we analyze the 5% worst system returns over the past 12 months on a monthly basis. Following Acharya et al. (2017), we use the overall market return, proxied by the S&P 500 index.

Appendix C Sensitivity Analyses

We compute MMFs' VaR from their past equity returns using 1-year rolling windows. The results are reported in Table C1, which confirm our main findings.

Table C1: MMFs US$ and US$ Off Shore using $\Delta CoVaR$ rolling window.

Dependent variable: ΔCoVaR	**MMFs US and MMFs Off Shore**	**MMFs US$**	**Prime**	**Government**	**MMFs US and MMFs Off Shore**	**Prime**	**Government**
	[i]	**[i]**	**[ii]**	**[iii]**	**[i]**	**[ii]**	**[iii]**
$\text{Size}_{i,t-1}$	-0.0004**	-0.0006	0.0007	0.0001	-0.0007	0.0004	0.0003
	(0.0002)	(0.0005)	(0.0005)	(0.0005)	(0.0004)	(0.0005)	(0.0005)
$\text{Size}_{i,t-1}$*Real Estate Boom_t	-0.0002***	-0.0003	-0.0002	0.0002	-0.0004*	-0.0001	0.0003*
	(0.0000)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
$\text{Size}_{i,t-1}$*Real Estate Bust_t	0.0001	-0.0004*	-0.0001	0.0003	-0.0002	-0.0002	0.0003
	(0.0001)	(0.0002)	(0.0003)	(0.0002)	(0.0002)	(0.0003)	(0.0002)
$\text{Size}_{i,t-1}$*Equity Boom_t	0.0000	-0.0004	0.0006*	0.0006**	-0.0002	0.0005*	0.0003
	(0.0001)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
$\text{Size}_{i,t-1}$*Equity Bust_t	0.0000	0.0001	0.0002	0.0000	0.0001	0.0005*	-0.0001
	(0.0001)	(0.0003)	(0.0003)	(0.0003)	(0.0002)	(0.0003)	(0.0003)
$\text{Wam}_{i,t-1}$	-0.0006**	-0.0016	0.0025	0.0004	-0.0032**	0.0051**	0.0021
	(0.0002)	(0.0022)	(0.0023)	(0.0023)	(0.0016)	(0.0017)	(0.0016)
$\text{Wam}_{i,t-1}$*Real Estate Boom_t	0.0002	-0.0054**	0.0057**	0.0069***	-0.0031**	0.0030*	0.0042**
	(0.0002)	(0.0019)	(0.0020)	(0.0019)	(0.0015)	(0.0016)	(0.0016)
$\text{Wam}_{i,t-1}$*Real Estate Bust_t	0.0019***	-0.0012	0.003	0.0035*	-0.0040***	0.0077***	0.0062***
	(0.0002)	(0.0020)	(0.0021)	(0.0020)	(0.0010)	(0.0011)	(0.0011)
$\text{Wam}_{i,t-1}$*Equity Boom_t	-0.0002	0.0089**	-0.0075**	-0.0097***	0.0094***	-0.0093***	-0.0107***
	(0.0003)	(0.0027)	(0.0028)	(0.0027)	(0.0020)	(0.0021)	(0.0020)
$\text{Wam}_{i,t-1}$*Equity Bust_t	-0.0006*	0.0046*	-0.0070**	-0.0053**	0.0051**	-0.0076***	-0.0061**
	(0.0003)	(0.0025)	(0.0027)	(0.0026)	(0.0019)	(0.0020)	(0.0019)
$\text{Wal}_{i,t-1}$	0.0004	0.001	-0.0016	-0.0016	0.0023	-0.0038**	-0.0027
	(0.0002)	(0.0023)	(0.0024)	(0.0023)	(0.0016)	(0.0017)	(0.0017)
$\text{Wal}_{i,t-1}$*Real Estate Boom_t	-0.0006**	0.0043**	-0.0046**	-0.0043**	0.0017	-0.0014	-0.0013
	(0.0002)	(0.0019)	(0.0020)	(0.0020)	(0.0015)	(0.0016)	(0.0016)
$\text{Wal}_{i,t-1}$*Real Estate Bust_t	-0.0009***	0.0005	-0.0013	-0.0015	0.0038***	-0.0060***	-0.0050***
	(0.0002)	(0.0021)	(0.0022)	(0.0022)	(0.0009)	(0.0010)	(0.0010)
$\text{Wal}_{i,t-1}$*Equity Boom_t	-0.0004	-0.0067**	0.0054*	0.0083**	-0.0070***	0.0072***	0.0092***
	(0.0003)	(0.0027)	(0.0029)	(0.0028)	(0.0019)	(0.0021)	(0.0020)
$\text{Wal}_{i,t-1}$*Equity Bust_t	-0.0010**	-0.0033	0.0048*	0.0038	-0.0037**	0.0047**	0.0045**
	(0.0003)	(0.0025)	(0.0026)	(0.0025)	(0.0018)	(0.0019)	(0.0019)
$\Delta\text{Size}_{i,t-1}$	-0.0025**	-0.0049***	0.0324***	0.0101	-0.0041***	0.0299**	0.0058
	(0.0010)	(0.0011)	(0.0085)	(0.0063)	(0.0011)	(0.0094)	(0.0057)
$\Delta\text{Size}_{i,t-1}$*Real Estate Boom_t	-0.0103***	-0.0288***	0.0209**	0.0335***	-0.0234***	0.0165**	0.0249***
	(0.0030)	(0.0064)	(0.0080)	(0.0071)	(0.0059)	(0.0077)	(0.0066)
$\Delta\text{Size}_{i,t-1}$*Real Estate Bust_t	-0.0083*	-0.0093	0.0215*	-0.0007	-0.0059	0.0186	-0.0149
	(0.0048)	(0.0109)	(0.0128)	(0.0134)	(0.0111)	(0.0135)	(0.0138)
$\Delta\text{Size}_{i,t-1}$*Equity Boom_t	0.0523***	0.2263***	-0.1645***	-0.2722***	0.1578***	-0.1264**	-0.1940***
	(0.0138)	(0.0394)	(0.0421)	(0.0439)	(0.0347)	(0.0405)	(0.0388)
$\Delta\text{Size}_{i,t-1}$*Equity Bust_t	0.0103	0.0381*	-0.0617**	0.0311	0.0289	-0.0650**	0.0106
	(0.0121)	(0.0209)	(0.0272)	(0.0397)	(0.0203)	(0.0264)	(0.0388)
ΔGDP_{t-1}	-0.0005***	-0.0007***			-0.0006***		
	(0.0000)	(0.0000)			(0.0000)		
ΔCPI_{t-1}	-0.0532***	-0.0617***			-0.0512***		
	(0.0040)	(0.0047)			(0.0045)		
10-year Government Bond_{t-1}	-0.0026***	-0.0033***			-0.0026***		
	(0.0001)	(0.0001)			(0.0001)		
Investment-to-GDP_{t-1}	-0.0008***	0.0006***			-0.0006**		
	(0.0002)	(0.0002)			(0.0002)		
Money Market MCI_{t-1}	0.0013***	0.0017***			0.0014***		
	(0.0001)	(0.0001)			(0.0001)		
Constant	0.0300***	0.0293***			0.0306***		
	(0.0020)	(0.0024)			(0.0040)		
Fixed Effects	YES	YES			YES		
Catogories Dummy (Prime and Government)	NO	YES			YES		
Bubbles Dummy	YES	YES			YES		
Dummy MMFs US*Bubbles	YES	YES			YES		
Dummy MMFs US$	YES	YES			NO		
Dummy MMFs US Offshore	NO	NO			YES		
Macro Controls	YES	YES			YES		
N. Obs.	134,083	106,108			134,083		
Adjusted R^2 *within*	0.22	0.33			0.26		
F-Test	64.62***	54.54***			34.95***		

The table reports the results between the measure of systemic risk for MMFs and asset price bubbles. *Size* is the MMF fund size defined as the natural logarithm of the fund portfolio's outstanding assets ($millions); *Weighted average maturity* (Wam) is the asset-weighted time (in days) until the securities in the portfolio mature for MMF; *Weighted average life* (Wal) is the weighted average life (in days); $\Delta Size$ is the Δln(Size) based on a twelve-month rolling window of portfolio assets for MMF. As macroeconomic controls, we consider: ΔGDP as the monthly growth rate of real GDP; ΔCPI is the monthly percentage change in the US Consumer Price Index; *10-year Government Bond* refers to the monthly rate of 10-year Government Bond; *Investment-to-GDP* as the monthly ratio between investment and real GDP; *Money Market MCI* is the market indicator for US money market. The dependent variable is $\Delta CoVaR$ rolling window. Robust (clustered) standard errors are reported in parentheses. *, **, *** denote the 10%, 5% and 1% significance level, respectively.

We also replicate our analyses after excluding the COVID-19 period, specifically from June 2019 to June 2020. The results, presented in Table C2, confirm our main findings.

Table C2: MMFs US$ and US$ Off Shore after excluding COVID-19 time period.

Dependent variable: ΔCoVaR	MMFs US and MMFs Off Shore	MMFs US$	Prime	Government	MMFs US and MMFs Off Shore	Prime	Government
	[i]	[i]	[ii]	[iii]	[i]	[ii]	[iii]
$Size_{i,t-1}$	-0.0005**	-0.0005	0.0005	-0.0005	-0.0005	0.0003	-0.0003
	(0.0002)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Size*Real Estate $Boom_t$	-0.0001	-0.0003	-0.0001	0.0003	-0.0003*	0	0.0004**
	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
$Size_{i,t-1}$*Real Estate $Bust_t$	0.0002**	-0.0005*	0.0001	0.0005*	-0.0003	0.0001	0.0006**
	(0.0001)	(0.0003)	(0.0003)	(0.0003)	(0.0002)	(0.0003)	(0.0003)
$Size_{i,t-1}$*Equity $Boom_t$	-0.0001	-0.0003	0.0001	0.0005*	-0.0002	0.0001	0.0003
	(0.0001)	(0.0003)	(0.0003)	(0.0003)	(0.0002)	(0.0003)	(0.0003)
$Size_{i,t-1}$*Equity $Bust_t$	-0.0001	0.0001	-0.0001	0.0000	0.0001	0.0001	-0.0001
	(0.0001)	(0.0003)	(0.0004)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
$Wam_{i,t-1}$	-0.0003	-0.0016	0.0025	0.0013	-0.0019	0.0031*	0.0017
	(0.0003)	(0.0023)	(0.0023)	(0.0023)	(0.0017)	(0.0018)	(0.0017)
$Wam_{i,t-1}$*Real Estate $Boom_t$	-0.0001	-0.0056**	0.0065**	0.0057**	-0.0053***	0.0060***	0.0055***
	(0.0002)	(0.0019)	(0.0020)	(0.0019)	(0.0015)	(0.0015)	(0.0015)
$Wam_{i,t-1}$*Real Estate $Bust_t$	0.0009***	0.0007	-0.0007	0.0006	-0.0052***	0.0081***	0.0063***
	(0.0002)	(0.0021)	(0.0022)	(0.0021)	(0.0012)	(0.0013)	(0.0012)
$Wam_{i,t-1}$*Equity $Boom_t$	-0.0006*	0.0067**	-0.0071**	-0.0074**	0.0071***	-0.0076***	-0.0088***
	(0.0003)	(0.0027)	(0.0028)	(0.0027)	(0.0020)	(0.0021)	(0.0021)
$Wam_{i,t-1}$*Equity $Bust_t$	0.0004	0.0042	-0.004	-0.0046	0.0054**	-0.0057**	-0.0063**
	(0.0004)	(0.0028)	(0.0030)	(0.0029)	(0.0023)	(0.0024)	(0.0023)
$Wal_{i,t-1}$	0.0004	0.0015	-0.0022	-0.002	0.0014	-0.0024	-0.0018
	(0.0002)	(0.0024)	(0.0024)	(0.0024)	(0.0018)	(0.0018)	(0.0018)
$Wal_{i,t-1}$*Real Estate $Boom_t$	-0.0006**	0.0050**	-0.0052**	-0.0051**	0.0048***	-0.0053***	-0.0048***
	(0.0002)	(0.0019)	(0.0020)	(0.0019)	(0.0014)	(0.0015)	(0.0015)
$Wal_{i,t-1}$*Real Estate $Bust_t$	-0.0009***	-0.0022	0.0021	0.0016	0.0042***	-0.0064***	-0.0051***
	(0.0002)	(0.0022)	(0.0023)	(0.0023)	(0.0009)	(0.0010)	(0.0010)
$Wal_{i,t-1}$*Equity $Boom_t$	-0.0002	-0.0057**	0.0057**	0.0068**	-0.0058**	0.0067**	0.0081***
	(0.0003)	(0.0027)	(0.0028)	(0.0027)	(0.0020)	(0.0021)	(0.0021)
$Wal_{i,t-1}$*Equity $Bust_t$	-0.0012**	-0.0021	0.0025	0.0028	-0.0031	0.0036	0.0043*
	(0.0004)	(0.0028)	(0.0029)	(0.0029)	(0.0022)	(0.0023)	(0.0022)
$\Delta Size_{i,t-1}$	-0.0023**	-0.0054***	0.0415***	0.0113*	-0.0043***	0.0393***	0.004
	(0.0011)	(0.0012)	(0.0102)	(0.0060)	(0.0011)	(0.0104)	(0.0053)
$\Delta Size_{i,t-1}$*Real Estate $Boom_t$	-0.0071**	-0.0131**	0.0126*	0.0138**	-0.0116**	0.0131*	0.0066
	(0.0027)	(0.0055)	(0.0072)	(0.0062)	(0.0054)	(0.0074)	(0.0061)
$\Delta Size_{i,t-1}$*Real Estate $Bust_t$	-0.0018	0.0056	0.0071	-0.004	0.0059	0.0033	-0.0145
	(0.0061)	(0.0150)	(0.0175)	(0.0177)	(0.0152)	(0.0174)	(0.0178)
$\Delta Size_{i,t-1}$*Equity $Boom_t$	0.0311**	0.1204***	-0.1295***	-0.1146***	0.0900***	-0.1110***	-0.0728**
	(0.0121)	(0.0282)	(0.0316)	(0.0319)	(0.0270)	(0.0330)	(0.0298)
$\Delta Size_{i,t-1}$*Equity $Bust_t$	0.0324**	0.0393*	-0.0786**	0.1220**	0.0384*	-0.0735**	0.0595
	(0.0155)	(0.0215)	(0.0299)	(0.0467)	(0.0219)	(0.0297)	(0.0458)
Constant	0.0221***	0.0323***			0.0178***		
	(0.0018)	(0.0019)			(0.0033)		
Fixed Effects	YES	YES			YES		
Catogories Dummy (Prime and Government)	YES	YES			YES		
Bubbles Dummy	YES	YES			YES		
Dummy MMFs US*Bubbles	YES	YES			YES		
Dummy MMFs US$	YES	YES			YES		
Dummy MMFs US Offshore	NO	NO			YES		
Time Dummy	YES	YES			YES		
N. Obs.	126,431	100,273			126,431		
Adjusted R^2 *within*	0.27	0.37			0.30		
F-Test	57.11***	58.43***			38.39***		

The table reports the results between the measure of systemic risk for MMFs and asset price bubbles. *Size* is the MMF fund size defined as the natural logarithm of the fund portfolio's outstanding assets ($millions); *Weighted average maturity* (Wam) is the asset-weighted time (in days) until the securities in the portfolio mature for MMF; *Weighted average life* (Wal) is the weighted average life (in days); $\Delta Size$ is the Δln(Size) based on a twelve-month rolling window of portfolio assets for MMF. As macroeconomic controls, we consider: ΔGDP as the monthly growth rate of real GDP; ΔCPI is the monthly percentage change in the US Consumer Price Index; *10-year Government Bond* refers to the monthly rate of 10-year Government Bond; *Investment-to-GDP* as the monthly ratio between investment and real GDP; *Money Market MCI* is the market indicator for US money market. The dependent variable is $\Delta CoVaR$. Robust standard errors are reported in parentheses. *, **, *** denote the 10%, 5% and 1% significance level, respectively.